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Predictors of mortality in insulin dependent diabetes: 10 year observational follow up study

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Abstract

***Objective*—To evaluate the prognostic significance of microalbuminuria and overt diabetic nephropathy and other putative risk factors for cardiovascular and all cause mortality in insulin dependent diabetes.**

***Design*—Ten year observational follow up study.**

***Setting*—Outpatient diabetic clinic in a tertiary referral centre.**

***Subjects*—All 939 adults with insulin dependent diabetes (duration of diabetes five years or more) attending the clinic in 1984; 593 had normal urinary albumin excretion (≤30 mg/24 h), 181 persistent microalbuminuria (31-299 mg/24 h), and 165 overt nephropathy (≥300 mg/24 h).**

***Main outcome measure*—All cause and cardiovascular mortality.**

***Results*—Fifteen per cent of patients (90/593) with normoalbuminuria, 25% (45/181) with microalbuminuria, and 44% (72/165) with overt nephropathy at baseline died during follow up. Cox multiple regression analysis identified the following significant predictors of all cause mortality: male sex (relative risk 2.03; 95% confidence interval 1.37 to 3.02), age (1.07; 1.06 to 1.08), height (0.96; 0.94 to 0.98), smoking (1.51; 1.09 to 2.08), social class V versus social class IV (1.70; 1.25 to 2.31), $\log_{10}$ urinary albumin excretion (1.45; 1.18 to 1.77), hypertension (1.63; 1.18 to 2.25), $\log_{10}$ serum creatinine concentration (8.96; 3.34 to 24.08), and haemoglobin A_{1c} concentration (1.11; 1.03 to 1.20). Age, smoking, microalbuminuria, overt nephropathy, and hypertension were significant predictors of cardiovascular mortality. Mortality in patients with microalbuminuria was only slightly increased compared with that in patients with normoalbuminuria. Median survival time after the onset of overt diabetic nephropathy was 13.9 years (95% confidence interval 11.8 to 17.2 years).**

***Conclusions*—Abnormally increased urinary albumin excretion and other potentially modifiable risk factors such as hypertension, smoking, poor glycaemic control, and social class predict increased mortality in insulin dependent diabetes. Microalbuminuria by itself confers only a small increase in mortality. The prognosis of patients with overt diabetic nephropathy has improved, probably owing to effective antihypertensive treatment.**

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Introduction

Patients with insulin dependent diabetes have increased mortality compared with the background population. The excess is due mainly to an increased risk of renal failure and cardiovascular disease in the subgroup of around 35% of patients who develop diabetic nephropathy.[1] Microalbuminuria is an established predictor of the later development of nephropathy in insulin dependent[2-4] and non-insulin dependent diabetes.[5,6] Microalbuminuria is also predictive of early cardiovascular and all cause mortality in non-insulin dependent diabetes[5,7,8] and possibly also insulin dependent diabetes.[9,10] Two small retrospective studies of microalbuminuric insulin dependent diabetic patients (n = 8 and n = 14 respectively) followed up for 23 and 18 years suggested that microalbuminuria is a strong risk marker for early death, particularly cardiovascular death.[9,10] We do not know, however, whether the increased mortality associated with microalbuminuria is due to the microalbuminuric state itself or due to the later development of diabetic nephropathy.

We conducted a 10 year observational follow up study of a large cohort of adult insulin dependent

diabetic patients with microalbuminuria and overt diabetic nephropathy to determine the prognostic significance of these complications for cardiovascular and all cause mortality. The study was initiated in 1984, and baseline data have been reported.[11]

Patients and methods

All 1024 adult patients with insulin dependent diabetes who satisfied certain criteria and were attending the outpatient clinic at Hvidöre Hospital in 1984 were asked to participate. The criteria were age 18 or over, duration of diabetes five years or more, and age 40 or under at onset of diabetes. Forty two patients were excluded because they had been referred by one of us (HHP),[11] and one or more 24 hour urine collections were obtained from 957 (97%) of the remainder.[11] Eighteen patients were excluded from follow up. Thus 939 patients were followed up till 1 January 1995 or until death (n = 207) or emigration (n = 6). Clinical data at baseline are presented in table 1. All the patients were white. Patients gave informed consent and the study was approved by the local ethics committee.

Procedures and methods used in the baseline cross sectional study were as described.[11] Twenty four hour urinary albumin excretion was measured in sterile urine by radioimmunoassay. Measurements were done in all patients at baseline and in most patients (n = 888) during regular follow up in our outpatient clinic. Microalbuminuria and overt diabetic nephropathy were defined as urinary albumin excretion 31-299 mg and 300 mg or more respectively per 24 hours in at least two out of three consecutive samples.[12] Urine samples were taken routinely at least once a year. When values were abnormal samples were requested at subsequent visits. Patients with previous persistent macroalbuminuria were classified as cases of overt nephropathy (n = 165) independently of present level of albuminuria (all patients classified as having overt nephropathy with urinary albumin excretion <300 mg/24 h in 1984 received antihypertensive treatment). Time of onset of microalbuminuria and overt nephropathy during follow up was defined as the first recorded positive urine sample in a series of three fulfilling the above criteria.

Arterial blood pressure was measured once on the right arm with a standard clinical sphygmomanometer (cuff size 25 x 12 cm) after 10 minutes' sitting. Diastolic blood pressure was recorded at the disappearance of Korotkoff sounds (phase V). Arterial hypertension was diagnosed according to the World Health Organisation's criteria (>160/95 mm Hg) or if treatment for hypertension was prescribed. Haemoglobin A_{1c} concentration was measured at least yearly with an isoelectric focusing method (normal range 4.1-6.1%). Owing to technical errors haemoglobin A_{1c} values in 1984 were obtained for only 480 of the 939 patients; in the remaining patients values from early 1985 were used. Ophthalmoscopy through dilated pupils was carried out by the same observer. Patients were classified as smokers if they smoked one or more cigarettes in 1984. Socioeconomic class (I-V) was determined in 1984 according to the Danish National Institute of Social Research,[13] based on case record information.

All patients were traced through the national register during the summer of 1995. If a subject had died before 1 January 1995 the date of death was recorded and information on the cause of death obtained from the death certificate. All death certificates were reviewed independently by at least two observers and the primary cause of death recorded. If the serum creatinine concentration measured at least once a year before death was >500 μmol/l the cause of death was coded as end stage renal disease independently of the cause of death on the death certificate. Additional information from necropsy reports was included in cases of hypoglycaemia or hyperglycaemia related death.

STATISTICAL ANALYSIS

Values are given as means and standard deviations or as medians and ranges. Continuous variables in the three groups were compared by the Kruskal-Wallis test and Mann-Whitney U test, categorical data being compared by χ^2 test. P values <0.05 (two sided) were considered significant.

Survival data (see fig 1) were analysed by using statistical methods for censored failure times.[14,15] Kaplan-Meier estimates of survival curves for the three levels of

Table 1—*Baseline clinical data in 939 patients with insulin dependent diabetes followed up from 1984 to end of 1994*

	Normoalbuminuria (n = 593)	Microalbuminuria (n = 181)	Overt nephropathy (n = 165)	P value
Sex (M/F)	302/291	96/85	95/70	NS
Mean age (years) (SD)	40 (12)	38 (14)	40 (13)	NS
Median duration of diabetes (years) (range)	17 (5-60)	21 (5-56)	22 (6-54)	<0.0001*†
Mean insulin dose (U/kg/day) (SD)	0.58 (0.17)	0.61 (0.20)	0.60 (0.18)	NS
Mean haemoglobin A_{1c} (%) (SD)	8.8 (1.7)	9.2 (2.0)	9.5 (1.8)	<0.0001,* <0.05†‡
Mean height (cm) (SD):				
Men	178 (8)	177 (6)	176 (7)	0.01
Women	165 (6)	166 (7)	163 (7)	NS
No (%) with retinopathy	407 (69)	157 (87)	162 (98)	<0.0001*†‡
Mean blood pressure (mm Hg) (SD):				
Systolic	133 (18)	138 (18)	147 (19)	<0.0001*†‡
Diastolic	80 (9)	83 (10)	88 (9)	<0.0001*†‡
No (%) with hypertension	108 (18)	62 (34)	107 (65)	<0.0001*†‡
Median urinary albumin (mg/24 h) (range)	10 (1-196)§	83 (31-398)§	920 (43-8213)§	<0.0001*†‡
Median serum creatinine (μmol/l) (range)	69 (36-128)	71 (43-164)	88 (37-857)	<0.0001*‡
No (%) of smokers	344 (58)	109 (60)	104 (63)	NS
No (%) in social class:				
I	44 (7)	12 (7)	8 (5)	
II	80 (14)	18 (10)	14 (9)	
III (non-manual + manual)	159 (27)	37 (20)	36 (21)	0.03*
IV	178 (30)	70 (39)	54 (33)	
V	132 (22)	44 (24)	53 (32)	

*Normoalbuminuria *v* overt nephropathy.
†Normoalbuminuria *v* microalbuminuria.
‡Microalbuminuria *v* overt nephropathy.
§Thirty nine patients with urinary albumin excretion >30 mg/24 h had intermittent microalbuminuria and were categorised as normoalbuminuric; two with intermittent values ≥300 mg/24 h were categorised as microalbuminuric; and 23 with overt diabetic nephropathy receiving antihypertensive treatment had urinary albumin excretion <300 mg/24 h.

albuminuria were compared by log rank test. Death rate data (see fig 2) were analysed by taking into account the actual level of albuminuria during follow up. Death rates were derived from the integrated hazard by using kernel function smoothing. When survival function was estimated from the onset of persistent macroalbuminuria (see fig 3) patients developing macroalbuminuria during the study contributed from the time of occurrence. Patients who were macroalbuminuric at the beginning of the study were left truncated and contributed for the time corresponding to the duration of macroalbuminuria at 1 January 1985. For example, a patient with four years of nephropathy at baseline was not considered to be at risk of dying in the first four years from the onset of nephropathy.

In the analysis of predictors of all cause and cardiovascular mortality Cox proportional hazards multiple regression analysis was used. This was based on time from entry into the study with stepwise backwards selection including sex and baseline measurements of age, duration of diabetes, height, smoking, social class (I-V, with the largest class (IV) as reference), microalbuminuria and overt nephropathy, $\log_{10}$ urinary albumin excretion, systolic and diastolic arterial blood pressure, hypertension, $\log_{10}$ serum creatinine concentration, haemoglobin A_{1c} concentration, and retinopathy status.[14 15] Results are described as relative risks (hazard ratios). Urinary albumin excretion and serum creatinine concentration were logarithmically transformed owing to the skewed distribution. Relative risk thus corresponded to a 10-fold increase in these variables. Confidence intervals were based on the normal approximation on the logarithmic scale.

Results

Table 1 gives the clinical details of patients at entry.

MORTALITY

Patients were followed up for a mean of 9.2 (0-10) years. During this period 207 (22%) of the 939 patients died. Ninety (15%) of the 593 patients with normoalbuminuria, 45 (25%) of the 181 with microalbuminuria, and 72 (44%) of the 165 with diabetic nephropathy died (normoalbuminuria *v* microalbuminuria P<0.01; normoalbuminuria *v* overt nephropathy P<0.0001; microalbuminuria *v* overt nephropathy P<0.001). Figure 1 shows the estimated survival curves. The underlying causes of death are listed in table 2. Diabetes was mentioned as a contributory cause of death on 178 (86%) death certificates. Cardiovascular disease was a major cause of death in all three groups (34-40% of cases). End stage renal disease was the cause of death in 25 (35%) patients who had overt nephropathy in 1984.

Figure 2 shows the estimated death rates, taking into account current age and current level of albuminuria during follow up. At age over 50 patients with microalbuminuria had significantly higher mortality than patients with normoalbuminuria but lower mortality than patients with overt nephropathy (normoalbuminuria *v* microalbuminuria P<0.05; overt diabetic nephropathy *v* normoalbuminuria or microalbuminuria P<0.0001).

Figure 3 shows the estimated survival curve for 263 patients with overt nephropathy (of whom 165 already had overt nephropathy in 1984, 59 microalbuminuria, and 39 normoalbuminuria). The median survival time was 13.9 years (95% confidence interval 11.8 to 17.2 years). Arterial blood pressure from the onset of nephropathy and during the whole follow up period was on average 149/86 (SD 18/7) mm Hg. In 1984, 86 (52%) patients with overt nephropathy were given antihyper-

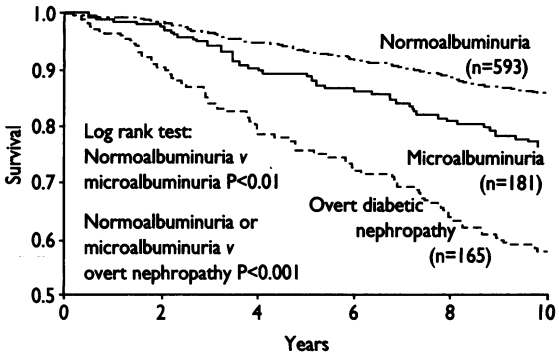

Fig 1—*Kaplan-Meier estimates of survival curves with respect to all cause mortality for the three levels of albuminuria in patients with insulin dependent diabetes*

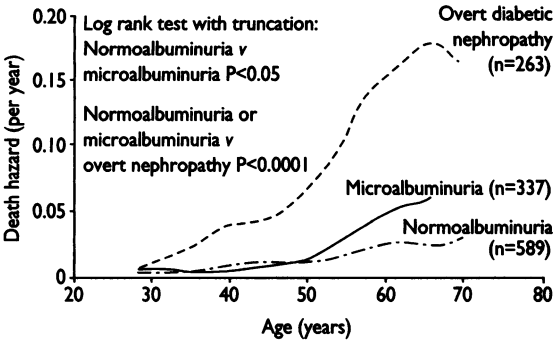

Fig 2—*Death rate (death hazard per year) according to current state of urinary albumin excretion. Patients may contribute to several groups if progressing from normoalbuminuria to microalbuminuria and to overt diabetic nephropathy*

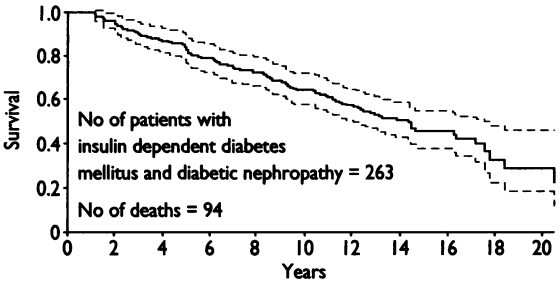

Fig 3—*Survival function from onset of overt diabetic nephropathy with simple confidence intervals based on Nelson-Aalen hazard and left truncated data (patients with overt nephropathy at baseline were left truncated and contributed from time corresponding to duration of overt nephropathy at 1 January 1985)*

Table 2—*Causes of death in patients with insulin dependent diabetes with normoalbuminuria (n = 593), microalbuminuria (n = 181), and overt diabetic nephropathy (n = 165) at baseline. Figures are numbers (percentages) of patients*

	Normoalbuminuria	Microalbuminuria	Overt nephropathy
All cardiovascular causes	33 (37)	18 (40)	23 (32)
Myocardial infarction	17 (19)	13 (29)	9 (13)
Cardiac insufficiency	12 (13)	4 (9)	9 (13)
Stroke	4 (4)	1 (2)	5 (7)
End stage renal disease	2 (2)	6 (13)	25 (35)
Ketoacidosis	4 (4)	1 (2)	2 (3)
Hypoglycaemia	2 (2)	2 (4)	0
Diabetes	6 (7)	2 (4)	4 (6)
Infections	9 (10)	2 (4)	5 (7)
Neoplasms	8 (9)	4 (9)	4 (6)
Suicide	4 (4)	2 (4)	0
Accident	0	2 (4)	1 (1)
Other causes (including unknown)	22 (24)	6 (13)	8 (11)
All cause mortality (% of group)	90 (15)	45 (25)	72 (44)

Table 3—*Predictors of all cause and cardiovascular mortality in patients with insulin dependent diabetes based on Cox multiple regression analysis (patients with missing values excluded)*

Variable	Relative risk	95% Confidence interval	P value
All cause mortality (n = 886; 183 deaths)			
Male sex	2.03	1.37 to 3.02	<0.001
Age	1.07	1.06 to 1.08	<0.0001
Height	0.96	0.94 to 0.98	<0.01
Smoking	1.51	1.09 to 2.08	<0.02
Social class V versus social class IV	1.70	1.25 to 2.31	<0.001
Log_{10} albuminuria†	1.45	1.18 to 1.77	<0.001
Hypertension	1.63	1.18 to 2.25	<0.01
Log_{10} serum creatinine†	8.96	3.34 to 24.08	<0.0001
Haemoglobin A_{1c}	1.11	1.03 to 1.20	<0.02
Cardiovascular mortality (n = 916; 71 deaths)			
Age	1.11	1.09 to 1.13	<0.0001
Smoking	2.23	1.31 to 3.79	<0.01
Microalbuminuria	1.87	1.03 to 3.40	<0.05
Overt nephropathy	2.97	1.68 to 5.24	<0.001
Hypertension	2.35	1.41 to 3.93	<0.01

†Relative risk corresponds to 10-fold increase in variable.

tensive treatment. Almost all treated patients (n = 82) received a diuretic (frusemide or bendrofluazide), often combined with metoprolol (40) or the vasodilator hydralazine (29). At the end of follow up 194 of 263 patients (74%) received antihypertensive treatment. A diuretic was used as monotherapy in 41 (21%) patients or in combination with an angiotensin converting enzyme inhibitor (53; 27%), metoprolol (16; 8%), or a calcium antagonist (18; 9%), and 63 (32%) received a combination of three or more types of antihypertensive.

COX SURVIVAL ANALYSIS

Age, sex, duration of diabetes, adult height, social class, presence of microalbuminuria or overt nephropathy, log_{10} urinary albumin excretion, systolic and diastolic blood pressure, presence of hypertension, log_{10} serum creatinine concentration, haemoglobin A_{1c} concentration, and presence of retinopathy were associated with risk of death in univariate Cox regression analysis (data not shown). The putative predictors of all cause and cardiovascular mortality were analysed in a backwards stepwise Cox proportional hazards analysis, and table 3 lists the variables significantly associated with an increased risk of early death. When analysis was restricted to patients without diabetic nephropathy in 1984 almost the same factors were found to be significant predictors of all cause mortality—namely, age, sex, short stature, low social class, presence of microalbuminuria, and diastolic blood pressure. Risk factors for cardiovascular mortality were age, diastolic blood pressure, and microalbuminuria.

Discussion

Our 10 year observational follow up study of 939 adults with insulin dependent diabetes shows that increased urinary albumin excretion, poor glycaemic control, and short stature were independent risk markers for all cause mortality after adjustment for well known cardiovascular risk factors such as age, sex, social class, arterial hypertension, and smoking. Predictors of cardiovascular mortality were microalbuminuria or overt nephropathy, arterial hypertension, smoking, and age. Our findings also show that the death rate in patients with microalbuminuria (adjusted for the development of overt nephropathy) was slightly higher than in patients with normoalbuminuria but substantially lower than in patients with overt nephropathy. Our large clinic based study of patients with insulin dependent diabetes complicated by nephropathy shows improved preservation of kidney function and a better prognosis during the past two decades than in previous studies,[1 16-18] reinforcing recent findings that effective antihypertensive treatment improved survival in insulin dependent diabetic patients with overt nephropathy.[19-21]

Conventional risk factors such as smoking, hypertension, male sex, age, and low socioeconomic class were also associated with increased mortality in our insulin dependent diabetic population. As in the background population male sex was related to all cause mortality.[16] However, in contrast with what is observed in the background population the absolute rate of cardiovascular mortality was similar in men and women with diabetes. This agrees with other studies of insulin dependent diabetes.[22] Smoking and hypertension were factors of special interest because they can be modified. We could not evaluate the influence of serum lipid values as no regular measurements were performed.

MICROALBUMINURIA

Microalbuminuria at baseline was an independent predictor of all cause and cardiovascular mortality compared with the normoalbuminuric state, confirming and extending results from retrospective studies of small numbers of insulin dependent diabetic patients with microalbuminuria.[9 10] This is mainly explained by microalbuminuria being a strong risk factor for the later development of overt diabetic nephropathy,[2-4] but our study also showed an excess mortality with microalbuminuria by itself (fig 2). This excess was apparent only after age 50. Rates of progression from microalbuminuria to overt diabetic nephropathy differ with the duration of diabetes,[23] which may partly explain the age dependent differences in risk of death between normoalbuminuric and microalbuminuric insulin dependent diabetic patients. Patients with diabetes for less than 15 years progress more rapidly to overt diabetic nephropathy than patients with long-standing insulin dependent diabetes.[23]

The link between microalbuminuria and cardiovascular disease is poorly understood. However, as reviewed by Parving *et al*, microalbuminuria is associated with many cardiovascular risk factors, such as raised arterial blood pressure, poor glycaemic control, dyslipoproteinaemia, increased platelet aggregability, endothelial dysfunction, autonomic nervous dysfunction, and left ventricular hypertrophy.[24] Several but not all studies have shown that strict metabolic control[25-28] and treatment with angiotensin converting enzyme inhibitors[29 30] can delay the progression from microalbuminuria to overt diabetic nephropathy. Our study was conducted before a general attempt to improve metabolic control in a large clinic was initiated (mean haemoglobin A_{1c} concentration at the end of follow up 8.8% (SD 1.5%)) and only 16% of our microalbuminuric insulin dependent diabetic patients were treated with angiotensin converting enzyme inhibitors at the end of follow up. Our study suggests that the estimated beneficial effect of screening and intervention for microalbuminuria is slightly less than originally assumed simply because microalbuminuria by itself carries an increased risk of early mortality, which was not considered in the original analysis.[31]

DIABETIC NEPHROPATHY AND ANTIHYPERTENSIVE TREATMENT

Excess mortality in insulin dependent diabetic patients with overt diabetic nephropathy has been recorded in many studies.[1 16-18] However, it is encouraging that the improved prognosis observed in smaller incidence cohorts of patients with overt nephropathy[19-21] is supported by our clinic based study of 263 patients (those with nephropathy at baseline or who developed

Key messages

- Abnormally increased urinary albumin excretion, hypertension, smoking, poor glycaemic control, and low social class predict increased mortality in insulin dependent diabetes
- Microalbuminuria predicts increased mortality due to progression to overt nephropathy
- Microalbuminuria by itself confers only a small increase in mortality after age 50
- The prognosis in patients with insulin dependent diabetes complicated by nephropathy has improved, probably owing to treatment with antihypertensive agents

nephropathy during follow up) followed up 10 years from inclusion (which could be up to 10 years from the onset of nephropathy) disclosing a median survival time of 14 years (fig 3). In previous studies of the natural course of diabetic nephropathy a median survival time of seven years was observed,[32 33] 66% of patients dying of uraemia and 19-23% of cardiovascular disease.[32] Our study was comparable with previous studies with respect to sex distribution of patients and age at onset of diabetes (16 *v* 14 years). As in other studies the end point of our study was death. However, five of our 263 patients with nephropathy were alive at the end of follow up, receiving renal replacement therapy which was not available previously.

Diabetic nephropathy does not develop within the first five years of diabetes and thus excluding patients at baseline with a duration of diabetes of less than five years would not affect comparability between this and previous studies of diabetic nephropathy. Krolewski *et al* found that three quarters of insulin dependent diabetic patients had developed end stage renal failure (including deaths from non-renal causes when the serum creatinine concentration exceeded 221 μmol/l) 15 years after the onset of diabetic nephropathy.[34] In our study only 35% of deaths in patients with overt nephropathy in 1984 were due to end stage renal failure and 33% to cardiovascular disease. Thus our study suggests an improved prognosis and a change in the mortality pattern (reduced end stage renal disease). This is most likely due to the aggressive use of antihypertensive agents in these patients,[19 35] though changes in other risk factors for progression of renal disease—for example, glycaemic control, hyperlipidaemia, and protein intake—cannot be excluded. It is also possible that a small improvement in time from diagnosis of diabetic nephropathy to death could be related to more frequent monitoring and thus earlier detection of overt diabetic nephropathy.

GLYCAEMIC CONTROL AND OTHER FACTORS

Poor glycaemic control was an independent risk factor for all cause mortality, a 1% increase in haemoglobin A_{1c} concentration being associated with an 11% increase in the risk of dying. This agrees closely with the increased risk of 12% for all cause mortality per 1% increase in glycated haemoglobin concentration reported in the Wisconsin study of patients with the onset of diabetes at younger ages.[18] Those workers also found an association between glycaemic control and mortality due to ischemic heart disease and stroke. As univariate analysis showed a similar trend in our study—that is, relative risk 1.11 (95% confidence interval 0.96 to 1.27) per 1% increase in haemoglobin A_{1c} concentration—the lack of significance of haemoglobin A_{1c} as a predictor of cardiovascular mortality may be due to the small number of events.

Our study showed an inverse relation between adult height and all cause mortality. This was also found in the Whitehall study of 17 530 civil servants independently of age and grade of employment.[36] Furthermore, the Whitehall study[36] and the physicians' health study[37] found height to be an independent risk factor for mortality due to coronary heart disease. Adult height has been shown to correlate inversely with urinary albumin excretion in diabetic[38] and non-diabetic men,[39] but our multivariate analysis showed height to be a risk factor independent of urinary albumin excretion.

Conclusion

Abnormally increased urinary albumin excretion together with other potentially modifiable risk factors such as arterial hypertension, smoking, poor glycaemic control, and social class and non-modifiable risk factors such as sex, age, and height predict increased mortality in insulin dependent diabetes. Microalbuminuria by itself confers only a small increase in mortality, and our study confirms an improved prognosis for patients with insulin dependent diabetes complicated by nephropathy compared with previous studies.

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Does the decline in child injury mortality vary by social class? A comparison of class specific mortality in 1981 and 1991

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Abstract

***Objective*—To examine whether the decline in child injury death rates between 1981 and 1991 varied by social class.**

***Design*—Comparison of class specific child injury death rates for 1979, 1980, 1982, and 1983, with those for the four years 1989-92.**

***Setting*—England and Wales.**

***Subjects*—Children aged 0-15 years.**

***Main outcome measures*—Death rates from injury and poisoning.**

***Results*—Death rates from injury and poisoning have fallen for children in all social classes. The decline for children in social classes IV and V (21% and 2% respectively), however, is smaller than that for children in social classes I and II (32% and 37%). As a result of the differential decline in injury death rates, socioeconomic mortality differentials have increased. In the four years 1979-80 and 1982-83 the injury death rate for children in social class V was 3.5 times that of children in social class I. For the four years 1989-92 the injury death rate for children in social class V was 5.0 times that of children in social class I. Poisson regression modelling showed that the trend in the decline in death rates across the social classes was unlikely to have arisen by chance alone.**

***Conclusions*—Socioeconomic inequalities in child injury death rates have increased. If these gradients persist, the Health of the Nation's target is likely to be met for children in the non-manual social classes but not for those in the manual social classes.**

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Introduction

The Health of the Nation strategy established the reduction of child injury mortality as a government priority.[1] A national target was set: the reduction of the injury death rate for children aged under 15 years by at least 33% by 2005 from a baseline of 6.7 deaths per 100 000 in 1990. Progress towards the target has been encouraging.[2] Child injury death rates have been falling steadily for the past two decades, and if this trend continues, the target will almost certainly be exceeded. Recently, with the publication of *Variations in Health*, the government has also signalled its resolve to tackle the problem of social class variations in health.[3] The social class gradient for deaths due to injuries is steeper than for any other cause of death in childhood.[4] It seems timely therefore to assess whether the rate of decline in child injury mortality varies by social class. We examined social class differences in reductions in child injury mortality by comparing class specific injury death rates in the early 1980s with those in the early 1990s.

Methods

The decennial supplement of occupational mortality published by the Office of Population Censuses and Surveys (now the Office for National Statistics) provides injury mortality data by occupational class for children aged 1-15 years in England and Wales for the four years 1979, 1980, 1982, and 1983.[5] Data for 1981 are unavailable because of an industrial dispute at that time involving members of the registration service. The supplement gives the numbers of deaths from and death rates for all injury and poisoning, as well as for several specific external causes of injury. Direct comparison with more recent data is made difficult by changes in the reporting of class based population data. Specifically, 1991 census data by social class are available only from published sources for the age group 0-15 years. Identical age ranges can be compared, however, by the inclusion of postneonatal deaths for 1981, which are published separately in the decennial supplement. Unfortunately, this is only possible for all deaths from injury and poisoning and not for specific causes of injury.

We obtained a data file containing the anonymised records of all child injury deaths (child defined as 0-15 years) for 1989-92 in England and Wales from the Office of Population Censuses and Surveys. Each record included the external cause of injury code according to the international classification of diseases, ninth revision (ICD-9 E code), year of death, and the parents' occupational class. For these analyses, we based the deceased child's social class on the father's social class unless this was missing, when we based it on the mother's social class. We then calculated child injury death rates by social class for 1989-92 using denominator data from the 1991 census. We calculated death rates for all deaths from injury and poisoning, motor vehicle accidents, pedestrian accidents, and accidents caused by fire and flames. Pedestrian accidents and accidents caused by fire and flames were the leading specific causes of child injury deaths in 1991. Because of the relatively small number of child injury deaths in any individual social class, the preci-