Diabetologia (2013) 56:1272–1281
DOI 10.1007/s00125-013-2873-5

ARTICLE

The clinical characteristics at diagnosis of type 2 diabetes in a multi-ethnic population: the South London Diabetes cohort (SOUL-D)

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Received: 14 December 2012 / Accepted: 5 February 2013 / Published online: 14 March 2013

Abstract
Aims/hypothesis This study aimed to investigate the clinical features of newly diagnosed type 2 diabetes in an urban multi-ethnic cohort.
Methods A population-based cross-sectional design was used. People diagnosed with type 2 diabetes in the preceding 6 months were recruited from primary care practices in three adjacent inner-city boroughs of South London, serving a population in which 20% of residents are of black African or Caribbean ethnicity. Sociodemographic and biomedical data were collected by standardised clinical assessment and from medical records. Multiple logistic regression methods were used to report associations between ethnicity and diabetes-complication status.
Results From 96 general practices, 1,506 patients were recruited. Their mean age was 55.6 (±11.07) years, 55% were men, 60% were asymptomatic at diagnosis and 51%, 38% and 11% were of white, black and South Asian/other ethnicity, respectively. Compared with white participants, black and South Asian/other participants were: younger (mean age 58.9 [±10.09], 52.4 [±11.19] and 51.5 [±10.42] years, respectively; $p<0.0001$); less likely to have neuropathy (10.1%, 3.6% and 4.4%; $p<0.0001$) or report coronary artery disease (12.7%, 4.8% and 7.3%; $p<0.0001$). In logistic regression, compared with white participants, black participants had lower levels of macrovascular complications (OR 0.52, 95% CI 0.32, 0.84; $p=0.01$). Male sex was independently associated with microvascular disease (OR 1.69, 95% CI 1.26, 2.28; $p<0.0001$).
Conclusions/interpretation The prevalence of complications at time of diagnosis was lower than expected, especially in black and South Asian/other ethnic groups. However, in multi-ethnic inner-city populations, onset of type 2 diabetes occurred almost 10 years earlier in non-white populations than in white participants, predicating a prolonged morbidity.

Keywords Complications · Cross-sectional design · Incidence · Population cohort · Prevalence · Type 2 diabetes mellitus

Abbreviations

ACR	Albumin:creatinine ratio
ADDITION	Anglo–Danish–Dutch study of Intensive Treatment In PeOple with screeN detected diabetes in primary care
CABG	Coronary artery bypass graft
CVA	Cerebrovascular accident
GP	General practitioner

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MI	Myocardial infarction
NIHR	National Institute for Health Research
SOUL-D	South London Diabetes cohort
UKPDS	United Kingdom Prospective Diabetes Study
VPT	Vibration perception threshold

Introduction

Type 2 diabetes mellitus is characterised by increased insulin resistance and/or reduced insulin secretion, either of which may be the principal driving factor at diagnosis [1]. In the absence of more tightly and perhaps genetically defined criteria, it is likely that different clinical type 2 diabetes phenotypes have different prognoses. This is of particular clinical relevance in settings with a high prevalence of type 2 diabetes, such as multi-ethnic and urban or industrialised settings. An important clinical window to characterise high-risk patients is at the time of diagnosis. However, there are only a few prospective cohorts that have characterised diabetes status at diagnosis of type 2 diabetes. The landmark United Kingdom Prospective Diabetes Study (UKPDS) reported 20 years ago that 30% of participants had microvascular complications at diagnosis [2], suggesting a pre-diagnosis duration of about 10 years [3]. These observations may not apply to current type 2 diabetes populations. Clinical practice has changed, with more aggressive screening in primary care. Two recent studies of people with new-onset diabetes, identified by screening, have not reported retinopathy data and both study populations, in common with UKPDS, were of predominantly white ethnicity [4–6]. A third study that purposefully recruited British Asians, and which included 40% with diabetes duration of less than 4 years, also did not report retinopathy status [7].

There has been no recent systematic clinical phenotyping of current type 2 diabetes populations at the time of diagnosis, especially in areas of high and differential morbidity [8–12]. There are likely to be cohort effects: changes in screening bringing forward the diagnosis, advances in medical management at all stages of the diabetes continuum and socio-environmental processes such as migration of high-risk populations, rendering the distribution of risk factors for worse diabetes outcomes in longstanding cohorts such as the UKPDS potentially out of date. Accumulating evidence for differential risk—not just for macrovascular, but also for microvascular disease—by ethnicity, requires comparative study by ethnicity. The aim of our study was to describe the clinical characteristics of people recently diagnosed with type 2 diabetes in an inner-city setting, and make comparisons between the different ethnic groups represented in that population.

Methods

Design This is a cross-sectional analysis of the baseline sample of the South London Diabetes (SOUL-D) study. SOUL-D is a prospective cohort of individuals newly diagnosed with type 2 diabetes established to investigate the role of a range of biopsychosocial factors on biomedical outcomes over 2 years. Ethical approval was granted by the King's College Hospital Research Ethics Committee (reference 08/H0808/1) and by Lambeth, Southwark, and Lewisham Primary Care Trusts (reference RDLSLB 410) and all participants gave informed consent.

Setting and sampling frame The setting comprised three adjacent London boroughs of Lambeth, Southwark and Lewisham, which serve a multi-ethnic and socioeconomically diverse population of approximately 0.75 million UK residents. The sampling frame included all 138 general practices (primary care services in the UK's Government-funded National Health Service) in these three boroughs [13]. This allowed for variations in health services provision. In the UK, there is a requirement for all general practices to set up and maintain an up-to-date diabetes register [14]. The diabetes register at each consenting practice was searched using study inclusion and exclusion criteria to identify potentially eligible patients at 6-monthly cycles. Figure 1 shows the study flow chart.

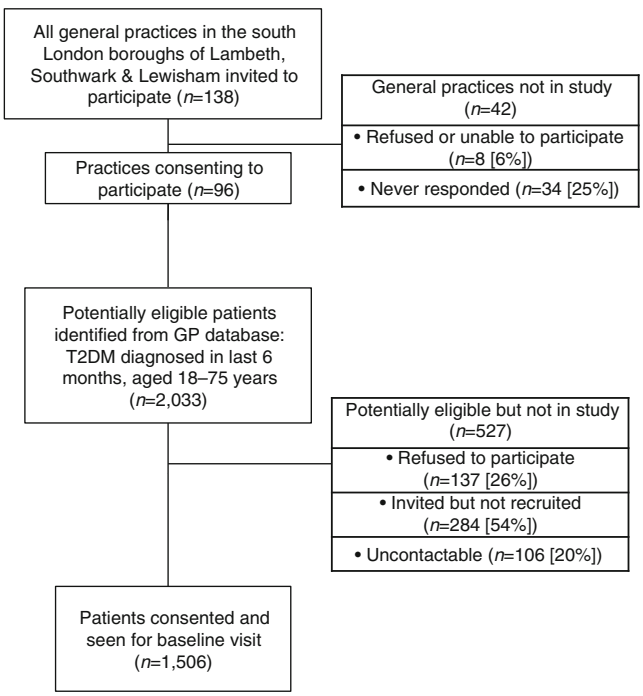

Fig. 1 SOUL-D study flow chart of first 1,506 participants recruited. T2DM, type 2 diabetes mellitus

Case definition Type 2 diabetes was diagnosed by clinical criteria according to WHO guidelines [15]. This was validated at recruitment by patient history and review of the participant's medical records. The inclusion criterion was age 18–75 years. The exclusion criteria were: evidence of diabetes duration of longer than 6 months; diabetes other than type 2 (such as gestational diabetes); move from another local primary care team; patient not fluent in English; temporary residence and/or residence outside the catchment area; known severe mental illness (dementia, bipolar disorder, substance dependence, personality disorder); a separate advanced or terminal condition; and severe advanced diabetes complications defined as being registered blind, requiring dialysis or having had an above-the-knee amputation.

Statistical analysis The main characteristics of the cohort are summarised as mean±SD or as proportion (percentage), stratified by ethnicity. Univariate and multivariate analyses of the association of sociodemographic, cardiovascular disease (CVD) risk factors, complication status and modality of diabetes diagnosis with ethnicity was conducted using Student's t test and one-way ANOVA for continuous data and χ^2 tests for categorical data and logistic regression. An α level of 1% was used to reduce type I errors. For logistic regression, the Nagelkerke R-squared statistic was presented to give an indication of the variance explained by the models [16].

Measures Baseline data were collected by a research assistant who administered a standardised data-collection schedule which included medical history, self-report questionnaires, current prescribed medications and physical examination. The main sociodemographic data collected were: age (years); sex; and self-reported ethnicity based on 2001 UK Census methods [17]. Height, weight and body mass index (kg/m^2) systolic and diastolic BP at diagnosis and HbA_{1c} (%), lipid profile (mmol/l) and urinary albumin:creatinine ratio (ACR) (μg/mg) were taken from the general practice's medical record at the time of diagnosis. The laboratory tests at diagnosis were analysed at the general practice's usual laboratory: HbA_{1c} using HPLC (Premier 9210 analyser, supplied by Menarini, Italy, all DCCT standardised); lipid profile using Siemens Advia 2400 analyser; glucose using hexokinase, plasma measurement (Siemens Diagnostics, Frimley, UK); and ACR using Siemens Advia 2400 and the PEG-enhanced immunoturbidimetric assay for urinary albumin and the Jaffé reaction for urinary creatinine.

The following classification was used to categorise mode of diabetes presentation: participants were asked whether they had: a clinical presentation with diabetes symptoms (polyuria, polydipsia, fatigue, blurred vision and weight loss) leading to their diagnosis; diabetes symptoms but diabetes was only diagnosed during opportunistic or screening blood or urine test; or no symptoms and diabetes diagnosed during opportunistic or screening blood or urine test. If diagnosis followed an emergency presentation or other method, a patient was categorised as: ketoacidosis; non-ketotic hyperosmolar state; ketosis without acidosis; diagnosis associated with pregnancy; or not known.

Macrovascular complications were defined as history of: myocardial infarction (MI); coronary artery bypass graft (CABG); cerebrovascular accident (CVA); and carotid or limb re-vascularisation. They were assessed by self-report and validated by medical records review. If there were several macrovascular complications, the date of the first presentation for each complication was recorded. Neuropathy was assessed at recruitment by measuring vibration perception threshold (VPT) using a neurosthesiometer (Scientific Laboratory Supplies, Wilford, Nottingham). The device was applied to the first toe ('big toe') on the left and right feet and participants were asked to say when they could feel a vibration through their toe. This was repeated three times for each toe and the lowest voltage sensed was recorded. A voltage of >25 V indicates significant sensory neuropathy and increased risk of ulceration [18]; patients with a VPT of ≥25 V were coded as neuropathic regardless of age. Nephropathy was assessed on a single occasion using the urinary ACR measured at diagnosis and participants were positive for microalbuminuria for ratios ≥3 and negative for ratios <3.

Single random assessment of ACR is the norm for excluding microalbuminuria during annual review in primary care owing to the convenience of acquiring the sample [19]. Retinopathy was assessed from the patient's first retinal eye screen. For all patients, this was performed by the local Diabetes Eye Complication Screening (DECS) service, using digital two-field photography according to national guidelines [20]. Images were coded by trained graders, using the English Retinopathy Minimum grading system [21]. Retinopathy was coded as any retinopathy present or absent.

Results

From May 2008 to April 2011, 96 (70%) general practices agreed to participate. We identified n=2,033 potentially eligible patients who had been diagnosed with type 2 diabetes within 6 months and recruited 1,506 (Fig. 1). Non-participants were younger (52.3 [±11.60] vs 55.6 [±11.07] years; p<0.0001) and more likely to be men (62.8% vs 55%; p=0.01) compared with participants. In a sub-sample of 851 records from 32 surgeries, language contributed to the exclusion of identified patients in 7.2%. Ethnicity data were available for only 11.7% (62/527) of non-participants, of whom 31 (50%) were white, 10 (16%) were black and 21 (34%) were of South Asian/other ethnicity.

The baseline characteristics of the first 1,506 participants recruited are given in Tables 1, 2 and 3. In summary, the average age was 55.63 years (±11.07), 55% were male; and 50.9%, 38.2% and 10.9% were of white, black and South Asian/other ethnicity, respectively (see Table 2 for an expanded classification); the mean duration of diabetes from diagnosis to recruitment was 4.4 months (±2.12) and the mean HbA_{1c} at diagnosis was 7.94% (±2.21) or 63.23 mmol/mol (±24.12). Fewer than 10% had at least one macrovascular complication and one-third (33.3%) had at least one microvascular complication. The majority (59.7%) were diagnosed by opportunistic or screening blood testing and had had no diabetes symptoms. Of the patients with diabetes symptoms at presentation, 455 (30.2%) were still diagnosed only at screening; only one in ten participants presented in pregnancy or with a diabetic emergency.

Compared with white participants, black participants: were almost 10 years younger; were more likely to be women; had higher HbA_{1c} levels, lower triacylglycerol and higher HDL-cholesterol; and were less likely to be prescribed lipid-lowering medication. Compared with white participants: South Asian/other participants were also almost 10 years younger; had lower systolic BP; and were less likely to be prescribed anti-hypertensive medication. White participants were more likely to smoke and to have neuropathy and a history of MI and CABG. Within the white group, the smokers were younger than non-smokers (56.44 [±9.94] years vs 59.77 [±10.02] years; $p<0.0001$).When we

Table 1 Main demographic and clinical characteristics stratified by ethnicity ($n=1,506$)

Characteristic	White ($n=767$)	Black ($n=575$)	South Asian/other ($n=164$)	p value	Post hoc test	Total
Age, years (SD)	58.9 (±10.09)	52.4 (±11.19)	51.5 (±10.42)	<0.0001	W>B,A	55.63 (11.07)
Men (%)	472 (61.5)	259 (45.0)	98 (59.8)	<0.0001	B<W,A	829 (55.0)
CVD risk at diagnosis						
Mean BMI (kg/m^2)	32.79 (±7.17)	32.39 (±6.39)	29.59 (±5.72)	<0.0001	A<B,W	32.28 (6.79)[a]
Mean HbA_{1c} (%)	7.56 (±1.90)	8.42 (±2.53)	7.94 (±1.98)	<0.0001	B>W	7.94 (2.21)[a]
Mean HbA_{1c} (mmol/mol)	59.15 (±20.77)	68.55 (27.65)	63.32 (21.60)			63.23 (24.12)[a]
Mean total cholesterol (mmol/l)	5.02 (±1.28)	4.94 (±1.20)	5.09 (±1.42)	0.291	NS	5.00 (1.27)[a]
Mean triacylglycerol (mmol/l)	2.26 (±1.67)	1.47 (±1.10)	2.12 (±1.33)	<0.0001	B<W	1.95 (1.49)
Mean LDL-cholesterol (mmol/l)	2.86 (±1.02)	3.10 (±1.06)	2.93 (±1.07)	<0.0001		2.97 (1.05)
Mean HDL-cholesterol (mmol/l)	1.18 (±0.36)	1.30 (±0.51)	1.19 (±0.37)	<0.0001	B>W	1.23 (0.43)[a]
Mean systolic BP (mmHg)	134.36 (±16.44)	135.11 (±16.51)	128.57 (±13.97)	<0.0001	A<B,W	134.04 (16.33)[a]
Mean diastolic BP (mmHg)	80.73 (±10.11)	82.83 (±11.10)	80.45 (±10.93)	0.001	B>W	81.50 (10.63)[a]
Smoker (%)	190 (25.3)	78 (14.4)	26 (17.0)	<0.0001	W>B	294 (19.8)[a]
Medication						
Statins (%)	481 (64.7)	285 (50.3)	98 (61.3)	<0.0001	W>B	864 (58.7)[a]
Anti-hypertensives (%)	365 (49.1)	288 (50.9)	55 (34.8)	0.001	W>A	708 (48.2)[a]
Microvascular complications						
Microalbuminuria (positive ACR) (%)	102 (16.9)	66 (14.4)	16 (12.3)	0.308	NS	184 (15.4)[a]
Retinopathy present (%)	109 (16.6)	89 (17.7)	24 (17.0)	0.890	NS	222 (17.1)[a]
Neuropathic (VPT ≥25 V) (%)	73 (10.1)	20 (3.6)	7 (4.4)	<0.0001	W>B,A	100 (7.0)[a]
At least one microvascular complication (%)	183 (36.7)	122 (31.2)	27 (25.5)	0.044	NS	332 (33.3)[a]
Macrovascular complications						
Previous MI (%)	59 (7.8)	10 (1.8)	8 (4.9)	<0.0001	W>B,A	77 (5.2)[a]
Previous CABG (%)	37 (4.9)	5 (0.9)	5 (3.0%)	<0.0001	W>B,A	47 (3.2)[a]
Previous CVA (%)	30 (4.0)	15 (2.6)	1 (0.6)	0.059	NS	46 (3.1)[a]
Previous limb/carotid re-vascularisation (%)	9 (1.2)	1 (0.2)	2 (0.2)	0.103	NS	12 (0.8)[a]
At least one macrovascular complication (%)	96 (12.7)	27 (4.8)	12 (7.3)	<0.0001	W>B,A	135 (9.1)[a]
Symptoms at diagnosis (%)	263 (34.9)	273 (48.0)	64 (39.0)	<0.0001	B>W,A	600 (40.3)[a]

A, South Asian/other; B, black; NS, non-significant; W, white

[a] Some missing cases

Table 2 Self-reported ethnicity of SOUL-D participants (n=1,506)[a]

Ethnicity	Frequency	%
White		
British	595	39.5
Irish	55	3.7
Other white	117	7.8
Mixed		
White and black Caribbean	5	0.3
White and black African	5	0.3
White and South Asian	12	0.8
Other mixed	25	1.7
South Asian		
Indian	33	2.2
Pakistani	11	0.7
Bangladeshi	13	0.9
Other South Asian	53	3.5
Black		
Caribbean	247	16.4
African	289	19.2
Other black	29	1.9
Chinese	1	0.1
Any other	16	1.1
Total	1,506	100

[a] The 2009 Office for National Statistics estimated the population of the three boroughs contributing to SOUL-D as 66.6% white, 20% black, 13.4% South Asian and other (7.6% South Asian) [39]

stratified by sex, the mean HbA_{1c} level was higher in men and BMI was lower in men in white and black participants but not in South Asians/others (Table 3). When comparisons were made between sexes, white and black men had higher HbA_{1c} and lower BMI than white and black women. These differences were not observed in South Asian participants. Total cholesterol was higher in black and South Asian/other women.

Following adjustment for age, sex and HbA_{1c} in logistic regression analysis, compared with white participants, black participants were less likely to have had at least one macrovascular complication (Table 4). There was an independent association between increasing age and increased likelihood of macrovascular complications and between male sex, higher HbA_{1c} at diagnosis and microvascular disease. Younger age groups with higher HbA_{1c} at diagnosis were more likely to present with symptoms.

Discussion

The aim of this study was to describe biomedical status at diagnosis of type 2 diabetes in a cohort of patients recruited from a multi-ethnic inner-city area in South London. The main findings demonstrated a substantially lesser degree of hyperglycaemia at diagnosis than in a UK cohort of people with new-onset diabetes recruited 25 to 30 years ago and a lower rate of diabetes complications. A majority of people diagnosed had not presented with osmotic symptoms but had been diagnosed on opportunistic or screening blood test, younger age and higher HbA_{1c} at diagnosis being independently associated with such symptoms at diagnosis. Older age was independently associated with macrovascular disease, and male sex and higher HbA_{1c} at diagnosis were independently associated with microvascular complications. Within the cohort, there was significantly earlier onset of type 2 diabetes in black and in South Asian/other ethnic groups, compared with the white group, by approximately 10 years. Black participants were significantly less likely than white participants to report macrovascular disease at the time of diagnosis, but there were no overall ethnic differences in microvascular disease at diagnosis.

There have been few studies of people with newly diagnosed type 2 diabetes. One recent study reported retinopathy and macrovascular disease each in one-third of people with type 2 diabetes of mean duration 9 years [12], and another 20–30% microvascular and 40% macrovascular complications in people with a mean of 4 years' duration [8]. Both populations were predominantly white. It is of interest to compare the SOUL-D participants with the well-characterised patient cohort of the UKPDS, which recruited people with newly diagnosed type 2 diabetes from primary care across the UK between 1977 and 1991 [2, 22] and the recent European Anglo–Danish–Dutch study of Intensive Treatment In PeOple with screeN detected diabetes in primary care (ADDITION-Europe) study, which recruited people diagnosed according to local diabetes screening policies in three European countries into an intervention targeting cardiovascular risk [6]. Looking first at the historical perspective, the SOUL-D cohort has a higher mean BMI than UKPDS (32.3 vs 27.5 kg/m^2), presumably a reflection of the known increase in obesity over the 20 years since the UKPDS sample was recruited [23], but smoking was less prevalent (19.8% vs 35% in UKPDS), perhaps reflecting the success of recent public health interventions [24]. Most notably, the SOUL-D population have a markedly lower HbA_{1c} at diagnosis than was the case for UKPDS (7.8% or 63.2 mmol/mol vs 9.1% or 76.0 mmol/mol) [22]. This is compatible with an earlier diagnosis in the new study, as are the data on prevalence of microvascular disease. The SOUL-D patients have a lower incidence of retinopathy than UKPDS patients (17% vs 36%) [25], and the incidence of neuropathy, assessed using VPT, was also lower: 7% for SOUL-D vs 11.5% for UKPDS [2]. The BP was roughly equivalent between SOUL-D participants at diagnosis and UKPDS participants at study entry (134/82 vs 135/82), although we cannot readily compare prevalence values of

Table 3 Main clinical characteristics of SOUL-D participants at diagnosis stratified by ethnicity and sex (n=1,506)

Characteristic	White				Black				South Asian/other			
	Men n=472	Women n=295	Total n=767	p value	Men n=259	Women n=316	Total n=575	p value	Men n=98	Women n=66	Total n=164	p value
Mean age (years)	58.5 (±9.86)	59.5 (±0.45)	58.9 (±10.09)	0.222	52.1 (±10.61)	52.7 (±11.65)	52.4 (±11.19)	0.479	50.3 (±10.63)	53.4 (±9.88)	51.54 (±10.42)	0.061
Mean HbA_{1c} (%)	7.71 (±2.01)	7.34 (±1.70)	7.56 (±1.90)	0.015	8.75 (±2.74)	8.16 (±2.31)	8.42 (±2.53)	0.010	7.96 (±2.07)	7.91 (±1.85)	7.94 (±1.98)	0.883
Mean HbA_{1c} (mmol/mol)	60.73 (±21.94)	56.68 (±18.58)	59.15 (±20.77)		72.08 (±29.99)	65.63 (±25.23)	68.55 (±27.65)		63.54 (±22.61)	62.99 (±20.22)	63.32 (±21.60)	
Mean BMI (kg/m^2)	31.51 (±6.10)	34.84 (±8.22)	32.79 (±7.17)	<0.0001	29.91 (±4.49)	34.43 (±6.98)	32.39 (±6.39)	<0.0001	28.98 (±5.39)	30.51 (±6.12)	29.59 (±5.72)	0.107
Mean total cholesterol (mmol/l)	5.00 (±1.34)	5.07 (±1.17)	5.02 (±1.28)	0.479	4.77 (±1.29)	5.10 (±1.10)	4.95 (±1.20)	0.002	4.81 (±1.08)	5.52 (±1.76)	5.09 (±1.42)	0.005

Table 4 Multivariable analysis of ethnicity and at least one macrovascular complication, at least on microvascular complication or symptoms at diagnosis of type 2 diabetes

Characteristic	≥1 macrovascular complication (n=1,273)[a]		≥1 microvascular complication (n=864)[b]		Symptoms at diagnosis of type 2 diabetes (n=1,281)[c]	
	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
Age (years)	1.06 (1.05, 1.09)	<0.0001	1.01 (1.00, 1.03)	0.15	0.97 (0.96, 0.98)	<0.0001
Men	1.42 (0.95, 2.13)	0.09	1.69 (1.26, 2.28)	<0.0001	0.91 (0.72, 1.17)	0.47
Ethnicity						
Overall		0.03		0.04		0.30
White[d]	1		1		1	
Black	0.52 (0.32, 0.84)	0.01	0.75 (0.54, 1.03)	0.08	1.18 (0.90, 1.55)	0.22
South Asian/other	0.88 (0.45, 1.75)	0.72	0.53 (0.31, 0.90)	0.02	0.90 (0.60, 1.34)	0.60
HbA_{1c} (%)	1.04 (0.94, 1.14)	0.45	1.17 (1.10, 1.26)	<0.0001	1.30 (1.23, 1.38)	<0.0001

Analysis adjusted for age, sex and HbA_{1c} at diagnosis

Variance [a] 10.5%, [b] 7.1%, [c] 15.3%

[d] White group used as reference group for ethnicity data

macrovascular disease events as UKPDS, an intervention study, excluded people with current, recent or multiple major events [22]. The expected correlations for macrovascular disease with increasing age were found in both SOUL-D and UKPDS [26]. An increased risk of microvascular disease in men in SOUL-D is consistent with other studies of peripheral neuropathy, retinopathy and microalbuminuria in type 2 diabetes [9, 27, 28]

The observed differences in complication status between SOUL-D and UKPDS reflect a change in the risk of microvascular disease prevalence, either because of biological change or better management of co-morbidities, possibly by changes to diabetes-complication monitoring and management in primary care in England. Of SOUL-D participants, 58% were being prescribed lipid-lowering medication, significantly higher than the 0.3% in UKPDS, and many more were receiving BP-lowering medication. However, the data are also compatible with earlier diagnosis. Sixty per cent of the SOUL-D cohort did not have osmotic symptoms at diagnosis, and diabetes was found by screening and opportunistic testing, supporting the contention that the lower microvascular complication rate is related, at least in part, to early diagnosis. Against this, the mean age of the SOUL-D cohort is, if anything, slightly higher than that of the UKPDS cohort (55.4 vs 53.3 years). The technology for retinal screening has progressed since UKPDS and the use of urinary ACR differs from the UKPDS method, in which urinary albumin concentrations were measured. Both of these factors are more likely to increase detection of complications and do not explain the findings we describe. Parenthetically, younger patients in the SOUL-D cohort were more likely to be symptomatic at diagnosis, which may indicate a lesser tolerance for ill health, less readiness to attend general practices to be tested or a more aggressive onset of disease in younger people.

ADDITION-Europe provides a more contemporary comparator for SOUL-D [6]. Early ACTID, an intervention study examining the effects of exercise in new-onset type 2 diabetes in south west England, which also recruited patients with diabetes of short duration, did not report HbA_{1c} at diagnosis, or prevalence of retinopathy [4, 5]. In ADDITION-Europe, the mean age of participants was about 60 years. HbA_{1c} at recruitment was 7% (53 mmol/mol), lower than for SOUL-D. The study has not reported rates of microvascular disease. Of recruits into ADDITION-Europe, 8% report having had a heart attack or stroke, comparable with the rates reported here.

One major difference between the SOUL-D population and those of UKPDS, ADDITION-Europe and Early ACTID is the ethnic diversity of SOUL-D: 51% of the study populations were white in SOUL-D, compared with 86%, 93–96% and 96%, respectively. Interracial differences may thus also contribute to some of the differences observed between the SOUL-D cohort and UKPDS. The SOUL-D study, based in three South London boroughs where approximately 20% of the population is black, gives us the opportunity to begin to explore differences in the natural history of diabetes by ethnicity, with a particular focus on the British black population. The enhanced proportion of people from this ethnic minority population is largely driven by its increased risk of diabetes (recent published prevalence figures for diabetes range from 5% to 10% for black men and from 2.1% to 8.4% for black women [29]), but also reflects the willingness of the population to engage in research. Our cohort reflects the black (38.2% in SOUL-D vs 34.3%) and South Asian (7.3% in SOUL-D vs 9.1%) population diabetes prevalence in Lambeth (data from NHS Lambeth, general practitioner [GP] disease register, quarter 2, 2009–10). While the classification of people as ‘black’ or ‘South Asian and other’ is very crude, we can draw some important conclusions about the influence of ethnicity on the diabetes process. Nevertheless, some factors appear to be driven by changes in the population and in medical practice over time—the mean BMI of the SOUL-D cohort is similar to that reported for ADDITION-Europe, 32.3 vs 31.6, although smoking prevalence in the ADDITION-Europe study (27–28%) is more similar to the UKPDS data. This may be influenced by cultural factors. Smoking prevalence in SOUL-D was higher in our white cohort, while patients recruited to Early ACTID, a predominantly white population, had an even lower prevalence. The Early ACTID cohort has a higher mean age than SOUL-D, recruiting people aged between 30 and 80 years, and in the white cohort of SOUL-D, smokers were younger than non-smokers, again reflecting sociological change over time.

Age at diagnosis varied significantly by ethnic group in SOUL-D, with white participants being significantly older at onset of type 2 diabetes, by almost 10 years, than black or South Asian/other ethnic groups. This has been reported for the British South Asians but, until now, has not been confirmed in the British black population. It matches the known increased risk for type 2 diabetes. Recent data from the Southall And Brent REvisited Study (SABRE) study confirm that, given similar environmental influences, the prevalence of type 2 diabetes is equally elevated in black and South Asian ethnic groups [30].

Black women were more strongly represented in the SOUL-D cohort than black men compared with other ethnic groups, which were predominantly male. Our data on those individuals eligible for SOUL-D but who declined to participate make it unlikely that this reflects only increased engagement in health: one contributor may be an increased tendency to obesity in black women [31]. BMI was significantly higher in white and black ethnic groups and in women, in keeping with the literature on metabolic syndrome and type 2 diabetes occurring at lower levels of

overall obesity in South Asians [32], and concurring with the increased incidence of diabetes in black women in the 40–50 years age group [31]. The lipid profiles of our groups are also of interest. Traditionally, it is considered that black patients of African origin with type 2 diabetes have a lower risk of MI [33, 34] (although a higher risk of stroke linked to greater rates of hypertension [35, 36]), and this has been ascribed to a more favourable lipid profile, but recent studies in African-American populations show a loss of this protection [37, 38]. The SOUL-D population shows the traditional pattern of lower HDL-cholesterol in the white and South Asian/other groups compared with black groups. We may speculate that the changing pattern of macrovascular disease in African-Americans with diabetes reflects a longer exposure or greater engagement with western lifestyles and/or a still more obesogenic environment. Interestingly, although systolic BP was higher in the black group compared with the South Asian/other group, the same was true of the white group vs the South Asian/other group.

Black patients were more likely to be symptomatic at diagnosis compared with the white group, and this was associated with an increased proportion of presentations with symptoms. This may relate to a lesser engagement with healthcare systems when well. Nevertheless, the prevalence of retinopathy did not differ significantly by ethnic group in SOUL-D participants. However, this does not rule out the potential for different ethnic groups to have different disease trajectories for microvascular disease. As well as the difference in age at diagnosis, a significantly different distribution of retinopathy prevalence by ethnicity has recently been reported in DRIVE-UK, a study of people with established diabetes, where the prevalence of diabetic retinopathy was 52% in the black cohort compared with 38% in whites and 42% in South Asians [9]. The duration of diabetes was not specified in DRIVE-UK. The Early ACTID programme has not reported on complication status [4, 5] nor has United Kingdom Asian Diabetes Study (UKADS) (in which 40% had a diabetes duration <4 years) reported on retinopathy [7], although microalbuminuria affected 19% and a further 4% had frank proteinuria, rates that are higher than in any of our three groups.

As this cross-sectional analysis of clinical characteristics around the time of diagnosis is the first report arising from the SOUL-D cohort, we have yet to see whether ethnicity predicts different disease trajectories. The answer to this question will become apparent during longer-term follow-up. In particular, we will be able to see whether ethnicity influences treatment regimen decisions, as appears to be the case in the UKADS study. It is already apparent that the earlier disease onset in the non-white SOUL-D population is significant.

Limitations of the SOUL-D cohort are that we excluded people who were housebound and not able to visit the GP and people who were not fluent in English. Detection of diabetes, especially if asymptomatic, is likely to be later in these groups. However, they formed only 7% of eligible patients. Potential for recall bias when we asked participants how they were diagnosed was minimised by checking their medical records. Because we were interested in biomedical status at diagnosis, we relied on routinely collected data recorded by the GP surgery for blood results and cardiovascular history. For the former, we were not able to determine whether the lipid tests were fasting, which may affect the interpretation of LDL-cholesterol and triacylglycerol levels. However, all bloods were assayed by all practices in one of three hospital laboratories, all participating in England's national quality assurance programme and using the same assay systems. For cardiovascular history, patient recall was substantiated by reference to the general practice record, although we did not collect new electrocardiographic data. The strengths of SOUL-D are: the high participation rate; the high representation of people of black ethnicity; and the comprehensiveness of the setting, as we recruited from 96 of the 138 GP practices in three South London boroughs.

In conclusion, this is the first multi-ethnic western urban new-onset type 2 diabetes cohort since UKPDS and, unlike UKPDS, our cohort includes people of diverse ethnic background at high risk of type 2 diabetes, with an emphasis on the relatively understudied British black population. We have demonstrated that onset of type 2 diabetes is approximately 10 years earlier in non-whites and that black women are more likely to be diagnosed with diabetes than black men. We have also demonstrated that more people are being diagnosed by routine testing and that the majority report no diabetes symptoms at diagnosis. This may explain the lower rate of microvascular disease and is consistent with a shorter duration of diabetes at diagnosis in the cohort than was the case when UKPDS recruited. Whether this will translate into reduced complications compared with other cohorts at similar disease durations remains to be seen. We found independent associations with ethnicity and macrovascular complications, with a higher prevalence in the white group which was also associated with increasing age. However, this was not the case for microvascular disease, for which male sex and higher HbA_{1c} were the most significant risk factors. Nevertheless, the earlier age at diagnosis with similar prevalence of diabetes-specific complications in our ethnic groups implies a greater risk of diabetes complications at any given age in the non-white groups. Our findings may assist health service providers to allocate resources for primary and secondary disease prevention.

Acknowledgements We would like to thank the patients who volunteered to participate in this study. We would also like to thank our research team, past and present: J. Schonbeck, J. Valka, N. Iles, S. Brooks, J. Hunt, K. Twist, R. Stopford, G. Knight, L. Marwood, A. Barlow, L. East, B. Jackson and E. Britneff. We also thank: the staff of the participating general practices in Lambeth, Southwark and Lewisham, especially M. Ashworth, C. Gostling and T. Evans; the Primary Care Research Network (PCRN-GL) for their assistance in recruiting the general practices; and the Diabetes Research Network and the South London Comprehensive Local Research network, for providing additional resources.

Funding This paper presents independent research funded by the National Institute for Health Research (NIHR) under its Programme Grants for Applied Research Programme (Grant Reference Number RP-PG-0606-1142). The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

Contribution statement All authors made substantial contributions to the conception and design, acquisition and analysis of the data and interpretation of the data. All authors contributed to the drafting and critical revision of the manuscript and gave final approval of the published version.

Duality of interest The authors confirm that there is no duality of interest associated with this manuscript.

References

1. Ekoe J-M, Zimmet PZ (2008) Diagnosis and classification. In: Ekoe J-M, Rewers M, Williams R, Zimmet P (eds) The epidemiology of diabetes mellitus. Wiley-Blackwell, Chichester, p 20
2. UKPDS (1998) Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet 352:837–853
3. Harris MI, Klein R, Welborn TA, Knuiman MW (1992) Onset of NIDDM occurs at least 4–7 yr before clinical diagnosis. Diabetes Care 15:815–819
4. Andrews RC, Cooper AR, Montgomery AA et al (2011) Diet or diet plus physical activity versus usual care in patients with newly diagnosed type 2 diabetes: the early ACTID randomised controlled trial. Lancet 378:129–139
5. Cooper A, Sebire S, Montgomery A et al (2012) Sedentary time, breaks in sedentary time and metabolic variables in people with newly diagnosed type 2 diabetes. Diabetologia 55:589–599
6. Griffin SJ, Borch-Johnsen K, Davies MJ et al (2011) Effect of early intensive multifactorial therapy on 5-year cardiovascular outcomes in individuals with type 2 diabetes detected by screening (ADDITION-Europe): a cluster-randomised trial. Lancet 378:156–167
7. Bellary S, O'Hare JP, Raymond NT et al (2008) Enhanced diabetes care to patients of south Asian ethnic origin (the United Kingdom Asian Diabetes Study): a cluster randomised controlled trial. Lancet 371:1769–1776
8. Lutgers HL, Gerrits E, Sluiter W et al (2009) Life expectancy in a large cohort of type 2 diabetes patients treated in primary care (ZODIAC-10). PLoS One 4:e6817
9. Sivaprasad S, Gupta B, Gulliford MC et al (2012) Ethnic variation in the prevalence of diabetic retinopathy in people with diabetes attending screening in the United Kingdom (DRIVE UK). PLoS One 7:e32182
10. Riste L, Khan F, Cruickshank K (2001) High prevalence of type 2 diabetes in all ethnic groups, including Europeans, in a British inner city: relative poverty, history, inactivity, or 21st century Europe? Diabetes Care 24:1377–1383
11. Mather HM, Keen H (1985) The Southall diabetes survey: prevalence of known diabetes in Asians and Europeans. BMJ 291:1081–1084
12. Ding J, Srachan M, Reynolds R et al (2010) Diabetic retinopathy and cognitive decline in older people with type 2 diabetes. Diabetes 59:2883–2889
13. OFNS (2003) Census 2001. Office of National Statistics, 2003. Available from www.statistics.gov.uk/census2001/pyramids/pages/1b.asp, accessed 2 October 2006
14. BMA Quality and outcomes framework guidance for GMS contract 2009/10: delivering investment in general practice. Available from www.bma.org.uk/images/qof0309_tcm41-184025.pdf, accessed 19 May 2011
15. WHO (1999) Definition, diagnosis and classification of diabetes mellitus and its complications. Report of a WHO consultation. World Health Organization, Geneva
16. Nagelkerke NJD (1991) A note on a general definition of the coefficient of determination. Biometrika 78:691–692
17. HMSO (2001) Census 2001. HMSO, London
18. Edmonds M, Foster A (2000) Managing the diabetic foot. Blackwell Science, London
19. Witte EC, Lambers Heerspink HJ, de Zeeuw D, Bakker SJL, de Jong PE, Gansevoort R (2009) First morning voids are more reliable than spot urine samples to assess microalbuminuria. J Am Soc Nephrol 20:436–443
20. NHS (2007) UK National Screening Committee. Essential elements in developing a national retinopathy screening programme, Workbook 4. Available from www.retinalscreening.nhs.uk, accessed 21 August 2012
21. ENSPDR English National Screening Programme for Diabetic Retinopathy. Available from www.retinalscreening.nhs.uk, accessed 20 April 2012
22. UKPDS (1991) UK prospective diabetes study (UKPDS): VIII. Study design, progress and performance. Diabetologia 34:877–890
23. World Health Organization (2006) Obesity. World Health Organization, Geneva
24. Office for National Statistics (2007) Smoking related behaviour and attitudes.. Available from http://www.ons.gov.uk/ons/rel/lifestyles/smoking-related-behaviour-and-attitudes/2007/index.html, accessed 1 May 2012
25. Stratton IM, Kohner EM, Aldington SJ et al (2001) UKPDS 50: risk factors for incidence and progression of retinopathy in type II diabetes over 6 years from diagnosis. Diabetologia 44:156–163
26. Knuiman MW, Welborn TA, McCann VJ, Stanton KG, Constable IJ (1986) Prevalence of diabetic complications in relation to risk factors. Diabetes 35:1332–1339
27. Magri CJ, Calleja N, Buhagiar G, Fava S, Vassallo J (2011) Predictors of vibration perception threshold in type 2 diabetic patients with proliferative retinopathy. Postgrad Med J 87:658–663
28. Papanas N, Symeonidis G, Mavridis G et al (2007) Ankle-brachial index: a surrogate marker of microvascular complications in type 2 diabetes mellitus? Int Angiol 26:253–257
29. NHS Information Centre (2006) Health Survey for England 2004: health of ethnic minorities. Available from www.ic.nhs.uk/statistics-and-data-collections/health-and-lifestyles-related-surveys/health-survey-forengland/health-survey-for-england-2004:-health-of-ethnic-minorities–full-report, accessed 7 December 2012
30. Tillin T, Hughes AD, Godsland IF et al (2013) Insulin resistance and truncal obesity as important determinants of the greater incidence of diabetes in Indian Asians and African Caribbeans compared with Europeans: the Southall and Brent Revisited (SABRE) cohort. Diabetes Care 36:383–393

31. Nguyen QM, Xu J-H, Chen W, Srinivasan SR, Berenson GS (2012) Correlates of age onset of type 2 diabetes among relatively young black and white adults in a community. Diabetes Care 35:1341–1346
32. Alberti KGMM, Zimmet P, Shaw J (2005) Metabolic syndrome—a new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabet Med 23:469–480
33. Singh GK, Siahpush M (2002) Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: an analysis of two national data bases. Hum Biol 74:83–109
34. Wild SMP (1997) Cross sectional analysis of mortality by country of birth in England and Wales, 1970–92. BMJ 314:705–710
35. Tillin T, Forouhi NG, McKeigue PM, Chaturvedi N (2006) The role of diabetes and components of the metabolic syndrome in stroke and coronary heart disease mortality in UK White and African-Caribbean populations. Diabetes Care 29:2127–2129
36. Chaturvedi N, McKeigue PM, Marmot MG (1993) Resting and ambulatory blood pressure differences in Afro-Caribbeans and Europeans. Hypertension 22:90–96
37. Jolly S, Vittinghoff E, Chattopadhyay A, Bibbins-Domingo K (2010) Higher cardiovascular disease prevalence and mortality among younger blacks compared to whites. Am J Med 123:811–818
38. Chaturvedi N, McKeigue PM, Marmot MG (1994) Relationship of glucose intolerance to coronary risk in Afro-Caribbeans compared with Europeans. Diabetologia 37:765–772
39. ONS Office for National Statistics. Population estimates by ethnic group. http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Population+Estimates+by+Ethnic+Group, accessed 7 December 2012