Life Expectancy and Cause-Specific Mortality in Type 2 Diabetes: A Population-Based Cohort Study Quantifying Relationships in Ethnic Subgroups

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OBJECTIVES

This study *1*) investigated life expectancy and cause-specific mortality rates associated with type 2 diabetes and *2*) quantified these relationships in ethnic subgroups.

RESEARCH DESIGN AND METHODS

This was a cohort study using Clinical Practice Research Datalink data from 383 general practices in England with linked hospitalization and mortality records. A total of 187,968 patients with incident type 2 diabetes from 1998 to 2015 were matched to 908,016 control subjects. Abridged life tables estimated years of life lost, and a competing risk survival model quantified cause-specific hazard ratios (HRs).

RESULTS

A total of 40,286 deaths occurred in patients with type 2 diabetes. At age 40, white men with diabetes lost 5 years of life and white women lost 6 years compared with those without diabetes. A loss of between 1 and 2 years was observed for South Asian and blacks with diabetes. At age older than 65 years, South Asians with diabetes had up to 1.1 years' longer life expectancy than South Asians without diabetes. Compared with whites with diabetes, South Asians with diabetes had lower adjusted risks for mortality from cardiovascular (HR 0.82 [95% CI 0.75–0.89]), cancer (HR 0.43 [95% CI 0.36–0.51]), and respiratory diseases (HR 0.60 [95% CI 0.48–0.76]). A similar pattern was observed in blacks with diabetes compared with whites with diabetes.

CONCLUSIONS

Type 2 diabetes was associated with more years of life lost among whites than among South Asians or blacks, with older South Asians experiencing longer life expectancy compared with South Asians without diabetes. The findings support optimized cardiovascular disease risk factor management, especially in whites with type 2 diabetes.

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The worldwide prevalence of type 2 diabetes is increasing rapidly (1). A large body of evidence shows that type 2 diabetes is associated with a 1.3- to 2.0-times higher risk of death, mostly resulting from cardiovascular disease (2–4). However, contemporary data on cause-specific mortality and life expectancy in type 2 diabetes are limited.

Ethnicity is widely acknowledged to influence the presentation of diabetes, the development of complications, and all-cause mortality (5). However, no study has reported the influence of ethnicity on life expectancy or cause-specific mortality in type 2 diabetes because most of the studies have focused on all-cause or simply cardiovascular mortality (6–8). Cause-specific mortality data could provide mechanistic insights into any observed ethnic disparities in all-cause mortality and thereby guide future research and public health strategies in type 2 diabetes.

The aims of this research were to *1*) compare years of life lost and cause-specific mortality associated with type 2 diabetes and *2*) quantify these relationships in white, black, and South Asian populations.

RESEARCH DESIGN AND METHODS

Data Sources

The Clinical Practice Research Datalink (CPRD) provides anonymized, longitudinal primary care medical records from participating U.K. general practices (9). Linkage with Hospital Episode Statistics (HES) and the Office for National Statistics (ONS) mortality data are also available for practices in England where they agree to record-linkage. We included 383 eligible general practices. The study was approved by the Independent Scientific Advisory Committee for CPRD research (ref. 15_123Mn).

Study Population

We identified an incident cohort of patients with diabetes (type 1 and type 2) whose first diagnostic code for diabetes was in the study period 1 January 1998 to 31 March 2015. The study period corresponds to the time window for which all patient-level data sets (CPRD, HES, and ONS) were eligible for linkage and had data coverage. An algorithm established by de Lusignan et al. (10), was implemented to classify patients with type 2 diabetes (Supplementary Fig. 1). This validated algorithm has been used in a number of studies using electronic health records data (11–13). Subjects with incident type 2 diabetes were matched with up to five control subjects by year of birth ($\pm$2 years), sex, general practice, and index date of diabetes diagnosis (details of control subject selection are shown in Supplementary Fig. 2). Control subjects were defined as patients without diabetes. Case patients with type 2 diabetes and control patients were observed from the index date until the study end date (31 March 2015), the practice's last data collection date, death, or transfer out of practice.

Study Variables

Cause of death was based on ICD-10 chapters or relevant subchapters from the linked national mortality records. Chapter headings were subsequently grouped into 10 mutually exclusive categories, as described in the Supplementary Methods.

Ethnicity was identified from the CPRD and through linkage with HES (details in Supplementary Fig. 3). All ethnicity codes were collapsed into five headings, developed by the Office for National Statistics (14): white, South Asian (a subclassification of Asian/British Asian), black/black British, other, and unknown. The overarching Asian/British Asian heading includes Indian, Pakistani, Bangladeshi, Chinese, and other Asian. For the South Asian classification, patients defined as Chinese were excluded and reclassified as "other" (which includes East/Southeast Asian ethnicities; for example, Korean, Japanese, Vietnamese, etc.).

Deprivation was quantified with the Index of Multiple Deprivation (IMD) 2010, a national scheme based on seven deprivation domains and available at small-area level to link with the address of the patient, categorized into five quintiles: IMD 1 (least deprived) up to IMD 5 (most deprived) (15). Further details on the IMD are provided in the Supplementary Methods.

Drug prescriptions at baseline were defined as a prescription within 90 days before or after the index date. Polyregimens in antidiabetic medications occurred if multiple different classes of drug were prescribed within the same month.

Biological measures at baseline (BMI, HbA_{1c}, total cholesterol, blood pressure) were defined as the closest measure up to 6 months before and 3 months after the index date. Smoking status (categorized as current, former, or never) was defined according to the closest smoking recording before the index date. Cardiovascular disease and renal disease (defined as chronic kidney disease stage 4 and above) were defined by Read code, up to the index date. All code lists used are available for download from www.clinicalcodes.org (16).

Statistical Methods

Abridged period life tables, based on the Chiang II method (17), were used to estimate life expectancy among patients with type 2 diabetes and control subjects without diabetes. The life tables were constructed from 1998 to 2015, aggregating death and population data into 5-year age intervals up to 80 years, as outlined in the Supplementary Methods. The difference in life expectancy was calculated as the estimated life expectancy in patients without diabetes minus the estimated life expectancy in people with type 2 diabetes.

Causes of death, categorized into 10 headings, were identified in men and women. In the primary analysis, unadjusted proportions of deaths in these categories were compared for patients with type 2 diabetes versus control patients. Under a competing-risks framework, a flexible parametric survival model was used to calculate hazards ratios (HRs) for all-cause and cause-specific morality associated with the presence of type 2 diabetes after adjusting for age, sex, ethnicity, deprivation, and calendar year.

Secondary analyses were performed to observe ethnic differences in life expectancy and mortality. Life expectancy estimates were calculated within ethnic-age-sex strata for white, South Asian, and black patients with diabetes and control patients. Stratification was applied in generating estimates of life expectancy because we were unable to match people with type 2 diabetes with control patients by ethnic group (further details are in the Supplementary Methods). Plots of the differences in life expectancy by ethnic group and sex were constructed by age-groups. All-cause and cause-specific mortality rates, stratified by diabetes (likelihood ratio test shown in Supplementary Fig. 4), were calculated for South Asian and black people compared with whites. All analyses were computed using Stata 14.1 software (StataCorp LP).

RESULTS

The study included 187,968 patients with incident type 2 diabetes (mean [SD] age: 61.8 ± 14 years; 55% males; 942,412 years of follow-up) and 908,016 control patients without diabetes (9,287,474 years of follow-up) matched for age, sex, practice, and index date (Table 1). At baseline, those with type 2 diabetes had higher BMI, blood glucose, and blood pressure levels, were more likely to be receiving antihypertensives, antiplatelets, and lipid-lowering agents, and were more likely to have cardiovascular disease and renal disease than those without diabetes. Most patients in both groups were white (77% of patients with type 2 diabetes; 72% of control patients). Baseline characteristics in white, South Asian, and black ethnic groups are reported in Supplementary Table 1. In the group with type 2 diabetes, 143,724 were white (mean [SD] age: 63 ± 14 years), 9,523 were South Asian (age: 53 ± 14 years), and 4,461 were black (age: 54 ± 14 years). HbA_{1c} values at baseline were higher in South Asians (8.2 ± 2.0%; 66 ± 22 mmol/mol) and blacks (8.5 ± 2.5%; 69 ± 27 mmol/mol) than in whites (7.9 ± 2.0%; 63 ± 22 mmol/mol), and they received more antidiabetic medications, including more polyregimens. BMI and blood pressure levels were lower in South Asians compared with whites. Smoking (current and former), cardiovascular disease, and renal disease were more prevalent in whites than in other ethnic groups.

Differences in life expectancy in age-sex strata were compared for those with type 2 diabetes and the control patients without diabetes (Supplementary Table 2). At the age of 40 years, men and women with type 2 diabetes experienced loss of several years of life compared with people without diabetes (men: 5.4 years; women: 6.3 years). The difference in life expectancy between those with and without type 2 diabetes was greater for women than for men at all ages and declined by age attained.

Ethnic-stratified life expectancy estimates showed the effect of diabetes in white men and women was greater than in South Asian and black individuals (Fig. 1 and Supplementary Table 3). For example, in white men aged 40 years, the estimated years of life expectancy loss associated with type 2 diabetes was 5.5 years (95% CI 5.3–5.7) and in white

Table 1—Baseline characteristics for those with type 2 diabetes and without diabetes (any type)*

	With type 2 diabetes *n* = 187,968	Without diabetes *n* = 908,016
Male	103,740 (55.2)	496,443 (54.7)
Age, years	61.8 ± 14.3	61.5 ± 14.3
Ethnicity		
White	143,724 (76.5)	653,390 (72.0)
South Asian	9,523 (5.1)	13,985 (1.5)
Black	4,461 (2.4)	10,576 (1.2)
Other	2,486 (1.3)	8,313 (0.9)
Unknown	27,774 (14.8)	221,752 (24.4)
Deprivation quintile		
1 (least deprived)	34,341 (18.3)	197,565 (21.8)
2	40,992 (21.8)	210,770 (23.2)
3	38,618 (20.5)	186,310 (20.5)
4	39,220 (20.9)	173,541 (19.1)
5 (most deprived)	34,463 (18.3)	138,599 (15.3)
Unknown	334 (0.2)	1,231 (0.1)
HbA_{1c}, % (mmol/mol)	8.0 ± 2.1 (64 ± 22)	5.8 ± 0.6 (40 ± 7)
Missing	59,843 (31.8)	890,960 (98.1)
BMI, kg/m^2	31.4 ± 6.4	27.3 ± 5.5
Missing	55,550 (29.6)	733,067 (80.7)
Cholesterol, mmol/L	5.2 ± 1.3	5.2 ± 1.2
Missing	51,756 (27.5)	714,131 (78.6)
Blood pressure, mmHg		
Systolic	140 ± 19	137 ± 19
Diastolic	81 ± 11	79 ± 10
Missing	34,841 (18.5)	510,539 (56.2)
Cardiovascular disease	37,767 (20.1)	68,435 (7.5)
Renal disease (stage ≥4)	2,339 (1.2)	2,381 (0.3)
Smoking status		
Current smoker	55,902 (29.7)	279,910 (30.8)
Former smoker	72,102 (38.4)	261,700 (28.8)
Never smoked	9,284 (4.9)	43,627 (4.8)
Unknown	50,680 (27.0)	322,779 (35.6)
Diabetes therapy		
No drugs	105,070 (55.9)	908,016 (100.0)
Monotherapy	70,962 (37.8)	
Metformin	54,097 (28.8)	
Sulfonylurea	11,790 (6.3)	
Other monotherapy	5,075 (2.7)	
Dual therapy	10,882 (5.8)	
Triple therapy	1,054 (0.6)	
Antihypertensive agent		
No drugs	84,955 (45.2)	93,728 (10.3)
Thiazides	33,741 (18.0)	49,836 (5.5)
Loop diuretics	19,045 (10.1)	16,759 (1.9)
Potassium-sparing diuretic	6,108 (3.3)	92,908 (10.2)
β-Blocker	36,323 (19.3)	20,387 (2.3)
α-Blocker	8,040 (4.3)	105,225 (11.6)
ACE inhibitor	55,202 (29.4)	38,531 (4.3)
Angiotensin-II receptor	16,333 (8.7)	96,915 (10.7)
Calcium-channel blocker	38,611 (20.5)	93,728 (10.3)
Antiplatelet agent		
No drug	139,230 (74.1)	793,048 (87.3)
Aspirin	46,172 (24.6)	107,925 (11.9)
Clopidogrel	5,053 (2.7)	11,855 (1.3)
Lipid-lowering agent		
No drug	105,262 (56.0)	767,752 (84.6)
Statin	81,043 (43.1)	136,191 (15.0)
Fibrate	2,076 (1.1)	2,914 (0.3)
Other	2,562 (1.4)	5,383 (0.6)

Continued on p. 4

Table 1—Continued

	With type 2 diabetes *n* = 187,968	Without diabetes *n* = 908,016
Follow-up duration from index date, years	5.0 ± 3.8	10.2 ± 4.9
Exit from study		
Death	40,286 (21.4)	181,338 (20.0)
Transferred out	26,004 (13.8)	202,692 (22.3)
Last collection of data	47,121 (25.1)	209,753 (23.1)
Study end	74,557 (39.7)	314,233 (34.6)

Data are shown as *n* (%) or as mean ± SD. *Patients with type 2 diabetes were matched to up to five patients without diabetes by year of birth (±2 years), sex, general practice and index date of diabetes diagnosis. Groups were not matched for ethnicity.

women was 6.7 years (95% CI 6.4–6.9). By comparison, in South Asian men aged 40 years, 1.0 year (95% CI 0.6–1.3) was lost to type 2 diabetes and in South Asian women, 0.5 years (95% CI 0.1–0.9) were lost. Correspondingly, 2.4 years (95% CI 1.7–3.2) were lost for black men, and 1.7 years (95% CI 1.0–2.3) were lost among black women. In whites aged >65 years, the presence of type 2 diabetes was associated with 3–4 years' shorter life expectancy. In contrast, in South Asian men and women aged >65 years, the presence of type 2 diabetes was associated with up to 1.1 years' longer life expectancy compared with South Asians without diabetes.

There were 40,286 deaths among patients with type 2 diabetes (crude mortality: 42.7/1,000 person-years) and 181,338 deaths in those without diabetes (crude mortality: 19.5/1,000 person-years) (Table 2). Compared with those without diabetes, type 2 diabetes was associated with a twofold higher all-cause mortality (HR 2.19; 95% CI 2.16–2.21]). The most common causes of death were similar across both populations (cardiovascular disease, malignancy, and respiratory disease). After taking into account the competing risks of different causes of death, type 2 diabetes was associated with significantly higher risks of death from every cause except suicide (Table 2 and Supplementary Table 4).

Crude mortality rates in whites, South Asians, and blacks are reported in Supplementary Table 5. In the adjusted analysis (Table 3), compared with whites with type 2 diabetes, all-cause mortality was lower in South Asian (HR 0.70; 95% CI 0.65–0.76) and black (HR 0.82; 95% CI 0.74–0.91) patients with type 2 diabetes. Compared with whites with type 2 diabetes, South Asians with type 2 diabetes had significantly lower adjusted risks for mortality from cardiovascular disease (HR 0.82; 95% CI 0.75–0.89), cancer (HR 0.43; 95% CI 0.36–0.51), and respiratory diseases (HR 0.60; 95% CI 0.48–0.76), and higher mortality (but not significantly) from renal disease (HR 1.50; 95% CI 0.93–2.46). A similar pattern was observed in black patients compared with white patients with type 2 diabetes, with a lower risk of death from cardiovascular disease (HR 0.83; 95% CI 0.75–0.93), cancer (HR 0.84; 95% CI 0.70–0.99), and respiratory disease (HR 0.62; 95% CI 0.46–0.84).

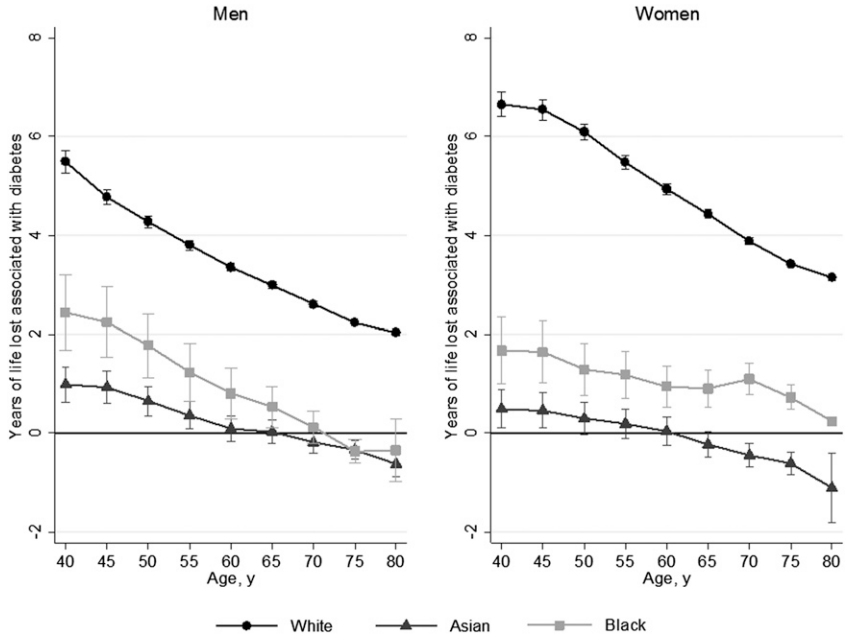

Figure 1—Difference in life expectancy between patients with and without type 2 diabetes at different ages in groups stratified by sex and ethnicity. For example, the line representing white men indicates that at the age of 40 years, white men with type 2 diabetes are predicted to die approximately 6 years earlier than white men without diabetes.

CONCLUSIONS

Main Findings

This large population-based retrospective cohort study provides several novel insights: *1*) compared with South Asians and blacks, whites (especially women) experienced more years of life lost associated with the presence of type 2 diabetes; *2*) older South Asian men and women with type 2 diabetes had longer life expectancy compared with South Asians without diabetes; and *3*) compared with whites with type 2 diabetes, South Asians and blacks with type 2 diabetes had lower risks of all-cause mortality and lower mortality from cardiovascular-, respiratory-, and cancer-specified causes. Further research into the mechanisms underlying these findings might provide useful insights into these ethnic disparities in type 2 diabetes outcomes, which may in turn guide public health strategies.

Effect of Diabetes on Life Expectancy by Sex and Ethnicity

Sex

In our cohort, the presence of type 2 diabetes was associated with a potential loss of life of 5 years in men and 6 years in women at an attained age of 40 years. Using data from prospective population-based studies involving participants recruited from 1960 to 2007, the Emerging Risk Factors Collaboration reported that at the age of 40, the presence of diabetes was associated with a loss of life of ~7.9 years in men and 8.2 years

Table 2—All-cause and cause-specific mortality rates among patients with type 2 diabetes compared with matched patients without diabetes, by sex*

	All patients (*N* = 221,624)					Men (*n* = 114,526)		Women (*n* = 107,098)	
	With type 2 diabetes		Without diabetes			With type 2 diabetes	Without diabetes	With type 2 diabetes	Without diabetes
Underlying cause	*n* (%)	Rate/1,000 py	*n* (%)	Rate/1,000 py	Adjusted HR† (95% CI)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
All causes	40,286	42.7	181,338	19.5	2.19 (2.16,2.21)	20,888	93,638	19,398	87,700
Malignant neoplasms	10,398 (25.8)	11.0	54,028 (29.8)	5.8	1.63 (1.60,1.67)	6,020 (28.2)	30,745 (32.8)	4,378 (22.6)	23,283 (26.6)
Circulatory disease	14,965 (37.2)	15.9	59,075 (32.6)	6.4	2.11 (2.07,2.15)	7,950 (38.1)	30,727 (32.8)	7,015 (36.2)	28,348 (32.3)
Ischemic heart disease	5,315 (35.5)		19,553 (33.1)			3,226 (40.6)	12,135 (39.5)	2,089 (29.8)	7,418 (26.2)
Cerebrovascular disease	4,068 (27.2)		17,391 (29.4)			1,860 (23.4)	7,263 (23.6)	2,208 (31.5)	10,128 (35.7)
Heart failure	3,510 (23.5)		12,099 (20.5)			1,889 (23.8)	6,366 (20.7)	1,621 (23.1)	5,733 (20.2)
Other circulatory	2,072 (13.9)		10,032 (17.0)			975 (12.3)	4,963 (16.2)	1,097 (15.6)	5,069 (17.9)
Diabetes‡	75 (0.2)	0.1	—	—	—	48 (0.2)	—	27 (0.1)	—
Renal failure	571 (1.4)	0.6	1,559 (0.9)	0.2	3.33 (3.00,3.69)	269 (1.3)	766 (0.8)	302 (1.6)	793 (0.9)
Infectious/parasitic disease	1,064 (2.6)	1.1	3,803 (2.1)	0.4	2.51 (2.33,2.69)	485 (2.3)	1,659 (1.8)	579 (3.0)	2,144 (2.4)
Respiratory disease	6,316 (15.7)	6.7	31,204 (17.2)	0.3	1.84 (1.79,1.89)	3,060 (14.7)	15,215 (16.3)	3,256 (16.8)	15,989 (18.2)
Diseases of digestive system	2,095 (5.2)	2.2	8,603 (4.7)	0.9	2.16 (2.06,2.27)	1,028 (4.9)	4,280 (4.6)	1,067 (5.5)	4,323 (4.9)
Disease of nervous system	1,140 (2.8)	1.2	7,569 (4.2)	0.8	1.48 (1.39,1.58)	559 (2.7)	3,645 (3.9)	581 (3.0)	3,924 (4.5)
Suicide	88 (0.2)	0.1	717 (0.4)	0.1	1.07 (0.85,1.34)	66 (0.3)	584 (0.6)	22 (0.1)	133 (0.2)
Other Causes	3,574 (8.9)	3.8	14,780 (8.2)	1.6	2.41 (2.31,2.50)	1,403 (6.7)	6,017 (6.4)	2,171 (11.2)	8,763 (10.0)

py, person-years. *Type 2 diabetes patients were matched to up to five patients without diabetes by year of birth (±2 years), sex, general practice and index date of diabetes diagnosis. Groups with and without diabetes were not matched for ethnicity; †HRs comparing groups with and without diabetes were adjusted for between-group differences in age, sex, ethnicity, deprivation, and calendar year; ‡Including diabetic coma, diabetic ketoacidosis, and other complications.

in women (18). We showed a lower number of life years lost associated with incident diabetes in a more contemporary cohort identified from 1998 to 2015. Mortality trends from years 2000 to 2011 in patients with type 2 diabetes from Australia also indicate significant decreases in all-cause, cardiovascular and diabetes mortality across all age-groups from 40 years (19). We extend these important pieces of work using linked primary care, hospitalization, and national mortality electronic health record data to show that this loss of life is driven largely by diabetes-associated mortality in white women and men. The greater effect of developing diabetes among women (compared with men) on all-cause mortality and coronary events has been reported previously, and we now extend these observations to include cause-specific mortality and life expectancy (20–22). The explanation for these observations is unclear, but could relate *1*) to women gaining more weight than men before developing diabetes and thereby undergoing larger obesity-related cardiovascular disease risk factor changes or *2*) to sex disparities in risk factor management (23,24).

Ethnicity

Here, we report for the first time that the presence of diabetes in older South Asians is associated with modest protection from all-cause mortality. Although "protection" from death has been described in elderly patients with type 2 diabetes (2), our data in South Asians are somewhat surprising. However, several factors could help to explain our findings: First, South Asian patients with type 2 diabetes were diagnosed younger (by 10 years) and at lower BMI levels than whites (mean 28.8 kg/m^2 compared with 31.6 kg/m^2). Treatment of South Asian and black patients with lifestyle intervention and medication at a young age, often before the development of macrovascular disease, may have preferentially slowed the progression of atherosclerosis and lowered the risk of cardiovascular death compared with those without diabetes. Second, the prevalence in our study of undiagnosed diabetes (~5%) among South Asians is likely to have been approximately twice as high as in whites (25). Therefore, undiagnosed (and untreated) individuals with diabetes in the community may have made a

Table 3—Adjusted all-cause and cause-specific mortality associated with age, sex and ethnicity (compared with whites), in people with type 2 diabetes and without diabetes

	Cause of death: Adjusted HR (95% CI)†									
	All-cause	Circulatory disease	Malignant neoplasms	Renal failure	Infectious disease	Respiratory disease	Diseases of digestive system	Diseases of nervous system	Suicide	Other
Type 2 diabetes										
Male	1.22* (1.19, 1.24)	1.33* (1.29, 1.37)	1.41* (1.35, 1.47)	1.08 (0.91, 1.28)	0.96 (0.85, 1.09)	1.18* (1.12, 1.24)	0.95 (0.87, 1.04)	1.08 (0.96, 1.21)	2.34* (1.44, 3.81)	0.80* (0.75, 0.86)
Age (years)	1.09* (1.09, 1.10)	1.10* (1.09, 1.10)	1.06* (1.06, 1.07)	1.11* (1.10, 1.11)	1.10* (1.09, 1.10)	1.12* (1.12, 1.13)	1.06* (1.05, 1.06)	1.10* (1.09, 1.10)	0.99 (0.97, 1.00)	1.12* (1.11, 1.12)
White	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
South Asian	0.70* (0.65, 0.76)	0.82* (0.75, 0.89)	0.43* (0.36, 0.51)	1.50 (0.93, 2.46)	1.01 (0.67, 1.54)	0.60* (0.48, 0.76)	0.48* (0.34, 0.69)	0.62 (0.37, 1.03)	0.94 (0.34, 2.63)	1.28* (1.02, 1.61)
Black	0.82* (0.74, 0.91)	0.83* (0.75, 0.93)	0.84* (0.70, 0.99)	1.06 (0.50, 2.24)	0.98 (0.55, 1.73)	0.62* (0.46, 0.84)	0.28* (0.14, 0.53)	0.81 (0.43, 1.52)	— (0)	1.59* (1.21, 2.08)
Without diabetes										
Male	1.39* (1.37, 1.40)	1.49* (1.47, 1.52)	1.53* (1.51, 1.56)	1.49* (1.35, 1.65)	1.09* (1.02, 1.16)	1.37* (1.34, 1.40)	1.18* (1.13, 1.23)	1.20* (1.15, 1.26)	3.67* (3.04, 4.43)	0.97 (0.94, 1.00)
Age (years)	1.09* (1.09, 1.10)	1.11* (1.10, 1.11)	1.06* (1.05, 1.06)	1.14* (1.14, 1.15)	1.11* (1.11, 1.12)	1.12* (1.11, 1.12)	1.07* (1.06, 1.07)	1.09* (1.09, 1.10)	0.98* (0.98, 0.99)	1.12* (1.11, 1.12)
White	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
South Asian	0.93* (0.87, 0.99)	1.05 (0.93, 1.18)	0.67* (0.59, 0.76)	1.46 (0.78, 2.72)	1.59* (1.11, 2.27)	0.95 (0.80, 1.11)	0.73* (0.53, 0.99)	0.67 (0.46, 0.98)	0.77 (0.32, 1.87)	1.79* (1.48, 2.16)
Black	1.07 (0.99, 1.15)	1.19* (1.03, 1.36)	1.11 (0.98, 1.26)	1.88 (0.94, 3.78)	1.88* (1.25, 2.84)	0.55* (0.42, 0.72)	0.59* (0.38, 0.90)	1.12 (0.77, 1.64)	0.49 (0.12, 1.95)	1.55* (1.20, 1.99)

*Indicates significance ($P < 0.05$); †All HRs are adjusted for sex, age, ethnicity, deprivation, calendar year (when appropriate).

modest contribution to the higher mortality in the group of South Asians without known diabetes.

Effect of Ethnicity on Mortality in People With Type 2 Diabetes

Prior Studies

We observed that when compared with whites with type 2 diabetes, South Asians and blacks with type 2 diabetes had lower risks of all-cause mortality and lower cardiovascular, respiratory, and cancer disease mortality. A small number of studies in type 2 diabetes have compared total mortality in different ethnic groups but none have provided cause-specific mortality data. For example, in research trial participants, the UK Prospective Diabetes Study (UKPDS) investigators reported that Afro-Caribbean (n = 312) and South Asian (n = 418) patients with type 2 diabetes experienced an 11–16% lower all-cause mortality compared with whites with type 2 diabetes (26). Further studies from the U.K. and Canada reported an ~40% lower total mortality risk in South Asian patients with diabetes compared with whites with diabetes (5,27).

Interpretation

Our findings suggest that in people with type 2 diabetes, the lower mortality risks in South Asians compared with whites may be partly explained by the lower prevalence of smoking, hypertension, obesity, and cardiovascular disease and greater exposure to antidiabetic medications, except sulfonylureas (linked to higher mortality). Mortality rates may also have been affected by the ethnic mix within our South Asian group: 52% were Indian, 23% were Pakistani, and 6.5% were Bangladeshi. Individuals of Indian origin have lower rates of chronic conditions and cardiovascular mortality than those of Bangladeshi and Pakistani origin (28,29). Similarly, smoking tends to be low in Indians (30), which would influence cancer, respiratory, and cardiovascular deaths (3,4,31). There may be further genetic, biological, or lifestyle factors that play a role in the lower mortality observed in South Asians compared with whites, such as enhanced cholesterol lowering with statins, (32) and perhaps a weaker relationship between BMI and cardiovascular mortality (33,34).

Clinical and Research Implications

We have highlighted health disparities among ethnic groups that have important research and public health implications. Further research is required to determine the reasons for the marked ethnic differences in the years of life lost associated with type 2 diabetes. The results of these research efforts will inform the design of appropriate clinical interventions. From a clinical perspective, the potential years of life years lost to type 2 diabetes is improving but is still higher than ideal, particularly in whites. Because we have shown that cardiovascular mortality remains the leading cause of death in patients with type 2 diabetes, efforts to optimize cardiovascular risk factor management, knowing that this can halve the risk of death in type 2 diabetes, need to be intensified (35,36).

Strengths and Limitations

The study has several strengths. First, we used a large population-based cohort of patients with type 2 diabetes identified in primary care and linked with national hospital and mortality records that offers advantages over research generated from databases based on hospital records only (e.g., U.S. insurance claims databases). This is because patients diagnosed with diabetes in hospital settings tend to have more advanced disease and are sicker with a higher mortality compared with those seen in primary care (37), and people using insurance-based health care systems may not be representative of the general population. Second, we used a sophisticated algorithm to identify individuals with type 2 diabetes based on several consistent clinical codes, age, prescriptions, BMI, and ethnicity. Third, we used an inception cohort, thereby reducing the important risks of survivor-bias and healthy subject–bias observed in prevalent cohorts (38–40). Fourth, we used linked health records to gain greater completeness of ethnicity data and to obtain a more reliable classification. Finally, we had adequate follow-up to assess mortality.

We acknowledge some limitations. First, although we studied large numbers of South Asian (n = 9,994) and black patients (n = 4,798) with type 2 diabetes, these were made up of smaller subgroups that were too small to analyze separately. Second, agreement in ethnicity recording in CPRD and HES data are high for those coded as "white" but may be less reliable for other ethnic groups (41,42); in cases of discrepant ethnicity recordings, we defined ethnicity as "unknown." Third, ethnicity data may have been more likely to be missing if a patient died early rather than later during follow-up because of a greater likelihood of having a hospital episode; however, only 18.5% of those patients in our study who died had an unknown ethnicity status. Fourth, we were unable to match on ethnicity, which may have influenced the risk estimates from our life expectancy and mortality analyses. Matching on CPRD ethnicity, before linkage to HES where a large proportion of ethnicity data were obtained, would have resulted in a substantially reduced cohort of case patients and control patients because the ethnicity of 59.5% of patients was not recorded in the CPRD or multiple discrepant ethnicities were recorded. Therefore, matching using the CPRD data only would have led to a loss of statistical power and precision in risk estimates relating to the minority ethnic groups. Matching for ethnicity after HES/ONS data linkage would have led to a 68–78% reduction in the sample size of black and South Asian groups, and therefore, this was not undertaken. The distribution of the matching variables in those with and without diabetes within each ethnic group was comparable, and therefore, the effect of not matching for ethnicity is likely to be small. Finally, our findings need to be confirmed in other populations outside England.

Summary

From this large primary care–based cohort, we have shown that white women and men experienced the greatest loss of life expectancy associated with type 2 diabetes compared with other ethnic groups and that older South Asian patients with type 2 diabetes had longer life expectancy than South Asians without diabetes. Compared with whites with type 2 diabetes, South Asian and black patients with type 2 diabetes had lower all-cause mortality and lower mortality resulting from cardiovascular, respiratory, and cancer diseases. These data call for replication studies and further research into the reasons for these marked ethnic differences. The findings support efforts to optimize cardiovascular disease risk factor management, especially in whites with type 2 diabetes, and to optimize type 2 diabetes screening among South Asians and Blacks.

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