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ORIGINAL ARTICLE

Examining trends in type 2 diabetes incidence, prevalence and mortality in the UK between 2004 and 2014

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Aims: Contemporary data describing type 2 diabetes prevalence, incidence and mortality are limited. We aimed to (1) estimate annual incidence and prevalence rates of type 2 diabetes in the UK between 2004 and 2014, (2) examine relationships between observed rates with age, gender, socio-economic status and geographic region, and (3) assess how temporal changes in incidence and all-cause mortality rates influence changes in prevalence.

Methods: Type 2 diabetes patients aged ≥ 16 years between January 2004 and December 2014 were identified using the Clinical Practice Research Datalink (CPRD). Up to 5 individuals without diabetes were matched to diabetes patients based on age, gender and the general practice. Annual incidence, prevalence and mortality rates were calculated per 10 000 person-years at risk (95% CI). Survival models compared mortality rates in patients with and without type 2 diabetes.

Results: Prevalence rates of type 2 diabetes increased from 3.21% (3.19; 3.22) in 2004 to 5.26% (5.24; 5.29) in 2014. Incidence rates remained stable, overall, throughout the study period. Higher incidence and prevalence rates were related to male gender and deprivation. Individuals with type 2 diabetes were associated with higher risk of mortality (Hazard ratio 1.26 [1.20; 1.32]). Mortality rates declined in patients with and without diabetes throughout the study period. The incidence and prevalence of type 2 diabetes in patients aged 16 to 34 years increased over time.

Conclusions: The rising prevalence of type 2 diabetes in the UK over the last decade is probably explained by patients living longer rather than by increasing incidence of type 2 diabetes.

KEYWORDS

CPRD, database research, incidence, prevalence, primary care, type 2 diabetes

1 | INTRODUCTION

The prevalence of diabetes is increasing rapidly worldwide.¹⁻⁴ In 2016, the World Health Organization (WHO) reported that nearly 422 million adults live with diabetes; this is an increase in global

prevalence from 4.7% in 1980 to 8.5% in 2014.⁵ Similarly, in the UK, diabetes is described as the fastest growing health condition⁶ where prevalence has almost doubled over the last 2 decades.^{7,8} However, studies in the UK were often based on restricted local areas within the country,⁹⁻¹¹ estimated either incidence¹² or prevalence¹⁰ of type

2 diabetes mellitus (T2DM), but not both simultaneously, or they examined trends over a short study period.¹¹ A recent study examined UK trends in T2DM incidence and prevalence from 2000 to 2013 but it did not consider regional variation or the potential influence of changing mortality rates.⁸

Using UK-based primary care data, we aimed to (1) assess temporal trends in incidence and prevalence rates of T2DM stratified by gender, age and social-deprivation between 2004 and 2014, (2) assess the contribution of incidence and mortality rates to observed prevalence, and (3) compare differences in all-cause mortality between patients with T2DM and those without diabetes.

2 | METHODS

2.1 | Data source

The Clinical Practice Research Datalink (CPRD) is an electronic database based on primary care health records in the UK.^{13,14} The CPRD provides longitudinal anonymized data on patient demographics, clinical diagnoses, prescribed treatments, tests, referrals and linkage to external datasets and disease registries. Currently, CPRD holds research-quality data on nearly 14 million patients registered with 697 general practices. Practice-level socio-economic data, as indicated by the index of multiple deprivation (IMD), is available. The IMD is a composite score constructed from the following domains of deprivation: finance, education, health, access to services and crime.¹⁵ The Quality and Outcomes Framework (QOF) scheme was introduced in 2004 as an incentive to UK general practices providing high-quality care including diabetes management.¹⁶ The study period was initiated at the QOF launch to maximize the quality of captured data.

2.2 | Patient population

2.2.1 | Examining incidence and prevalence

Patients aged ≥ 16 years with ≥ 1 diagnostic Read code for T2DM between January 2004 and December 2014, with data of an acceptable quality, were included. Patients with codes for type 1 diabetes were excluded.

2.2.2 | Examining all-cause mortality

Patients with ≥ 1 diagnostic code for T2DM, who were registered for ≥ 90 days in an up-to-standard general practice and were ≥ 16 years of age at diagnosis between 2004 and 2014 were identified. We excluded patients with any clinical code for type 1 diabetes. The up-to-standard criterion indicates that practice data are of high quality for use in research, based on the continuity of data recording and mortality rate compared with the expected range.^{13,14} Up to 5 patients without diabetes were matched to each T2DM patient on age (birth year difference of ≤ 2 years), gender and the general practice they are registered with.

Eligible patients were followed up from their index date, the earliest date of T2DM diagnosis, until the earliest date among the following events: date of last data collection for the practice; patient transfer out of the practice; end of study (December 31, 2014) or death. Comparators without diabetes were assigned the corresponding index date of the diabetes case and followed up in the same manner.

2.3 | Statistical analyses

2.3.1 | Incidence and prevalence rates

Overall and annual crude incidence rates of T2DM were calculated by dividing the number of new cases diagnosed in a given year by the total population at risk. Calculated incidence rates were expressed per 10 000 person-years (PYR) at risk with 95% confidence intervals (95% CI). Overall and annual standardized incidence rates were calculated by age at diagnosis, UK country, or deprivation quintiles by adjusting for the respective factors. For instance, for estimation of gender-specific incidence rates by UK country, rates were standardized by age and deprivation quintiles.

Overall and annual crude prevalence rates were calculated as percentage (95% CI) and per 10 000 PYR at risk (95% CI). Rates were calculated as the number of existing T2DM patients in a given year (without restriction regarding past record of T2DM) divided by the total number of registered patients for that year. As with incidence rates, standardized prevalence rates were adjusted for age, UK country or deprivation quintile, depending on the stratification of interest.

To assess if results will differ from annual rates, incidence and prevalence rates were calculated also over a fixed number of years using two sets of intervals: (1) over 6-/5-year intervals (2004-2009 and 2010-2014); (2) over 4-/3-/4-year intervals (2004-2007; 2008-2010; 2011-2014). Incidence and prevalence rates were also calculated in patients aged 16 to 34 years and ≥ 35 years to assess temporal changes in patients diagnosed with diabetes at a young age.

2.3.2 | All-cause mortality rates

The main demographic characteristics of matched T2DM patients and individuals without diabetes (comparators) were identified. Continuous variables were summarized as mean (SD) or median (interquartile range) and categorical variables as count (percentage). Annual crude mortality rates were calculated as the annual number of deceased individuals with T2DM or comparators divided by the person-years on that year. Cox proportional hazard models, stratified by the matching set identifier, were used to compare differences in all-cause mortality rates between patients with and individuals without diabetes and to estimate the hazard ratio (HR) (95% CI). Schoenfeld residuals were used to test proportional hazards assumptions. As a sensitivity analysis, the model was restricted to patients registered in general practices who participated in the full length of the study (2004 to 2014).

Stata Software: release 14 (Statacorp, College Station, Texas) was used for all analyses.

3 | RESULTS

3.1 | Incidence of type 2 diabetes

The standardized incidence rate per 10 000 person-years (PYR) (95% CI) was 44.80 (44.11; 45.49) in 2004 and remained stable, overall, until 2013 before decreasing slightly to 36.89 (36.19; 37.61) in 2014. A peak in the number of incident cases was observed in 2006. By gender, the incidence of T2DM was higher in males than in females (Table 1 and Figure S1). Over the 11-year period, the mean incidence per 10 000

TABLE 1 Gender-specific annual standardized incidence and prevalence rates per 10 000 patients

Year	Incidence		Prevalence	
	Males	Females	Males	Females
2004	52.10 (51.04; 53.17)	38.24 (37.35; 39.13)	380.31 (377.48; 383.13)	268.56 (266.22; 270.90)
2005	49.06 (48.05; 50.07)	36.53 (35.67; 37.39)	419.48 (416.57; 422.39)	297.43 (295.01; 299.84)
2006	64.29 (63.13; 65.44)	46.93 (45.96; 47.90)	470.13 (467.07; 473.19)	334.57 (332.02; 337.12)
2007	49.25 (48.24; 50.26)	35.28 (34.44; 36.12)	500.85 (497.69; 504.01)	356.91 (354.28; 359.55)
2008	49.87 (48.85; 50.88)	34.52 (33.69; 35.35)	526.61 (523.39; 529.84)	373.25 (370.56; 375.93)
2009	52.02 (50.98; 53.06)	35.76 (34.92; 36.61)	552.90 (549.59; 556.21)	390.49 (387.74; 393.25)
2010	51.59 (50.54; 52.64)	34.65 (33.80; 35.50)	580.39 (576.95; 583.82)	407.17 (404.33; 410.01)
2011	47.90 (46.87; 48.92)	33.43 (32.59; 34.27)	601.61 (598.07; 605.14)	422.71 (419.78; 425.63)
2012	48.54 (47.50; 49.59)	34.00 (33.14; 34.86)	613.24 (609.62; 616.85)	428.73 (425.76; 431.71)
2013	51.26 (50.14; 52.39)	35.98 (35.06; 36.90)	621.23 (617.43; 625.03)	431.46 (428.35; 434.57)
2014	42.59 (41.49; 43.68)	31.83 (30.91; 32.75)	625.45 (621.37; 629.52)	437.28 (433.94; 440.62)

PYR was 50.77 (47.26; 54.28) in men, and 36.10 (33.44; 38.77) in women. In 2004, incidence rates were 52.10 (51.04; 53.17) in men and 38.24 (37.35; 39.13) in women. From 2007 onwards, incidence rates were fairly stable in both males and females. The incidence was higher in older age groups of both men and women (Figure 1, Panel I.A).

Incidence rates were higher, overall, in Wales and Northern Ireland in comparison to England and Scotland. Peak incidence in 2006 was less sharp in Wales than in the other 3 countries (Figure 1, Panel I.B). Patients residing in the most socially-deprived areas had the highest incidence rates (Figure 1, Panel I.C). Estimated crude incidence rates were very similar to standardized rates (Table S1). The incidence over year intervals was similar to annual rates as 45.0 (44.72; 45.27) for the period 2004 to 2009 and 41.73 (41.42; 42.04) for the period 2010 to 2014. In patients aged 16 to 34 years, overall incidence rates increased by 25% from 2.76 (2.44; 3.08) to 3.44 (3.04; 3.83) between 2004 and 2014. Gender-specific annual rates were also estimated in the 3 age-groups (Figure S2).

3.2 | Prevalence of type 2 diabetes

The prevalence of T2DM increased steadily over time. Overall, standardized prevalence rates nearly doubled from 3.21% (3.19; 3.22) to 5.26% (5.24; 5.29) between 2004 and 2014. By gender, the mean prevalence per 10 000 PYR was higher in men (536, 95% CI: 478.94; 592.37) than in women (377, 95% CI: 338.69; 415.60) (Table 1 and Figure S3). In both genders, prevalence rates were positively related to age (Figure 1, Panel II.A), and they were higher in Wales and Northern Ireland (Figure 1, Panel II.B) and in areas of greater deprivation (Figure 1, Panel II.C). Estimated crude prevalence rates were very similar to the standardized rates (Table S2). The prevalence over year intervals was similar to annual prevalence rates. In patients aged 16 to 34 years, the prevalence per 10 000 PYR almost doubled from 10.56 (9.67; 11.46) to 20.85 (19.47; 22.23) in women and increased from 10.11 (9.25; 10.96) to 16.78 (15.55; 18.02) in men (Figure S4).

3.3 | All-cause mortality

A total of 176,562 T2DM patients, diagnosed between 2004 and 2014, and 881,901 matched controls were included in the analysis (Figure 2). Mean \pm SD age was 62.5 ± 13.6 years, 77% were

registered in English practices and 10% in Scottish practices; 16% were from least deprived areas [IMD quintile 1] and 21% were from most deprived areas [IMD quintile 5] (Table 2). Among diabetes patients, 44% were receiving lipid-regulating medications and 52% had hypertension as compared to 4% and 30%, respectively, in controls.

In the survival analysis, the cohort of matched diabetes cases and controls was followed for a total of 4555 266 person-years (mean \pm SD follow-up for cases: 4.31 ± 3.0 years; mean \pm SD follow-up for controls: 4.30 ± 3.0 years). Mortality rates per 10 000 PYR (95% CI) declined between 2004 and 2014 from 319 (309; 329) to 216 (182; 257) in T2DM cases and from 251 (247; 255) to 136 (124; 150) per 10 000 PYRs in individuals without diabetes (Figure 3 and Table S3). Annual gender-specific mortality rates were calculated (Figure S5). When assessed by the duration of follow-up, the excess risk associated with T2DM ranged between HR 1.28 (1.23; 1.32) during the first year of follow-up and HR 1.47 (1.32; 1.65) for follow-up of over 9 years. This change of hazard over time affected the proportionality assumption and resulted in the need to report the risk of mortality at a median follow-up interval (3.9 years). The proportionality of hazards was assessed annually up to ≤ 9 years and for >9 years of follow up. At median duration of follow up, the overall risk of all-cause mortality was significantly higher in patients with T2DM compared to individuals without diabetes (HR: 1.26, 1.20; 1.32). Schoenfeld residuals indicated the proportionality of the hazard function ($P = .66$). By gender, the excess risk was HR 1.24 (1.17; 1.32) in males and HR 1.28 (1.20; 1.37) in females. Similar results were found in the sensitivity analysis restricted to fully-contributing practices: HR 1.27 (1.21; 1.34) with proportional hazards ($P = .27$).

4 | DISCUSSION

4.1 | Main findings

We have shown that T2DM prevalence rates rose by two-thirds while incidence rates were generally stable in the UK for the period 2004 to 2014. Ageing population is the likely explanation for the observed increase in prevalence. Incidence and prevalence rates were markedly higher in men than in women and this trend persisted throughout the study period after adjusting for age, UK country and

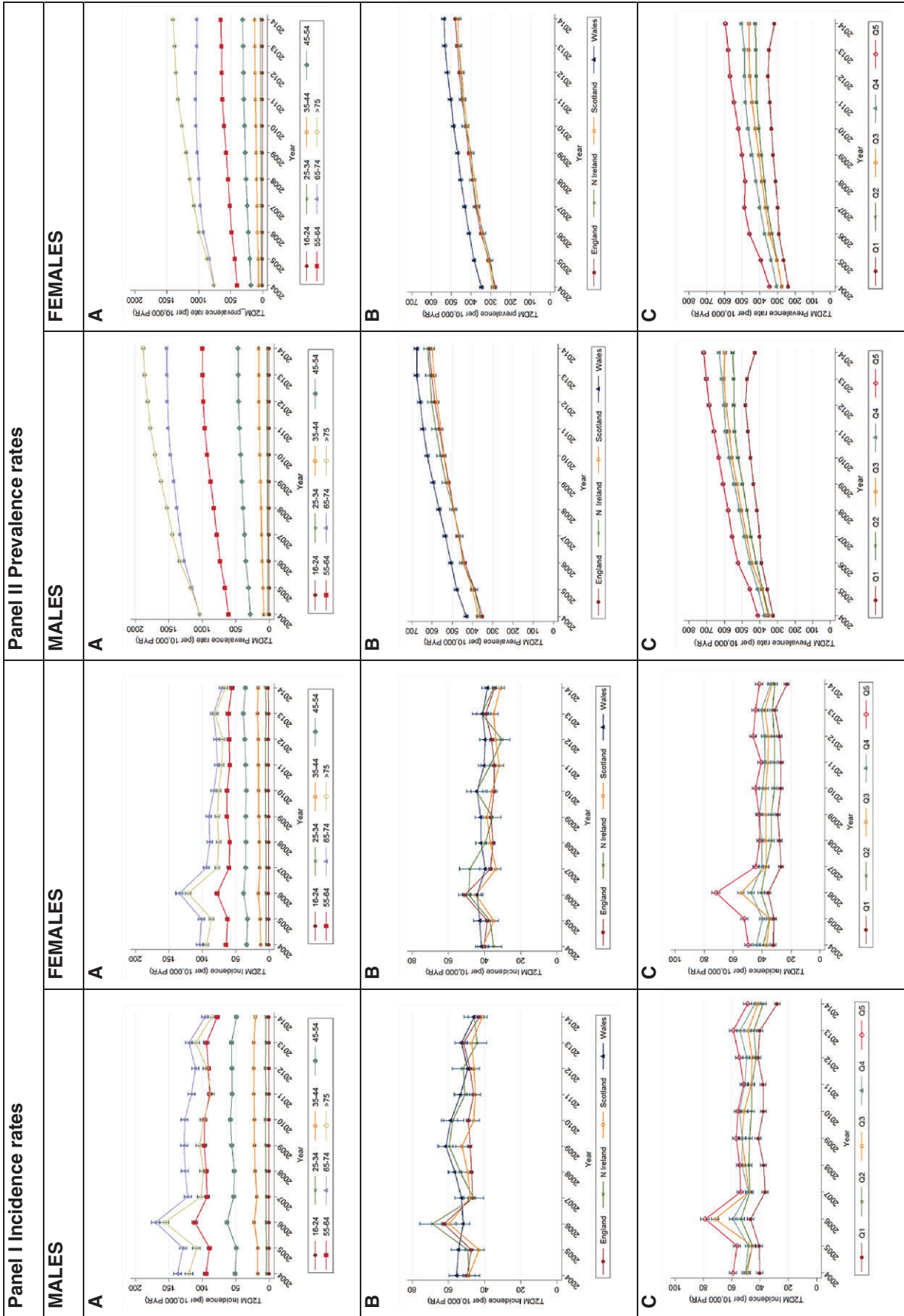


FIGURE 1 Gender-specific annual standardized incidence (Panel I) and prevalence (Panel II) rates per 10 000 PYR (95% CI) by A, age bands; B, UK nation and C, neighborhood deprivation quintile (Q1, least deprived; Q5, most deprived)

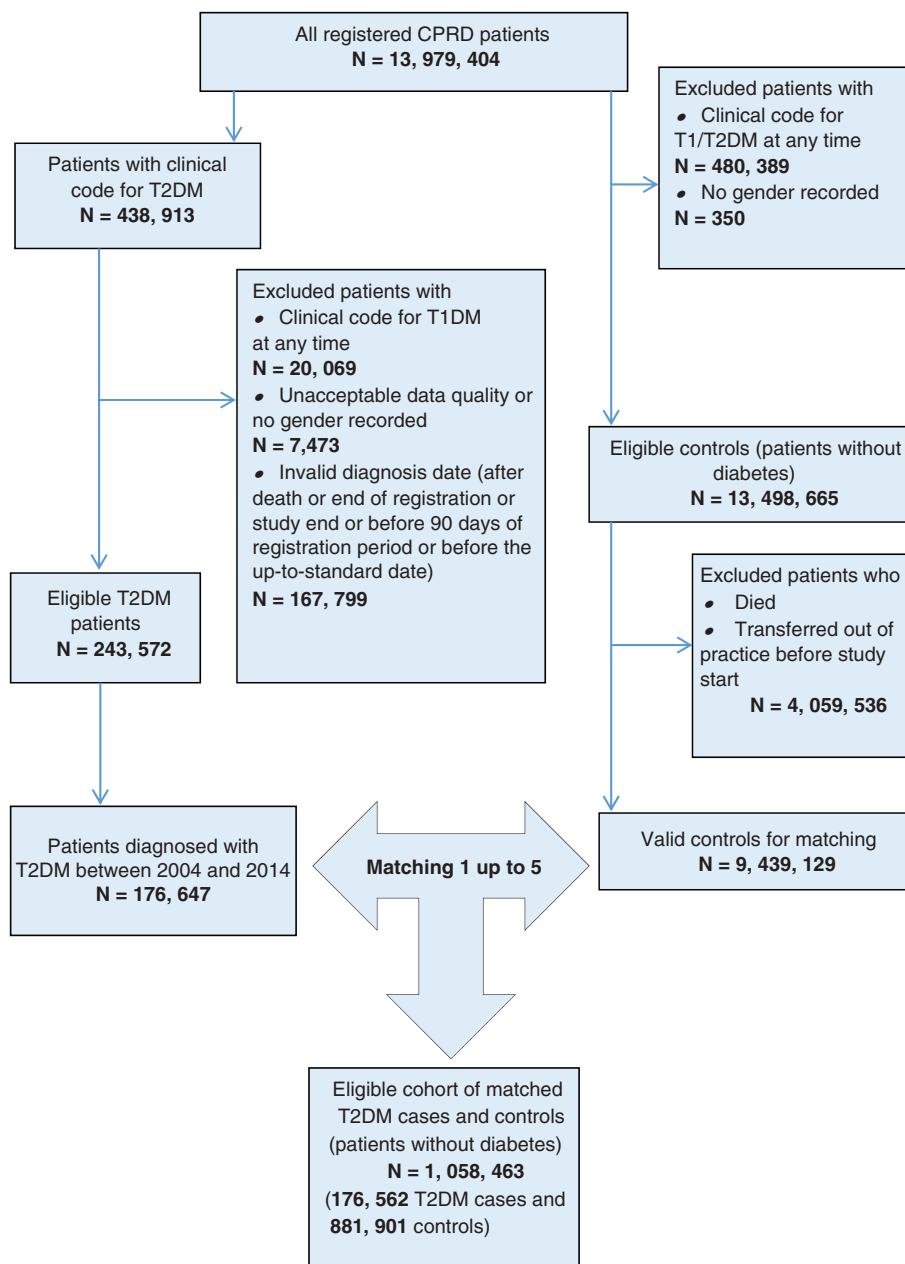


FIGURE 2 Flow diagram for identification of the 1:5 matched cohort of patients with and without diabetes for mortality analysis. T1DM, type 1 diabetes mellitus; T2DM, type 2 diabetes mellitus

socio-economic status. Older male patients living in deprived areas were the most likely individuals to develop T2DM or to have prevalent T2DM.

We found that all-cause mortality rates declined over the study period in all patients. Significantly higher mortality rates were observed in patient with T2DM compared to patients without diabetes. This finding builds up to previous reports that diagnosis with diabetes is associated with greater risk of mortality when compared to the general population.^{17–19} The reason for the observed increases in mortality rates in 2006 is unclear. The increase is probably driven by the higher numerator (number of deaths) and denominator (person-years in analysis) as the cohort matched in 2006 was the largest among all annual cohorts. For increases observed in 2013, the Office for National Statistics (ONS) reported a 1.5% increase in deaths in 2013 compared to 2012.²⁰ The mortality gap between diabetes cases and controls, however, appears to widen in 2014. This is most probably driven by risen death rates in 2014 in male patients with diabetes, unlike the decline

observed in female patients with diabetes and in both male and female controls (Figure S5). Importantly, this gap narrows again in 2015 when analysis extended to 2015 (data not shown).

4.2 | Prior studies

The reported findings add to the existing knowledge, as the majority of previous studies examined the epidemiology of combined type 1 and T2DM,^{7,21} estimated incidence¹² or prevalence of T2DM,¹⁰ and not both simultaneously, covered a short study period,¹¹ or were based on restricted local areas within the UK, which limits the generalizability of the findings for nationwide representation.^{9–11} Moreover, few studies have assessed the association between incidence, prevalence and mortality in patients with T2DM.

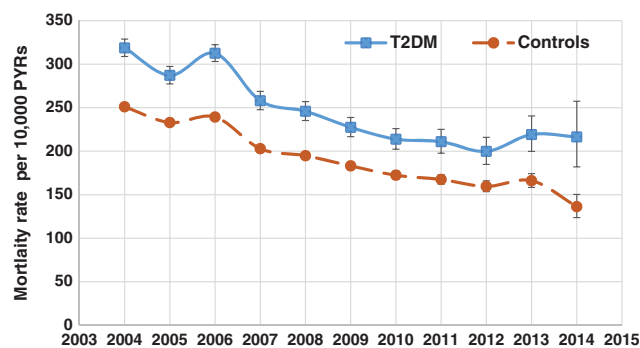
For example, a Dutch study estimated these rates in T2DM between 1998 and 2000.³ However, the study was smaller than the present study (N = 4423) and mortality rates were compared to the

TABLE 2 Baseline characteristics of (1:5) matched type 2 diabetes cases and patients without diabetes (controls)

Characteristic	Cases N = 176 562	Controls N = 881 901
Age bands, N (%)		
16 to 24 years	476 (0.3)	2380 (0.3)
25 to 34 years	3385 (1.9)	16 924 (1.9)
35 to 44 years	13 903 (7.9)	69 512 (7.9)
45 to 54 years	32 089 (18.2)	160 418 (18.2)
55 to 64 years	45 931 (26.0)	229 589 (26.0)
65 to 74 years	44 872 (25.4)	224 227 (25.4)
≥75 years	35 906 (20.3)	178 851 (20.3)
Female, N (%)	78 549 (44.5)	392 384 (44.5)
Follow-up (years) Median (IQR)	3.9 (4.8)	3.8 (4.9)
Number of deaths, N (%)	20 312 (11.5)	79 951 (9.1)
Co-medications, N (%)		
Diuretics	20 640 (11.7)	7952 (0.90)
α-adrenoceptor blockers	7527 (4.3)	2762 (0.31)
β-adrenoceptor blockers	41 507 (23.5)	17 906 (2.03)
Calcium-channel blockers	41 471 (23.5)	20 474 (2.32)
ACE inhibitors	49 628 (28.1)	19 903 (2.26)
ARBs	17 175 (9.7)	6564 (0.74)
Antiplatelet drugs	45 741 (25.9)	19 424 (2.20)
Lipid-regulating drugs	77 402 (43.8)	34 221 (3.88)
Comorbidities, N (%)		
Asthma	21 329 (12.08)	83 865 (9.51)
COPD	10 540 (5.97)	39 714 (4.50)
Hypothyroidism	13 653 (7.73)	49 942(5.66)
Osteoarthritis	37 546 (21.27)	151 469(17.18)
Chronic kidney disease	13 527 (7.66)	46 618 (5.29)
Schizophrenia	3045 (1.72)	7803 (0.88)
Dementia	1685 (0.95)	10 556 (1.20)
Depression	40 072 (22.70)	162 361 (18.41)
Epilepsy	2710 (1.53)	13 483 (1.53)
Hyperlipidaemia	34 607(19.60)	101 579 (11.52)
Hypertension	92 199 (52.22)	263 692 (29.90)
Peripheral vascular disease (PVD)	5538 (3.14)	15 804 (1.79)
Myocardial infarction	12 194 (6.91)	31 744 (3.60)
Congestive heart failure	7357 (4.17)	18 052 (2.05)
Atrial fibrillation	10 720 (6.07)	31 545 (3.58)
Stroke	6445 (3.65)	20 278 (2.30)
Transient ischemic accident (TIA)	5532 (3.13)	19 926 (2.26)
Cancer	11 446 (6.48)	51 690 (5.86)

Abbreviations: ACE, angiotensin converting enzyme; ARB, angiotensin-II receptor blocker; COPD, chronic obstructive pulmonary disease; IQR, interquartile range.

general population, including patients with diabetes, which led to lower mortality rate ratios. The results showed an increasing prevalence but did not assess temporal changes in mortality and incidence. The study reported only overall crude and age/gender adjusted incidence rates per 10 000 patients of 22.0 and 22.7, respectively. The UK incidence were higher than that observed in the Netherlands as reported at 3.69 per 1000 PYR in men and 3.06 per 1000 PYR in women in 2000.⁸

**FIGURE 3** Crude annual mortality rates per 10 000 person-years (PYRs) (95% CI) for type 2 diabetes (T2DM) cases and matched patients without diabetes (controls) during follow-up

A Canadian study reported a 69% increase in the prevalence of diabetes between 1995 and 2005, which was attributed to increased incidence by 31% from 6.6 to 8.2 per 1000 patients and a 25% decline in mortality.²¹ This study examined all types of diabetes, and mortality rates were not adjusted for socio-economic data. In comparison, our UK incidence was lower (4.5 per 1000 patients in 2004). The higher prevalence of diabetes in Canada compared to the UK has been reported previously.²² In a separate report, temporal trends in mortality rates in individuals with and without diabetes in Canada and the UK were compared.¹⁷ Patients with diabetes had higher mortality risks, but these excess risks declined between 1996 and 2009 in both study cohorts (mortality rate ratios of up to 1.51 [1.48; 1.54]), perhaps reflecting improvements in general healthcare and diabetes care.

Concerning gender, the higher incidence and prevalence rates observed in men compared to women has been reported previously in England and Wales,²³ the UK,⁸ Taiwan² and Europe.⁴ In contrast, women are more likely to have T2DM in the Netherlands.³

Concerning age, our finding that the incidence of T2DM at a young age has increased over the past decade builds upon a previous study that assessed early incidence in patients aged <40 years during the period 1991 to 2010.¹²

We showed decreasing mortality rates, which is in agreement with UK national reports, in individuals with and without diabetes between 1983 and 2013²⁴ and in Scotland between 1993 and 2004.⁹ Our findings also showed a 26% higher risk of mortality in T2DM patients compared to those without diabetes, confirming the mortality gap highlighted in many guidelines and reports on the association between diabetes and premature death.^{18,25} However, the observed excess risk was slightly lower than that from other reports.^{17,18} This difference may be explained by improvements in care in the T2DM population over recent years (e.g. in cardiovascular disease management) and to the similar durations of follow-up between cases and matched controls. The latter (similar follow-up durations) was also observed in a recent report.¹⁹ In our study, the similar duration of follow-up was driven mainly by the practice-determined censor point (last date for contribution of data) which was the main censor point in the identified matched cohort.

This excess risk of mortality in diabetes patients was comparable to more recent studies.^{19,26} For example, a large study from Sweden,

followed up matched T2DM cases for 4.6 years and controls for 4.8 years and showed that the adjusted HR for all-cause mortality associated with diabetes was 1.15 (1.14; 1.16) between 1998 and 2011.¹⁹ The investigators attributed this comparatively low excess risk to improved medical care over time. In keeping with this idea, we showed that antihypertensive and lipid-lowering therapies were prescribed for up to 28% and 44%, respectively, of patients with type 2 diabetes. Similar to our CPRD results, the latest National Diabetes Audit (NDA) data on complications and mortality (2012-2013)²⁷ reported: (1) a 32% excess risk for mortality in T2DM patients than in the general population; (2) that excess risk was higher in women; (3) that excess risk for mortality in patients with T2DM declined between the 2009 to 2010 and 2011 to 2012 audits, recommending that further studies are needed to examine the future patterns of this reduced trend.

4.3 | Worldwide perspective on type 2 diabetes incidence and prevalence

The observed incidence plateau in our study was seen previously in 2 relevant UK studies. Firstly, our overall stable incidence is comparable to the trend observed between 2004 and 2012 in a similar primary care database (THIN).⁸ Secondly, the incidence rates of T2DM reported using CPRD were also stable between 2003 and 2006; they increased between 2007 and 2009 before decreasing again in 2010.¹²

Importantly, a recent study assessed whether the quality of recording of diabetes in the UK has affected the reported incidence and prevalence estimates of diabetes between 1995 and 2014.²⁸ The conclusion, in contrast to previous reports, was that the incidence of diabetes, based on diagnostic codes, has not increased in the UK since 2004, suggesting that the choice of codes has a significant effect on incidence estimates. This important finding agrees with the approach adopted in our case definition strategy (excluding type 1 diabetes cases) which aimed to minimize misclassification of T2DM.

International diabetes organizations have reported on the increasing prevalence rates of diabetes, but not necessarily on incidence rates in all regions.^{22,29}

The number of people with diabetes is increasing in the UK and worldwide.¹⁻⁴ Our findings showed a rapidly increasing prevalence of T2DM in the UK over the last decade, which builds on the findings of relevant observational studies and national reports.^{8,9,25,30} The prevalence rates reportedly increased from 2.3% to 5.3% between 2000 and 2013 in the UK,⁸ from 5.8% to 8.5% between 2000 and 2007 in Taiwan,² and from 2.2% to 2.9% between 1998 and 2000 in the Netherlands.³ It is important to note however, when comparing diabetes prevalence rates, that in many countries prevalence rates are estimated from surveys of a part of the country as very few countries have national registries.^{22,31} As some of the reported diabetes prevalence rates are survey-based¹ or based on self-reports,⁴ the strengths of our findings are highlighted as the UK prevalence estimates are based on national QOF data collected from general practices. In relation to the UK country-specific prevalence of T2DM, our findings showed that Wales had the highest standardized rates. This is in agreement with the 3 most recent reports by Diabetes UK (a leading UK charity focused on diabetes research), comparing the prevalence rates of

diabetes in the 4 UK nations, in which Wales had the second highest rate after England in 2012, but the highest estimates in 2013 and 2014.²⁵

4.4 | Potential influence of QOF scheme and HbA1c-driven type 2 diabetes diagnosis

The overall stable incidence rates in our study are similar to the trend reported previously in Taiwan between 2000 and 2007.² However, the transient increase in incident T2DM cases in 2006 is most probably attributable to the QOF changes implemented in April of the same year.³² A second slight elevation in incidence was observed during the period 2012-2013, which may be related to the WHO recommendation in 2011 to use HbA1c for T2DM diagnosis.³³

4.5 | Clinical and policy implications

The improved life expectancy in T2DM is likely to reflect improvements in population health and improvements in diabetes care in the UK.¹⁷ This highlights the importance of effective strategies for screening and for management of modifiable risk factors for cardiovascular disease, as clearly demonstrated in clinical trials and observational studies.³⁴⁻³⁶ For example, long-term follow-up of the Steno 2 trial cohort has shown that 8 years of intensified, multifactorial, target-driven treatment of T2DM led to 8 years of life gained.³⁶ Therefore, the findings presented in our study have important implication for diabetes care. These findings provide additional impetus to tackle clinical inertia in the management of modifiable cardiovascular risk factors in T2DM. The findings should also inform social and health policymakers regarding addressing social deprivation and establishing effective preventative measures that could avoid the morbidity, mortality and huge financial costs associated with T2DM.

4.6 | Strengths and limitations

Our study has several strengths. This is the first large study to provide insight into the inter-relationship between prevalence, incidence and mortality rates in T2DM patients across the UK. Secondly, the study had a large sample size, representative of the UK population and drawing on nearly 14 million CPRD patients. Thirdly, the study included patients from the 4 UK countries, increasing the external validity of our findings. Fourthly, the selected study period was relevant to the current clinical practice scheme, ranging from QOF introduction to 2014. Fifthly, our incidence and prevalence rates were adjusted for several factors including country within the UK; this enabled an assessment of country-specific temporal rates which may reflect on the effectiveness of local diabetes prevention and management strategies.

We acknowledge some limitations in our study. Firstly, our T2DM cohort was based on diagnosed cases in the primary care database and represents consulting prevalence rates for T2DM. However, overall prevalence rates were similar to annual national estimations.^{25,30} Secondly, although the all-cause mortality analysis took into account several important covariates, the possibility of residual confounding cannot be excluded.

4.7 | Conclusions

We have shown that T2DM prevalence rates rose by two-thirds while incidence rates were generally stable in the UK for the period 2004 to 2014. Improvements in life expectancy were observed during the study period, which is probably the key driver of the observed increase in prevalence. Higher incidence and prevalence rates were observed in older males from more socially deprived areas. The incidence of T2DM at a young age increased over the past decade. Patients with T2DM were at significantly higher risk of all-cause mortality than were patients without diabetes. These data support ongoing efforts to improve the prevention and effective management of T2DM through social and medical intervention.

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This study is based on data from the CPRD obtained under license from the UK Medicines and Healthcare products Regulatory Agency (MHRA). However, the interpretation and conclusions in this paper are those of the authors alone. The study protocol was approved by CPRD's Independent Scientific Advisory Committee (ISAC) (reference: 15_149RMn). Parts of this study were presented at the 32nd International Conference on Pharmacoepidemiology and Therapeutic Management (ICPE), Dublin, Ireland, August 25 to 28, 2016.

Conflict of interests

S. S. Z., D. T. S., M. J. C. and R. A. E. have no conflict of interest to disclose. D. M. A. has received grant funding from Abbvie and has served on advisory boards for Pfizer and GSK. M. K. R. has received educational grant support from MSD and Novo Nordisk; has modest stock ownership in GSK; and has consulted for Roche.

Author contributions

D. T. S., D. M. A., M. K. R., R. A. E. and S. S. Z. contributed to the study protocol. D. T. S., D. M. A., M. K. R. and S. S. Z. contributed to the study design. S. S. Z. extracted and analysed the data and drafted the manuscript, and all authors reviewed and edited the manuscript before submission. S. S. Z. performed all the statistical analyses, with D. T. S., D. M. A. and M. J. C. supervision. S. S. Z. had full access to all study data and takes responsibility for the integrity of the data and the accuracy of data analyses. S. S. Z.'s PhD sponsor (The Libyan Ministry for Higher Education) was not involved in the study design, analysis, interpretation of data, or preparation of this manuscript.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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