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Osteoarthritis and Cartilage

Trends in incidence and prevalence of osteoarthritis in the United Kingdom: findings from the Clinical Practice Research Datalink (CPRD)

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SUMMARY

Objective: This study aimed to explore the incidence and prevalence of OA in the UK in 2017 and their trends from 1997 to 2017 using a large nationally representative primary care database.
Design: The UK Clinical Practice Research Datalink (CPRD) comprising data on nearly 17.5 million patients was used for the study. The incidence and prevalence of general practitioner diagnosed OA over a 20 years period (1997–2017) were estimated and age-sex and length of data contribution standardized using the 2017 CPRD population structure. Cohort effects were examined through Age-period-cohort analysis.
Results: During 1997–2017, there were 494,716 incident OA cases aged ≥20 years. The standardised incidence of any OA in 2017 was 6.8 per 1000 person-years (95% CI 6.7 to 6.9) and prevalence was 10.7% (95% CI 10.7–10.8%). Both incidence and prevalence were higher in women than men. The incidence of any-OA decreased gradually in the past 20 years at an annual rate of −1.6% (95%CI -2.0 to −1.1%), and the reduction speeded up for people born after 1960. The prevalence of any-OA increased gradually at an annual rate of 1.4% (95% CI 1.3–1.6%). Although the prevalence was highest in Scotland and Northern Ireland, incidence was highest in the East Midlands. Both incidence and prevalence reported highest in the knee followed by hip, wrist/hand and ankle/foot.
Conclusion: In the UK approximately one in 10 adults have symptomatic clinically diagnosed OA, the knee being the commonest. While prevalence has increased and become static after 2008, incidence is slowly declining. Further research is required to understand these changes.

Introduction

Osteoarthritis (OA) is one of the commonest long-term conditions, causing significant impairment of physical function. It can affect several joints which may further compound functional impairment and participation restriction. In the absence of any cure, the burden of OA is increasing globally with an estimated 28% of the older population (>60 years) having OA[1]. The 2017 Global Burden of Disease (GBD) report ranked hip and knee OA as the 11th highest contributor to global disability and the 23rd highest cause of disability adjusted life years (DALYs)[2]. Increasing life expectancy and the ageing population are expected to make OA the fourth leading cause of disability by 2020[3] and a significant increase in DALYs has already been noted from 2007 to 2017.[2]

Whilst DALYs provide useful data on disease burden, accurate information on changing incidence and prevalence of a disease provides an alternative picture to help guide effective preventive and management planning. To date, very few studies have examined trends of OA incidence and prevalence using national representative cohort data. The lack of such information creates challenges in reliable estimation of the burden of OA. Worldwide, the estimated incidence of OA has varied from a low of 14.6 per

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1000 person-years in Canada[4] to a high of 40.5 per 1000 person-years in the UK[5]. Only three countries have reported increasing trends of the incidence of OA, whereas none has published prevalence trend data. In Sweden, age-standardized hospitalization rates due to hip and knee OA increased from 1998 to 2014[6] and in Canada crude incidence rates increased during 2000–2008 from 11.8 to 14.2 per 1000 person-years in men, and from 15.7 to 18.5 person-years in women[4]. However, one UK study using the Clinical Practice Research Datalink (CPRD) reported no change in trends of incidence of physician-diagnosed OA (1992–2013)[5]. Seven years of consultation data till 2010 reveals nearly 8.75 million people in the UK had visited any health facility for treatment of OA, and by 2035, 8.3 million people in the UK aged 45 years or over could have symptomatic knee OA.[7]

Primary care is the usual first point of contact for someone with symptomatic OA. The UK CPRD is a primary care database that represents the community burden in better ways than hospital (secondary care) records and allows evaluation of the trends of incidence and prevalence over time. However, these estimates depend on the nature of consultation, the coding system and other individual factors. While the incidence measures the aetiological impact of OA, the prevalence measures the disease burden to inform health resource requirements. Although there have been some incidence and prevalence studies from the UK[5,8,9], they have given inconsistent results through use of different definitions and sampling methods. Therefore, the recent trend and natural history of OA in UK primary care remains largely unknown.

This study aimed to explore both the incidence and prevalence of OA (overall and joint specific) in the UK during the period 2017 and their trends during 1997–2017 using a large nationally representative primary care database.

Methods

This was a descriptive study using longitudinal primary care database of the UK.

Source population

The CPRD is a large database of general practice electronic medical records that is generalisable to the wider UK population. As of 31st December 2017, the CPRD contained data on 17,480,766 individuals from 736 general practices. Recording of ailment is mandatory for every visit and there is no limit on the number of diagnoses entered. The database contains information on symptoms, diagnoses, prescriptions, referrals, tests, immunisations, life style factors, information on medical staff, health promotion activities, management and quality outcome framework indicators[10]. Substantial research has been undertaken to examine the validity and completeness of the CPRD and has provided satisfactory results[11]. More details about the database can be found at https://cprd.com/primary-care. This study was approved by the independent scientific advisory committee for CPRD research (protocol reference: 19_030 R). No further ethical permissions were required for the analyses of these anonymized patient level data.

Study population

CPRD data available for patients registered from 1st January 1997 until 31st December 2017 was used for the study. Inclusion criteria were individual records with: (1) people aged 20 years or more during each study year of 1997–2017; (2) active registration for at least 12 months with the up-to-standard practice prior to the study start date (determined by CPRD database standards); and (3) data quality flagged as 'acceptable' in the database.

Case definition of OA

Incident OA was defined as the first diagnosis of OA within each study year. Prevalent OA was defined as having an OA diagnosis by 1st July of each study year. We used Read codes: a medical coding system of clinical terms used by national health services (NHS), UK[12]. The available Read code list (www.keele.ac.uk/mrr) to identify people with a General Practitioners (GP) diagnosed OA was adapted according to our inclusion and exclusion criteria. We used the exact list but excluded two OAs (acromio-clavicular and sterno-clavicular joints), because of the possible low accuracy of diagnosis at these joints and the expected incidence is very low. The codes obtained from the given website was previously matched with ICD-10 codes (Musculoskeletal disorder chapter)[9]. Even though not all OA joint codes have been validated, a recently published article shows the positive predictive value (PPV) for Read codes for hip OA in people aged 60 and over was nearly 80% and suitable for research purposes[13]. The Read codes for OA (N05…) used in the study was further screened by two independent GPs before the use (Appendix 1).

The index date was defined as the date of the first diagnosis of OA recorded in the database. Patients meeting the following criteria were excluded from both incidence and prevalence estimation: (1) any recording of joint diseases (rheumatoid arthritis, psoriatic arthritis, systemic lupus erythematosus, ankylosing spondylitis, septic arthritis, spondyloarthropathy or crystal disease and human parvovirus B19 infection) before or within 3 years after the index date; (2) any record of specific non-OA diagnosis (soft-tissue disorders, other bone/cartilage diseases) at the same joint in the 12 months before or after the recorded OA consultation; and (3) any history of joint injury within 1 year prior to the index date. In the absence of a recording of OA during the study year, any recording of joint replacement was taken as a proxy measure of OA.

Estimation of incidence and prevalence

The annual incidence rate for OA was defined as the number of incident (new) OA cases between 1st January and 31st December, divided by the number of person-years at risk for each calendar year from 1997 to 2017. Person-years of follow-up were calculated for eligible people at risk (i.e., no previous diagnosis of OA) from the latest of 1st January to the earliest date of transfer-out, last data collection, incident diagnosis of OA, death or 31st December of the study year. The annual prevalence of OA was calculated by dividing the number of people ever diagnosed with OA at 1st July of each calendar year, by the total number of eligible people in the population at the same time point of the calendar year.

Statistical analysis

The incidence and prevalence for each year from 1997 to 2017 were standardised according to age (5 years band), sex and length of data contribution (observation period) using the CPRD population structure in the year 2017 as reference. This method of adjustment for the observation period has been used previously[14]. The length of data contribution of each patient was defined as the period from the up to standard date for participants to 1st July of each calendar year for prevalence and 1st January of each calendar year for incidence. Up to standard date is always later the registration date. The length of data contribution was then categorised in four groups 0–3 years, 4–6 years, 7–9 years and $\geq$ 10 years. Standardization by length of data contribution was done because higher estimates were observed for longer lengths of data contribution (Supplementary fig S1). For 1997, no data contribution was seen for $\geq$ 10 years (Supplementary Figs. S1 and S2). Because, even

though the first registration date with the database was traced back before 1987, the up to standard practice data started recording in 1988, which is acceptable as a quality data, as per CPRD. For sex specific estimation, only age and length of data contribution standardisation was done. Age-sex standardized incidence and prevalence of OA in 2014 were calculated for all 13 regions of the UK and plotted using choropleth maps in QGIS software (V.3, Open source)[15]. The prevalence and incidence for the UK region after 2014 could not be estimated adequately because of lack of information from the East Midlands region from 2015 onwards.

Age-sex and length of data standardized trends (overall and sex specific) of the incidence and prevalence of OA were calculated for any-OA, joint specific and unspecified OA for 1998–2017. Unspecified OA cases are coded as 'unspecified' in the database without any mentioning of the site involved. We computed the incidence and prevalence across each age group for both sexes only for the year 2017. The 95% confidence interval (CIs) were derived based on the assumption of a Poisson distribution for the observed cases. The trends were tested using Joinpoint regression analysis[16] with Joinpoint software (Version 4.6.0.0)[17]. Bayesian Information Criterion (BIC) was used to identify the 'join points', which describes the significant change across the trend line and best-fit data series. Using BIC, a maximum of three joinpoints were selected. Annual percentage changes (AAPC) for each segment and average AAPC for the entire study period were calculated at the significance level of 0.05 using the empirical model[18]. Additional, trend analysis of joint pain incidence was done using the same database. Details are provided in Supplementary Fig. S8.

Both incidence and prevalence trends were modelled as a function of age at diagnosis, period (year of diagnosis) and birth (year of birth) cohort. To assess the cohort effect, age-period-cohort (A-P-C) analysis was undertaken[19]. For visual clarity incidence and prevalence were aggregated in 5-year age groups for period and birth cohort graphs. The A-P-C analysis was performed in R using the package 'Epi' and 'APC'[20–22]. Statistical analyses were performed using STATA (SE v 15, STATA corp, Texas) and R(V 5.2, R software, Austria).[23,24]

Results

Incidence and prevalence

In 2017, the total person-years of follow up for any-OA was 1,495,497 with 10,147 incident OA cases, and the incidence was 6.8 per 1000 person-years (95% CI 6.7 to 6.9 per 1000 person-years). The incidence was higher in women (8.1; 95% CI 7.9 to 8.3) than in men (5.5; 95% CI 5.3 to 5.7 per 1000 person-years). The age-specific incidence in 2017 shows that OA was very rare in people less than 30 years of age. The incidence was 0.08 per 1000 person-years in both sexes which increased gradually with age and peaked at 75–79 years at 27 per 1000 person-years (95% CI 23.5 to 29.8 per 1000 person-years) in women and 18 per 1000 person-years (95% CI 15.4 to 20.6 per 1000 person-years) in men [Fig. 1(A)].

Of 1,690,618 eligible individuals in 2017, 181,464 had a recorded diagnosis of any-OA. The prevalence in 2017 was 10.8% (95% CI: 10.7–10.9%) which was higher in women (12.8%; 95% CI 12.8–12.9%) than men (8.6%; 95% CI 8.5–8.7%) across all age groups. The prevalence increased sharply at age 40–44 years in women and 45–49 years in men. In both men and women, the increasing trend continued until age group of >80 years, reaching the peak of 47% for women and 35% for men [Fig. 1(B)].

The joint-specific OA incidence (per 1000 person-years) in 2017 was highest for knee (2.3; 95% CI 2.2 to 2.4) followed by hip (1.1; 95% CI 1.1 to 1.2), wrist and hand (0.65; 95% CI 0.6 to 0.7) and ankle and foot (0.2; 95% CI 0.2 to 0.2). The incidence of unspecified OA was 5.2 per 1000 person-years (95% CI 5.1 to 5.3). All joint-specific incidence rates were higher in women than in men. The detailed distribution across age in both men and women is given in Supplementary Fig. S3. In descending order, the overall prevalence according to joint site in 2017 was; knee (2.9%, 95% CI 2.7–2.9%), hip (1.5%, 95%CI 1.4–1.5%), wrist or hand (0.5%, 95%CI 0.5–0.5%) and

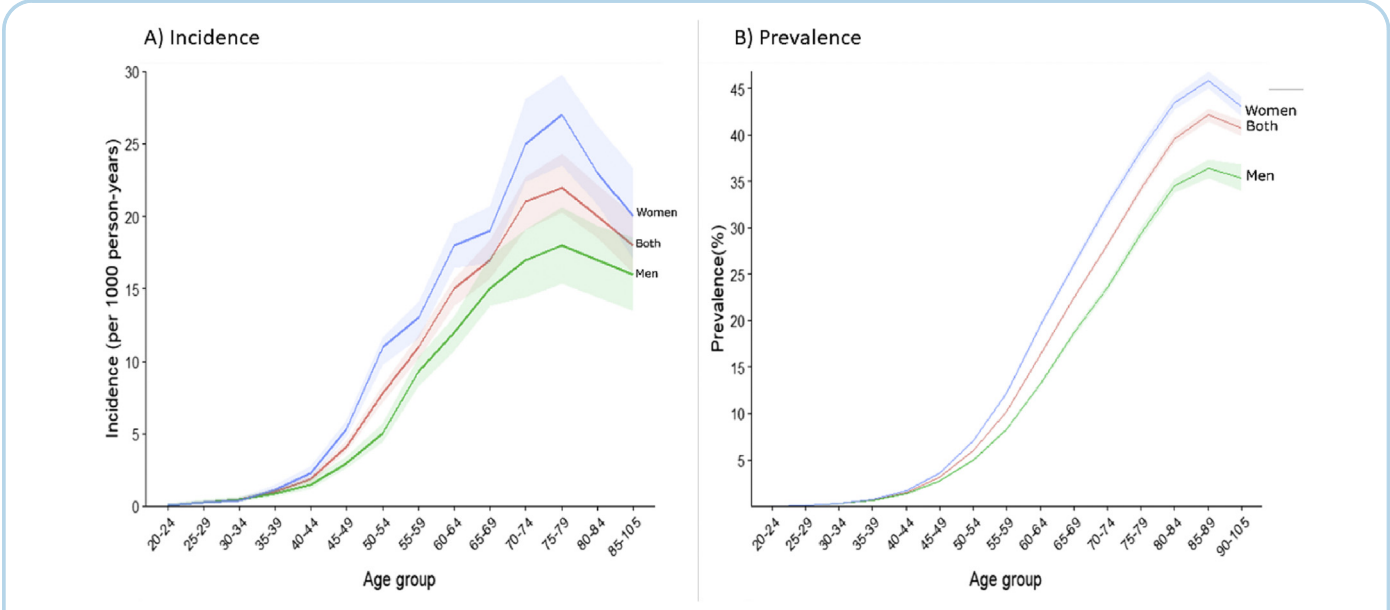

Fig. 1 Age specific incidence (A) and prevalence (B) of OA in 2017.

Year	Incidence (per 1000 person-years)					Prevalence (%)				
	Person-Year	Cases	Crude Incidence [95% CI]	Age-sex standardized [95% CI]	Age-sex-LOD standardized [95% CI]	Eligible population	Cases	Crude Prevalence [95% CI]	Age-sex standardized [95% CI]	Age-sex-LOD standardized [95% CI]
1997	1,321,487	12,296	9.30 [9.14–9.47]	9.17 [9.00–9.34]		5,711,501	195,362	3.42 [3.40–3.44]	6.15 [6.11–6.19]	
1998	1,509,159	14,817	9.81 [9.66–9.97]	9.05 [8.89–9.20]	9.50 [7.43–12.67]	5,781,677	215,113	3.72 [3.70–3.74]	7.20 [7.16–7.24]	8.23 [8.06–8.40]
1999	1,831,971	17,216	9.39 [9.26–9.54]	8.87 [8.73–9.01]	9.69 [9.00–10.37]	5,848,216	234,835	4.01 [3.98–4.03]	7.41 [7.37–7.45]	8.47 [8.39–8.55]
2000	2,262,732	20,599	9.10 [8.98–9.22]	8.97 [8.84–9.11]	9.61 [9.31–9.92]	5,896,329	255,264	4.32 [4.30–4.35]	7.41 [7.37–7.44]	8.94 [8.88–9.00]
2001	2,534,401	23,615	9.31 [9.19–9.43]	9.20 [9.07–9.32]	9.36 [9.15–9.57]	5,900,383	276,091	4.77 [4.74–4.80]	7.87 [7.83–7.90]	9.08 [9.03–9.13]
2002	2,858,237	26,597	9.30 [9.19–9.41]	9.37 [9.25–9.49]	9.64 [9.44–9.84]	5,862,771	296,445	5.05 [5.02–5.08]	7.98 [7.95–8.01]	9.27 [9.22–9.32]
2003	3,046,692	29,358	9.63 [9.52–9.74]	9.63 [9.51–9.74]	10.00 [9.81–10.19]	5,788,957	317,611	5.48 [5.45–5.51]	8.19 [8.16–8.22]	9.47 [9.42–9.52]
2004	3,247,175	32,543	10.02 [9.91–10.13]	10.06 [9.95–10.17]	10.42 [10.23–10.61]	5,705,620	339,718	5.95 [5.92–5.98]	8.55 [8.52–8.58]	9.77 [9.73–9.82]
2005	3,317,484	33,093	9.97 [9.86–10.08]	10.15 [10.04–10.26]	10.33 [10.15–10.52]	5,615,033	363,534	6.47 [6.43–6.52]	9.06 [9.03–9.09]	10.21 [10.16–10.26]
2006	3,346,598	30,840	9.21 [9.11–9.31]	9.39 [9.29–9.50]	9.55 [9.37–9.72]	5,467,107	378,799	6.92 [6.90–6.94]	9.44 [9.42–9.47]	10.62 [10.57–10.66]
2007	3,374,993	30,236	8.95 [8.88–9.06]	9.15 [9.04–9.25]	9.49 [9.32–9.65]	5,294,313	388,708	7.34 [7.30–7.38]	9.73 [9.71–9.76]	10.64 [10.60–10.68]
2008	3,381,824	30,261	8.94 [8.84–9.05]	9.20 [9.10–9.30]	9.59 [9.44–9.74]	5,112,496	398,003	7.78 [7.74–7.82]	10.07 [10.04–10.10]	10.91 [10.87–10.95]
2009	3,362,701	29,387	8.73 [8.63–8.83]	8.99 [8.89–9.10]	9.36 [9.22–9.50]	4,924,529	405,402	8.23 [8.20–8.26]	10.35 [10.32–10.38]	10.91 [10.88–10.95]
2010	3,314,620	27,133	8.18 [8.09–8.28]	8.42 [8.32–8.52]	8.74 [8.62–8.87]	4,689,058	403,343	8.60 [8.56–8.64]	10.54 [10.51–10.57]	10.93 [10.90–10.96]
2011	3,235,505	26,100	8.06 [7.96–8.16]	8.30 [8.20–8.40]	8.48 [8.36–8.59]	4,421,201	398,434	9.01 [8.96–9.06]	10.69 [10.66–10.72]	10.94 [10.91–10.97]
2012	3,196,392	24,727	7.73 [7.64–7.83]	7.95 [7.85–8.05]	8.10 [7.90–8.30]	4,165,371	391,691	9.40 [9.36–9.44]	10.76 [10.73–10.79]	10.87 [10.84–10.90]
2013	3,030,317	23,409	7.72 [7.62–7.82]	7.87 [7.77–7.97]	7.94 [7.84–8.05]	3,812,788	374,298	9.82 [9.78–9.86]	10.87 [10.84–10.90]	10.90 [10.87–10.93]
2014	2,758,065	21,113	7.65 [7.55–7.75]	7.74 [7.64–7.85]	7.75 [7.65–7.86]	3,314,992	337,168	10.17 [10.14–10.20]	10.96 [10.93–10.99]	10.95 [10.92–10.98]
2015	2,360,852	17,690	7.49 [7.38–7.60]	7.52 [7.41–7.63]	7.51 [7.40–7.62]	2,761,702	290,020	10.50 [10.47–10.53]	10.94 [10.90–10.97]	10.93 [10.90–10.96]
2016	1,889,587	13,540	7.16 [7.04–7.28]	7.18 [7.06–7.30]	7.17 [7.05–7.29]	2,100,061	223,948	10.66 [10.63–10.69]	10.96 [10.93–11.00]	10.95 [10.92–10.99]
2017	1,495,497	10,146	6.78 [6.67–6.93]	6.78 [6.67–6.93]	6.78 [6.67–6.93]	1,690,618	181,464	10.77 [10.72–10.82]	10.77 [10.72–10.82]	10.77 [10.72–10.82]
AAPC (%)		494,716			−1.6[-2.0 to −1.1]					1.4 [1.3 to 1.6]*

Age-sex and length of data contribution (LOD) standardization was done using 2017 CPRD population as standard population. For 1997, LOD standardisation was not calculated because of absence of data for ≥ 10 years (See Supplementary Figs. S1 and S2).

IR: Incidence Rate; CI: Confidence Interval; AAPC: Annual Average Percentage Change; **P*-value.

Table I Crude and standardized incidence and prevalence of OA in the UK from 1997 to 2017

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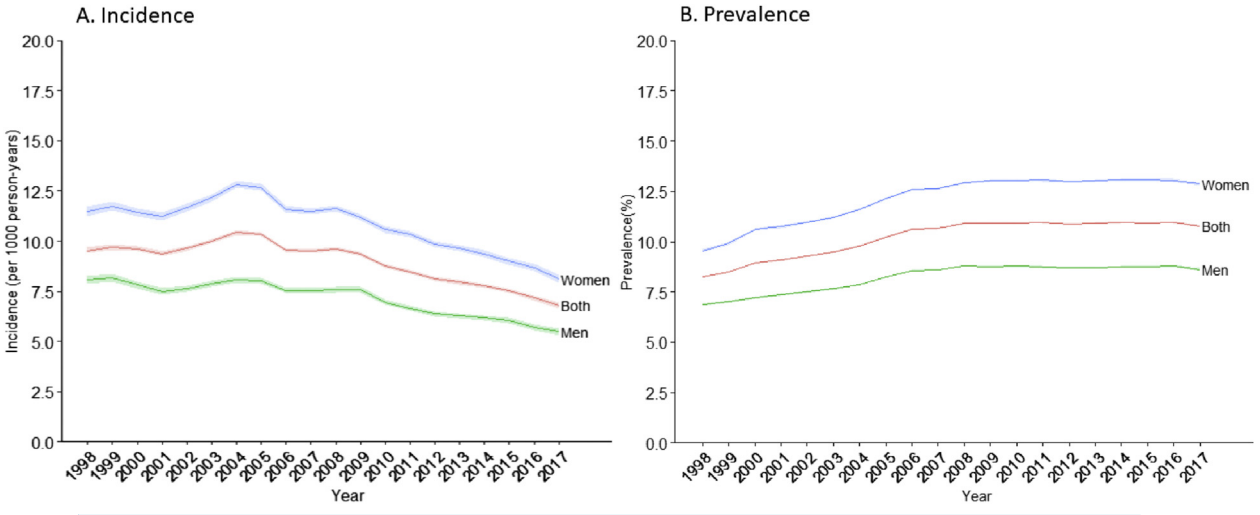

Fig. 2 Trends of standardized incidence (A) and prevalence (B) between 1998 and 2017.

ankle or foot (0.3%, 95% CI 0.3–0.3%). The prevalence of unspecified OA was 7.6% (95%CI 7.5–7.6%). The distribution of joint site and unspecified OA across the sex is provided in Supplementary Fig. S4.

Temporal trends of incidence and prevalence

The incidence (both crude and standardised) of any OA decreased over time during the study period, changing from 9.5 per 1000 person-years (95% CI 9.4 to 9.7 per 1000 person-years) to 6.8 per 1000 person-years (95% CI 6.7 to 6.9 per 1000 person-years) (Table I). Similar trends were seen in both women and men [Fig. 2(A)]. The incidence of OA in men declined from 8.0 per 1000 person-years (95% CI 7.8 to 8.3 per 1000 person-years) in 1997 to 5.5 per 1000 person-years (95% CI 5.3 to 5.7 per 1000 person-years) in 2017, whereas in women the incidence reduced from 11.5 per 1000 person-years (95% CI 11.2 to 11.7 per 1000 person-years) to 8.1 per 1000 person-years (95%CI 7.9 to 8.3 per 1000 person-years). Joinpoint analysis identified two points of changes in overall trend at 2002 and 2005. The AAPC was −1.6% (95% CI -2.0 to −1.1%), indicating a slight decline in the incidence since 1998. Women (−1.9.1%; 95% CI -2.2 to −1.6%) had a higher decline in rates compared to men (−1.5%; −1.1 to −1.9%). No change in trend was observed for ankle and foot and wrist and hand sites. Whereas, unspecified OA trend was on decline, while OA at knee and hip showed slightly increasing trend. Details of joint specific incidence trends are given in Supplementary Fig. S5 and sex wise distribution is given in supplementary table S1.

In contrast, prevalence increased from 1998 to 2017 (Table I). The age and length of data standardised rates were found to rise in both men and women across the years. The overall prevalence of

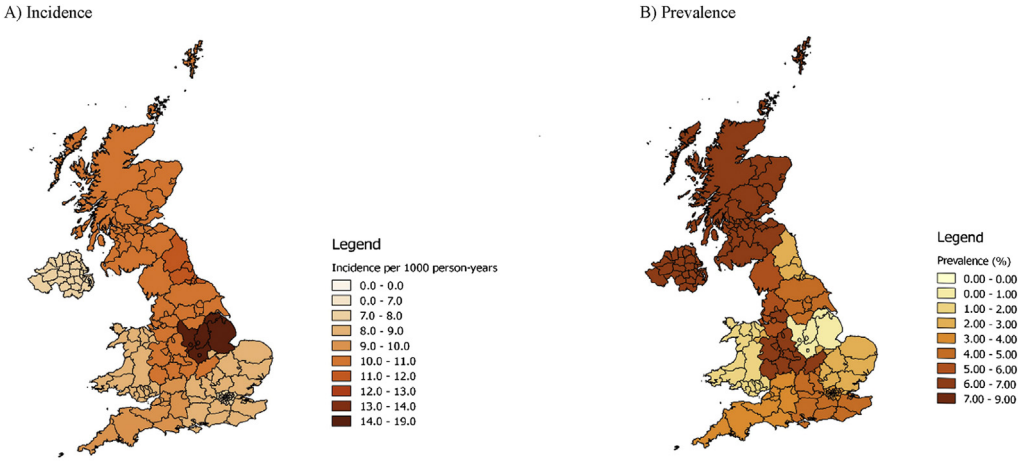

Fig. 3 Geographic variations in the incidence (A) and prevalence (B) of OA in the UK in 2014.

people with any OA in 2017 was found to increase to 10.7% from 8.2% in 1998, 1.3 times increase in prevalence over this period [Fig. 2(B)]. The average annual percentage change was 1.4% (95% CI 1.3–1.6%) for any OA, whereas among women it was a 1.6% (95% CI 1.4–1.8%) and in men a 1.3% (95% CI 1.1–1.4%) change each year. The prevalence of OA in joint-specific OA in 2017 also increased from 1998 except for ankle and foot. Details are given in Supplementary Fig. S6 and sex wise distribution is given in supplementary table S2. The additional analysis on trends of incidence of joint pain recorded in the CPRD shows a sudden increase in the trends after 2003 (Supplementary Fig. S8).

Geographic distribution

In 2014, the East Midlands and the North East had the highest incidence rates of OA of 12.6 per 1000 person-years and 11.7 per 1000 person-years respectively. Lowest incidence rates were seen in Northern Ireland and South East England [Fig. 3(A)]. The prevalence of any OA varied from one region to another within the UK. In 2014 the highest age and sex standardised prevalence were in Scotland, West Midlands and Northern Ireland ranging from 7% to 9%. The prevalence ranged from 3% to 5% in the Southern region [Fig. 3(B)].

Cohort effects

The incidence was found to decline according to the birth cohorts. For people in the same age group, those born later were less likely to have OA than those born earlier (Fig. 4). The reduction speeded up gradually after 1960, particularly for people aged 20–40 years, suggesting a potential aetiological change after 1960 that led to people being less likely to develop OA. In contrast, prevalence increased gradually by age but remained almost constant for people born after 1960. The plot of distribution of incidence and prevalence across the age groups for different periods of birth is provided as supplementary material (Supplementary Figs. S7(A) & S7(B)).

Discussion

This study confirms a high burden of OA in the UK with a current (year 2017) prevalence of 10.7% and incidence of 6.8 per 1000 person-years in people aged 20 and over. The prevalence of OA has increased at a rate of 1.4% per year since 1998, whereas the incidence is declining at a rate of −1.6% per year. Geographically, the prevalence and incidence of OA are not uniformly distributed. Scotland, Northern Ireland and West Midlands had higher prevalence compared to the rest of the country, whereas, the incidence was higher in East midlands and North-Eastern regions.

The standardised incidence of OA in 2013 estimated from CPRD among people aged 45 years or more was 6.3 per 1000 person-years[5]. In another study, Yu *et al.* reported the standardised rates of any OA incidence in 2010 as 8.6 per 1000 person-years among persons aged 15 years or more in a UK regional administrative database[25]. According to the literature, the prevalence of OA among people aged 45 years and over varies between 20% and 35%[26,27]. Our estimated prevalence among people aged 45 years or more using the entire CPRD database was nearly 23%. Global burden of disease reports the prevalence of knee and hip was 7.3% and musculoskeletal disease profile report from the NHS shows the prevalence in 2015–16 was nearly 12%[2,28]. Comparing the incidence and prevalence across studies is very difficult because of the wide differences in study population, case definition, database quality and standardisation methods[4,27,29]. Values similar to our prevalence estimates have been reported in the UK by Jordan *et al.*[30] using a database with better recording pattern, as the GPs from this region actively participate in musculoskeletal research.[31]

These differences should not affect comparisons within the study such as, incidence by age and sex. The increase in incidence and prevalence of OA with age and in women supports existing epidemiological evidence[32]. The sudden rise of both prevalence and incidence at age of 40 years in women has been explained through biological sex hormone changes and also has been reported uniformly in previous studies[33,34]. The incidence pattern with age also concurs with previous studies in the UK and other countries.[5,29]

In both sexes, the prevalence and incidence of 'unspecified' OA was high compared to reported joint-specific OA, a finding also reported by Yu *et al.*[25] Such 'unspecified' reporting reflects the

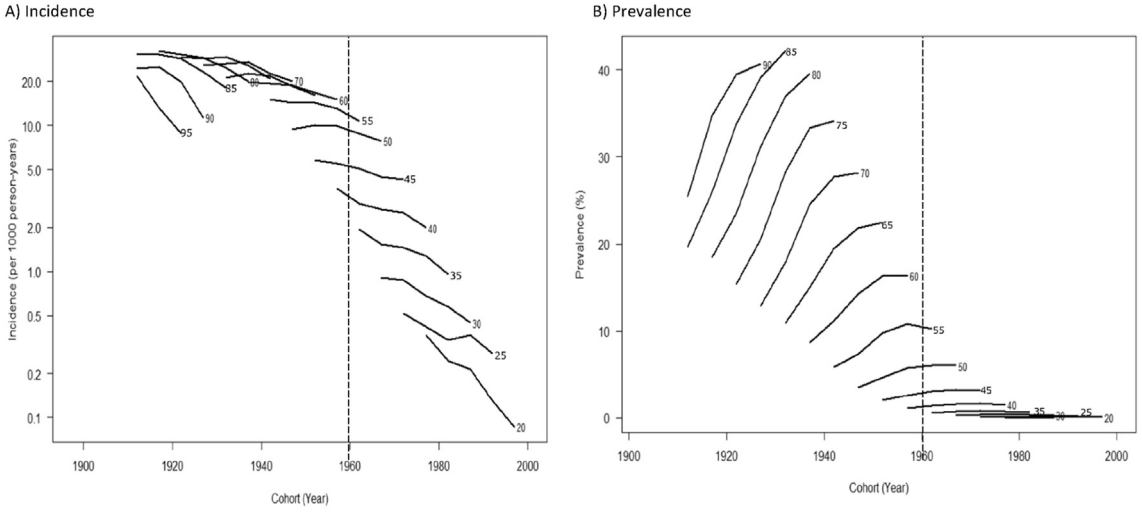

Fig. 4 Age-period-cohort analysis of trend of OA (1997–2017) incidence (A) and prevalence (B) in the UK.

recording pattern in primary care, though whether the term 'unspecified' is a substitute to record multiple joint involvement, remains unclear. The higher burden of knee and hip OA in this study reflects consultation behaviour, for example a preference to seek advice for large joint rather than small joint problems. There is wide variation in reported prevalence of OA at individual joint sites. Again, this could indicate different methods of ascertainment, and whether diagnosis is purely clinical or based on presence of radiographic OA changes. Also the findings are likely to underrepresent true prevalence and incidence, as more than 12% of people with hip OA never consult GPs about their condition, even if it is symptomatic.[13]

Trends of incidence and prevalence

Surprisingly, there was an overall slow decline in incidence rates for any-OA since 1998. Yu *et al.* found no change in trends of incidence physician-diagnosed OA for the period 1997–2013 among people aged 45 years or more[5]. One other population-based study in the US found no increase in trends of radiographic knee OA during the period 1974–1994 after adjusting for body mass index (BMI) change[35]. The Joinpoint analysis reveals a slight rise in incidence from 2000 to 2004 followed by a slow decline. We found significant increase in rate for knee and hip joint-specific incidence, but the 'unspecified' OA rate was declining, indicating possible improvement in clinical coding. Perhaps the increase in trend of 'joint-pain' after the year 2005 partially explains the gap (Supplementary Fig. S6) if physicians became more prone to report symptoms rather than a specific diagnosis. We observed a nearly 1.3 times increase in standardized prevalence of OA from 1998 to 2017, with an annual percentage increase of 1.4%. Globally, contribution of OA to the total prevalent cases has increased by 8.5% from 1990 to 2017 and in the UK the prevalence has increased from 6.3% in 1990–7.7% in 2017[2]. The increase in prevalence with the slow declining incidence rate is surprising. Especially, the increased prevalence trend could be because of the cumulative nature of the longitudinal database from electronic health records. CPRD is a dynamic database with people moving in and out of the database at any time point, which changes the eligible population every year. Also, we found the prevalence trend is becoming stable since 2008, which partially explains the effect of declining incidence.

Age-period-cohort effects, length of data contribution and the participation of practices in the CPRD database influence the incidence estimates[14,30]. Our age-period-cohort analysis shows a strong cohort effect in incidence among people born after the 1960s. It suggests that people born after this period may expose less to physically very demanding occupations such as coal-mining, farming and certain heavy industrial work because of change in patterns of occupation in the UK since 1960s including the mining activities[36]. We standardised for the length of data contribution period to eliminate the problem of prevalent cases for OA for robust incidence estimates. In contrast, prevalence remained almost unchanged in people born after 1960s (Fig. 4), indicating the treatment of this condition may remain same.

Geographical distribution

Scotland and the middle region of England and had higher incidence rates in 2014 compared to the rest of the UK[5]. The reasons for regional variation could be differences in practice areas, socioeconomic conditions, lifestyles and health seeking behaviours. Interestingly, higher prevalence in the Northern region largely matches the obesity distribution in the Northern region of the UK compared to the South.[37]

Limitations of the study

In addition to the highlighted caveats on coding of the diseases and data contribution, a few more limitations do exist. The case definition relied on the clinical diagnosis by the general practitioners without requiring demonstration of structural OA on imaging. However, concordance between symptoms and radiographic OA (the usual way to assess structural OA) is variable and often poor, depending on the joint site being assessed[38]. Patient-centred outcomes rather than imaging changes are key determinants of disability and burden of disease, and the National Institute for Health and Care Excellence (NICE) recommends that a purely clinical diagnosis is sufficient and that imaging should be reserved for specific situations such as atypical clinical features or rapid progression of symptoms[39]. Coding of joint specific OA in a consultation database is always controversial. The index date reflects the date of allocation of Read codes for OA and does not reflect disease onset or the date of diagnosis. However, the date of allocation of a Read code for OA would be expected to be within a few months of the date of diagnosis[13]. We did not perform a validation study for the OA definitions used in this study, therefore the results are open to misclassification bias. Caution must be taken when comparing the prevalence and incidence of this study with that reported in other studies. However, we believe this will not affect the internal validity, such as prevalence and incidence by age and gender, and temporal trends of OA/joint pain in the past 20 years in the UK as they all were based on the same Read codes to define the disease. Furthermore, because our estimates are based on GP consultations for symptomatic regional joint pain, and not all people with symptomatic OA will consult their GP, these data may underestimate the true community prevalence and incidence of symptomatic OA. Unlike other chronic conditions, OA is not included in Quality and Outcome Framework (QOF) by the NHS in 2004. QOF is an incentivising program, which rewards GP practices in England for quality delivery of primary care including the diagnosis and recording of conditions. Therefore, the prevalence and incidence might have been underestimated. In addition, the exclusion criteria used in our study might have led to underestimation of the burden. Also, health care accessibility might influence the estimation. CPRD might have the duplication of people, because of the movement of patients from one practice area to other and being recorded with new unique identifier. However, we assume, the rate of migration might be similar in both OA group and 'at-risk' population. Even though, the method of standardising by length of data observation has been used previously for calculating trends using electronic health records, some residual confounding by length of data observation might still exist. Another limitation is the geographical presentation of the estimates, which needs cautious interpretation because of the non-uniform practices involved in the database.

Conclusion

One in 10 adults aged 20 years or more in the UK has GP-diagnosed OA and the knee was the leading site. The incidence of GP-diagnosed OA is declining, but the prevalence is rising slowly in the UK. A cohort effect was observed, that is, within the same age groups people born after 1960s had lower incidence than those born earlier. If it is a real change in trend or change in recoding and

reporting pattern needs to be studied. Also, further research is necessary to understand these temporal trends in OA.

Contributor and guarantor information

SS, WZ and MD conceived and designed the study. SS and WZ acquired the data. SS performed the analysis and CC, AS and WZ supervised the statistical analysis. SS, AS, CM, CC, WZ, CFK and MD interpreted the results. SS and WZ drafted the manuscript. All authors contributed to the critical revision of the manuscript for important intellectual content. WZ, CC and MD supervised the study. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Competing interests

This study had no financial competing interests.

The authors declare that they have no conflict of interest.

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Role of the funding sources

The sponsors did not participate in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript and the decision to submit the manuscript for publication.

Studies involving humans or animals

No direct participant recruitment was done for the study. This study was approved by the independent scientific advisory committee for CPRD research (protocol reference: 19_030 R).

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Data sharing statement

We used anonymised data on individual patients on which the analysis, results, and conclusions reported in the paper are based. The CPRD data is not distributable under licence. However, the relevant data can be obtained directly from the agency (https://www.cprd.com/). The codes developed for the analysis can be available upon a valid request.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.joca.2020.03.004.

Appendix 1

Read codes for Osteoarthritis

Read Code	Name of the condition
N05zJ00	Osteoarthritis NOS, of hip
N053512	Hip osteoarthritis NOS
N05z511	Hip osteoarthritis NOS
N053500	Localised osteoarthritis, unspecified, pelvic region/thigh
N051500	Localised, primary osteoarthritis of the pelvic region/thigh
N052500	Localised, secondary osteoarthritis of pelvic region/thigh
N054500	Oligoarticular osteoarthritis, unspecified, of pelvis/thigh
N05z500	Osteoarthritis NOS, pelvic region/thigh
Nyu2E11	[X] Unilateral secondary coxarthrosis
Nyu2200	[X]Other dysplastic coxarthrosis
Nyu2300	[X]Other post-traumatic coxarthrosis
Nyu2100	[X]Other primary coxarthrosis
Nyu2E00	[X]Other secondary coxarthrosis
Nyu2400	[X]Other secondary coxarthrosis, bilateral
N051900	Primary coxarthrosis, bilateral
N05zL00	Osteoarthritis NOS, of knee
N05z611	Knee osteoarthritis NOS
N053600	Localised osteoarthritis, unspecified, of the lower leg
N05z600	Osteoarthritis NOS, of the lower leg
N051600	Localised, primary osteoarthritis of the lower leg
N052600	Localised, secondary osteoarthritis of the lower leg
N054600	Oligoarticular osteoarthritis, unspecified, of lower leg
N053611	Patellofemoral osteoarthritis
N05zM00	Osteoarthritis NOS, of tibio-fibular joint
Nyu2511	[X] Unilateral primary gonarthrosis
N051B00	Primary gonarthrosis, bilateral
Nyu2811	[X] Unilateral secondary gonarthrosis
Nyu2800	[X]Other secondary gonarthrosis
Nyu2700	[X]Other secondary gonarthrosis, bilateral
Nyu2500	[X]Other primary gonarthrosis
N052C00	Post-traumatic gonarthrosis, unilateral
N05zN00	Osteoarthritis NOS, of ankle
N05z700	Osteoarthritis NOS, of ankle and foot
N05zU00	Osteoarthritis NOS, of IP joint of toe
N05zT00	Osteoarthritis NOS, of lesser MTP joint
N05zS00	Osteoarthritis NOS, of 1st MTP joint
N05zR00	Osteoarthritis NOS, of other tarsal joint
N05zP00	Osteoarthritis NOS, of subtalar joint
N05z712	Foot Osteoarthritis NOS
N05zQ00	Osteoarthritis NOS, of talonavicular joint
N053700	Localised osteoarthritis, unspecified, of the ankle and foot
N051700	Localised, primary osteoarthritis of the ankle and foot
N051E00	Localised, primary osteoarthritis of toe
N052700	Localised, secondary osteoarthritis of the ankle and foot
N05z713	Toe osteoarthritis NOS
N05z711	Ankle osteoarthritis NOS
N054700	Oligoarticular osteoarthritis, unspecified, of ankle/foot
Nyu2900	[X]Other primary arthrosis of first carpometacarpal joint
N051C00	Primary arthrosis of first carpometacarpal joints, bilateral
Nyu2A00	[X]Other post-traumatic arthrosis/1st carpometacarpal joint
Nyu2B00	[X]Other 2ndry arthrosis/1st carpometacarpal joints, bilaterl
N053400	Localised osteoarthritis, unspecified, of the hand
N051400	Localised, primary osteoarthritis of the hand
N05011	Heberden's node
N052400	Localised, secondary osteoarthritis of the hand
N05z412	Thumb osteoarthritis NOS
N050700	Heberden's node with arthropathy
N054400	Oligoarticular osteoarthritis, unspecified, of hand
N050112	Bouchard's node
N05zH00	Osteoarthritis NOS, of DIP joint of finger
N050300	Bouchard's node with arthropathy
N05zG00	Osteoarthritis NOS, of PIP joint of finger
N05z311	Wrist osteoarthritis NOS
N05z400	Osteoarthritis NOS, of the hand

(*continued on next page*)

(*continued*)

Read Code	Name of the condition
N051D00	Localised, primary osteoarthritis of the wrist
N05z411	Finger osteoarthritis NOS
N05zE00	Osteoarthritis NOS, of wrist
N05zF00	Osteoarthritis NOS, of MCP joint
N050100	Generalized OA of hand
N06z311	Wrist arthritis NOS
N051800	Localised, primary osteoarthritis of other specified site
N051.00	Localised, primary osteoarthritis
N051z00	Localised, primary osteoarthritis NOS
N051000	Localised, primary osteoarthritis of unspecified site
N052.00	Localised, secondary osteoarthritis
N052z00	Localised, secondary osteoarthritis NOS
N052800	Localised, secondary osteoarthritis of other specified site
N050000	Osteoarthritis and allied disorders
N054.00	Oligoarticular osteoarthritis, unspecified
N054900	Oligoarticular osteoarthritis, unspecified, multiple sites
Nyu2.00	[X]Arthrosis
Nyu2000	[X]Other polyarthrosis
N054000	Oligoarticular osteoarthritis, unspec, of unspecified sites
N05z000	Osteoarthritis NOS, of unspecified site
N05..00	Osteoarthritis and allied disorders
N054800	Oligoarticular osteoarthritis, unspecified, other spec sites
N05z.00	Osteoarthritis NOS
N053z00	Localised osteoarthritis, unspecified, NOS
N053800	Localised osteoarthritis, unspecified, of other spec site
N05zz00	Osteoarthritis NOS
N053000	Localised osteoarthritis, unspecified, of unspecified site
N05..11	Osteoarthritis
N05z800	Osteoarthritis NOS, other specified site
N054z00	Osteoarthritis of more than one site, unspecified, NOS
N06z.11	Arthritis
N050500	Secondary multiple arthrosis
N050400	Primary generalized osteoarthrosis
N050Z00	Generalized OA NOS
N050200	Generalised OA Multiple sites
N050.00	Generalised OA

NOS- 'not otherwise specified.
We did not include acromio-clavicular and sterno-clavicular joint OA because of the possible accuracy of diagnosis at these joints and the expected incidence is very low.

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