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Objective. Prevalence of osteoarthritis (OA) is expected to increase due to population aging. However, there is little information on the trends in the incidence of OA over time. The purpose of this study was to describe changes in physician-diagnosed OA incidence rates between 1996–1997 and 2003–2004 in British Columbia (BC), Canada.

Methods. We used data on all visits to health professionals and hospital admissions covered by the Medical Services Plan of BC (population ~4 million) for the fiscal years 1991–1992 through 2003–2004. Rates were standardized to the BC population in 2000. We used 2 definitions of OA: 1) at least 1 visit or hospitalization with a diagnostic code for OA, and 2) at least 2 visits or 1 hospitalization with a code for OA. Incidence rates were calculated with a 5-year run-in period to exclude prevalent cases.

Results. Between 1996–1997 and 2003–2004, crude incidence rates of OA based on definition 1 increased from 10.5 to 12.2 per 1,000 in men and from 13.9 to 17.4 per 1,000 in women. The age-standardized rates did not change in men and increased from 14.7 to 16.7 per 1,000 in women. Incidence rates based on definition 2 were almost 50% lower, but the trends were similar.

Conclusion. We observed an increase in the incidence of OA in both men and women due to population aging and an additional increase in women beyond the effect of aging. These trends have important implications for public health and provision of health services to this very large group of patients.

INTRODUCTION

The number of people with arthritis is expected to increase as the population ages (1). Based on demographic trends, Badley and Wang (2) projected a 47% increase in the prevalence of self-reported arthritis or rheumatism diagnosed by a health professional in Canada between 1991 and 2031. Using a similar approach, Hootman and Helmick (3) projected a 40% increase in self-reported, doctor-diagnosed arthritis prevalence in the US between 2005 and 2030, whereas Fontaine et al (4) estimated a 60% increase between 2005 and 2050. However, these models assumed a constant age-specific prevalence of arthritis. Factors other than age may contribute to changes in prevalence (5). In a study by Perruccio et al (6), the prevalence of self-reported arthritis in Canada increased more than expected from 1994 to 2003 due to the effect of age.

The most common form of arthritis is osteoarthritis (OA) (7). OA prevalence may increase beyond the effect of age due to the rising prevalence of obesity (2–6) and other factors. However, OA-specific population data are extremely limited. Furthermore, although most population studies of arthritis have focused on prevalence, incidence rate may be a better measure of disease dynamics in the population because it responds more quickly to changes in
diagnosed between April 1, 1991 and March 31, 1996. March 31, 1997), we excluded from the numerator persons
become incident cases. For example, when calculating the 5-year run-in period (prevalent cases) were not eligible to
definition of OA for the first time during a given 1-year
dence rates were calculated for fiscal years (from April 1 to
incidence and prevalence of OA are strongly influenced by
risk factors and is not influenced by disease duration
To our knowledge, there have been no studies of trends
in the incidence of OA anywhere in the world. Given the
large health and economic burden of OA (9), trends in the
incidence and prevalence of this disease have substantial
public health implications. We conducted a study of changes in OA incidence over time in a large, geographi-
cally defined population (British Columbia [BC], Canada)
using an administrative database maintained by the pro-
vincial Ministry of Health.

MATERIALS AND METHODS

Database. We used data on all visits to health profes-
sionals and hospital admissions covered by the Medical
Services Plan (MSP) of BC for the fiscal years 1991–1992
through 2003–2004. The database included International
Classification of Diseases, Ninth Revision (ICD-9) diagno-
tic codes, date and type of service, birth and death dates,
sex, and MSP registration start and exit dates. We also
obtained information about hospital admission and dis-
charge dates and up to 25 diagnoses coded on hospital
discharge summaries. Missing data for the variables of
interest were negligibly rare.

Definition of OA. There is no consensus as to the best
definition of OA in an administrative database, and both
incidence and prevalence of OA are strongly influenced by
the choice of definition (10). Consistent with a previous
study (10), we used 2 definitions. Definition 1 required at
least 1 visit to a health professional or 1 hospitalization
with the ICD-9 code 715 (osteoarthritis and allied disor-
ders). Definition 2 required at least 2 visits to a health
professional within 2 years (and not on the same day) or 1
hospitalization with the ICD-9 code 715. A visit was de-
efined as any service covered by the MSP with the exclu-
sion of diagnostic procedures and certain other proce-
dures, such as dialysis/transfusion, anesthesia, obstetrics,
or therapeutic radiation. Visits to all types of health profes-
sionals were included. During the study period, health
professionals in BC used the ICD-9 classification for MSP
coding. ICD-10 was introduced for hospital codes in 2001.
Hospital codes for the years 2001–2002 through 2003–
2004 were converted from ICD-10 to ICD-9 using a conver-
sion manual (11).

Calculation of incidence. Incidence rate was defined as
the number of new cases of OA during a given period
divided by person-time at risk (8). Age–sex–specific inci-
dence rates were calculated for fiscal years (from April 1 to
March 31) 1996–1997 through 2003–2004. The number of
new cases (numerator of incidence rate) in a given age/sex
category was calculated as those patients who met our
definition of OA for the first time during a given 1-year
period. Persons diagnosed with OA during the preceding
5-year run-in period (prevalent cases) were not eligible to
become incident cases. For example, when calculating the
incidence rate for 1996–1997 (i.e., from April 1, 1996 to
March 31, 1997), we excluded from the numerator persons
diagnosed between April 1, 1991 and March 31, 1996.

Person-time (PT) for a given fiscal year (April 1 to March
31) was estimated by the following formula: PT = N × (1 −
P) × C, where N is the BC census population, P is the
prevalence proportion (both on October 1), and C = 0.988
is the MSP coverage rate. In this formula, midperiod prev-
ance of OA is used to exclude person-time contributed by
prevalent cases from the denominator of incidence rate.
Prevalence proportion was defined as the number of af-
ected persons in the population at a specified time di-
vided by the number of persons in the population at that
time. Prevalence on October 1 was calculated as the aver-
age of prevalence on March 31 of the same year and March
31 of the following year.

Population estimates by age and sex for March 31 of
each year were calculated by linear interpolation between
the estimates for July 1 of the previous year and July 1 of
the same year, obtained from the BC Vital Statistics
Agency (12). Because BC census estimates take into ac-
count death and migration, we did not adjust for those
demographic events. The MSP coverage rate was estimated
at 98.8% using information from the BC Ministry of Health.

Incidence rates were standardized (direct method) using
the 2000 BC population as the standard and were ex-
pressed per 1,000 person-years. Trends in incidence were
shown by plotting the crude and standardized rates against
the fiscal years of diagnosis.

Effect of run-in time. The duration of run-in time, i.e.,
observation time needed to eliminate prevalent cases and
calculate person-time at risk, affects the estimated inci-
dence rates in administrative data (9,10,13). To assess the
magnitude of this effect, we calculated sex-specific inci-
dence rates for the fiscal year 2003–2004 using a 12-year
run-in period (from April 1, 1991). These rates were com-
pared with incidence rates based on a 5-year run-in period
used in the analysis of trends.

RESULTS

and 2003–2004, the total number of new OA cases in BC
based on definition 1 increased from 43,546 to 55,911. The
 crude incidence rates of OA increased from 10.5 (95% 
ci 5.6 lower than rates based on definition 1,
but the trends were similar. Crude rates for definition 2
increased between 1996–1997 and 2003–2004 from 5.7
(95% CI 5.5–5.7) to 6.3 (95% CI 6.19–6.41) per 1,000 in
men and from 7.5 (95% CI 7.37–7.62) to 9.3 (95% CI
9.14–9.41) per 1,000 in women. Age-standardized rates in
men showed year-to-year fluctuations (range 5.7–6.3) but
no trend, whereas in women the rates increased from 8.0
(95% CI 7.83–8.10) to 8.9 (95% CI 8.73–8.99) per 1,000 (Table 1 and Figure 1).

**Age-specific rates.** The age-specific incidence rates (definition 1) between 1996–1997 and 2003–2004 are presented graphically for men in Figure 2 and for women in Figure 3. In men, differences between 1996–1997 and 2003–2004 were generally small (9% at most). Rates increased substantially (>15%) during this period for women age 40–79 years, with the greatest increase (22%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Men Crude rate per 1,000</th>
<th>Men Age-standardized rate per 1,000</th>
<th>Women Crude rate per 1,000</th>
<th>Women Age-standardized rate per 1,000</th>
</tr>
</thead>
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<tr>
<td>1996–1997</td>
<td>10.5</td>
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<td>13.9</td>
<td>14.7</td>
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<td>11.2</td>
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<td>15.4</td>
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<td>10.9</td>
<td>14.5</td>
<td>14.9</td>
</tr>
<tr>
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<td>11.7</td>
<td>16.1</td>
<td>16.4</td>
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<td>2000–2001</td>
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<td>11.8</td>
<td>16.1</td>
<td>16.1</td>
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<tr>
<td>2001–2002</td>
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<td>11.4</td>
<td>16.0</td>
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<tr>
<td>2002–2003</td>
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<tr>
<td>2003–2004</td>
<td>12.2</td>
<td>11.6</td>
<td>17.4</td>
<td>16.7</td>
</tr>
</tbody>
</table>

* Incidence rates were directly standardized using the population of British Columbia in 2000 as the standard and expressed per 1,000 person-years. Definition 1 required at least 1 visit or 1 hospitalization with the International Classification of Diseases, Ninth Revision (ICD-9) code 715. Definition 2 required at least 2 visits within 2 years or 1 hospitalization with the ICD-9 code 715.
Figure 2. Age-specific incidence rates of osteoarthritis (definition 1) in British Columbia, Canada, from 1996–1997 to 2003–2004 for men.

Figure 3. Age-specific incidence rates of osteoarthritis (definition 1) in British Columbia, Canada, from 1996–1997 to 2003–2004 for women.

in those age 60–69 years. In persons <39 years of age, the rates in 2003–2004 were lower than in 1996–1997. Trends in age-specific rates were generally similar for definition 2, although the rates were substantially lower (data not shown).

DISCUSSION

In this study, we analyzed trends in OA incidence over time in a large, geographically defined population (BC, Canada). Crude rates increased in both men and women, but more so in women. With respect to age-standardized rates, we did not find a clear trend in men. We did find an increase in age-standardized OA incidence rates in women. These rates increased between 1996–1997 and 2003–2004 by 8.3–11.1%, depending on the definition of OA. Approximately half of the increase in crude incidence rates among women could be accounted for by population aging.

To our knowledge, there are no other published studies of trends in OA incidence or prevalence. Perruccio et al (6) studied changes in the prevalence of self-reported arthritis/rheumatism diagnosed by a health professional between 1994 and 2003 from 3 cycles of the National Population Health Survey and 2 cycles of the Canadian Community Health Survey in Canada. Overall, prevalence increased from 13.4% to 17.6%, i.e., by nearly 50%. The authors also found that age- and sex-specific prevalence proportions increased. Such data are consistent with an increasing trend in the incidence of age-standardized OA observed in our study. However, it should be noted that an increase in disease prevalence does not necessarily imply a simultaneous increase in incidence.

Several studies in Canada and the US have provided long-term projections of the prevalence of self-reported arthritis based on projected changes in the age structure of the population and assuming constant age-specific prevalence proportions (1–4). These studies found a 1.2% (Canada) to 1.3% (US) average increase in crude prevalence per year. The results of such studies are not directly comparable with our data. We studied OA rather than self-reported arthritis, used data from an administrative database rather than population surveys, and looked at trends in incidence rates in a single Canadian province from 1993 to 2003. Nevertheless, it is noteworthy that the changes in the incidence of OA due to population aging observed in our data (after subtracting changes in age-standardized incidence from changes in crude incidence) were in the same direction and of a similar order of magnitude as changes in the prevalence of arthritis projected in previous studies.

Our data have several limitations. Incidence rates depend on the definition of OA (10). Rates based on definition 1 in our study were lower than self-reported arthritis incidence rates in the National Population Health Survey in Canada reported by Wilkins (14). Rates based on definition 2, although almost 50% lower than those based on definition 1, were higher than radiographic plus symptomatic OA incidence of combined hip, knee, and hand OA in Massachusetts reported by Oliveria et al (15). Such relationships between self-reported arthritis, physician-coded OA, and radiographic plus symptomatic OA of specific joints are epidemiologically plausible.

Incidence rates of OA in administrative data are also influenced by the run-in time (observation time prior to the year for which incidence is calculated) that is needed to eliminate prevalent cases from the numerator of the incidence rate and to calculate person-time for the denominator. In this study, we used a 5-year run-in period to allow for 7 years of followup. Our sensitivity analysis showed that the overall incidence rates in 2003–2004 based on a 12-year run-in time were lower than the rates based on a 5-year run-in time by 15% in men and 17% in women (data not shown).

Diagnostic and coding errors, including an incorrect preliminary diagnosis, may lead to patients without OA being falsely classified as having OA. False negatives may occur because a person with OA does not see a physician, is not correctly diagnosed, is given a wrong diagnostic code, or is coded for a comorbid condition (10). A study by Harrold et al in the US estimated the positive predictive value of administratively coded OA at 62% (16). Although the accuracy of the diagnosis and coding of OA in our database is unknown, it seems reasonable to assume that the accu-
racy remained fairly constant during the study period and therefore would not affect the observed trends.

Because we analyzed data on patients diagnosed with OA in a database maintained for administrative purposes, the observed trends may be due to factors other than actual changes in the incidence of the disease. Factors that could potentially produce spurious trends in an administrative database include changes in diagnostic criteria or methods, introduction of new screening tests, changes in the coding habits of physicians or ICD coding, changes in access to care, increased awareness of the disease and willingness to treat it among both patients and physicians, and errors in the denominators. In OA, the methods of diagnosis used in clinical practice have not changed in the past decade. There have been no major changes in diagnostic methods or criteria for OA or significant changes in access to care in BC. No changes in ICD coding (except for hospitalized patients) occurred during the study period. Errors in the denominators are probably relatively minor and unlikely to have changed over time. It is noteworthy that we observed a different trend for men versus women. A spurious trend due to the aforementioned factors would presumably apply to both sexes equally.

We are not aware of any new requirements, incentives, or encouragements with respect to disease coding in BC during the study period. However, public awareness of OA may have increased recently. It is possible that joint pain, especially among the elderly, that was once dismissed as normal aging is now more often regarded as a disease that prompts a visit to a doctor. This effect may have been enhanced by the introduction of new drugs for the treatment of musculoskeletal pain, such as cyclooxygenase 2 inhibitors. Access to surgical treatment for OA in Canada has generated public attention due to increasing wait times. It is difficult to judge whether these factors may have influenced the frequency of OA coding among family physicians, who are responsible for the vast majority of new diagnoses. We have no data on the radiographic OA stage at the time of diagnosis in primary care. The rates of knee and hip replacement surgeries have increased in Canada (and other countries) over the past 2 decades (17). It is not clear to what extent this reflects better access to surgical treatment, changes in indications for surgery, greater acceptance of surgery by patients, or increased incidence and/or progression of OA (18,19).

While a spurious trend in administratively coded OA incidence in BC is difficult to rule out completely, an increasing trend in age-standardized rates seems consistent with the effect of obesity. Obesity is a strong risk factor for knee OA and a weaker risk factor for hip and hand OA (20). The prevalence of obesity has been on the rise in BC and elsewhere, in both men and women (21). In addition, the effect of obesity on knee OA may be stronger in women (22) and knee OA is more common in women (23). Another important risk factor for OA is occupational exposure to heavy physical labor (24). It seems likely that this exposure has declined in the past few decades. We do not have any data to indicate whether this decline was greater among men than women. Joint injury is also an established risk factor for OA. Although there is some indication that self-reported injury rates have increased in Canada, systematic information on trends in occupational and sports-related joint injuries is lacking (6,25). Other risk factors such as genetics, hormonal factors, congenital anomalies, vitamins and minerals, joint anatomy/alignment, muscle strength, and neuromuscular control are either less strongly established or their prevalence is unlikely to have changed in the past 1–2 decades (26).

In conclusion, we have found an increase in age-standardized incidence of diagnosed OA in women in BC and no change in men. Because the data come from an administrative database, we cannot rule out the possibility that these trends are affected by factors related to the diagnosis or coding of OA by physicians rather than the true incidence of the disease. Whatever the cause of the observed trends, OA is diagnosed more and more often by physicians, especially in women. The diagnosis of OA has serious consequences for the patient and the health care system. More studies are needed to assess plausible scenarios for future OA prevalence based on demographic trends and changes in the major risk factors. Administrative databases can play an important role in OA surveillance, and more validation studies of administrative diagnosis, as well as efforts to standardize the definitions across studies and databases, are urgently needed.

AUTHOR CONTRIBUTIONS

Dr. Kopec had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study design. Kopec, Rahman, Cibere, Aghajanian, Anis, Badley.

Acquisition of data. Kopec, Cibere, Aghajanian, Anis.


Statistical analysis. Rahman, Sayre.

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