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Clinical, humanistic, and economic burden of osteoarthritis among noninstitutionalized adults in the United States

X. Zhao †, D. Shah †, K. Gandhi ‡, W. Wei §, N. Dwibedi †, L. Webster ‖, U. Sambamoorthi † *

† Department of Pharmaceutical Systems & Policy, West Virginia University School of Pharmacy, Morgantown, WV, USA
‡ Teva Pharmaceutical Industries, Frazer, PA, USA
§ Regeneron Pharmaceuticals, Tarrytown, NY, USA
‖ PRA Health Sciences, Salt Lake City, UT, USA

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SUMMARY

Objective: To estimate the burden of osteoarthritis (OA) among noninstitutionalized adults (≥18 years of age) in the US.

Design: Weighted nationally representative data from the 2015 Medical Expenditure Panel Survey were used to estimate OA prevalence in noninstitutionalized adults and compare adults with OA to those without OA for clinical (pain interference with activities [PIA], functional limitations), humanistic (health-related quality-of-life [HRQoL]) and economic outcomes (healthcare costs, wage loss). Productivity/wage loss was estimated among employed working-age adults (18–64 years). Multivariable regression analyses examined the associations between OA and outcomes.

Results: In 2015, 10.5% (25.6 million) of noninstitutionalized US adults reported having any OA. Regression analyses indicated that adults with OA were significantly more likely than those without OA to report moderate (adjusted odds ratios [AOR] 1.99; 95% confidence interval [CI] 1.65–2.40] or severe PIA (AOR 2.59; 95% CI 2.21–3.04), any functional limitation (AOR 2.51; 95% CI 2.21–2.85), and poorer HRQoL on the SF-12 version 2 Physical Component Summary score (adjusted beta [standard error] −3.88 [0.357]; $P < 0.001$). Adjusted incremental annual total healthcare costs and lost wages among adults with OA relative to those without OA were $1778 and $189 per person, respectively, resulting in estimated national excess costs of $45 billion and $1.7 billion, respectively.

Conclusions: OA affects approximately 10% of noninstitutionalized adults in the US, resulting in substantial clinical, humanistic, and economic burdens.

Introduction

Osteoarthritis (OA) is the most common form of arthritis. Although prevalence estimates for OA vary depending on definition, data source, and methods, it has been reported that at least 13% of the adult population in the United States (US), approximately 31 million adults, are affected[1]. The increasing age-adjusted prevalence of OA, which has more than doubled between 1999 and 2014[2], is due to a variety of factors that include both the aging of the population and changes in lifestyles such as increased obesity.

Although the typical progression of OA is slow, the presence of pain, even before progression to joint failure, results in substantial disability[3,4]. The presence of pain in OA impairs function, reduces participation in daily activities, and increases healthcare utilization, with patient-reported and economic burdens higher in individuals with OA who have pain relative to those with OA who do not have pain[5].

While OA is associated with a high overall disease burden[6–8], few studies have comprehensively evaluated the incremental burden associated with OA relative to those without OA across clinical (pain-related interference, functional status), humanistic (health-related quality-of-life [HRQoL]), and economic outcomes (healthcare costs, lost wages). Additionally, while many OA studies have focused on an older population, several studies specifically

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* Address correspondence and reprint requests to: U. Sambamoorthi, Robert C. Byrd Health Sciences Center, 5706 Health Sciences Center, Morgantown, WV 26506. Tel: 1304-293-5101.

E-mail addresses: xozhao@mix.wvu.edu (X. Zhao), drshah@mix.wvu.edu (D. Shah), kl_gajria@hotmail.com (K. Gandhi), wenhui.wei@regeneron.com (W. Wei), nidwibedi@hsc.wvu.edu (N. Dwibedi), lrwebstermd@gmail.com (L. Webster), usambamoorthi@hsc.wvu.edu (U. Sambamoorthi).

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demonstrated that OA pain has a substantial impact among working-age individuals[5,9,10]. Therefore, the objectives of this study were to determine the US prevalence of OA in adults ($\geq$18 years of age) based on a nationally representative sample of the civilian noninstitutionalized population, and to estimate the excess clinical, humanistic, and economic burdens of OA relative to those without OA in this population.

Methods

Data source

The data source for this retrospective, observational, cross-sectional study was the 2015 Medical Expenditure Panel Survey (MEPS). MEPS is sponsored by the Agency for Healthcare Research and Quality (AHRQ), and is a nationally representative annual survey of the civilian noninstitutionalized population in the US[11,12]. The data in MEPS are collected from families and individuals about demographic characteristics, socioeconomic status, medical conditions, health status such as functional and activity limitations, HRQoL, use of medical services, medical expenditures, access to care, and health insurance coverage. MEPS aggregates the International Classification of Diseases (ICD) codes into 263 mutually exclusive clinically meaningful categories using Clinical Classification Software resulting in unique clinical classification codes (CCC) (https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp).

Study sample

The study sample consisted of noninstitutionalized civilian individuals with and without OA, who were $\geq$18 years of age and alive during the full calendar year of the survey (2015). Presence of OA (Yes/No) was identified by self-report of having OA as listed as a priority condition enumeration (i.e., the section of the survey that captures a summary assessment of each person's physical and mental health including a select group of medical conditions), or through the CCC of 203 in the medical conditions files.

Measures

Prevalence

The overall prevalence of OA was estimated for the US population of noninstitutionalized adults, and the prevalence by demographic variables (age, sex, and race/ethnicity) was also examined.

Clinical burden

The clinical burden was defined by the extent of pain interference with activities (PIA), and the presence of functional limitations. Assessment of PIA was derived from the 12-item Short Form Health Survey version 2 (SF-12v2)[13] bodily pain-interference item: “During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?” with response options of “not at all,” “a little bit,” “moderately,” “quite a bit,” and “extremely”. In the current analysis, these responses were re-categorized as no/mild (“not at all” or “a little bit”), moderate (“moderately”), and severe (“quite a bit” or “extremely”).

Functional limitations, dichotomized as “yes” or “no”, included those related to activities of daily living (ADL)[14,15] and instrumental activities of daily living (IADL)[16,17], as well as physical, social, cognitive, and work limitations. While ADL is defined as the basic activities necessary for daily function (bathing, eating, dressing, transferring, toileting, and walking), IADL are ADL that, although not required for daily functioning, contribute to maintaining an individual's independence (housework, preparing meals, taking medications, shopping, telephoning, and managing money).

Humanistic burden

The humanistic burden included physical and mental health components of HRQoL, assessed based on the Physical Component Summary (PCS) and Mental Component Summary (MCS) subscales of the SF-12v2[13]. These subscales are derived from positively weighting specific domains of the SF-12v2; the PCS weights the domains of physical function, role physical, bodily pain, and general health, and the MCS weights the domains of vitality, social function, role emotional, and mental health. The PCS and MCS scores are normed to the US population (mean = 50, SD = 10) and range from 0 to 100, with higher scores indicating better physical and mental health status[13].

Economic burden

The economic burden included estimation of direct all-cause healthcare costs for all adults and indirect costs related to lost wages among employed working-age adults (18–64 years). Direct all-cause medical costs were defined as the sum of all direct payments for health care provided during the year by the insurance plus the family and patient's out-of-pocket (OOP) spending. MEPS derives direct payments for healthcare from different types of insurance including private, Medicaid, Medicare, Veterans Health Administration, and others. The OOP spending included deductibles, copayment, coinsurance for services, and payments for services not covered by health insurance. In addition, third-party all-cause costs were calculated separately by subtracting OOP from the total. Indirect costs related to lost wages were estimated using the human capital approach, where total number of missed work hours in a year were multiplied by the average hourly wage. Missed work hours were estimated from missed workdays reported by the survey respondents, assuming 8 working hours a day. Missed days at work were derived from the response to the following question in the MEPS: “How many times [did you] miss more than a half-day of work since the last interview?” This question is asked in all rounds of the MEPS, among individuals aged 18 years or older who are not self-employed and had income from a job during the survey period; the total number of workdays missed in a year provided by the MEPS data (MEPS variable: DDNWRK15) was used. MEPS also queries hourly wages in each round among the surveyed population. The mean of all reported hourly wages of a respondent was used to represent the average hourly wage; the hourly wage was imputed using the mean hourly wage of all employed adults in the specific group (i.e., adults with OA/adults without OA) for those with missing hourly wage data.

Statistical analysis

Rao-Scott chi-square tests for categorical variables and *t*-tests for continuous variables were used to detect significant unadjusted group differences between adults with and without OA. Multivariable regression analyses were conducted to examine the associations between OA and the clinical, humanistic, and economic outcomes. To assess the association between OA and each type of functional limitation, separate multivariable logistic regression models were built. Associations between OA and humanistic outcomes (PCS and MCS scores) were evaluated using ordinary least square (OLS) regressions. The adjusted analyses, which included PIA, reflect adults who provided data about this outcome. Generalized linear models (GLM) with log link and gamma distribution were used to examine the association between OA and healthcare costs. Specific variables included in these regressions were: age, sex, race/ethnicity, marital status, educational level, employment status, economic status defined by the federal poverty level threshold, geographic region, health insurance coverage, prescription drug coverage, number of physical comorbidities, depression and anxiety (not included in the regression analysis for MCS), body mass index, smoking status, and exercise.

Rather than simply comparing costs between the two groups (OA and non-OA) for a reference-case scenario, robust estimates of incremental costs were obtained from the parameter estimates of GLM using the counterfactual recycled prediction technique[18]; all costs are in US dollars (US$) for the year 2015.

Since patients were not matched using propensity scores matching, *post hoc* sensitivity analyses were conducted to address potential imbalance between OA and non-OA populations. These analyses applied inverse probability weights (IPWs) to adjust for covariate imbalance between adults with OA and those without OA. IPWs were calculated from adjusted probabilities from multivariable logistic regression on OA with the same independent variables used in the regression analyses. Separate inverse probability treatment weighting (IPTW)-adjusted regression models examined associations of OA with clinical and humanistic outcomes. Given that recycled prediction has the advantage of avoiding covariate imbalance between comparison groups[18], the estimates of economic burden of OA were not considered to be subject to covariate imbalance. Thus, IPTW-adjusted analyses were not conducted for economic outcomes.

Analyses were conducted using the survey procedures in SAS version 9.4 (SAS Institute Inc., Cary, NC) or in STATA 14 (StataCorp LLC, College Station, TX) to account for the complex design of the MEPS; prevalence and cost estimates were weighted to be nationally representative.

Results

Prevalence of OA

Among all the adults in the eligible sample who did not report OA in the household file, 99.8% did not have a medical care encounter with an OA diagnosis. Of those who did report OA in the household file, only 42% had sought medical care for OA during 2015; adults who had been diagnosed with OA, at any point, may not have received medical care for OA in 2015.

The weighted prevalence of OA in noninstitutionalized US adults, using the overall weighted population as the denominator, was 10.5% (25.6 million) in 2015. The weighted prevalence of OA varied across regions: 11.4% in the Northeast, 11.1% in the Mid-West, 10.7% in the South, and 8.9% in the West. Prevalence rates also significantly differed by demographic characteristics (all $P < 0.001$) (Fig. 1). The weighted prevalence in females was 13.3% relative to 7.5% in males, and non-Hispanic Whites had a higher prevalence (13.3%) than African-Americans (7.5%) or Hispanics (4.2%). The prevalence of OA increased with age and was lowest in adults aged 18–39 and 40–49 years, 1.8% and 6.3%, respectively, 14.8% in those aged 50–64 years, and highest among those aged 65–74 and ≥ 75 years, 24.2% and 26.9%, respectively.

Population characteristics

All demographic characteristics were significantly different between the OA and non-OA populations (Table I): adults with OA were older (46.9% vs 16.2% ≥ 65 years of age); mostly female (65.8% vs 50.2%); a lower proportion of the total OA population was employed (43.7% vs 70.2%); and a lower proportion were employed among those of working age (66.7% vs 79.4%). Health characteristics were also significantly different between the two populations (Table I). Relative to those without OA, the OA population was characterized by greater obesity (39.4% vs 29.7%) and less exercise (43.5% vs 52.4%), with higher proportions on public insurance (29.8% vs 19.5%) and using opioids (32.7% vs 13.8%; $P < 0.001$).

Pain interference, functional limitations, and health status

In the unadjusted analysis, the clinical and humanistic, burdens were significantly higher among adults with OA relative to those without OA. The proportion of adults with OA who experienced moderate-to-severe PIA was higher than those without OA (40.8% vs 15.1%; $P < 0.001$) [Fig. 2(a)], as were the proportions of adults with OA who reported limitations across all functional categories (ADL, IADL, physical, social, cognitive, and work) (all $P < 0.001$) [Fig. 2(b)]. Adults with OA reported significantly lower mean (SE) scores relative to those without OA on the PCS (40.8 [0.4] vs 50.1 [0.1]; $P < 0.001$) and MCS (50.7 [0.3] vs 51.5 [0.1]; $P < 0.05$).

The adjusted odds ratios (AOR) from the multivariable logistic regression analyses indicated that adults with OA were significantly more likely than those without OA to report moderate PIA (AOR 1.99; 95% confidence interval [CI] 1.65–2.40) or severe PIA (AOR 2.59; 95% CI 2.21–3.04) [Fig. 2(c)]. Adults with OA were also

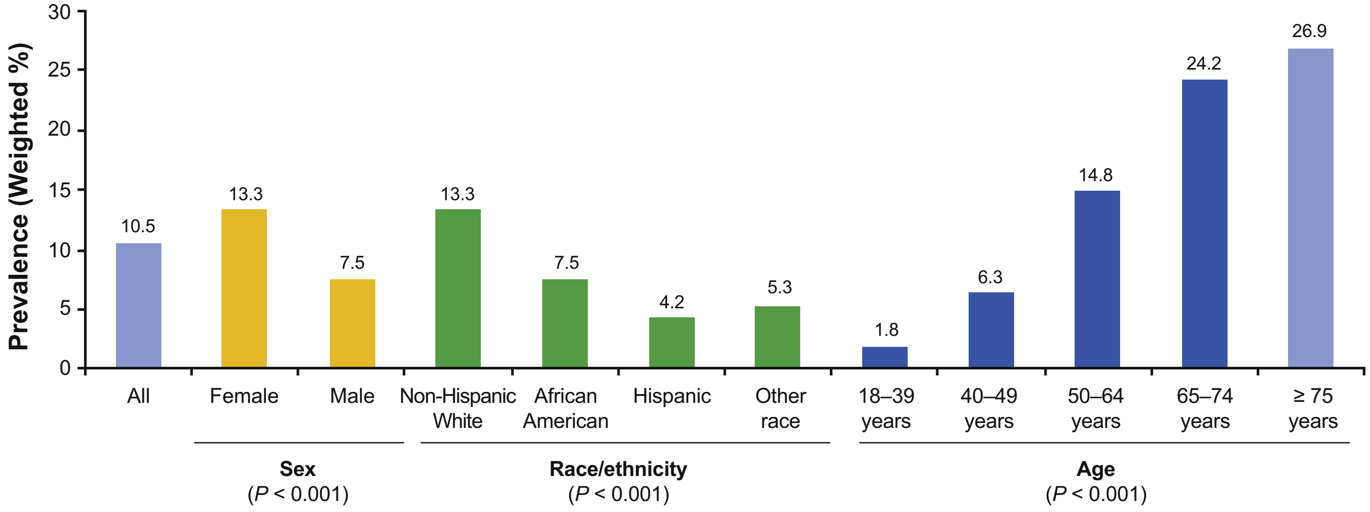

Fig. 1. Estimated prevalence of osteoarthritis in non-institutionalized adults in the United States.

Table I
Demographic and health characteristics

Variable	Weighted percent		P
	OA (weighted n = 25,562,623)	Without OA (weighted n = 218,129,881)	
Age distribution			<0.001
18–39 years	6.5	41.9	
40–49 years	9.8	17.0	
50–64 years	36.8	24.9	
65–74 years	26.4	9.7	
≥75 years	20.5	6.5	
Female	65.8	50.2	<0.001
Race/ethnicity			<0.001
Non-Hispanic White	80.6	61.5	
African-American	8.5	12.2	
Hispanic	6.3	16.9	
Other	4.5	9.4	
Marital status			<0.001
Married	60.5	52.4	
Widow	13.0	4.8	
Separated/divorced	17.9	12.0	
Never married	8.5	30.8	
Education			<0.001
Less than high school	9.5	13.8	
High school	28.1	29.2	
More than high school	62.2	56.4	
Employed			
Total population	43.7	70.2	<0.001
Among working-age adults (18–64 years)[*]	66.7	79.4	<0.001
Economic status[†]			0.007
Poor	11.1	11.5	
Near poor	16.5	16.9	
Middle income	25.0	28.7	
High income	47.4	43.0	
Geographic region			0.041
Northeast	19.5	17.8	
Midwest	22.1	20.9	
South	38.4	37.3	
West	19.9	24.0	
Health insurance			<0.001
Private	67.3	70.3	
Public	29.8	19.5	
Uninsured	2.9	10.2	
Prescription drug coverage	54.6	59.9	<0.001
Opioid use	32.7	13.8	<0.001
No. of physical comorbidities[‡]			<0.001
None	18.3	54.4	
One	20.0	19.3	
Two	21.5	12.8	
Three or more	40.2	13.5	
Depression and Anxiety			<0.001
No depression/anxiety	67.2	81.7	
Depression only	13.4	6.3	
Anxiety only	10.6	7.6	
Both depression and anxiety	8.7	4.3	
Body mass index			<0.001
Under/normal weight	28.1	35.2	
Overweight	31.6	33.0	
Obese	39.4	29.7	
Missing	0.9	2.1	
Current smoker			<0.001
Yes	11.3	13.5	
No	80.2	73.2	
Missing	8.6	13.3	
Exercise			<0.001
Yes	43.5	52.4	
No	55.9	46.6	
Missing	0.6	1.0	

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[*] Employed working-age adults with OA = 667 (weighted n = 11,159,569), and for without OA = 14,466 (weighted n = 153,083,255).

[†] Economic status, based on family income in relation to the federal poverty line (FPL) and accounting for family size and composition, was categorized as poor (<100% FPL), near poor (100–200% FPL), middle income (200–400% FPL), and high income (≥400% FPL).

[‡] Number of physical comorbidities included asthma, cancer, chronic obstructive pulmonary disease, diabetes mellitus, hypertension, cardiovascular diseases, liver diseases, rheumatoid arthritis, renal diseases, human immunodeficiency virus, gastroesophageal reflux disease, and other endocrine disorders.

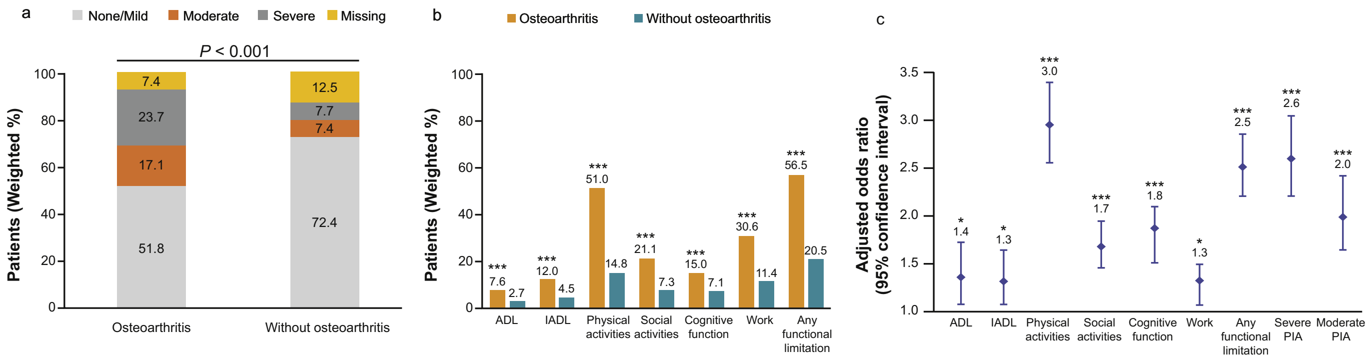

Fig. 2. Patients' self-report of the clinical burden of osteoarthritis. (a) Unadjusted analysis of pain interference with activities. (b) Unadjusted analysis of functional limitations. (c) Adjusted odds ratios of pain interference and functional limitations. The analysis reflects PIA adults who provided data on PIA, and was adjusted for age group, sex, race/ethnicity, marital status, educational level, employment status, economic status, geographic region, health insurance coverage, prescription drug coverage, number of comorbidities, depression and anxiety, body mass index, smoking status, and exercise. ADL = activities of daily living; IADL = instrumental activities of daily living. *$P < 0.05$ and ***$P < 0.001$ vs without osteoarthritis.

significantly more likely than those without OA to report any functional limitation (AOR 2.51; 95% CI 2.21–2.85) and limitations across ADL, IADL, physical activities, and social or work function (all $P < 0.001$), as well as cognitive function ($P < 0.05$) [Fig. 2(c)].

Similarly, in the adjusted analysis, adults with OA had significantly poorer physical health status on the PCS than those without OA; the adjusted mean PCS score was 47.10 for adults without OA, and having OA was associated with a significantly lower PCS score by 3.88 points while holding other factors constant (i.e., adjusted beta [SE] −3.88 [0.357]; $P < 0.001$). In contrast, mental health status on the MCS was comparable between the populations, with adjusted mean MCS scores of 45.33 and 45.15 for those with and without OA, respectively (adjusted beta [SE] 0.18 [0.230]; $P = 0.56$).

Cost burden

The unadjusted annual direct medical costs were significantly higher across cost categories (all $P < 0.001$) for adults with OA relative to those without OA [Fig. 3(a)]. The significantly higher annual direct medical costs per person across cost categories among adults with OA relative to those without OA resulted in adjusted incremental annual healthcare costs per person of $1778, $1590, and $189 for total, third party, and OOP costs, respectively (all $P < 0.001$) [Fig. 3(b)].

Among employed working age adults, the mean (SE) annual number of missed workdays per adult was 5.6 (0.5) for those with OA compared with 3.1 (0.1) for those without OA. These missed workdays resulted in an approximately 2-fold higher wage loss ($P < 0.001$) among the adults with OA [Fig. 3(c)]. Adjusted lost wages were also significantly higher in the employed OA population, resulting in incremental costs of $189 ($P < 0.001$) [Fig. 3(d)].

Based on total annual healthcare costs of $7585 per person with OA and the adjusted incremental annual OA-related healthcare costs of $1778 per person, the extrapolated national estimate of annual healthcare costs among adults with OA, using the 10.5% prevalence observed in this study, was $193.9 billion, with adjusted excess costs of $45.4 billion annually relative to those without OA (Fig. 4). Similarly, for third party, OOP, and lost wages, extrapolated annual costs were $171.9 billion, $23.3 billion, and $6.7 billion, respectively, with adjusted excess costs relative to the non-OA population of $40.6 billion, $4.8 billion, and $1.7 billion, respectively (Fig. 4).

Sensitivity analyses

Results of the sensitivity analyses showed that a good balance was achieved between adults with OA and those without OA after applying IPTWs across all the covariates, except for sex and smoking status (Supplementary Table 1). Results of the IPTW-adjusted regression models (with adjustment of sex and smoking status) revealed similar results to those of the main analyses (Table II).

Discussion

Evaluating the burden of OA is critical to the process of determining management strategies from the perspectives of all healthcare stakeholders. This study is the first to provide robust estimates on the incremental burden of OA relative to adults without OA using a comprehensive set of outcomes in a nationally representative sample of noninstitutionalized adults that was not restricted to an older population. The study is consistent with the Economic, Clinical, and Humanistic Outcomes (ECHO) model that recommends the approach of using traditional clinical-based outcomes with contemporary and relevant measures[19]. Within this model, the results of the current study further support the need to evaluate both clinical and humanistic outcomes in tandem and in recognition of the move towards patient-centered care as an integral component of treatment decisions. The data source and results also enabled estimates of overall OA prevalence and prevalence by demographic characteristics.

While the estimate of OA prevalence in the current study (10.5%, 25.6 million adults) is somewhat lower than the 13.4% (30.8 million adults) best estimate in a previously published MEPS study that used a looser definition of probable OA, it is also higher than the 6.3% prevalence based on the strictest definition that relied exclusively on an ICD-9-CM diagnosis[1]. As with most epidemiologic studies, estimates are dependent on definition, population, and methodology such as the manner of identifying individuals with OA, which may be through radiography, symptomatology, or medical history/physical examination. The current analysis identified OA through ICD-9 codes from self-reported healthcare encounters or from the priority condition enumeration, and alternative methods of identification, such as radiographic imaging, which result in the highest reported prevalence rates[20], would likely provide different estimates.

The higher prevalence in females and older age groups was consistent with the epidemiologic literature[21] and, notably, the results also provide the OA prevalence by race/ethnicity. Previous reports of OA prevalence in racial/ethnic groups focused on specific age groups and/or specific joints, and were sometimes defined primarily by radiographic disease[22,23], resulting in prevalence

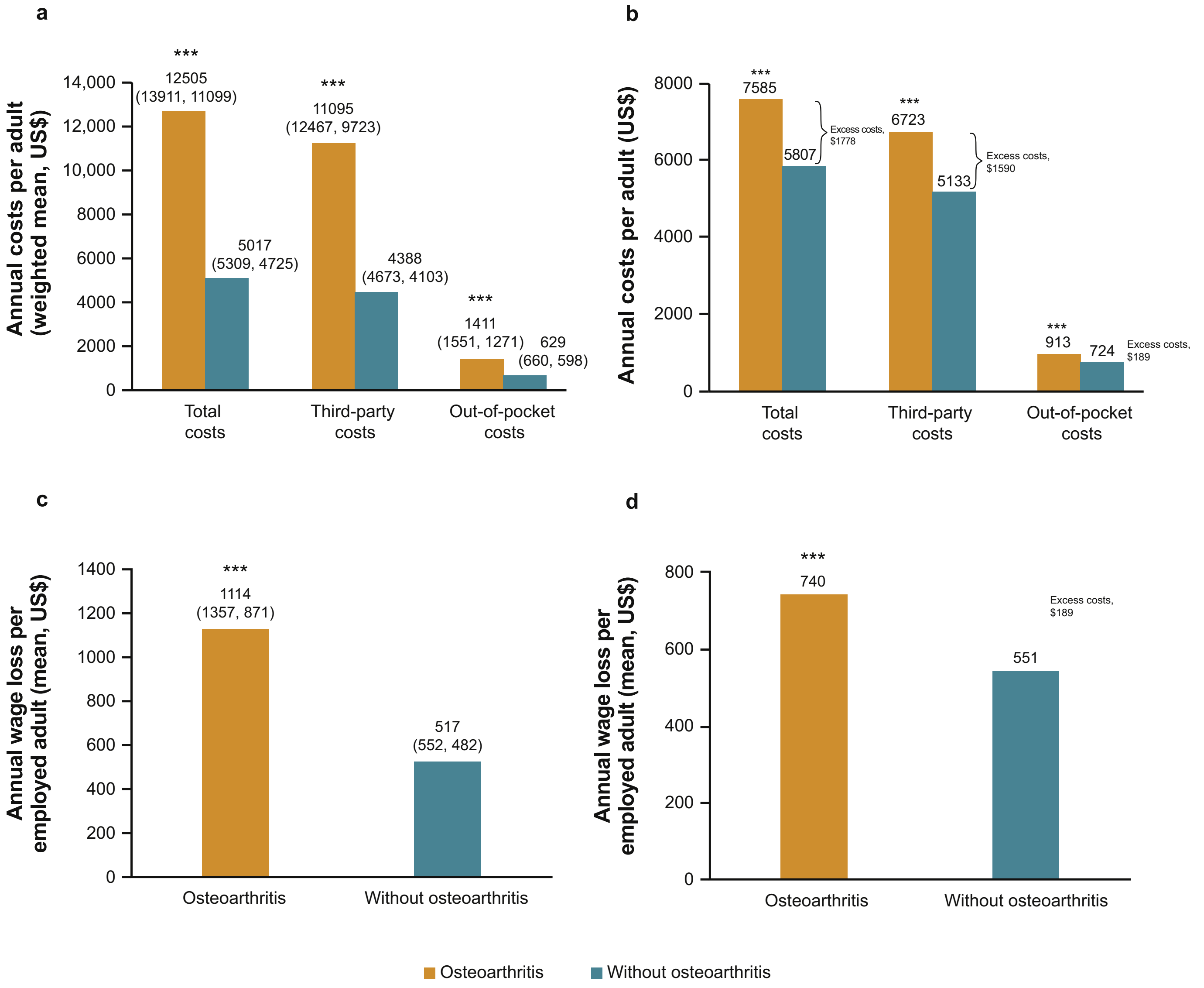

Fig. 3. The annual economic burden per person including direct medical costs (a, b) and wage loss (c, d) by unadjusted (a, c) and adjusted (b, d) analyses. Costs related to lost wages are only for employed, working age adults (18–64 years of age). Variables in the adjusted model were age group, sex, race/ethnicity, marital status, educational level, employment status, economic status, geographic region, health insurance coverage, prescription drug coverage, number of comorbidities, depression and anxiety, body mass index, smoking status, and exercise. Numbers in parentheses are 95% confidence intervals. ***$P < 0.001$ vs without osteoarthritis. US$ = United States dollar.

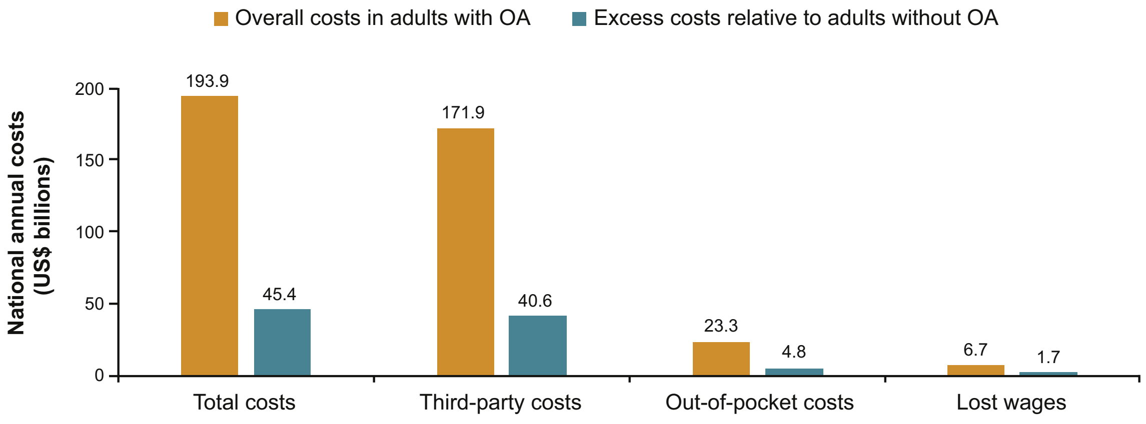

Fig. 4. Adjusted national annual costs of osteoarthritis for the US noninstitutionalized population. The model adjusted for age group, sex, race/ethnicity, marital status, educational level, employment status, economic status, geographic region, health insurance coverage, prescription drug coverage, number of comorbidities, depression and anxiety, body mass index, smoking status, and exercise. Costs related to lost wages are only for employed, working age adults (18–64 years of age). OA = osteoarthritis; US$ = United States dollar (for 2015).

Table II
Comparisons of results from the sensitivity analyses (IPTW-adjusted) and the main analyses (multivariable regression)

Outcomes	AOR (95% CI) of OA vs Non-OA	
	IPTW-adjusted (sensitivity analyses	Multivariable regression (main analyses)
PIA*		
Moderate	2.29 (1.58–3.31)***	2.59 (2.21–3.04)***
Severe	2.14 (1.56–2.91)***	1.99 (1.65–2.40)***
Functional limitations†		
ADL	1.17 (0.46–3.03)	1.36 (1.07–1.73)*
IADL	1.68 (1.19–2.36)**	1.32 (1.07–1.64)*
Work limitation	1.66 (1.31–2.11)***	1.68 (1.45–1.94)***
Physical limitation	3.45 (2.52–4.71)***	2.95 (2.55–3.40)***
Cognitive limitation	1.47 (1.12–1.92)**	1.29 (1.08–1.54)**
Any limitation	2.93 (2.12–4.04)***	2.51 (2.21–2.85)***
	Beta (standard error) of OA	
PCS	−4.93 (1.12)***	−3.88 (0.36)***
MCS	0.48 (0.51)	0.18 (0.30)

ADL = activities of daily living; AOR = adjusted odds ratio; CI = confidence interval; IADL = instrumental activities of daily living; IPTW = inverse probability treatment weights; MCS = Mental Component Summary score; OA = osteoarthritis; PCS = Physical Component Summary score; PIA = pain interference with activities.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
[*] No/mild PIA was the reference group.
[†] No limitation was the reference group.

estimates among these groups that are different than those reported here.

The proportion of employed adults with OA (43.7%) was similar to that reported in another study (41.1%) that consisted of physician-diagnosed individuals with OA within the same age range as the current study[24]. However, while more than half of the adults with OA (53.4%) were of working age (18–64 years), they were less likely to be employed compared with the age group without OA. This lower rate of employment is consistent with previous studies that suggest OA is a predictor of early exit from the workforce[10,25]. Taken together, these observations support the concept that OA is not just a disease of older adults, but also affects workforce participants, and they suggest that earlier disease recognition and appropriate management may be of benefit to employers as well as healthcare stakeholders.

Unadjusted and adjusted analyses indicated significantly higher clinical burden in terms of PIA and functional limitations among adults with OA relative to those without OA. In particular, the burden of pain was substantial, as indicated by AORs of 1.99 and 2.59 for moderate and severe PIA, respectively, among those with OA. These results can be interpreted as adults with OA having a 2- or 2.6-fold greater likelihood for moderate or severe PIA relative to those without OA. Similarly, significantly higher proportions of adults with OA had functional limitations, and the AORs indicated a 2.5-fold greater likelihood for any functional limitation and an almost 3-fold greater likelihood for limitations in physical activities relative to adults without OA. Not surprisingly, there was also a significantly higher likelihood of cognitive limitations, consistent with the recognized association of cognitive impairment with pain[26]. These functional limitations resulting from pain are, thus, likely to have a substantial impact on productivity because it has previously been reported that lost productivity among adults with OA is mediated directly through the presence of pain and indirectly through the impact of pain on physical function[9].

After adjustment, adults with OA had poorer physical health status (PCS) and comparable mental health status (MCS) relative to adults without OA. The decrease in PCS is clinically relevant; the adjusted difference of −3.88 points on the PCS exceeds the value of 3 that is generally considered to be clinically meaningful on the summary scores[27]. This greater impact on physical components of HRQoL relative to mental components is consistent with previous reports[8] and with what may be expected for a disease that affects the joints and is characterized by reduced function. Notably, robustness of these results was suggested by the similarity between the main analyses and the sensitivity analyses. Given that recycled prediction has the advantage of avoiding covariate imbalance between comparison groups[18], the estimates of economic burden of OA were not considered to be subject to covariate imbalance. Thus, IPTW-adjusted analyses were not conducted for economic outcomes.

Both unadjusted and adjusted healthcare costs in the OA population were substantially and statistically significantly higher relative to the non-OA population across cost categories, with the magnitude of the differences consistent with what has been reported in other studies[8].

Notably, employed working-age adults with OA had more missed workdays than their counterparts without OA, with the difference in days missed from work similar to a previous MEPS study[28]. While lost wages were based on days missed from work, the overall lost productivity costs are likely to be underestimated since presenteeism (reduced productivity while at work) accounts for a higher proportion of lost productivity than absenteeism in employed adults with OA[5,24]. Furthermore, given the results showing that a significantly lower percentage of adults with OA were employed compared with controls without OA, the indirect costs associated with OA might be underestimated in this study.

The extrapolated national costs of OA approach $200 billion annually, and excess disease-specific costs accounted for almost 25% of this total. A substantial portion of this burden is borne by the individuals themselves, who spent nearly $4.8 billion more OOP compared with those without OA. While the total costs were substantially higher than the $41.7 billion reported in another recent study using MEPS data[28], that study evaluated only employed adults during an earlier time period (2011), and identified the OA population based exclusively on ICD-9 codes.

It has previously been suggested that the societal cost of OA could be between 0.25% and 0.50% of a country's gross domestic product (GDP)[7]. The extrapolated overall costs of OA in the current study represent 1.1% of GDP for 2015 ($18.16 trillion)[29] with excess costs specifically related to OA equivalent to 0.25% of the GDP.

Strengths and limitations

Strengths of this study include that it is nationally representative and that it was not restricted to an older population but comprehensively evaluated the burden of OA across all adults.

However, several study limitations should also be considered. Since data are based on self-reported information from participants, there is the potential for misclassification of disease state, as well as recall and social desirability biases. The MEPS does not include institutionalized individuals or those living with undiagnosed OA, potentially underestimating the burden and reducing generalizability of the results. Furthermore, OA and non-OA populations were not matched, potentially resulting in bias due to variables that may have contributed to misspecified regression. While it may also be considered that lack of identification of the anatomic location of the OA may represent another limitation, as the burden may vary depending on the location, the weight-bearing joints of the knee and hip are commonly affected[30]. Another limitation is that healthcare resource utilization categories and their associated costs were not individually evaluated and, thus, drivers of direct medical costs could not be determined. Furthermore, it should be noted that, as the prevalence estimate of OA is 10.5%, odds ratios should not be interpreted as risk ratios. Last, because of the cross-sectional nature of the survey, relationships should be considered associative rather than causal.

Conclusions

This study, the first to provide robust estimates on the incremental burden of OA among all adults (aged ≥18 years) using a comprehensive set of outcomes in a nationally representative sample, demonstrated that OA results in significantly higher disease burden across clinical, humanistic, and economic outcomes relative to adults without OA. While the clinical burden among adults with OA was characterized by more PIA and functional limitations and the humanistic burden showed poorer HRQoL, the economic burden was represented by higher healthcare costs and higher indirect costs due to lost wages. Extrapolating these costs resulted in estimates that approach $200 billion annually, of which excess costs associated with OA account for almost one-quarter of the total costs ($45 billion).

These findings suggest the need for integration of a broader assessment of outcomes to guide management strategies, guidelines, and healthcare policy relevant for OA.

Author contributions

All authors made substantial contributions to the conception and design of the study, analyses and interpretation of data, drafting of the manuscript, and critical revisions for intellectual content. All authors also approved the final version of the manuscript for submission.

Conflict of interest

W Wei is an employee of Regeneron Pharmaceuticals with stock ownership. K Gandhi was an employee of Teva Pharmaceutical Industries with stock ownership at the time of this study. L Webster has served on advisory boards for Charleston Laboratories, Depomed, and Inspirion, and has served as a consultant to Alcobra, Bonti, Charleston Laboratories, Eaglet, Depomed, Indivior, Insys, Kempharm, Pernix, Pain Therapeutics, Shionogi, Daiichi Sankyo, Trevena, Trevi, and Teva. X Zhao, D Shah, N Dwibedi, and Usha Sambamoorthi, have no personal relationship with other people or organizations that could potentially and/or inappropriately influence (bias) their work and conclusions.

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Supplementary data

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