Scientific Research Publishing

Open Journal of Orthopedics, 2024, 14, 270-286
https://www.scirp.org/journal/ojo
ISSN Online: 2164-3016
ISSN Print: 2164-3008

The Increase in Total Knee Replacement Surgery in China: A 10-Year Real-World Study

Hirose Shakya*, Anjing Chen*, Zong-Ke Zhou#

Department of Orthopedics, West China Hospital/West China School of Medicine, Sichuan University, Chengdu, China
Email: #zhouzongke@scu.edu.cn

How to cite this paper: Shakya, H., Chen, A.J. and Zhou, Z.-K. (2024) The Increase in Total Knee Replacement Surgery in China: A 10-Year Real-World Study. *Open Journal of Orthopedics*, **14**, 270-286.
https://doi.org/10.4236/ojo.2024.146024

Received: April 17, 2024
Accepted: June 23, 2024
Published: June 26, 2024

Abstract

Total knee arthroplasty (TKR) is the most common and costly surgical procedure performed, and it is considered one of the most successful clinical interventions for patients suffering from severe knee osteoarthritis (OA). The incidence of TKR, including demographics, incidence rates, lengths of hospital stay, and costs, was estimated from 2010 to 2019 by analyzing data extracted from the Joint Surgery Department in our hospital, which included a total of 6770 patients. We calculated the TKR risk ratios to compare the rate of TKR between different covariables such as gender, age group, and primary diagnoses. The annual volume of TKR increased by fivefold (5.14%), with a higher incidence observed in the 60 to 69 age group constituting approximately 36% of cases. There has also been an increase in incidence among young people (<50), which now stands at 6.2%. The rate ratio (RR) per female vs. male was found to be 3.0 and the RR of OA vs. RA was 0.09. The mean average length of stay (ALOS) in the hospital decreased from 15 to just 5 days during this period. Additionally, the adjusted mean cost per patient increased significantly from ¥ 38261 ± 3630.63 to ¥ 53115.17 ± 2831.35. The majority of TKR recipients were over 60 years old with osteoarthritis being identified as the main causative agent. It is worth noting that women are more susceptible to knee arthritis and there is a concerning shift toward younger individuals being affected by this disease. Our results indicate a rise in in-hospital costs alongside a significant decline in hospital ALOS for TKR procedures. We predict an unprecedented rise in TKR incidence in the coming years due to population aging and improving economic conditions in China.

Keywords

Database, Medical Resources, Total Knee Replacement

*Hirose Shakya and Anjing Chen contributed equally to this study.
#Corresponding author.

1. Introduction

Osteoarthritis (OA) is a degenerative joint disease [1] and is the leading cause of long-term disability [2] [3] [4] resulting in progressive disorder of joint function. It is also recognized as the leading cause of disability and poor-quality life among elderly populations within developed countries [1].

Knee OA is prevalent particularly within East Asian countries [5]. with its occurrence increasing with age, especially among women. In adults over the age of 45, 6% to 13% of men are affected, whereas 7% to 19% of women are affected, demonstrating a 45% lower risk of incidence for men [6] [7]. The prevalence of OA is markedly higher among women than men and increases noticeably with age [8] [9]. Knee OA occurs in 12% of American adults 65 years old or elder, and in 13% of women and 10% of men 60 years old or older in the United States [10] [11] [12]. The prevalence of OA is 15% in women and 5.6% in men 60 years old or older in Beijing, China [13]. The current occurrence of OA among the elderly population in Taiwan region is about 37% of individuals over 50 years old. The demographic crisis of aging is spreading worldwide, including in China but a full view of the epidemiology has not been obtained. In China, few medical reports have investigated the trends in the prevalence of primary TKRs. We sought to estimate the incidence of TKR from 2010 to 2019 by demographics, incidence rates, lengths of stay, and medical expenses.

Total knee replacement (TKR) is a general surgical operation with a high success rate that improves the function and quality of life in patients with a disorder in the knee joint [14] [15]. The rate of TKR has been steadily increasing over the last 2 decades [16] [17]. It has consistently been demonstrated to provide long-lasting pain relief and substantial and sustained improvement in joint functioning and health-related quality of life [14] [18]-[23]. TKR does not typically reduce mortality, but the procedure results in marked improvements in health-related quality of life and functional status and is highly cost-effective [24] [25].

2. Materials and Methods

We obtained hospitalization records from the Joint Surgery Department at our hospital and utilized the data to identify all individuals who underwent primary total knee replacement (TKR) between 2010 and 2019. This study only included elective surgeries for individuals above 17 years of age. Procedures performed for the treatment of chronic or complicated diseases, unicompartmental arthroplasty, bilateral TKRs, revision TKR, medical complications requiring extended hospitalization, traffic accidents, and complex cases requiring additional procedures were excluded from the study. Cases where patients were accommodated in VIP wards that incurred additional hospital charges were also excluded. After analyzing detailed records of all hospital admissions, a total of 6770 TKR procedures were eligible for inclusion in the study.

The research variables included in this study comprised sex (male and fe-

male), and age distribution of TKR recipients with changes categorized into five groups: <50 years old, 50 - 59 years old, 60 - 69 years old, 70 - 79 years old, and ≥80 years old; primary diagnoses classified into three groups: osteoarthritis (OA), rheumatoid arthritis (RA), and Others (GA, OD, HA, etc); the average length of stay (ALOS); and unit cost associated with this operation.

Statistical Analysis

The disease patterns of medical resource utilization (in-hospital cost and length of hospital stay), are described by the number of cases or means with standard deviation. To compare the rates of TKR between co-variables, we calculated the TKR risk ratios of these variables (gender, age, age group, and primary diagnoses). One-way ANOVA was used for the determination of statistical significance in hospital cost and length of hospital stay in different years. A p-value < 0.01 was considered to indicate statistical significance. All the analyses were performed with SPSS software version 21.0 (SPSS, Chicago, IL).

3. Results

We examined the demographic characteristics and prevalence of key co-morbid conditions for patients who underwent TKR between 2010 and 2019. For simplicity, data are presented separately for each year. We examined changes in the mean number during each 10 years. All analyses were performed for primary TKR.

3.1. Demographic Trends

The baseline clinical characteristics of participants with TKR are shown in Table 1. In all, 6770 TKR surgeries were performed during the 10-year study period from 2010 to 2019.

Table 1. Case distribution of total knee replacement (TKR) from 2010 to 2019.

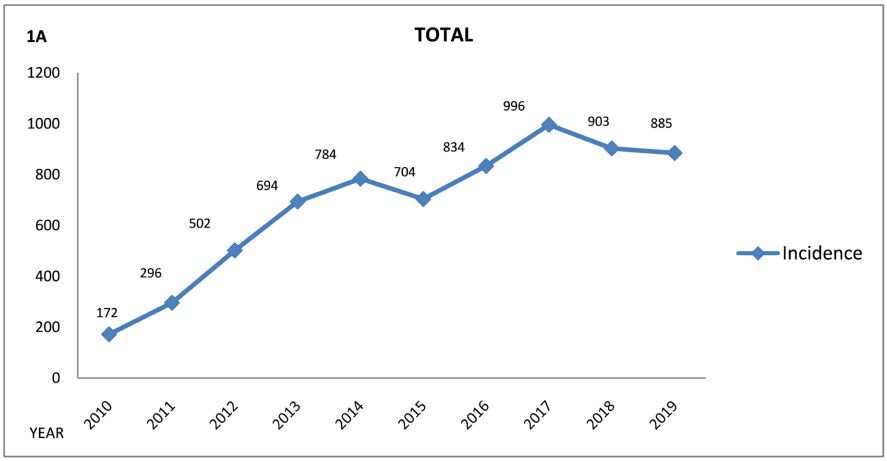
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
No. of Procedure	172	296	502	694	784	704	834	996	903	885
Gender										
Female	140 (81.39)	229 (77.36)	382 (76.09)	522 (75.21)	562 (71.68)	544 (77.27)	635 (76.13)	735 (73.79)	677 (74.97)	693 (78.30)
Male	32 (18.60)	67 (22.63)	120 (23.90)	172 (24.78)	222 (28.31)	160 (22.72)	199 (23.86)	261 (26.20)	226 (25.02)	192 (21.69)
Age	64.11±8.80	64.01±8.84	63.87±9.77	64.44±9.45	64.58±9.13	65.36±9.24	65.74±8.74	66.59±8.64	65.84±9.24	66.11±9.67
Age group										
<50	9 (5.23)	21 (7.09)	40 (7.96)	60 (8.64)	50 (6.37)	41 (5.82)	51 (6.11)	58 (5.82)	43 (4.76)	50 (5.64)
50-59	40 (23.25)	71 (23.98)	112 (22.31)	162 (23.34)	176 (22.44)	139 (19.74)	179 (21.46)	173 (17.36)	130 (14.39)	133 (15.02)
60-69	60 (34.88)	97 (32.77)	181 (36.05)	250 (36.02)	276 (35.2)	254 (36.07)	298 (35.73)	372 (37.34)	330 (36.54)	319 (36.04)
70-79	61 (35.46)	97 (32.77)	157 (31.27)	194 (27.95)	257 (32.78)	241 (34.23)	267 (32.01)	334 (33.53)	338 (37.43)	312 (35.25)
≥80	2 (1.162)	10 (3.37)	12 (2.39)	28 (4.03)	25 (3.18)	29 (4.11)	39 (4.67)	59 (5.92)	62 (6.86)	71 (8.02)

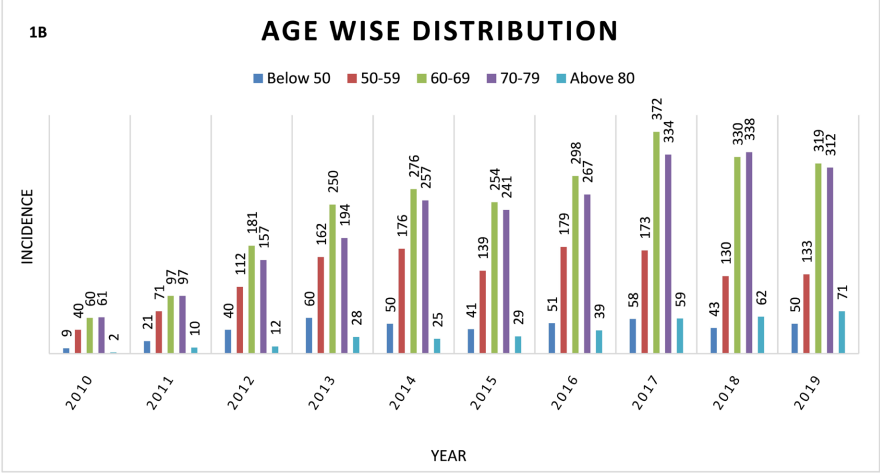
Note: Inside parenthesis indicate percentage.

The number of TKRs significantly increased from 172 in 2010 to 885 in 2019 (an increase of 514.53%). The highest incidence was seen in 2017 (Figure 1A). The increasing trend for the rate of TKR was seen in all age categories between 2010 and 2019, and the highest was distributed among the older age group of 60 - 69 followed by 70 - 79 years old. However, a large increase in the distribution of TKR was also observed in the 50 - 59 age group, whose incidence rate increased approximately 3.3 times. Rates of TKR in young people (<50) were also consistently greater in the present study (Figure 1B).

An increasing trend was observed in the total knee replacement (TKR) rate for both sexes over the 10-year study period. The incidence of TKR was significantly higher in women than in men across all age groups studied. Specifically, the incidence of TKR in men increased from 32 cases in 2010 to 192 cases in 2019 (Figure 2A), representing a six-fold increase. Similarly, the incidence of TKR in women increased by 4.9 times, rising from 140 cases to 693 cases during the same time frame (Figure 2B). The incidence rates of TKR stratified by sex are depicted in Figure 1C. Notably, individuals aged between 60 and 69 exhibited the highest incidence of TKR for both men and women.

Furthermore, there was a substantial increase in TKR among women aged ≥80 years; however, a similar pattern was not observed among men within this age





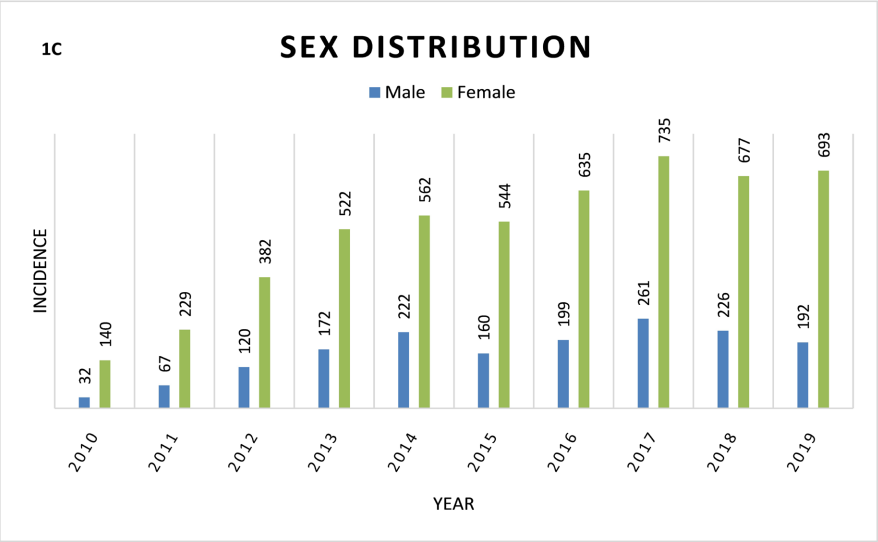
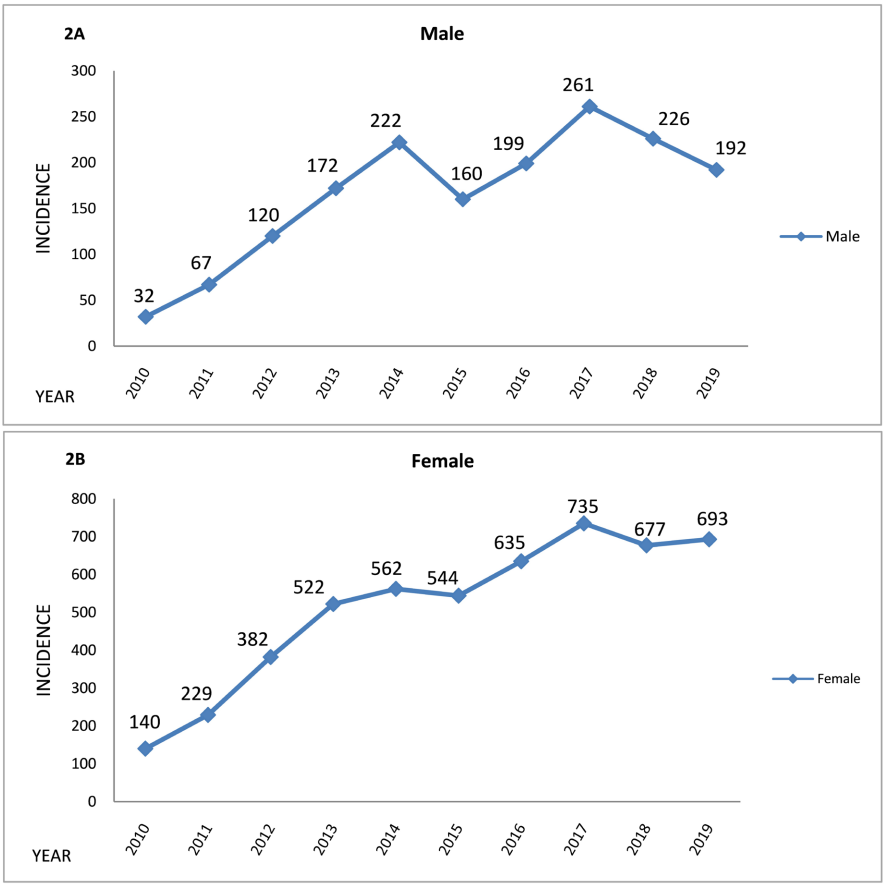
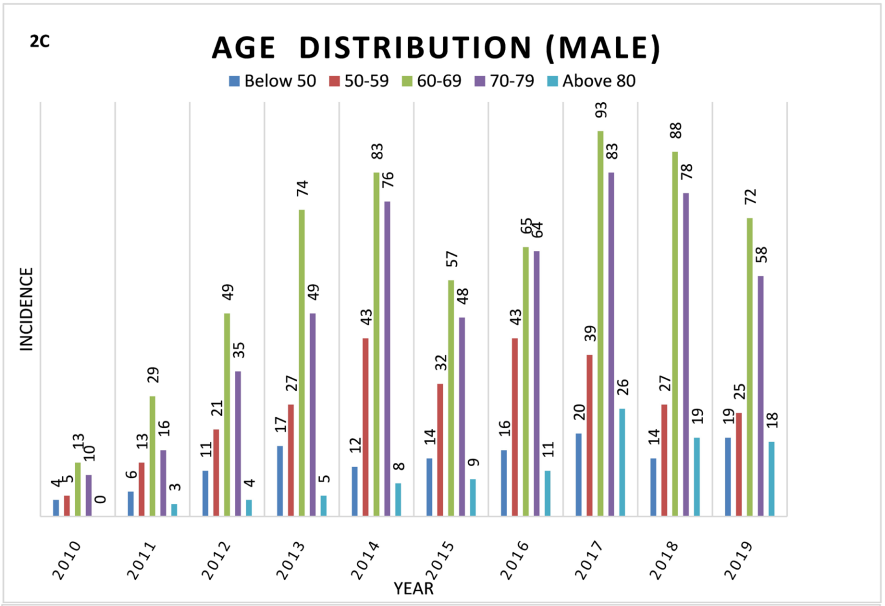
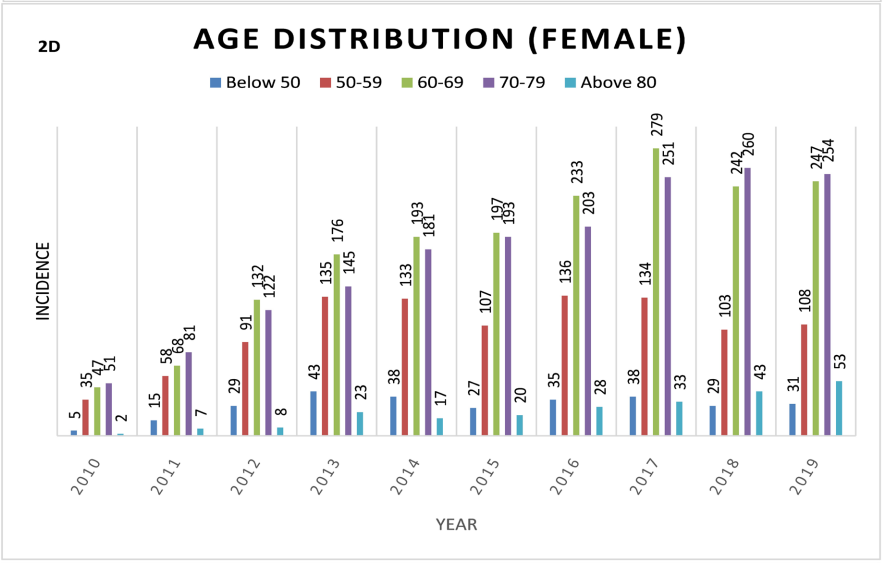
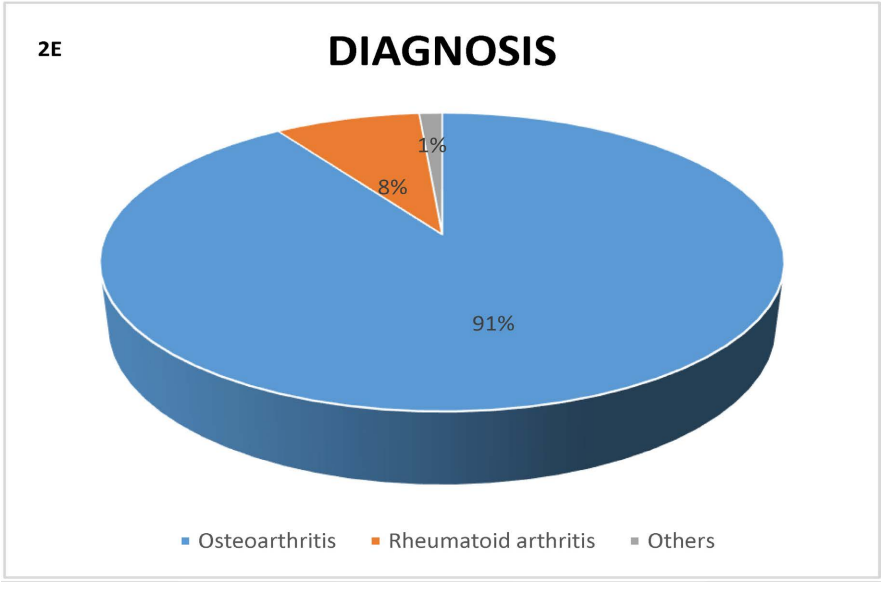


Figure 1. (A) Distribution of the incidence of rates of primary TKRs in 10 years. The number of TKRs significantly increased from 2010 to 2019 with the highest incidence in 2017. (B) The increasing trend for the rate of TKR was seen in all age categories between 2010 and 2019, and the highest was distributed among the older age group of 60 - 69 followed by 70 - 79 years old. However, a large increase in the distribution of TKR was also observed in the 50 - 59 age group. The rate of TKR in young people (<50) was also consistently greater in the present study. (C) Distribution of primary TKRs showed incidence rates were higher in females compared to males.




2C
AGE DISTRIBUTION (MALE)
Below 50
50-59
60-69
70-79
Above 80
INCIDENCE
YEAR
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019


2D
AGE DISTRIBUTION (FEMALE)
Below 50
50-59
60-69
70-79
Above 80
INCIDENCE
YEAR
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019


2E
DIAGNOSIS
1%
8%
91%
Osteoarthritis
Rheumatoid arthritis
Others

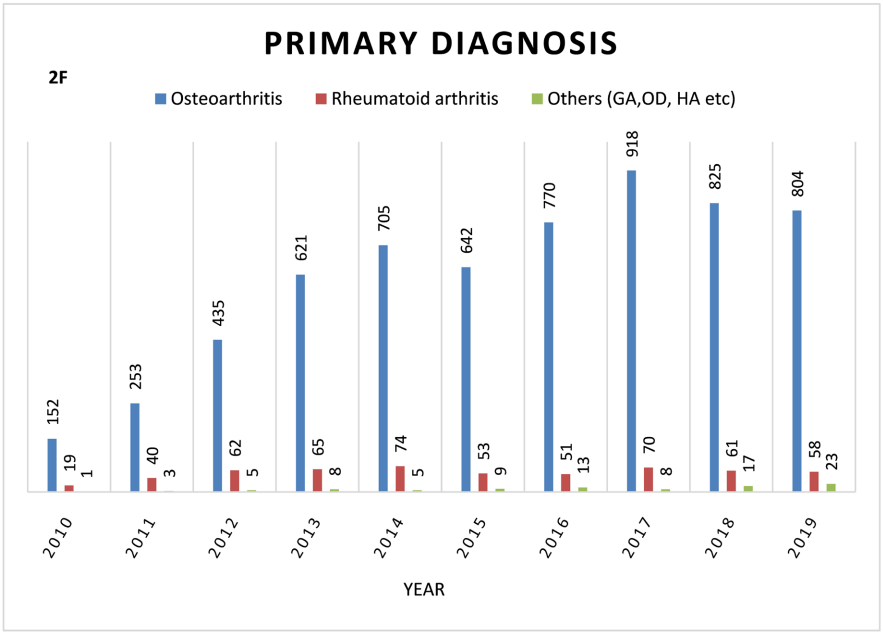


Figure 2. (A) Year-wise distribution of incidence in males and (B) in females. An increase in incidence was observed in both sexes with the highest incidence in 2017. (C) Age distribution concerning year in males and (D) in Females. The highest incidence was seen in the 60 - 69 age group in both sexes (E) Overall diagnosis of osteoarthritis and rheumatoid arthritis and (F) Primary diagnosis showed an increase in Osteoarthritis yearly basis.

group (Figure 2C and Figure 2D). Throughout the study period, it was found that the rate of TKR incidence among females was approximately three times that of males from 2010 to 2019. Additionally, the average age of patients undergoing TKR rose from 64.11 ± 8.80 years in 2010 to 66.11 ± 9.67 years in 2019-a gradual increase of about two years.

Furthermore, there was a substantial increase in TKR among women aged ≥80 years; however, a similar pattern was not observed among men within this age group (Figure 2C and Figure 2D). Throughout the study period, it was found that the rate of TKR incidence among females was approximately three times that of males from 2010 to 2019. Additionally, the average age of patients undergoing TKR rose from 64.11 ± 8.80 years in 2010 to 66.11 ± 9.67 years in 2019 -a gradual increase of about two years.

3.2. Trends in Medical Resources

Table 2 presents the gender-specific distribution of osteoarthritis incidence and changing trends related to basic characteristics and medical resources allocated to TKR procedures. The findings indicate that females had more than threefold higher susceptibility rates compared to males (81.39% vs. 18.60%, 71.68% vs. 28.31%, and 78.30% vs. 21.69%) respectively in 2010, 2014, and 2019 with 90 % of cases primarily diagnosed with osteoarthritis (Figure 2E). The rise in cost during hospital stays was also observed. However, the average length of stay was significantly reduced (15.1 4± 6.61 vs. 5.34 ± 2.4).

The primary diagnosis during the study period was OA, which ranged from 85.47% to 92.32% (Figure 2F). The average cost for individuals undergoing TKR increased from ¥38261 ± 3630.63 to ¥53115.17 ± 2831.35 (Figure 3A), representing a statistically significant increase of 38.82% with a p-value < 0.0001. Additionally, the ALOS for TKR notably declined from 15.14 to 5.34 days (Figure 3B), also showing statistical significance with a p-value < 0.0001.

3.3. Predictors for TKR

Table 3 shows the rate ratios of the risk factors for TKR. The rate ratio (RR) of TKR per female compared with males was 3:1. Compared to the < 50 age group,

Table 2. Distribution of medical resource usage in total knee replacement from 2010 to 2019.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
No of procedure	172	296	502	694	784	704	834	996	903	885
Gender										
Female	140 (81.39)	229 (77.36)	382 (76.09)	522 (75.21)	562 (71.68)	544 (77.27)	635 (76.13)	735 (73.79)	677 (74.97)	693 (78.30)
Male	32 (18.60)	67 (22.63)	120 (23.90)	172 (24.78)	222 (28.31)	160 (22.72)	199 (23.86)	261 (26.20)	226 (25.02)	192 (21.69)
Primary Diagnosis										
OA	152 (88.37)	253 (85.47)	435 (86.65)	621 (89.48)	705 (89.92)	642 (91.19)	770 (92.32)	918 (92.16)	825 (91.36)	804 (90.84)
RA	19 (11.04)	40 (13.51)	62 (12.35)	65 (9.36)	74 (9.43)	53 (7.52)	51 (6.11)	70 (7.02)	61 (6.75)	58 (6.55
Others (GA, OC, HA)	1 (0.58)	3 (1.01)	5 (0.99)	8 (1.15)	5 (0.63)	9 (1.27)	13 (1.55	8 (0.80)	17 (1.88)	23 (2.59)
Cost	38261.00 ± 3630.63	38830.96 ± 2590.97	40745.34 ± 3399.06	40948.49 ± 2689.65	40928.89 ± 2812.90	43057.97 ± 3836.57	49159.40 ± 3303.72	51297.57 ± 4035.13	52014.77 ± 2612.56	53115.27 ± 2831.35
ALOS	15.14 ± 6.61	13.60 ± 7.37	13.46 ± 5.91	12.12 ± 5.11	12.28 ± 5.03	11.62 ± 3.96	9.25 ± 3.24	8.49 ± 3.43	6.66 ± 2.82	5.34 ± 2.40

OA =osteoarthritis, RA = rheumatoid arthritis, GA= Gouty arthritis, OC= Osteochondritis dissecans, HA= Hemophilic arthritis, ALOS= average length of stay. Inside parenthesis indicate percentage.

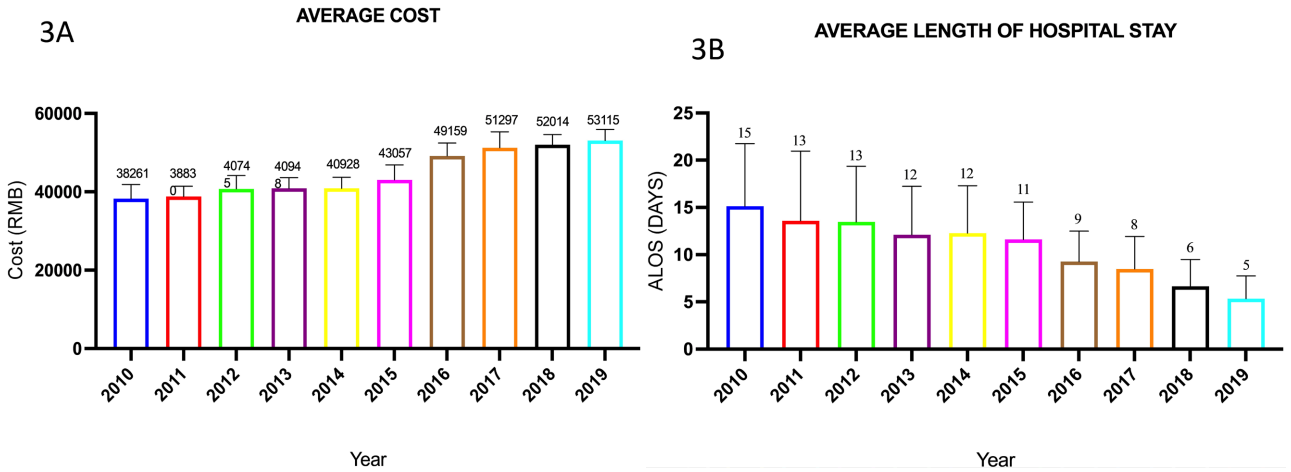


Figure 3. (A) Average cost of TKA from 2010 to 2019 indicated a rise in treatment cost (B) Average length of hospital stayshas significantly decreased for TKA pre-operative and post-operative.

the RR for TKR was 3:1 in the 50 to 59 age group, and increased to 5:7 in the 60 to 69 age group and then decreased slightly to5:33 inthe70to79agegroup; it was even lower at 0:79 in the ≥ 80agegroup. Patients with RA and Others (GA, OC, HA) as their primary diagnoses had a lower risk for TKR (RR = 0.090, RR = 0.015 respectively) than those with OA.

Table 3. Rate ratio of covariable for Primary total knee replacement rate.

	RR
Female*	3.1
<50**	-
50 - 59	3.1
60 - 69	5.7
70 - 79	5.33
≥80	0.79
OA***	-
RA	0.090
Others (GA, OC, HA)	0.015

*Female compared to males
**All age groups compared to < 50 age group
***RA and another disease (GA, OC, HA) compared to OA
OA = osteoarthritis, RA = rheumatoid arthritis, GA = Gouty arthritis, OC = Osteochondritis dissecans, HA=, Hemophilic arthritis, RR= Rate ratio)

4. Discussion

TKA has a remarkable history of clinical success in relieving pain and improving function for patients with arthritic knees [26]. TKA substantially improves quality-adjusted life expectancy for patients with arthritic knees, and TKAs are cost-effective in the United States across all risk groups [24] [27]. Available data suggest that approximately 600,000 TKA procedures are performed annually in the United States at a cost of approximately $15,000 per procedure [24] [26] [28].

Several studies have shown that the incidence of TKR has increased annually. Our study found that the rate of TKR robustly increased over the years 2010 to 2019, with a much larger increase observed among women compared to men. In 2010, only 172 individuals underwent primary TKR, which gradually increased to 885 in 2019. This represents an increase of 514.53% over 10 years. This upward trend is consistent with findings from studies conducted by Tien *et al.* and Kumar *et al.* [29] [30]. According to Tien's study, the prevalence of TKR was 22.86 per 100,000 persons in 1996 and it increased to 54.95 per 100,000 persons in 2004-a rate increase of 140.38%. Kumar's study showed that the prevalence rate of TKR was 28.5 per 100,000 persons in 1998 and increased to 56. 8 per 100,000 persons in 2009 an increase in the rate of 99.1% [29] [30]. The rise in

TKA can be seen as an indication of the success of this procedure in safely reducing pain and improving functional status for an aging population [31] [32]. However, the surge in TKA can also be viewed as yet another source of strain on government, insurers, individuals, and businesses struggling with unremitting growth in healthcare spending [33] [34] [35].

The age-adjusted total knee replacement (TKR) rate in Wisconsin, United States increased by 81.5% from 1990 to 2000, rising from 162 to 294 per 100,000 [16]. In Southern California, the primary TKR rate also saw a significant increase, rising from 6.3 per 10,000 in 1995 to 11.0 per 10,000 in 2004, representing a growth of 74.60% [36]. Ravi's study utilized databases from the Healthcare Cost and Utilization Project and the Institute for Clinical Evaluative Sciences to estimate the prevalence of total joint arthroplasty (TJA) for hip and knee in the United States and Ontario, Canada. The rates of total knee arthroplasty (TKA) increased by approximately 59% in the United States and 73% in Ontario between 2001 and 2007 [37]. The annual primary TKR volume increased 161.5% from 93,230 to 226,177 between 1991 and 2010 [38].

Furthermore, the annual volume of primary TKA surged by 161.5%, increasing from 93,230 to 226177 between 1991 and 2010. In Australia, an increase was observed as well with primary TKA for osteoarthritis jumping from 10132 in 1994 to 14472 in 1998, a rise of 42.8% [39]. Meanwhile, Korea experienced an astounding 407% increase in primary TKA rates from 2001 to 2010, based on data from the Health Insurance Review and Assessment Service of Korea [40]. Another prior study conducted in Taiwan region revealed an even more dramatic surge, in which the annual incidence rate skyrocketed by 202.59% during the time frame of 1996 to 2010. Policies addressing an aging population should include considerations for healthcare utilization of TKR and prevention of osteoarthritis [41].

Gender differences were evident when it came to TKR rates. Women exhibited higher rates due to a greater prevalence of osteoarthritis-related disability compared to me [42]. Our study found that women had a threefold higher rate of TKR than men, a finding consistent with previous studies [30] [31]. Hawker *et al.* also reported similar results, stating that the women's potential need for arthroplasty was three times greater than that of men [43]. Furthermore, TKR rates showed an upward trend with increasing patient age. Similar findings regarding gender-specific TKR studies have been reported in other countries. Many studies have indicated that knee osteoarthritis is more prevalent among women than men [44] [45] [46] [47]. In Sweden, the total knee replacement (TKR) rate is 1.93 times higher in women than in men. A similar gender gap in TKR rates has also been observed in the United States [16] [48]. This indicates that arthritis is a significant health concern for women, who are more likely than men to experience disability due to arthritis [43]. Numerous studies have demonstrated that joint arthroplasty is an effective and cost-efficient treatment for advanced arthritis of the hip and knee, providing pain relief and reducing

functional disability [49] [50] [51] [52].

The results of this study revealed higher TKR rates among individuals aged 60 to 69, which contrasts with findings from other Western and Asian countries where TKR rates were higher among those aged 70 to 79. This trend can be attributed to the increase in symptomatic osteoarthritis (OA) with advancing age [1] [30] [41] [53]. The average age of patients undergoing TKR has increased over time. Advances in the medical management of OA may lead patients to postpone joint replacement surgery, resulting in a gradual rise in the average age of TKR recipients [54]. Notably, there has been a significant increase in the number of procedures performed on younger patients (<50) in this study. This shift towards younger recipients is concerning as most evidence regarding outcomes following total knee arthroplasty (TKA) comes from studies focused on elderly patients. There are several potential explanations for the rising TKA rates among younger patients; our findings may indicate a genuine increase in the number of young individuals diagnosed with end-stage arthritis due to either increased incidence or improved surveillance efforts.

In the United States, the main diagnosis of TKR patients is OA (approximately 86% - 87%) [17] [29]. A study by Tien *et al.* in Taiwan Region noted that about 94% of TKR patients had OA from 2002 to 2004 [29]. Our study revealed that the majority of patients who underwent TKR procedures were diagnosed with OA, with 90.84% of them having OA in 2019. The close association between an aging society and the risk of OA has not been thoroughly investigated in epidemiologic studies on TKR utilization in the Chinese population over a long period [41].

We observed a rise in the mean cost per patient and a notable decline in the ALOS for TKR, from 15 days to 5 days. This reduction may be attributed to advances in medical technology and sciences [55]. In the United States, LOS decreased from 7.9 days (95% CI: 7.8 – 7.9) during 1991 - 1994 to 3.5 days (95% CI: 3.5 – 3.5) during 2007 - 2010 [38]. The finding of a decreasing trend in ALOS was consistent with results from other studies conducted in Taiwan Region [29] [56] [57] [58]. However, the ALOS for TKR in China was longer than that in the United States, indicating potential for improvement in TKR treatment.

The median charge for TKR procedures at hospitals increased from $19,309 to $29,509 (a factor of 1.53) between 1997 and 2004 in the United States [36] which aligns with our study's observation of rising costs as well - average hospital charges for TKR increased from ¥38,261 to ¥53,115.17 (an increase by ~39%). Previous studies have identified strong relationships between various clinical parameters and hospital charges [41] leading patients to seek hospitals with high surgical quantity and treatment from experienced surgeons when faced with increasing charges [59] [60]. Another possible reason for rising total medical expenditures is an aging population coupled with increased life expectancy [61].

A recent survey report by the Ministry of Health of the People's Republic of China showed the total number of joint arthroplasties performed annually is growing rapidly with a 19% increase per year reported between 2000 and 2006

[62]. Despite this dramatic increase, concerns exist as the high cost of surgical procedures and relatively low insurance reimbursement are significant barriers to gaining access to joint arthroplasty that likely contributed to some patients forging joint arthroplasty. This financial constraint may limit access to care and has potentially decreased the quality of life for patients with arthritis and their families, increased burden on society, increased societal costs to care for these individuals, and also led to a decrease in the productivity of the labor force in China. Furthermore, it may have also negatively impacted the advancement of medical services in China [63].

There are several limitations to the present study. This study retrospectively analyzes the cost of a single center. It is important to consider that costs may vary significantly between institutions, especially across different countries, for institutional costs, patient costs, and third-party payer costs (whether government or private insurance companies) for the same procedure. Additionally, it is crucial to note that the data from the single institution examined in this study may not be indicative of charges at other institutions in China; however, we believe it is representative of potential charges at other institutions.

5. Conclusion

Our findings indicate a substantial increase in the utilization of primary knee replacement with the majority of TKR recipients being >60 years old and osteoarthritis being the main cause. Women are more susceptible to knee arthritis owing to a major health problem. Furthermore, the demographics of joint replacement recipients shifted to younger people which is concerning. We also observed a significant decline in hospital LOS and increases in hospital costs. Likewise, this study provides an analysis of TKR in China, and the results may be used as a reference for future planning of resources for TKR. Further study may investigate the specific rehabilitation interventions and components following lower extremity joint replacement so that we can better understand the effect of different treatment modalities.

Patient Informed Consent

The study protocol received approval from the Institutional Review Board (IRB) of West China Medical Center, Sichuan University. Formal consent was not required for this type of study. All data were obtained from the National Health Database of China, which is hosted on a server at our institution. Our center was responsible for managing the database and ensuring data entry standardization and accuracy. This study included consecutive patients undergoing primary unilateral total knee arthroplasty (TKA) in our department from January 2010 to December 2019.

Funding

This research was supported by the National Natural Science Foundation of

China (No. 82172394 and U22A20280); the National Key Research and Development Program of China (No.2022YFC2503100 and2022YFC2503104); 1.3.5 project for disciplines of excellence, West China Hospital, Sichuan University (No. 2023HXFH012) and Tibet Autonomous Region Science and Technology Plant Joint Funding Projects (No. XZ202201ZY0041G). The funding sources had no role in manuscript conception, paper writing and design, data analysis interpretation, and publication.

Acknowledgment

The authors would like to express their appreciation to Mr. Hirdaya Ratna Shakya M.Sc. for his guidance and expert opinion regarding the improvement of this manuscript and Lang Li for his support.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Fransen, M., Bridgett, L., March, L., Hoy, D., Penserga, E. and Brooks, P. (2011) The Epidemiology of Osteoarthritis in Asia. *International Journal of Rheumatic Diseases*, **14**, 113-121. https://doi.org/10.1111/j.1756-185x.2011.01608.x

[2] Kramer, J.S., Yelin, E.H. and Epstein, W.V. (1983) Social and Economic Impacts of Four Musculoskeletal Conditions. *Arthritis & Rheumatism*, **26**, 901-907. https://doi.org/10.1002/art.1780260712

[3] Hadler, N.M. (1985) Osteoarthritis as a Public Health Problem. *Clinics in Rheumatic Diseases*, **11**, 175-185. https://doi.org/10.1016/s0307-742x(21)00538-5

[4] Badley, E.M., Rasooly, I. and Webster, G.K. (1994) Relative Importance of Musculoskeletal Disorders as a Cause of Chronic Health Problems, Disability, and Health care Utilization: Findings from the 1990 Ontario Health Survey. *The Journal of Rheumatology*, **21**, 505-514.

[5] Arden, N. and Nevitt, M. (2006) Osteoarthritis: Epidemiology. B*est Practice & Research Clinical Rheumatology*, **20**, 3-25. https://doi.org/10.1016/j.berh.2005.09.007

[6] Kao, M. and Tsai, Y. (2012) Living Experiences of Middle-Aged Adults with Early Knee Osteoarthritis in Prediagnostic Phase. *Disability and Rehabilitation*, **34**, 1827-1834. https://doi.org/10.3109/09638288.2012.665127

[7] Richmond, J., Hunter, D., Irrgang, J., Jones, M.H., Levy, B., Marx, R., *et al.* (2009) Treatment of Osteoarthritis of the Knee (Nonarthroplasty). *Journal of the American Academy of Orthopaedic Surgeons*, **17**, 591-600. https://doi.org/10.5435/00124635-200909000-00006

[8] Andrianakos, A.A., Kontelis, L.K., Karamitsos, D.G., Aslanidis, S.I., Georgountzos, A.I., Ka-ziolas, G.O., *et al.* (2006) Prevalence of Symptomatic Knee, Hand, and Hip Osteoarthritis in Greece: The ESORDIG Study. *The Journal of Rheumatology*, **33**, 2507-2513.

[9] Grotle, M., Hagen, K.B., Natvig, B., Dahl, F.A. and Kvien, T.K. (2008) Prevalence and Burden of Osteoarthritis: Results from a Population Survey in Norway. *The Journal of Rheumatology*, **35**, 677-684.

[10] Zhang, Y. and Jordan, J.M. (2010) Epidemiology of Osteoarthritis. *Clinics in Geriatric Medicine*, **26**, 355-369. https://doi.org/10.1016/j.cger.2010.03.001

[11] Kim, H.A., Kim, S., Seo, Y.I., Choi, H.J., Seong, S.C., Song, Y.W., *et al.* (2008) The Epidemiology of Total Knee Replacement in South Korea: National Registry Data. *Rheumatology*, **47**, 88-91. https://doi.org/10.1093/rheumatology/kem308

[12] Felson, D.T. and Zhang, Y. (1998) An Update on the Epidemiology of Knee and Hip Osteoarthritis with a View to Prevention. *Arthritis & Rheumatism*, **41**, 1343-1355. https://doi.org/10.1002/1529-0131(199808)41:8<1343::aid-art3>3.0.co;2-9

[13] Zhang, Y., Xu, L., Nevitt, M.C., Aliabadi, P., Yu, W., Qin, M., *et al.* (2001) Comparison of the Prevalence of Knee Osteoarthritis between the Elderly Chinese Population in Beijing and Whites in the United States: The Beijing Osteoarthritis Study. *Arthritis & Rheumatism*, **44**, 2065-2071. https://doi.org/10.1002/1529-0131(200109)44:9<2065::aid-art356>3.0.co;2-z

[14] Jones, C.A., Beaupre, L.A., Johnston, D.W.C. and Suarez-Almazor, M.E. (2007) Total Joint Arthroplasties: Current Concepts of Patient Outcomes after Surgery. *Rheumatic Disease Clinics of North America*, **33**, 71-86. https://doi.org/10.1016/j.rdc.2006.12.008

[15] Bourne, R.B., Chesworth, B.M., Davis, A.M., Mahomed, N.N. and Charron, K.D.J. (2010) Patient Satisfaction after Total Knee Arthroplasty: Who Is Satisfied and Who Is Not? *Clinical Orthopaedics & Related Research*, **468**, 57-63. https://doi.org/10.1007/s11999-009-1119-9

[16] Jain, N.B., Higgins, L.D., Ozumba, D., Guller, U., Cronin, M., Pietrobon, R., *et al.* (2005) Trends in Epidemiology of Knee Arthroplasty in the United States, 1990-2000. *Arthritis & Rheumatism*, **52**, 3928-3933. https://doi.org/10.1002/art.21420

[17] Medical Advisory Secretariat (2005) Total Knee Replacement: An Evidence-Based Analysis. *Ontario Health Technology Assessment Series*, **5**, 1-51.

[18] Ethgen, O., Bruyère, O., Richy, F., Dardennes, C. and Reginster, J. (2004) Health-Related Quality of Life in Total Hip and Total Knee Arthroplasty. *The Journal of Bone & Joint Surgery*, **86**, 963-974. https://doi.org/10.2106/00004623-200405000-00012

[19] Jandrić, S. and Manojlović, S. (2009) Quality of Life of Men and Women with Osteoarthritis of the Hip and Arthroplasty. *American Journal of Physical Medicine & Rehabilitation*, **88**, 328-335. https://doi.org/10.1097/phm.0b013e318194fa24

[20] Jones, C.A., Voaklander, D.C., Johnston, D.W. and Suarez-Almazor, M.E. (2000) Health Related Quality of Life Outcomes after Total Hip and Knee Arthroplasties in a Community Based Population. *The Journal of Rheumatology*, **27**, 1745-1752.

[21] Mariconda, M., Galasso, O., Costa, G.G., Recano, P. and Cerbasi, S. (2011) Quality of Life and Functionality after Total Hip Arthroplasty: A Long-Term Follow-Up Study. *BMC Musculoskeletal Disorders*, **12**, Article No. 222. https://doi.org/10.1186/1471-2474-12-222

[22] Montin, L., Leino-Kilpi, H., Suominen, T. and Lepistö, J. (2007) A Systematic Review of Empirical Studies between 1966 and 2005 of Patient Outcomes of Total Hip Arthroplasty and Related Factors. *Journal of Clinical Nursing*, **17**, 40-45. https://doi.org/10.1111/j.1365-2702.2007.01944.x

[23] Quintana, J.M., Escobar, A., Arostegui, I., Bilbao, A., Azkarate, J., Goenaga, J.I., *et al.* (2006) Health-Related Quality of Life and Appropriateness of Knee or Hip Joint Replacement. *Archives of Internal Medicine*, **166**, 220-226. https://doi.org/10.1001/archinte.166.2.220

[24] Losina, E., Walensky, R.P., Kessler, C.L., Emrani, P.S., Reichmann, W.M., Wright, E.A., *et al.* (2009) Cost-effectiveness of Total Knee Arthroplasty in the United States. *Archives of Internal Medicine*, **169**, 1113-1121. https://doi.org/10.1001/archinternmed.2009.136

[25] Krummenauer, F., Wolf, C., Günther, K. and Kirschner, S. (2009) Clinical Benefit and Cost Effectiveness of Total Knee Arthroplasty in the Older Patient. *European Journal of Medical Research*, **14**, Article No. 76. https://doi.org/10.1186/2047-783x-14-2-76

[26] Healy, W.L., Rana, A.J. and Iorio, R. (2011) Hospital Economics of Primary Total Knee Arthroplasty at a Teaching Hospital. *Clinical Orthopaedics & Related Research*, **469**, 87-94. https://doi.org/10.1007/s11999-010-1486-2

[27] Yao, L. (2009) Knee Replacements Are Determined to Be Cost Effective. *Wall Street Journal*, D1-D2.

[28] Kurtz, S., Mowat, F., Ong, K., Chan, N., Lau, E. and Halpern, M. (2005) Prevalence of Primary and Revision Total Hip and Knee Arthroplasty in the United States from 1990 through 2002. *The Journal of Bone and Joint Surgery*, **87**, 1487-1497. https://doi.org/10.2106/00004623-200507000-00010

[29] Tien, W., Kao, H., Tu, Y., Chiu, H., Lee, K. and Shi, H. (2008) A Population-Based Study of Prevalence and Hospital Charges in Total Hip and Knee Replacement. *International Orthopaedics*, **33**, 949-954. https://doi.org/10.1007/s00264-008-0612-1

[30] Kumar, A., Tsai, W., Tan, T., Kung, P., Chiu, L. and Ku, M. (2015) Temporal Trends in Primary and Revision Total Knee and Hip Replacement in Taiwan Region. *Journal of the Chinese Medical Association*, **78**, 538-544. https://doi.org/10.1016/j.jcma.2015.06.005

[31] Cram, P., Vaughan-Sarrazin, M.S., Wolf, B., Katz, J.N. and Rosenthal, G.E. (2007) A Comparison of Total Hip and Knee Replacement in Specialty and General Hospitals. *The Journal of Bone & Joint Surgery*, **89**, 1675-1684. https://doi.org/10.2106/jbjs.f.00873

[32] Manley, M., Ong, K., Lau, E. and Kurtz, S.M. (2009) Total Knee Arthroplasty Survivorship in the United States Medicare Population. *The Journal of Arthroplasty*, **24**, 1061-1067. https://doi.org/10.1016/j.arth.2008.06.011

[33] Chernew, M., Goldman, D. and Axeen, S. (2011) How Much Savings Can We Wring from Medicare? *New England Journal of Medicine*, **365**, e29. https://doi.org/10.1056/nejmp1110593

[34] Baicker, K. and Chernew, M.E. (2011) The Economics of Financing Medicare. *New England Journal of Medicine*, **365**, e7. https://doi.org/10.1056/nejmp1107671

[35] Smith-Bindman, R., Miglioretti, D.L. and Larson, E.B. (2008) Rising Use of Diagnostic Medical Imaging in a Large Integrated Health System. *Health Affairs*, **27**, 1491-1502. https://doi.org/10.1377/hlthaff.27.6.1491

[36] Khatod, M., Inacio, M., Paxton, E.W., Bini, S.A., Namba, R.S., Burchette, R.J., *et al.* (2008) Knee Replacement: Epidemiology, Outcomes, and Trends in Southern California 17,080 Replacements from 1995 through 2004. *Acta Orthopaedica*, **79**, 812-819. https://doi.org/10.1080/17453670810016902

[37] Ravi, B., Croxford, R., Reichmann, W.M., Losina, E., Katz, J.N. and Hawker, G.A. (2012) The Changing Demographics of Total Joint Arthroplasty Recipients in the United States and Ontario from 2001 to 2007. *Best Practice & Research Clinical Rheumatology*, **26**, 637-647. https://doi.org/10.1016/j.berh.2012.07.014

[38] Cram, P., Lu, X., Kates, S.L., Singh, J.A., Li, Y. and Wolf, B.R. (2012) Total Knee

Arthroplasty Volume, Utilization, and Outcomes among Medicare Beneficiaries, 1991-2010. *JAMA*, **308**, 1227-1236. https://doi.org/10.1001/2012.jama.11153

[39] Wells, V.M., Hearn, T.C., McCaul, K.A., Anderton, S.M., Wigg, A.E.R. and Graves, S.E. (2002) Changing Incidence of Primary Total Hip Arthroplasty and Total Knee Arthroplasty for Primary Osteoarthritis. *The Journal of Arthroplasty*, **17**, 267-273. https://doi.org/10.1054/arth.2002.30414

[40] Koh, I.J., Kim, T.K., Chang, C.B., Cho, H.J. and In, Y. (2013) Trends in Use of Total Knee Arthroplasty in Korea from 2001 to 2010. *Clinical Orthopaedics & Related Research*, **471**, 1441-1450. https://doi.org/10.1007/s11999-012-2622-y

[41] Lin, F., Chen, H., Lin, C., Chiu, Y., Lee, H., Chang, H., *et al.* (2018) The Increase in Total Knee Replacement Surgery in Taiwan Region. *Medicine*, **97**, e11749. https://doi.org/10.1097/md.0000000000011749

[42] Lakkireddy, M., Kiran Kumar, K.K., Karra, M., Palthi, S. and Patnala, C. (2018) Analysis of Total Knee Replacements in a South Indian Institute. *International Journal of Research in Orthopaedics*, **4**, 187-192. https://doi.org/10.18203/issn.2455-4510.intjresorthop20180046

[43] Hawker, G.A., Wright, J.G., Coyte, P.C., Williams, J.I., Harvey, B., Glazier, R., *et al.* (2000) Differences between Men and Women in the Rate of Use of Hip and Knee Arthroplasty. *New England Journal of Medicine*, **342**, 1016-1022. https://doi.org/10.1056/nejm200004063421405

[44] Lawrence, J.S., Bremner, J.M. and Bier, F. (1966) Osteo-Arthrosis: Prevalence in the Population and Relationship between Symptoms and *X*-Ray Changes. *Annals of the Rheumatic Diseases*, **25**, 1-24. https://doi.org/10.1136/ard.25.1.1

[45] Felson, D.T., Naimark, A., Anderson, J., Kazis, L., Castelli, W. and Meenan, R.F. (1987) The Prevalence of Knee Osteoarthritis in the Elderly: The Framingham Osteoarthritis Study. *Arthritis & Rheumatism*, **30**, 914-918. https://doi.org/10.1002/art.1780300811

[46] Anderson, J.J. and Felson, D.T. (1988) Factors Associated with Osteoarthritis of the Knee in the First National Health And Nutrition Examination Survey (Hanes I). *American Journal of Epidemiology*, **128**, 179-189. https://doi.org/10.1093/oxfordjournals.aje.a114939

[47] van Saase, J.L., van Romunde, L.K., Cats, A., Vandenbroucke, J.P. and Valkenburg, H.A. (1989) Epidemiology of Osteoarthritis: Zoetermeer Survey. Comparison of Radiological Osteoarthritis in a Dutch Population with That in 10 Other Populations. *Annals of the Rheumatic Diseases*, **48**, 271-280. https://doi.org/10.1136/ard.48.4.271

[48] Robertsson, O., Dunbar, M.J., Knutson, K. and Lidgren, L. (2000) Past Incidence and Future Demand for Knee Arthroplasty in Sweden: A Report from the Swedish Knee Arthroplasty Register Regarding the Effect of Past and Future Population Changes on the Number of Arthroplasties Performed. *Acta Orthopaedica Scandinavica*, **71**, 376-380. https://doi.org/10.1080/000164700317393376

[49] Hawker, G., Wright, J., Coyte, P., Paul, J., Dittus, R., Croxford, R., *et al.* (1998) Health-Related Quality of Life after Knee Replacement. *The Journal of Bone and Joint Surgery*, **80**, 163-173. https://doi.org/10.2106/00004623-199802000-00003

[50] Chang, R.W. (1996) A Cost-Effectiveness Analysis of Total Hip Arthroplasty for Osteoarthritis of the Hip. *JAMA*: *The Journal of the American Medical Association*, **275**, 858-865. https://doi.org/10.1001/jama.1996.03530350040032

[51] Bunker, J.P., Frazier, H.S. and Mosteller, F. (1994) Improving Health: Measuring Effects of Medical Care. *The Milbank Quarterly*, **72**, 225-258.

https://doi.org/10.2307/3350295

[52] Liang, M.H., Cullen, K.E., Larson, M.G., Thompson, M.S., Schwartz, J.A., Fossel, A.H., *et al.* (1986) Cost-effectiveness of Total Joint Arthroplasty in Osteoarthritis. *Arthritis & Rheumatism*, **29**, 937-943. https://doi.org/10.1002/art.1780290801

[53] Jordan, J.M., Helmick, C.G., Renner, J.B., Luta, G., Dragomir, A.D., Woodard, J., *et al.* (2007) Prevalence of Knee Symptoms and Radiographic and Symptomatic Knee Osteoarthritis in African Americans and Caucasians: The Johnston County Osteoarthritis Project. *The Journal of Rheumatology*, **34**, 172-180.

[54] Lin, H.C., Kuo, N.W., Yang, C.M. and Hsu, Y.H. (2002) Identifying Quality Dimensions for Quality Assurance under the Case Payment System in Taiwan Region. *New Taipei Journal of Medicine*, **4**, 34-43.

[55] Barry, M.C., Mackle, T., Joyce, L., Kelly, C., McGrath, F., Bouchier-Hayes, D., *et al.* (2003) Endoluminal Graft Stenting of Peripheral Aneurysms: Questionable Results Compared with Conventional Surgery. *The Surgeon*, **1**, 42-44. https://doi.org/10.1016/s1479-666x(03)80008-2

[56] Chang, C.C. and Hung, W.F. (2001) Impact of NHI Payment on Medical Utilization of Total Hip Replacement and Total Knee Replacement. *Taiwan Journal of Public Health*, **20**, 440-450.

[57] Healy, W.L. and Iorio, R. (2007) Implant Selection and Cost for Total Joint Arthroplasty. *Clinical Orthopaedics & Related Research*, **457**, 57-63. https://doi.org/10.1097/blo.0b013e31803372e0

[58] Mitsuyasu, S., Hagihara, A., Horiguchi, H. and Nobutomo, K. (2006) Relationship between Total Arthroplasty Case Volume and Patient Outcome in an Acute Care Payment System in Japan. *The Journal of Arthroplasty*, **21**, 656-663. https://doi.org/10.1016/j.arth.2005.09.007

[59] Ilfeld, B.M., Mariano, E.R., Williams, B.A., Woodard, J.N. and Macario, A. (2007) Hospitalization Costs of Total Knee Arthroplasty with a Continuous Femoral Nerve Block Provided Only in the Hospital versus on an Ambulatory Basis. *Regional Anesthesia and Pain Medicine*, **32**, 46-54. https://doi.org/10.1097/00115550-200701000-00009

[60] Gonano, C., Leitgeb, U., Sitzwohl, C., Ihra, G., Weinstabl, C. and Kettner, S.C. (2006) Spinal versus General Anesthesia for Orthopedic Surgery: Anesthesia Drug and Supply Costs. *Anesthesia & Analgesia*, **102**, 524-529. https://doi.org/10.1213/01.ane.0000194292.81614.c6

[61] Haralson, R.H. (2009) Prevalence, Health Care Expenditures, and Orthopedic Surgery Workforce for Musculoskeletal Conditions. *JAMA*, **302**, 1586-1587. https://doi.org/10.1001/jama.2009.1489

[62] Zang, J. and Qin, S. (2021) The Analysis Report of Surgical Treatment of Limb Deformity and Disability: 35,075 Cases. *Genij Ortopedii*, **27**, 331-336. https://doi.org/10.18019/1028-4427-2021-27-3-331-336

[63] Zhang, Y., Zhang, H., Clarke, H.D. and Hattrup, S.J. (2012) Analysis of Total Joint Arthroplasty Costs in Chinese Patients. *The Journal of Arthroplasty*, **27**, 1423-1428.E1. https://doi.org/10.1016/j.arth.2012.01.014