Journal of ISAKOS 7 (2022) 118–131

Contents lists available at ScienceDirect

Journal of ISAKOS

journal homepage: www.elsevier.com/locate/jisakos

State of the Art Review

Knee registries: state of the art

Eran Beit Ner [1,2], Norimasa Nakamura [3,4], Christian Lattermann [5], Michael James McNicholas [6,7,*]

[1] Department of Trauma and Orthopaedic Surgery, Manchester University NHS Foundation Trust, Manchester, UK
[2] Department of Orthopedic Surgery, Yitzhak Shamir Medical Center (Assaf Harofeh), affiliated to the Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel, Zerifin, Israel
[3] Global Center of Medical Engineering and Informatics, Osaka University, Osaka, Japan
[4] Orthopaedic Surgery, Osaka University Graduate School of Medicine, Osaka, Japan
[5] Department of Orthopaedic Surgery MassGeneralBrigham (MGB), Brigham and Women's Distinguished Chair in Orthopaedic Surgery Chief: Division of Sports Medicine Director: Cartilage Repair Center Brigham and Women's Hospital Harvard Medical School, Chestnut Hill, Massachusetts, USA
[6] Trauma and Orthopaedics, Liverpool University Hospitals NHS Foundation Trust, Liverpool, UK
[7] Division of Cell Matrix Biology and Regenerative Medicine, Faculty of Biology, Medicine and Health, School of Biological Sciences, The University of Manchester, Manchester, UK

ARTICLE INFO

Keywords:
knee injuries
anterior cruciate ligament
arthroplasty
replacement
patient outcome assessment
osteotomy
articular cartilage restoration
registry
post marketing surveillance

ABSTRACT

Sports injuries, trauma and the globally ageing and obese population require increasing levels of knee surgery. Shared decision making has replaced the paternalistic approach to patient management. Evidence-based medicine underpins surgical treatment strategies, from consenting an individual patient to national healthcare system design. The evolution of successful knee-related registries starting from specific arthroplasty registries has given rise to ligament reconstruction, osteotomy and cartilage surgery registries developing as platforms for surgical outcome data collection. Stakeholders include surgeons and their patients, researchers, healthcare systems, as well as the funding insurers and governments. Lately, implant manufacturers have also been mandated to perform postmarket surveillance with some hoping to base that on registry data.

Aiming to assess the current status of knee-related registries, we performed a comprehensive literature and web search, which yielded 23 arthroplasty, 8 ligament, 4 osteotomy and 3 articular cartilage registries. Registries were evaluated for their scope, measured variables, impact and limitations.

Registries have many advantages as they aim to increase awareness of outcomes; identify trends in practice over time, early failing implants, outlier surgeon or institution performance; and assist postmarketing surveillance. International collaborations have highlighted variations in practice. The limitations of registries are discussed in detail. Inconsistencies are found in collected data and measured variables. Potential measurement and selection biases are outlined. Without mandated data collection and with apparent issues such as unverified patient reporting of complications, registries are not designed to replace adverse event recording in place of a proper safety and efficacy study, as demanded by regulators. Registry 'big data' can provide evidence of associations of problems. However, registries cannot provide evidence of causation.

Hence, without careful consideration of the data and its limitations, registry data are at risk of incorrectly drawn conclusions and the potential of misuse of the results. That must be guarded against.

Looking at the future, registry operators benefit from a collective experience of running registries as they mature, allowing for improvements across specialties. Large-scale registries are not only of merit, improving with stakeholder acceptance, but also are critical in furthering our understanding of our patients' outcomes. In doing so, they are a critical element for our future scientific discourse.

Introduction

Patient registries have proven themselves as an important tool for observational studies. The use of registries enables physicians, researchers and pharmaceutical and implant manufacturers to assess patient, drug and medical devices-related information.[1] Registries have

* Correspondence to Michael James McNicholas, Trauma and Orthopaedics, Liverpool University Hospitals NHS Foundation Trust, Liverpool L14 3LB, UK.
E-mail address: mike.mcnicholas@liverpoolft.nhs.uk (M.J. McNicholas).

https://doi.org/10.1136/jisakos-2021-000625
Received 6 February 2021; Accepted 10 June 2021
Available online 9 February 2022

several advantages over other study designs, namely, their large size, real-world data appeal and potential for long-term follow-up. In addition, they allow for critical analyses such as clinical/cost-effectiveness assessment, evaluation of failing implants and thus, postmarket surveillance of implants and techniques, which has increasingly been mandated in our field.[2]

The first orthopaedic registries were hospital-based or regional-based databases. The Leeds Bone Tumour Registry was the earliest published database found in our search of the literature, established in 1958.[3] The first national scale registry was the Swedish Knee Arthroplasty Register (SKAR), which was founded in 1975.[4] Their goal was to evaluate the revision outcomes of knee arthroplasties. Following the realisation of the opportunity and further improvements in the process, many countries and organisations have created new registries, not only for joint arthroplasty but also for other techniques (anterior cruciate ligament reconstruction (ACLR)) or other anatomical sites (spine, shoulder, foot and ankle). These registries help to contribute to better assessment of surgical procedures, patient selection, implant design and economic data.

While registries aim to increase awareness for the importance of outcomes, they are particularly powerful tools to identify outliers and trends in practice over time. They support evidence-based practice and enable some elements of monitoring postmarketing surveillance. Thus, registries are powerful tools to help patients, clinicians, health systems and commercial manufacturers in their diagnostic and treatment-related decision-making processes. Moreover, registries can also serve as the historical control of new products and interventions as alternative to randomised controlled trials (RCTs).

However, registries have recognised weaknesses too. While registry data are effective at identifying trends, registry studies are observational studies with inherent limitations. First, registries may take several years to reach high enough enrolment numbers to give representative results. This might lead to early unreliable reports with both false-positive and false-negative associations. Second, registry-based studies evaluate associations and not causation. Hence, they 'point the finger to a problem' but do not explain the exact reason why a problem happens. The identification of trends should trigger relevant hypotheses that then should be tested.

Despite their limitations, registries allow for the collection and interpretation of valuable epidemiological, demographic, economic and outcome measures related data characterising different aspects of surgical or non-surgical treatment.

The importance of registries has been widely accepted in the last couple of decades as it has been recognised that it serves patients, healthcare professionals, commercial manufacturers and government/national authorities. However, despite the potential advantages, establishing a successful registry is not an easy task, and many issues should be taken into consideration when planning the structure of the database. According to Kolling *et al*,[5] a successful registry should be measured by several key factors which include the way it is organised (funding, maintenance, methods of data collection, etc); documentation (which is measured by a validated scoring system and completeness of more than 90% of the target population data); and data handling and the scientific output of a register (both publications and periodic reports). Although their report was aimed to assess national arthroplasty registries, their key points are also pertinent to other registries.

The objective of this paper was to review the current status of knee-related registries, discuss their scope, measured variables, impact and limitations. We focused on knee arthroplasty, ligament, osteotomy and cartilage injury registries.

Methods

The membership list of the International Society of Arthroplasty Registries[6] and the Network of Orthopaedic Registries of Europe (standing committee of the EFORT[7]) were reviewed in order to identify the most influential knee arthroplasty registries. Ligament, osteotomy and cartilage registries were identified using web searching using the key words "knee", "registry or registries", "ligament or ACL"; "osteotomy or osteotomies"; "cartilage or chondral". These were validated through a search on PubMed, Embase, Web of Science and the Cochrane Library databases (figure 1). Inactive registries were excluded from this review. Each registry was evaluated using its annual report, official websites and publications in peer-reviewed journals (table 1). Several variables were extracted to assess the structure of the registry, its maturity as a functional registry and its potential impact. These variables are summarised in tables 2–9. PubMed, Embase, Web of Science and the Cochrane Library databases were also reviewed to identify publications which demonstrate the use and impact of these registries.

Data from each included registry were extracted and organised in tables according to the registry focus—arthroplasty, ligament, osteotomy and cartilage. Extracted data included name of registry, catchment area (national, regional and global), date established, number of pathways for specified indications for primary and revision surgeries according to registry focus (eg, implant type/fixation for arthroplasty registries, graft type for ACLR, and lesion size and location for cartilage injuries). Furthermore, the most recently published reports were reviewed for availability of measured variables. Where an official report was unavailable or when the report was written in a language other than English, peer-reviewed publications were analysed. These variables include demographics (gender, age and Body Mass Index (BMI)), surgical outcomes and complications, patient-reported outcome measures (PROMs), use of prophylactic antibiotics and thromboprophylaxis. The complete lists of these findings are presented in tables 6–9.

Knee arthroplasty registries

The first national knee arthroplasty registry was established in Sweden in 1975. The other Scandinavian countries developed theirs during the 1980s and 1990s. There are many national knee arthroplasty registries, 10 of which met our inclusion criteria and are evaluated in this paper. Most registries allow open access to their annual reports. However, some reports are only available for local physicians (including the Scandinavian registries), and evaluation of their data was made possible as they are included in peer-reviewed publications.

Some hospital-based and regional registries were used as the foundations for later established national registries. The Geneva Arthroplasty Registry is a good example for this process.[1] Besides its participation in the Swiss Arthroplasty Registry, it continues to operate as a stand-alone registry with many variables which were not included in most of the national registries. These include additional patient information such as comorbidities and patient activity.

Except for the Scottish and Romanian national registries, all registries recorded implant design/model and method of fixation (cemented, cementless or hybrid). The indication for revision surgery was well documented in most registries. A comparison between the recording of other variables is detailed in tables 2 and 6. One important finding is the inconsistency in PROM assessment. The majority of registries did not record PROMs and used revision as the endpoint. The registries which did are summarised in table 6. This is also true for recording of prophylactic antibiotic administration and thrombosis prophylaxis use. However, lacking PROMs in their last available reports, some registries reported that they have started or will start collection of PROMs in the near future (ie, the Norwegian, Canadian, New Zealand and Australian registries).

Patient-related factors such as age and sex were recorded in all reviewed registries. BMI was recorded in most registries. However, other variables such as socioeconomic status, comorbidities, medical complications, and perioperative adjuvant treatment such as antibiotics and thromboprophylaxis use were documented inconsistently. Regarding the latter two issues, we found the Portuguese registry to be unique among national registries because of its recording of many important variables which are more characteristic of smaller regional/hospital registries. It

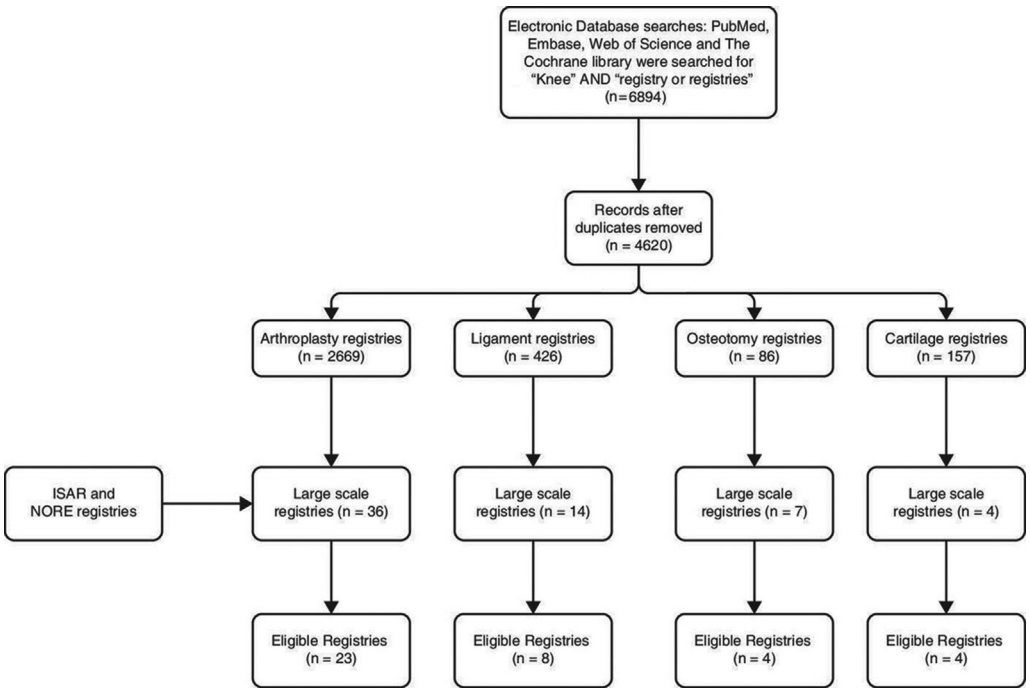

Figure 1. Literature search process. ISAR, International Society of Arthroplasty Registries; NORE, Network of Orthopaedic Registries of Europe.

Table 1
Summary of literature search results: number of publications by topic

	Knee registries	Knee arthroplasty registries	Knee ligament registries	Knee osteotomy registries	Cartilage injury registries
PubMed	2138	1434	245	41	105
Embase	2434	1232	231	53	78
Web of Science	1940	1288	268	46	79
The Cochrane Library	382	130	33	8	13
Before removal of duplications	6894	4084	777	148	275
After removal of duplications	4620	2669	426	86	157

collects comorbidities, level of primary surgeon and assistant, surgical approach, patella intervention, general and regional anaesthesia details, financial coverage and more.

Ligament registries

Ligament registries are younger than arthroplasty registries. The first recorded ligament registry was the Multicenter Orthopaedic Outcomes Network in 2002. The Scandinavian registries followed in 2004–2005. Currently published postoperative follow-up times are between 1 and 3 years. Some registries declare the intention of continuing follow-up until 10 years postoperatively. As of yet, the Swedish Ligament Registry is the only registry to achieve this goal. The extracted data are summarised in tables 3 and 7.

All the reviewed registries and studies recorded data on concomitant injuries. Ligament registries in general assess PROMs, an improvement from many of the arthroplasty registries, but there is no uniformity in the PROMs chosen. As with the arthroplasty registries, inconsistencies exist with regard to perioperatively and intraoperatively collected data. While several registries report postoperative radiological assessment, none of the registries require documentation of the tunnel position at both the femoral and tibial sides. Such documentation can improve the registry's data quality, as malposition is known to be a critical determinant of postoperative laxity.[8]

In general, data on healthcare use or healthcare costs are lacking.

A unique feature reporting a stated termination plan after 10 years of follow-up for its registry duration has been a design feature of the Multi-Centre ACL Revision Study[9] that ended its recruitment process in 2011.

Knee osteotomy registries

There has been a recent resurgence in interest in this procedure particularly for younger osteoarthritic (OA) patients' treatment. Purely osteotomy-focused registries have been developed during the past decade, with some of them still in their early stages of development. This manifests in limited reports and relatively low numbers of registry-based publications in peer-reviewed journals. The Finnish National Hospital Discharge Register (FNHDR) is one of the oldest registries, starting data collection in 1956 and achieving nationwide coverage in 1967.[10] In 2012, Niinimäki *et al* described osteotomy surgery records in his registry, although a registry that was not osteotomy focused. Nevertheless, they identified a total of 6004 osteotomies (5734 patients) between the years 1987 and 2008.[11] In 2013, The SKAR used its well-established platform and prospectively started collecting data from patients who underwent a knee osteotomy. Their first report was published in 2014,[12] and their most recent report which summarised 2018, reported 163 new records, reaching a total record of over 934 (despite the 2016 annual report being unavailable for analysis). Their report includes comprehensive data of patient characteristics, including prior knee surgeries, indication for surgery and perioperative data, including approach, type of fixation, type of anaesthesia, operating time and prophylactic treatments (tables 4 and 8). In 2014, the UK established a separate registry for osteotomies—the UK Knee Osteotomy Registry (UKKOR).[13] This is the largest

Table 2
Arthroplasty registry general information: name, type, year established, number of primary and revision total knee arthroplasties, implant type, fixation type, indication for revision and link to website/publication/annual report

Register/country	Type (national/ hospital/ regional)	Year established/ year of first reported case	Primary knee arthroplasties (n)	Implant type	Fixation type	Revision/ reoperation knee arthroplasties (n)	Indication for revision
Swedish Knee Arthroplasty Register[55]	National	1975	302 607 (2019)	✓	✓	28 164 (2019)	N/A
Finnish Arthroplasty Register[56]	National	1980	217 406 (March 2020)	✓	✓	18 097 (March 2020)	N/A
Norwegian Arthroplasty Register[57]	National	1987	97 022 (2018)	✓	✓	648 (2018)	✓
Geneva Arthroplasty Register[1]	Hospital	1996	4202 (2016)	✓	✓	355 (2016)	✓
Danish Knee Arthroplasty Register[58]	National	1997	104 476 (2015)	✓	✓	12 372 (2015)	✓
Australian Orthopaedic Association National Joint Replacement Registry[59]	National	1999	719 601 (2019)	✓	✓	62 999 (2019)	✓
New Zealand Joint Registry[60]	National	1999	110 678 (2019)	✓	✓	8647 (2019)	✓
The Scottish Arthroplasty Project[61]	Regional	1999, data available since 2001	Over 67 600 (2019)	N/A	N/A	Over 4230 (2019)	✓
Register of Orthopaedic Prosthetic Implants−RIPO Emilia Romagna[62]	Regional	2000	94 840 (2018)	✓	✓	8019 (2018)	✓
Romanian Arthroplasty Register[63]	National	2001	37 254 (2020)	N/A	N/A	1186 (2020)	N/A
The Canadian Joint Replacement Registry[64]	National	2001	70 502 in 2018 alone	Only general groups	✓	4889 in 2018 alone	✓
Kaiser Permanente National Implant Registry[65]	Multiregional registry	2001	21 104 in 2018 alone	✓	✓	1138 in 2018 alone	✓
The National Joint Registry for England, Wales, Northern Ireland, and Isle of Man and the Royal College of Surgeons of England[66]	National	2002	1 193 830 (2019)	✓	✓	517 099 (2019)	✓
Valdoltra Hospital Arthroplasty Register[67]	Hospital registry*	2002	10 703 (2019)	✓	✓	870 (2019)	✓
Catalan Arthroplasty Register[68]	Regional	2005	60 192 (2014)	✓	✓	6689 (2014)	✓
The Italian Arthroplasty Registry[69]	Multiregional registry	2006	65 259 (2017)	✓	✓	4846 (2017)	✓
Dutch Arthroplasty Register[70]	National	2007	206 362 (2010–2019)	✓	✓	21 729 (2010–2019)	✓
Belgian National Arthroplasty Register[71]	National	2009	28 642 (2015)	✓	✓	733 during 2014	✓
Portuguese Arthroplasty Register[72]	National	2009	4234 (2014)	✓	✓	272 (2014)	✓
Endoprothesenregister Deutschland[73]	National	2010	119 131 knees in 2018 alone	✓	✓	13 378 in 2018	✓
American Joint Replacement Registry[74]	National	2010 Joined the AAOS registry programme in 2017	828 999 (2019)	✓	✓	58 409 (2019)	✓
Lithuanian Arthroplasty Register[75,76]	National	2011	4269 (September 2015)	✓	✓	46+10 reoperations (September 2015)	✓
Swiss Arthroplasty Register[77]	National	2012	82 089 (2019)	✓	✓	11 410 (2019)	✓

N/A, not applicable.

osteotomy-focused registry in the world to date. In their annual report from 2018, they reported data from 49 surgeons who contributed 1652 patients (a total of 1776 procedures), of which 621 had already undergone surgery.[14] The Australian Orthopaedic Association National Joint Replacement Registry started their process of prospectively registering osteotomies in 2016[15] and was approved to add a knee osteotomy pathway by the local federal authorities. Their most recent annual report did not state the number of osteotomies and their data were not available for this review.[16]

Cartilage registries

There are few cartilage registries with only three accessible operative registries. The extracted data are summarised in tables 5 and 9. Only one registry is operated at a national level—the Danish National Patient Register (DNPR). However, despite the fact that over 22 254 cases of primary cartilage repair or reconstruction are recorded in the DNPR (1996–2011[17]), it is not a cartilage-oriented registry and consequently has some methodological limitations. One example is the potential underestimation of the incidence of cartilage injury. The DNPR is based on the documentation of surgical procedures in which cartilage injuries were addressed. This could lead to an overestimation of the proportion of high-grade injuries as many low-grade injuries are treated non-operatively and may be missed.[17]

The other two registries were established more recently. The German Cartilage Registry (KnorpelRegister DGOU, German Society for Orthopaedics and Trauma Surgery)[18] is a multicentre registry that was founded in 2013. This registry is based on a web-based remote data entry system from 23 cartilage repair centres in Germany, Austria and Switzerland, with up to 72 patients entered per month. As a multicentre registry, it has many advantages including records of lesion size, location, and aetiology. It holds records of both preoperative MRI for lesion assessment and postoperative MRI for regenerated cartilage assessment. It collects information regarding the surgical technique, the objective and subjective outcomes, including revision rates.[19] One drawback of this registry is the lack of information regarding concomitant injuries and perioperative complications.

The International Cartilage Regeneration and Joint Preservation Society (ICRS) global cartilage registry was launched in 2016. It is a multilingual, multinational registry, collecting data from surgeons of over 50 countries. It was designed to focus on cartilage injury, its natural history and management outcomes. As opposed to the other cartilage registries, it collects data about both low-grade and high-grade lesions which are treated either surgically or non-surgically. It records lesion location and modality of treatment. Other collected data include concomitant injuries, operative complications and use of prophylactic antibiotics. It does not report MRI data. This registry records EuroQol Five-Dimensional that will eventually lead to the ability to compare cost-

Table 3
Ligament registry general information: name, type, year established, number of primary ACLRs, graft type, fixation type, follow-up time, number of revisions, incidence of concomitant injuries and link to website/publication/annual report

Register/country	Type (national/ hospital/ regional)	Year established/ year of first reported case	Aetiology	Primary ACLRs (n)	Graft type	Fixation type	Follow-up time	ACLRs (n)	Meniscus injury rate	Cartilage injury rate	Combined injury rate
Multicenter Orthopaedic Outcomes Network[78]	Multicentre	2002	✓	>4400	✓	✓	Up to 10 years	N/A	Holds data on concomitant	Injuries	
The Norwegian National Knee Ligament Registry[79]	National	2004	✓	25 228 (2019)	✓	✓	Clinical follow-up of 1–2 years and individual follow-up of 10 years	2498	16 135 (12 913 surgical procedures)	1027 surgical procedures, but 61%–84% of the cartilage concomitant injuries were not treated.	N/A
The Swedish National Anterior Cruciate Ligament Register[80]	National	**2005**	✓	45 090	✓	✓	Clinical follow-up of 1–2 years and individual follow-up of 10 years	3322	4% meniscal suturing in primary ACLR and 17% in revision ACLR (2018)	1858 (2014)	**2929 (2014)**
Kaiser Permanente Anterior Cruciate Ligament Reconstruction Registry[81]	National	2005	✓	43 480 (2018)	✓	✓	3 years	5724 (2018)	60.8% in primary ACLR and 53.2% in revision (2011)	25.2% in primary ACLR and 37.5% in revision (2011)	N/A
The Danish Anterior Cruciate Ligament Reconstruction Registry[82,83]	National	2005	✓	22 775 (2014)	✓	✓	1-year clinical, and 10-year individual follow-up	1099 (2010) with reported 4.7% revision rate	26%	20%	N/A
Multi-Centre ACL Revision Study[9]	Multi-Centre	2006	N/A	N/A	V	N/A	2 years following revisions (eventually 10 years)	1205 (recruitment ended in 2011)	Holds data for both the primary ACLR and revision surgery		
UK National Ligament Registry[40]	National	2013	✓	9794 (2018)	✓	✓	2 years	N/A	4647 (47.4%)	316/9794 (32.3%)	5129 (52.3%)
New Zealand ACL Registry[84]	National	2014	✓	8463 (2018)	✓	✓	5 years	906 (2018)	39% medial, 35% lateral	MFC 25.5%	N/A

ACLR, anterior cruciate ligament reconstruction; MFC, medial femoral condyle; N/A, not applicable.

Table 4
Osteotomy registry general information: name, type, year established, number of primary osteotomies, location of osteotomy, number of reoperations, indication for reoperation and link to website/publication/annual report

Register/country	Type (national/ hospital/ regional)	Year established/year of first reported case	Primary osteotomies (n)	Proximal tibia/distal femur/other or N/A	Reoperations (n)	Type of osteotomy	Indication
Finnish National Hospital Discharge Register[11]	National	1956	6004 (1987–2008)	Not fully documented	N/A	N/A	N/A
Swedish Knee Arthroplasty Register (osteotomies)[55]	National	2013	934 (until 2019, with missing data of 2016)	>658/52/4 (data were not available for the first 2 years and 2016)	>50 (since 2013)	✓	✓
UK Knee Osteotomy Registry[85]	National	2014	621 (already undergone surgery	526/77/18	<18 (a specific number was not stated)	✓	✓
AOANJRR[59]	National	2016 (2018, formally approved as part of the AOANJRR	N/A	N/A	N/A	N/A	N/A

AOANJRR, Australian Orthopaedic Association National Joint Replacement Registry; N/A, not applicable.

effectiveness of differing techniques.[2]

The UK's National Institute for Health and Care Excellence recommends that clinicians collect and enter data from patients undergoing mosaicplasty onto this registry.[20]

The Swiss Medical Regulation Authority has mandated data collection onto the ICRS registry for all patients treated using Spherox, a product containing spheroids of human autologous matrix-associated chondrocytes for implantation.[21]

Results

Our search process is described in figure 1. Database search yielded 4620 papers on knee registries: 2669 arthroplasty registry papers, 426 ligament registry papers, 86 osteotomy registry papers and 157 cartilage registry papers (table 1). Our search identified 23 arthroplasty registries, 8 ligament registries, 4 osteotomy and 3 cartilage registries that fulfilled our inclusion criteria. Despite some inconsistencies in the most recent year of annual reports available, to date, the total numbers of primary knee replacements and revision/reoperation surgeries recorded in these registries are more than 4.451 million and 786 225, respectively (table 2).

Eight ligament registries yielded 154 830 records of primary ACLR surgeries and 14 754 records of reoperation following ACLR (table 3).

The cumulative number of recorded osteotomies in the available reports is over 7559. The type of osteotomy was available for the UKKOR and SKAR, of which 1184 were high tibial osteotomy procedures and 129 were distal femoral osteotomies (table 4). The cartilage registries document 28 744 records of primary cartilage repair/reconstruction surgeries (table 5).

Discussion

Registries have proven themselves as important tools for physicians, researchers, patients, industry and health providers.

One example of the impact of registries can be found in the study of Boyer *et al.*[22] They compared 190 registries-based publications with 476 from RCTs and 40 from meta-analyses. They found that registry-based studies had the highest impact between the three (calculating by the median number of citations in the 3-year period after publication).

The most prominent advantage of registries is their large cohort size, which in turn enables study of large populations and cases which are difficult to randomise,[23] with better representation of the 'real-world' population. Registries not only point out failures or problematic techniques,[11] but they can also point to potential beneficial trends.[24]

Furthermore, registries may affect perioperative standards of care as in the case of Jameson *et al*'s study that assessed the UK National Joint Registry (NJR), the Hospital Episode Statistics and the administrative database for all hospital admissions to the English National Health Service (NHS), and compared the aspirin with low-molecular-weight heparin (LMWH) for thromboprophylaxis in total knee arthroplasty (TKA) patients and reported no significant differences in terms of venous thromboembolism cases, 90-day mortality and major (cerebrovascular and gastrointestinal) haemorrhage. This demonstrated an association between aspirin use and a higher operative management for wound complications. Jameson *et al*'s group acknowledge their findings' weaknesses including fundamental limitations of registry-based cohort such as lack of randomisation. For example, higher-risk patients were probably more likely to receive LMWH as a prophylactic measure. This in turn might result in underestimation of the effect of both treatments.[25]

Registries' findings can be viewed as level IIc or level IV evidence,[26] while RCTs' conclusions are defined as level I evidence, and they are considered by many to be the most influential study design. RCTs have strict inclusion and exclusion criteria to compare an intervention against standard of care in equal groups. Registries provide information on the outcome of large numbers of patients with the real-world indications for surgery and patient results that extend beyond the confines of the narrow criteria of an RCT. By incorporating a well-planned framework to their protocols, one future role for clinical registries could be to serve as independent outcome instruments.

Another advantage of using registry data is the ability to compare the outcomes between registries and highlight pertinent differences found. Differences in patients' characteristics, standard of care and clinical outcomes can give clinicians and decision makers another perspective to their findings and in some cases raise unexpected questions.[27 28]

Over the years, registries have illustrated positive outcomes for surgical interventions studied, but also raised red flags when potentially harmful trends were recognised. Such was the case in the removal of the Articular Surface Replacement™ (ASR™) (DePuy Orthopaedics, Warsaw, Indiana, USA) following the negative outcomes, recognised in the 2007 UK NJR report.[29] While this report did not lead to a direct dismissal of the devices, it led to a regulatory authorities' intervention and further evaluations which eventually lead to the desired outcome of poorly performing implants being removed from the marketplace.

Registry-based studies evaluate association, not causation. To exemplify this, Niinimäki *et al* who used the FNHDR (Finland) to evaluate the outcomes of high-tibial osteotomies measured by time of survival until conversion to TKA.[30] They reported an overall 10-year survivorship of 89%, with conversion to TKA as the endpoint. They reported a worse survivorship from 1998 to 2008 than in the years from 1987 to 1998. They concluded that one explanation for this difference was the lower experience of younger surgeons who may still have been demonstrating a learning curve effect due to the decreased in popularity as documented by the incidence of osteotomies and concomitant upward trend in the use of TKA.[11] This resulted in an effort to increase training of those learning

Table 5
Cartilage injury registry general information: name, type, year established, aetiology, location, size, number of primary cartilage restoration surgeries, restoration modality, follow-up time, number of revisions, incidence of concomitant injuries and link to website/publication/annual report

Register/country	Type (national/hospital/regional)	Year established/year of first reported case	Aetiology	Location	Size	Primary cartilage restoration surgeries (n)	Restoration modality	Follow-up time	Revision cartilage restoration surgeries (n)	Concomitant injury rate		
										Total	Ligament injury rate	Meniscus injury rate
Danish National Patient Register[17,86]	National	1976	N/A	N/A	N/A	22 254 (1996–2011)	✓	N/A	N/A	10 263/22 224 (48%)	1129/10 263 (11%)	2258/10 263 (22%)
The German Cartilage Registry (KnorpelRegister DGOU-German Society for Orthopaedics and Trauma Surgery)[18,87]	Multicentre	2013	✓	✓	✓	5339 (2017) Over 6400 (2019)	✓	Minimum of 5 years, aims to 10 years	88 (May 2017)	N/A	✓	✓
ICRS's Global Nonarthroplasty Registry[21]	Global	2016	N/A	✓	N/A	90 reported cartilage repair or restoration (out of total of 535 pathways (2019)	✓	Currently 2 years, aims to 10 years	N/A	29/90	2/29 (6.89%)	4/29 (13.79%)

ICRS, International Cartilage Regeneration and Joint Preservation Society; N/A, not applicable.

osteotomy surgery and in keeping with UK guidelines for unicompartmental knee arthroplasty (UKA), potentially concentrating numbers in fewer centres, which would lessen the learning curve effect that they showed in their study and improve patients' outcomes.

Another limitation of registry data is the inconsistency of data recorded and a lack of unification of terminology. One common difference which we found in the registries was the use of the term 'revision'. While some registries address revision as any following surgery in which change of any component is replaced (the SKAR or the UK NJR), others differentiate reoperation and revision. Subsequent surgeries such as secondary patellar resurfacing are considered reoperation, and only removal and replacement of all the prosthesis are referred as revision in the Norwegian registry.[31] This may lead to a potential measurement bias which is the result of different data collection methods and assessment measurements. This often limits the validity of conclusions drawn from some registry-based studies. An example for this potential bias can be found in the UK NJR records in which secondary patellar resurfacing is analysed as a revision procedure.[32] However, the effectiveness of secondary patellar resurfacing is a matter of controversy with latest reports and estimation of 44%–64% satisfaction after this procedure,[33 34] with the additional risk of introducing potential surgery-related complications, all of which can affect the findings of success and complication rate following revision surgeries reported by the UK NJR.

In many arthroplasty registries, the main endpoint negative outcome measure was revision. However, with 20% of TKA patients reporting dissatisfaction, PROM measures have been added to registries as some failures do not reach revision surgery. Some have also added other measures such as records of complications and readmission. The use of TKA in younger patients follows different trends due to those patients often having increased demands and occasionally unrealistic expectations. This will require further attention and stratification of data. One problem with using PROMs is that some of them display a significant ceiling effect. This is a potential issue when the Oxford Knee Score or the American Knee Society Score is used.[35]

Cohort size

Registries aim to record data of large number of cases. These large cohorts making the study of populations which are difficult to randomise, possible. Svantesson *et al* used the Swedish National Ligament Registry (NLR) to assess the long-term impact of concomitant medial and lateral collateral ligament (MCL and LCL, respectively) injuries on ACLR outcomes.[23] Their goal was to compare the outcomes of ACLR surgeries with or without combined MCL/LCL treatment. Using this registry, they managed to compare 19 457 cases. Their results showed an increase risk of ACLR revision when concomitant MCL injury was not addressed at the time of the surgery. Interestingly, their study also reported less favourable patient reported outcomes at 2 years after the combined surgical treatment of anterior cruciate ligament (ACL) and MCL tears with better outcomes from conservative management of the MCL injury followed by ACLR. The presence of concomitant LCL injury did not seem to negatively affect the outcomes of ACLR surgeries compared with surgical treatment of isolated ACL tears.

One of the registries' most fundamental advantages is their size. However, this can also become a potential limitation. Exceptionally large study populations can be used to statistically identify extremely subtle differences claiming 'statistical significance', which is commonly measured by small p values and narrow CIs. Statistical significance, however, does not always reflect a clinical significance and without careful interpretation may lead to incorrect decisions.[36] Another potential weakness of large datasets is that unless they report on the different outcomes of different models within an arthroplasty 'family', successful outcomes of one combination of such implants that is more commonly used may disguise poor outcomes from a different combination of models within the same family.

Reporting compliance is an issue for registries.[37] Since participation is

Table 6
Variables reported by arthroplasty registry: demographics, revision rate/survival, surgical complications, medical complications, mortality, use of prophylactic antibiotics, thrombosis prophylaxis, PROMs, radiological assessment, healthcare use and healthcare costs

Register/country	Demographics	Revision rate/ survival	Surgical complications	Medical complications	Mortality	Use of prophylactic antibiotics	Thrombosis prophylaxis	PROMs	Radiological assessment	Healthcare use	Healthcare costs
Swedish Knee Arthroplasty Register[55]	✓	✓	N/A	N/A	✓	✓	✓	VAS KOOS	✓	✓	N/A
Finnish Arthroplasty Register[56]	✓	✓	✓	N/A	✓	N/A	N/A	N/A	N/A	✓	N/A
Norwegian Arthroplasty Register[57]	✓	✓	N/A	N/A	✓	✓	✓	Started on 2019	N/A	N/A	N/A
Geneva Arthroplasty Register[1]	✓	✓	✓	N/A	✓	N/A	✓	SF-12	✓	✓	✓
Danish Knee Arthroplasty Register[58]	✓	✓	✓	N/A	✓	N/A	N/A	N/A	N/A	✓	✓
Australian Orthopaedic Association National Joint Replacement Registry[59]	✓	✓	N/A	N/A	✓	N/A	In process	Pilot study started in 2018	N/A	N/A	N/A
New Zealand Joint Registry[60]	✓	✓	N/A	N/A	✓	✓	N/A	OKS	N/A	N/A	N/A
The Scottish Arthroplasty Project[61]	✓	✓	✓	✓	✓	N/A	N/A	N/A	N/A	✓	N/A
Register of Orthopaedic Prosthetic Implants−RIPO Emilia Romagna[62]	✓	✓	✓	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A
Romanian Arthroplasty Register[63]	✓	✓	N/A	N/A	✓	N/A	N/A	N/A	N/A	N/A	N/A
The Canadian Joint Replacement Registry[64]	✓	✓	N/A	N/A	N/A	N/A	N/A	In process	N/A	In process	Since 2018
Kaiser Permanente National Implant Registry[65]	✓	✓	✓	✓	✓	✓	N/A	N/A	N/A	✓	N/A
The National Joint Registry for England, Wales, Northern Ireland, and Isle of Man and the Royal College of Surgeons of England[66]	✓	✓	N/A	N/A	✓	N/A	N/A	N/A	N/A	N/A	N/A
Valdoltra Hospital Arthroplasty Register[67]	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Catalan Arthroplasty Register[68]	✓	✓	✓	N/A	✓	N/A	N/A	N/A	N/A	✓	N/A
The Italian Arthroplasty Registry[69]	✓	✓	N/A	N/A	✓	N/A	N/A	N/A	N/A	✓	✓
Dutch Arthroplasty Register[70]	✓	✓	N/A	N/A	✓	N/A	N/A	NRS EQ-5D KOOS-PS OKS	N/A	N/A	N/A
Belgian National Arthroplasty register[71]	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Portuguese Arthroplasty Register[72]	✓	✓	N/A	N/A	N/A	✓	✓	N/A	N/A	✓	✓
Endoprothesenregister Deutschland[73]	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
American Joint Replacement Registry[74]	✓	✓	✓	✓	✓	N/A	N/A	KOOS JR PROMIS-10, VR-12, OKS, SF-36, WOMAC Knee Society Knee Scoring System	N/A	✓	N/A
Lithuanian Arthroplasty Register[75,76]	✓	✓	N/A	N/A	✓	N/A	N/A	N/A	N/A	N/A	N/A
Swiss Arthroplasty Register[77]	✓	N/A	N/A	N/A	✓	N/A	N/A	N/A	N/A	N/A	N/A

EQ-5D, EuroQol Five-Dimensional; KOOS, Knee Injury and Osteoarthritis Outcome score; KOOS JR, Knee Injury and Osteoarthritis Outcome Score for Joint Replacement; KOOS-PS, KOOS Physical Function Shortform; N/A, not applicable; NRS, Numeric Rating Scale; OKS, Oxford Knee Score; PROM, patient-reported outcome measure; PROMIS-10, Patient-Reported Outcomes Measurement Information System; SF-12, 12-Item Short Form Health Survey ; SF-36, 36-Item Short Form Health Survey; VAS, visual analogue score; VR-12, The Veterans RAND 12 Item Health Survey; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Table 7
Variables reported by ligament registry: demographics, revision rate/survival, surgical complications, medical complications, mortality, use of prophylactic antibiotics, thrombosis prophylaxis, PROMs, radiological assessment, healthcare usen and healthcare costs

Register/Country	Demographics	Revision rate/survival	Surgical complications	Medical complications	Mortality	Use of prophylactic antibiotics	Thrombosis prophylaxis	PROMs	Radiological assessment	Healthcare use	Healthcare costs
Multicenter Orthopaedic Outcomes Network[78]	✓	✓	N/A	N/A	N/A	N/A	N/A	IKDC KOOS Marx activity level	✓	N/A	N/A
The Norwegian National Knee Ligament Registry[79]	✓	✓	✓	✓	✓	✓	✓	KOOS	N/A	N/A	N/A
The Swedish National anterior cruciate ligament register[80]	✓	✓	N/A	N/A	✓	✓	N/A	KOOS EQ-5D	✓	✓	✓
Kaiser Permanente Anterior Cruciate Ligament Reconstruction Registry[81]	✓	✓	✓	✓	✓	N/A	N/A	Lysholm Tegner Activity Scores	✓	N/A	N/A
The Danish Anterior Cruciate Ligament Reconstruction Registry[82,83]	✓	✓	✓	✓	✓	✓	✓	KOOS Tegner Activity Score	✓	N/A	N/A
Multi-Centre ACL Revision Study[9]	✓	✓	N/A	N/A	N/A	N/A	N/A	IKDC KOOS Marx activity level WOMAC	N/A	N/A	N/A
UK National Ligament Registry[40]	✓	N/A	✓	✓	N/A	✓	✓	IKDC KOOS Tegner Activity Score VAS EQ-5D	✓	N/A	N/A
New Zealand ACL Registry[84]	✓	✓	✓	✓	N/A	✓	N/A	KOOS Marx activity level	N/A	N/A	N/A

EQ-5D, EuroQol Five-Dimensional; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome score; N/A, not applicable; PROM, patient-reported outcome measure.

Table 8
Variables reported by osteotomy registry: demographics, revision rate/survival, surgical complications, medical complications, mortality, use of prophylactic antibiotics, thrombosis prophylaxis, PROMs, radiological assessment, healthcare use and healthcare costs

Register/country	Demographics	Revision rate/ survival	Surgical complications	Medical complications	Mortality	Use of prophylactic antibiotics	Thrombosis prophylaxis	PROMs	Radiological assessment	Healthcare use	Healthcare costs
Finnish National Hospital Discharge Register[11]	✓	✓	N/A	N/A	✓	N/A	N/A	N/A	N/A	N/A	N/A
Swedish Knee Arthroplasty Register (osteotomies)[55]	✓	✓	N/A	N/A	N/A	✓	✓	N/A	N/A	✓	N/A
UK Knee Osteotomy Registry[85]	✓	In process	In process	In process	In process	N/A	N/A	KOOS OKS OKS-APQ EQ-VAS EQ-5D	✓	N/A	✓
AOANJRR[59]	✓	✓	N/A	N/A	✓	N/A	In process	N/A	N/A	N/A	N/A

AOANJRR, Australian Orthopaedic Association National Joint Replacement Registry; EQ-5D, EuroQol- 5 Dimension; EQ-VAS, EuroQol vertical visual analogue scale; KOOS, Knee Injury and Osteoarthritis Outcome score; N/A, not applicable; OKS, Oxford Knee Score; OKS-APQ, Oxford Knee Score – Activity and Participation Questionnaire; PROM, patient-reported outcome measure.

voluntary in most registries, there is a potential selection bias. Moreover, costs and time requirements to assure high level of follow-up are high,[38] adding to the registries operative challenge. Encouraging enough, the UK experience of the NJR and the NLR reveals gradual increase in compliance since their establishments.[39 40] However, for the NJR, this trend was evident only after data entry was mandated for the UK doctors.[39]

Potential selection bias can also be found when comparing different modalities of treatment, different techniques or different implants. This is not an exclusive pitfall of registry-based papers. Nevertheless, when assessing large numbers, it should be acknowledged when planning the methods for extracting data and analysing it. For example, when designing a comparative study between TKA and UKA, one must remember that UKA may be used in younger or older patients. Without proper planning and matching processes, analysis of these potentially two different populations may lead to skewed results.

Despite its many advantages, if clinicians and health authorities are not mandated to enter data, then uptake and consistency of data input can be an issue. Registries need governments or national health system funding in order to be successful on a health policy scale. Start-up costs are high for each registry and depending on the size of the measured countries and populations, costs may vary from several hundreds of thousands and to several millions of euros or US dollars.[41] A fledging registry needs the support of the relevant orthopaedic association and cooperation and commitment of their member clinicians. Without the involvement of health authorities and healthcare professionals, both establishment and maintenance of a fledgling registry are difficult to achieve.[42] Other costs include general maintenance and registration costs of implants, devices or operations. In order to be worth the investment, regulators and national health systems must recognise the value of establishing and operating registries. The importance of early recognition of adverse effects and early failures is one of the most important roles of registries. One key factor is the involvement of not only clinicians but also official regulators. Current medical devices reporting regulations of both the European Union and the USA aim to promote patients' safety. Both require manufacturers to carry out postmarketing surveillance of new implants, evaluating benefits and harms of both newly introduced and well-established devices.

Trend recognition

Petursson *et al*[24] reviewed the Norwegian joint registry to compare the survivorship of hybrid and cemented TKAs. They found better or equal survivorship in the hybrid implants compared with the comparable cemented brand version laying to rest widely held concerns over this technique. They were able to show that in terms of time-efficiency hybrid, TKA can be a good option without increased risk of revision.

Another example of trend recognition can be found in the work of Niinimäki *et al.* They assessed the FNHDR and analysed the Finnish experience of knee osteotomies between the years 1987 and 2008. They witnessed a steady decrease in the number of osteotomies that were performed which correlated to the increased incidence of TKA.[11] However, a slight increase in the incidence of these procedures was seen in younger patients under 50 years of age. This emphasised that this technique is still a relevant surgical skill for OA treatment in younger patients.

Another advantage is the ability to compare between different registries. Bohm *et al* of the Canadian Joint Replacement Registry (CJRR) compared the CJRR to other main registries.[27] They identified a higher incidence of TKA in women in Canada compared with Sweden. Despite the suspected multifactorial causes for this difference, they hypothesised that this might also be the result of higher rates of obesity in Canada. Different trends in choice and outcomes of implant and fixation methods between the two national registry cohorts were also noted. Another example of such process was demonstrated by Prentice *et al*,[28] who compared data from six ACL registries. They reported similar demographics, injury characteristics, revision rates and incidence of

Table 9
Variables reported by cartilage injury registry: demographics, revision rate/survival, surgical complications, medical complications, mortality, use of prophylactic antibiotics, thrombosis prophylaxis, PROMs, radiological assessment, healthcare use and healthcare costs

Register/country	Demographics	Revision rate/survival	Surgical complications	Medical complications	Mortality	Use of prophylactic antibiotics	Thrombosis prophylaxis	PROMs	Radiological assessment	Healthcare use	Healthcare costs
Danish National Patient Register[17,86]	✓	N/A	✓	✓	✓	✓	N/A	N/A	N/A	✓	✓
The German Cartilage Registry (KnorpelRegister DGOU, German Society for Orthopaedics and Trauma Surgery)[18,87]	✓	N/A	N/A	N/A	N/A	N/A	N/A	IKDC KOOS Lysholm Score, Tegner Score and Numerical Analogue Scale	ICRS score and a magnetic resonance tomographic assessment of the regenerated cartilage using the MOCART score	N/A	N/A
ICRS's Global Nonarthroplasty Registry[21]	✓	✓	✓	✓	✓	✓	N/A	KOOS KUJALA EQ-5D	N/A	N/A	Indirectly by the EQ-5D

EQ-5D, EuroQol Five-Dimensional; ICRS, International Cartilage Regeneration and Joint Preservation Society; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome score; MOCART, magnetic resonance observation of cartilage repair tissue; PROM, patient-reported outcome measure.

surgical outcomes. However, several differences in patient management were observed, including time to reconstruction, concomitant injuries, graft selection and method of fixation.

Mohammad *et al* used the UK NJR's data to compare cemented and cementless UKAs.[43] The first-generation UKA was cemented and associated with an increased 10-year revision rate compared with TKA. This and the more demanding technique led many surgeons to refrain from using it. However, over the years, with improvements in instrumentation and technique, UKA gained new attention. One of these developments was cementless fixation. However, randomised control studies and cohorts could not prove significant long-term differences between the two methods. One of the suggested reasons was the small number of patients participating in those studies. In order to overcome this issue, Mohammad *et al*, analysing the UK NJR's data, showed that cementless UKA might be of merit as better 10-year implant survival rate was seen.[43] Their findings also validated the 2016 report of the New Zealand Joint Registry,[44] which found lower revision rate for cementless UKA. The main indication for revision in the cementless group was aseptic loosening. However, the cementless cohort was reported to have decreased unexplained postoperative pain and overall lysis; they suggested that this could be due to better fixation of the uncemented implants.

Adverse effects

Administrative claims data benefit from the high patient numbers, but their disadvantages include lack of precision of coding schemes.[45] When assessing complication rates following anterior cruciate ligament reconstruction in the English NHS 13 941 operations, they reported deep venous thrombosis (DVT) on 0.30% of the cases, pulmonary thromboembolism (PE) on 0.18%,[46] no in-hospital deaths, wound complication on 0.75%, 0.25% underwent a further procedure to wash out the infected knee joint and 1.36% on readmissions.[47]

In their assessment of 180 717 Australian elective knee arthroscopies, Bohensky *et al* reported[48] that the most common adverse outcomes were DVT 0.36%, effusion and synovitis 0.09%, PE 0.10%, haemarthrosis, readmission rate was 0.77%, and there were 55 deaths (0.03%). Overall, there were 6.4 adverse outcomes per 1000 elective knee arthroscopy procedures (0.64%).[48] Since 2015, there have been six annual reports from the UK NJR, none of which reported complication rates approaching those described previously. No complications are documented in the first report of the ICRS global registry. This was said to be typical of the earlier registry reports for soft tissue procedures, but in reality, complications will ultimately be shown to be in the frequencies reported for the arthroscopic techniques used for debridement and articular cartilage biopsy harvest and commonly associated procedures such as ACLR.[2]

Postmarketing surveillance

One example of postmarketing surveillance which led to a global intervention was the case of the market removal of ASR resurfacing system (DePuy Orthopaedics) following negative outcomes reported and recognised in the 2007 UK NJR report with a high 5-year revision rate.[29] These reports did not lead to a direct dismissal of the devices but rather lead to regulatory authorities' intervention and further evaluations which eventually lead to the desired outcome of poorly performing implants being removed from the marketplace.

It has been stated that national arthroplasty registers monitoring of adverse outcomes are sufficiently robust that they 'have to be used for research and post-market surveillance'.[49] Others disagree and conclude that these data may be too insensitive, such as using revision as an endpoint for the success of knee arthroplasty as it was exaggerating the success of total knee replacements in comparison to partial knee replacement.[50] It is essential to consider confounding factors when analysing observational datasets.[51] Several factors may play a role here such as inconsistently attributed causes of failure between registries or patients' inaccurate reporting of the presence of complications but not

their absence. The sensitivity of patient-reported complications, for example, needs to be improved.[52] The information registries generated may complement more traditional data collection systems employed in postmarket surveillance studies but is not designed to replace them.

Cost-effectiveness assessment

With appropriate design of data collection, registries may be able to assess cost-effectiveness. Weeks *et al*[53] used the Australian National Joint Replacement Registry in order to assess and compare the cost effectiveness of TKA with or without patellar resurfacing. After analysing the 2014 annual report of the Australian registry, assessing the outcome measures and estimating the costs from a Canadian point of view, their country of interest, they reported lower revision rates for TKA with patellar resurfacing. With a 14-year review of a retrospective cohort, they reported lower costs ($12 917.01 vs $13 296.63) and higher quality-adjusted life year. This, in turn, led them to conclude that patellar resurfacing in TKA is cost-effective. Their results are important for two main reasons. First, counterintuitively, they found that despite a longer operating time and the cost of the patellar implant, this more time-consuming procedure was worth performing. Their second and more important implication was their use of another country's national registry in order to answer a question which was relevant to their own health system policy.

Registries can help predict change in demands of different populations[54] and, in turn, could be used for policy making when health administrators plan the costs and future needs of a health system.

In their 2015 comparative analysis of the NJR, Patel *et al* predicted a major increase in demand for both primary TKA and revision TKA from 2012 to 2030. Despite some limitations which relate to general features of the NJR and other registries, their projections had implications for the economic burden which they were expecting to witness.[54] They also compared their estimations to those of other registries such as the Swedish and the New Zealand's arthroplasty registries and found similar trends. These examples emphasise the importance to healthcare administrators and decision makers with involvement and use of registries.

Box 1
Key articles

- Kolling C, Simmen BR, Labek G, Goldhahn J. Key factors for a successful National Arthroplasty Register. J Bone Joint Surg Br. 2007 Dec;89(12):1567–73.
- Boyer P, Boutron I, Ravaud P. Scientific production and impact of national registers: the example of orthopaedic national registers.Osteoarthritis and Cartilage. 2011 Jul;19(7):858–63.
- Rolfson O, Bohm E, Franklin P, Lyman S, Denissen G, Dawson J, *et al.* Patient-reported outcome measures in arthroplasty registries: Report of the Patient-Reported Outcome Measures Working Group of the International Society of Arthroplasty RegistriesPart II. Recommendations for selection, administration, and analysis. Acta Orthopaedica. 2016 Jun 15;87(sup1):9–23.
- Lübbeke A, Silman AJ, Barea C, Prieto-Alhambra D, Carr AJ. Mapping existing hip and knee replacement registries in Europe. Health Policy. 2018 May;122(5):548–57.
- Wilson I, Bohm E, Lübbeke A, Lyman S, Overgaard S, Rolfson O, *et al.* Orthopaedic registries with patient-reported outcome measures. EFORT Open Reviews. 2019 Jun;4 (6):357–67.
- Biant LC, Conley CW, McNicholas MJ. The First Report of the International Cartilage Regeneration and Joint Preservation Society's Global Registry. Cartilage. 2020 Feb 19;1947603520907664.

Box 2
Keys for successful registry

- Organisation
- Funding.
- Maintenance.
- Methods of data collection.
- Documentation
- Validated scoring systems.
- Coverage of more than 90% of the target population data.
- Data handling
- Scientific output
- Publications.
- Periodic reports.

Box 3
Advantages

- Large database/cohort.
- Can identify trends in practice and outcomes.
- Enable certain elements of postmarketing surveillance.
- Can be compared the other registries and highlight, searching for pertinent differences.
- Helps physicians practising evidence-based medicine and healthcare systems reaching evidence-based policies.

Box 4
Limitations and pitfalls

- Limited level of evidence.
- Inconsistency in terminology.
- Inconsistencies in collected data and measured variables.
- Potential measurement and selection biases.
- Inability to assess causation.

Box 5
Future perspectives

- Standardisation of data collection.
- Coverage goals>90% of target population.
- Increased involvement of health systems, professional associations and clinicians for funding, operating and assessing these registries.
- Global collaboration between registries.
- Registries as a more accessible data source.

Conclusion

Registries have become important instruments for physicians, researchers, patients, health economists, industry and health providers when selecting patient treatment and designing health policies. Over the past three decades, registries have evolved significantly. The efficiency of collection and the coverage continue to improve. Nevertheless, even with

the improvements we have seen over the years, it is increasingly recognised that collection of high-quality and surgeon-validated data using validated scoring systems which are sensitive to change and do not have ceiling effects is of paramount importance.[35] In order to meet these needs, cooperation of governments, professional associations and clinicians is crucial for funding, operating and assessing these registries. Robust and accurate adverse event documentation is required in order to convince regulatory authorities of the safety of knee procedures under their review. Knee registries are adding useful information to aid decision making for all interested parties, but that there is a constant evolution ongoing which will continue to improve the ease of data input, allowing greater understanding of such generalisable real-world results.

Acknowledgements

EB-N has a research Fellowship in Manchester University NHS foundation trust, under the EFORT scholarship supported by Medacta International.

Contributors

All authors certify that they have participated sufficiently in the work to take public responsibility for the content. EB and MJM conceptualised and designed the work, participated in the acquisition and analysis of the data. All authors participated in interpretation of the data. EB and MJM drafted the manuscript together with NN and CL who helped editing it critically for important intellectual content. All authors gave final approval of the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding

The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests

MJMcN is Chair of the ICRS Global Registry Committee and on the Steering Committee of the UK National Ligament Registry. NN is a *Journal of ISAKOS* Editorial Board member.

Provenance and peer review

Commissioned; externally peer reviewed.

Ethics statements

Patient consent for publication Not required.

References

1 Lübbeke A, Silman AJ, Barea C, et al. Mapping existing hip and knee replacement registries in Europe. Health Policy 2018;122:548–57. https://doi.org/10.1016/j.healthpol.2018.03.010. http://www.ncbi.nlm.nih.gov/pubmed/29598886.
2 Biant LC, Conley CW, McNicholas MJ. The first report of the International cartilage regeneration and joint preservation society's global registry. Cartilage 2020;203:194760352090766. https://doi.org/10.1177/1947603520907664.
3 Limb D, Dreghorn C, Murphy JK, et al. Primary lymphoma of bone. Int Orthop 1994;18:180–3. https://doi.org/10.1007/BF00192476. http://www.ncbi.nlm.nih.gov/pubmed/7927969.
4 Knutson K, Lewold S, Robertsson O, et al. The Swedish knee arthroplasty register. A nation-wide study of 30,003 knees 1976-1992. Acta Orthop Scand 1994;65:375–86. https://doi.org/10.3109/17453679408995475. http://www.ncbi.nlm.nih.gov/pubmed/7976280.
5 Kolling C, Simmen BR, Labek G, et al. Key factors for a successful national arthroplasty register. J Bone Joint Surg Br 2007;89:1567–73. https://doi.org/10.1302/0301-620X.89B12.19409. http://www.ncbi.nlm.nih.gov/pubmed/18057354.
6 ISAR. International Society of Arthroplasty Registries (ISAR). Available: https://www.isarhome.org/members.
7 NORE. Network of Orthopaedic Registries of Europe. Available: https://www.efort.org/about-us/nore/.
8 Howell SM, Gittins ME, Gottlieb JE, et al. The relationship between the angle of the tibial tunnel in the coronal plane and loss of flexion and anterior laxity after anterior cruciate ligament reconstruction. Am J Sports Med 2001;29:567–74. https://doi.org/10.1177/03635465010290050801. http://www.ncbi.nlm.nih.gov/pubmed/11573914.
9 Wright RW, Huston LJ, Nwosu SK. Meniscal and articular cartilage predictors of clinical outcome after revision anterior cruciate ligament reconstruction. Am J Sports Med 2016;44:1671–9. https://doi.org/10.1177/0363546516644218.
10 Sund R. Quality of the Finnish hospital discharge register: a systematic review. Scand J Public Health 2012;40:505–15. https://doi.org/10.1177/1403494812456637. http://www.ncbi.nlm.nih.gov/pubmed/22899561.
11 Niinimäki TT, Eskelinen A, Ohtonen P, et al. Incidence of osteotomies around the knee for the treatment of knee osteoarthritis: a 22-year population-based study. Int Orthop 2012;36:1399–402. https://doi.org/10.1007/s00264-012-1508-7. http://www.ncbi.nlm.nih.gov/pubmed/22354471.
12 W-Dahl A, Lidgren L, Sundberg M, et al. Introducing prospective national registration of knee osteotomies. A report from the first year in Sweden. Int Orthop 2015;39:1283–8. https://doi.org/10.1007/s00264-014-2621-6. http://www.ncbi.nlm.nih.gov/pubmed/25500955.
13 Elson DW, Dawson M, Wilson C, et al. The UK knee osteotomy registry (UKKOR). Knee 2015;22:1–3. https://doi.org/10.1016/j.knee.2014.10.004. http://www.ncbi.nlm.nih.gov/pubmed/25467935.
14 Elson MD, Wilson A, Dawson MM. The United Kingdom knee osteotomy registry - The first annual reportUKKOR. 2018. https://secure.amplitude-registry.com/UKKOR/Content/Ukkor_AnnualReport_RGB.pdf. [Accessed 20 July 2021].
15 Vertullo C. Feasibility of an Australian knee osteotomy registry. Orthop J Sports Med 2016;4:23259671165S0003. https://doi.org/10.1177/2325967116S00033.
16 Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip, Knee & Shoulder Arthroplasty: 2019 Annual Report. Adelaide AOA; 2019. https://aoanjrr.sahmri.com/annual-reports-2019.
17 Mor A, Grijota M, Nørgaard M, et al. Trends in arthroscopy-documented cartilage injuries of the knee and repair procedures among 15-60-year-old patients. Scand J Med Sci Sports 2015;25:e400–7. https://doi.org/10.1111/sms.12330. http://www.ncbi.nlm.nih.gov/pubmed/25262959.
18 Mehl J, Otto A, Willinger L, et al. Degenerative isolated cartilage defects of the patellofemoral joint are associated with more severe symptoms compared to trauma-related defects: results of the German cartilage registry (KnorpelRegister DGOU). Knee Surg Sports Traumatol Arthrosc 2019;27:580–9. https://doi.org/10.1007/s00167-018-5184-z. http://www.ncbi.nlm.nih.gov/pubmed/30284008.
19 Pestka JM, Luu NH, Südkamp NP, et al. Revision surgery after cartilage repair: data from the German cartilage registry (KnorpelRegister DGOU). Orthop J Sports Med 2018;6:232596711775262. https://doi.org/10.1177/2325967117752623.
20 National Institute for Health and Care Excellence (NICE). Mosaicplasty for symptomatic articular cartilage defects of the knee. Interventional procedures guidance IPG607; 2018. https://www.nice.org.uk/guidance/ipg607/chapter/1-Recommendations.
21 The International Cartilage Regeneration and Joint Preservation Society's (ICRS's) Global Nonarthroplasty Registry. Available: https://cartilage.org/society/icrs-patient-registry/registry-annual-reports/.
22 Boyer P, Boutron I, Ravaud P. Scientific production and impact of national registers: the example of orthopaedic national registers. Osteoarthritis Cartilage 2011;19:858–63. https://doi.org/10.1016/j.joca.2011.02.006. http://www.ncbi.nlm.nih.gov/pubmed/21362489.
23 Svantesson E, Hamrin Senorski E, Alentorn-Geli E, et al. Increased risk of ACL revision with non-surgical treatment of a concomitant medial collateral ligament injury: a study on 19,457 patients from the Swedish national knee ligament registry. Knee Surg Sports Traumatol Arthrosc 2019;27:2450–9. https://doi.org/10.1007/s00167-018-5237-3. http://www.ncbi.nlm.nih.gov/pubmed/30374568.
24 Petursson G, Fenstad AM, Havelin LI, et al. Better survival of hybrid total knee arthroplasty compared to cemented arthroplasty. Acta Orthop 2015;86:714–20. https://doi.org/10.3109/17453674.2015.1073539. http://www.ncbi.nlm.nih.gov/pubmed/26179889.
25 Jameson SS, Baker PN, Charman SC, et al. The effect of aspirin and low-molecular-weight heparin on venous thromboembolism after knee replacement: a non-randomised comparison using national joint registry data. J Bone Joint Surg Br 2012;94:914–8. https://doi.org/10.1302/0301-620X.94B7.29129. http://www.ncbi.nlm.nih.gov/pubmed/22733945.
26 OCEBM Levels of Evidence Working Group. The Oxford 2011 Levels of Evidence; 2016. https://www.cebm.net/2016/05/ocebm-levels-of-evidence/.
27 Bohm ER, Dunbar MJ, Bourne R. The Canadian joint replacement Registry-what have we learned? Acta Orthop 2010;81:119–21. https://doi.org/10.3109/17453671003685467. http://www.ncbi.nlm.nih.gov/pubmed/20170434.
28 Prentice HA, Lind M, Mouton C, et al. Patient demographic and surgical characteristics in anterior cruciate ligament reconstruction: a description of registries from six countries. Br J Sports Med 2018;52:716–22. https://doi.org/10.1136/bjsports-2017-098674. http://www.ncbi.nlm.nih.gov/pubmed/29574451.
29 National Joint Registry for England and Wales. 7th Annual Report, 2010. Hemel Hempstead NJR; 2010. https://www.njrcentre.org.uk/njrcentre/Portals/0/NJR%207th%20Annual%20Report%202010.pdf.
30 Niinimäki TT, Eskelinen A, Mann BS, et al. Survivorship of high tibial osteotomy in the treatment of osteoarthritis of the knee: Finnish registry-based study of 3195

knees. J Bone Joint Surg Br 2012;94:1517–21. https://doi.org/10.1302/0301-620X.94B11.29601. http://www.ncbi.nlm.nih.gov/pubmed/23109632.
31 Delaunay C. Registries in orthopaedics. Orthop Traumatol Surg Res 2015;101: S69–75. https://doi.org/10.1016/j.otsr.2014.06.029. http://www.ncbi.nlm.nih.gov/pubmed/25553603.
32 National Joint Registry for England and Wales. 16th Annual Report, 2019. Hemel Hempstead NJR; 2019. https://reports.njrcentre.org.uk/Portals/0/PDFdownloads/NJR%2016th%20Annual%20Report%202019.pdf.
33 van Jonbergen H-PW, Boeddha AV, M van Raaij JJA. Patient satisfaction and functional outcomes following secondary patellar resurfacing. Orthopedics 2016;39: e850–6. https://doi.org/10.3928/01477447-20160509-05. http://www.ncbi.nlm.nih.gov/pubmed/27172365.
34 Lonner JH. Patellar resurfacing: rarely if ever necessary – affirms. Orthop Proc 2016; 98-B:1; https://online.boneandjoint.org.uk/doi/abs/10.1302/1358-992X.98BSUPP_22.CCJR2015-100.
35 Jenny J-Y, Louis P, Diesinger Y. High activity arthroplasty score has a lower ceiling effect than standard scores after knee arthroplasty. J Arthroplasty 2014;29:719–21. https://doi.org/10.1016/j.arth.2013.07.015.
36 Ranganathan P, Pramesh CS, Buyse M. Common pitfalls in statistical analysis: clinical versus statistical significance. Perspect Clin Res 2015;6:169–70. https://doi.org/10.4103/2229-3485.159943.
37 Bedeir YH, Hasselfeld KA, Kuechly HA, et al. Risk factors associated with ACL registry compliance: can we predict who will follow-up? Eur J Orthop Surg Traumatol 2019; 29:645–50. https://doi.org/10.1007/s00590-018-2327-3. http://www.ncbi.nlm.nih.gov/pubmed/30361988.
38 Lovelock TM, Broughton NS. Follow-up after arthroplasty of the hip and knee : are we over-servicing or under-caring? Bone Joint J 2018;100-B:6–10. https://doi.org/10.1302/0301-620X.100B1.BJJ-2017-0779.R1. http://www.ncbi.nlm.nih.gov/pubmed/29305444.
39 Porter M, Armstrong R, Howard P, et al. Orthopaedic registries - the UK view (National Joint Registry): impact on practice. EFORT Open Rev 2019;4:377–90. https://doi.org/10.1302/2058-5241.4.180084. http://www.ncbi.nlm.nih.gov/pubmed/31210975.
40 The National Ligament Registry. The Fifth Annual Report (2019); 2019. https://www.uknlr.co.uk/pdf/annual-report-2019.pdf.
41 Becherer BE, Spronk PER, Mureau MAM, et al. High risk device registries: global value, costs, and sustainable funding. J Plast Reconstr Aesthet Surg 2018;71:1362–80. https://doi.org/10.1016/j.bjps.2018.05.048. http://www.ncbi.nlm.nih.gov/pubmed/29945828.
42 Serra-Sutton V, Allepuz A, Espallargues M, et al. Arthroplasty registers: a review of international experiences. Int J Technol Assess Health Care 2009;25:63–72. https://doi.org/10.1017/S0266462309090096. http://www.ncbi.nlm.nih.gov/pubmed/19126253.
43 Mohammad HR, Matharu GS, Judge A, et al. Comparison of the 10-year outcomes of cemented and cementless unicompartmental knee replacements: data from the National joint Registry for England, Wales, Northern Ireland and the Isle of man. Acta Orthop 2020;91:76–81. https://doi.org/10.1080/17453674.2019.1680924.
44 New Zealand Joint Registry. Seventeen Year Report January 1999 to December 2015; 2016. https://nzoa.org.nz/sites/default/files/NZJR%2017%20year%20Report.pdf.
45 Pugely AJ, Martin CT, Harwood J, et al. Database and registry research in orthopaedic surgery: Part I: Claims-Based data. J Bone Joint Surg Am 2015;97: 1278–87. https://doi.org/10.2106/JBJS.N.01260. http://www.ncbi.nlm.nih.gov/pubmed/26246263.
46 Lizzio VA, Gulledge CM, Meta F, et al. Using a web-based data collection platform to implement an effective electronic patient-reported outcome registry. Arthrosc Tech 2019;8:e535–9. https://doi.org/10.1016/j.eats.2019.01.012. http://www.ncbi.nlm.nih.gov/pubmed/31334007.
47 Jameson SS, Dowen D, James P, et al. Complications following anterior cruciate ligament reconstruction in the English NHS. Knee 2012;19:14–9. https://doi.org/10.1016/j.knee.2010.11.011. http://www.ncbi.nlm.nih.gov/pubmed/21216599.
48 Bohensky MA, deSteiger R, Kondogiannis C, et al. Adverse outcomes associated with elective knee arthroscopy: a population-based cohort study. Arthroscopy 2013;29: 716–25. https://doi.org/10.1016/j.arthro.2012.11.020. http://www.ncbi.nlm.nih.gov/pubmed/23395251.
49 Varnum C, Pedersen AB, Rolfson O, et al. Impact of hip arthroplasty registers on orthopaedic practice and perspectives for the future. EFORT Open Rev 2019;4: 368–76. https://doi.org/10.1302/2058-5241.4.180091. http://www.ncbi.nlm.nih.gov/pubmed/31210974.
50 Goodfellow JW, O'Connor JJ, Murray DW. A critique of revision rate as an outcome measure: re-interpretation of knee joint registry data. J Bone Joint Surg Br 2010;92: 1628–31. https://doi.org/10.1302/0301-620X.92B12.25193. http://www.ncbi.nlm.nih.gov/pubmed/21119165.
51 Stammers JG, Kuo A, Hart AJ, et al. Registry Data-Valuable lessons but beware the confounders. J Arthroplasty 2017;32:S63–7. https://doi.org/10.1016/j.arth.2017.02.003. http://www.ncbi.nlm.nih.gov/pubmed/28318869.
52 Heo SM, Naylor JM, Harris IA, et al. Reliability of patient-reported complications following hip or knee arthroplasty procedures. BMC Med Res Methodol 2019;19: 11–5. https://doi.org/10.1186/s12874-018-0645-0. http://www.ncbi.nlm.nih.gov/pubmed/30634917.
53 Weeks CA, Marsh JD, MacDonald SJ, et al. Patellar resurfacing in total knee arthroplasty: a cost-effectiveness analysis. J Arthroplasty 2018;33:3412–5. https://doi.org/10.1016/j.arth.2018.07.001. http://www.ncbi.nlm.nih.gov/pubmed/30122432.
54 Patel A, Pavlou G, Mújica-Mota RE, et al. The epidemiology of revision total knee and hip arthroplasty in England and Wales: a comparative analysis with projections for the United States. A study using the National joint registry dataset. Bone Joint J 2015; 97-B:1076–81. https://doi.org/10.1302/0301-620X.97B8.35170. http://www.ncbi.nlm.nih.gov/pubmed/26224824.
55 The Swedish Knee Arthroplasty Register. Annual Report 2019; 2019. http://myknee.se/pdf/SVK_2019_1.0_Eng.pdf.
56 Finnish Arthroplasty Register. Available: https://www.thl.fi/far/#data/knee_km.
57 The Norwegian Arthroplasty Register. Available: http://nrlweb.ihelse.net/eng/.
58 Danish Knee Arthroplasty Register. Available: https://www.sundhed.dk/content/cms/99/4699_dkr-rapport-2016.pdf.
59 Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Available: https://aoanjrr.sahmri.com/.
60 New Zealand Joint Registry (NZJR). Available: https://nzoa.org.nz/nzoa-joint-registry.
61 Scottish Arthroplasty Project. Annual report 2019; 2019. https://www.arthro.scot.nhs.uk/Reports/Visualisation.html.
62 Regional Register of Orthopaedic Prosthetic Implantology. Report of R.I.P.O. Overall data hip, knee and shoulder arthroplasty in Emilia-Romagna region (Italy) 2000-2017; 2019. https://ripo.cineca.it/authzssl/pdf/report_eng_2017.pdf.
63 Romanian Arthroplasty Register (R.N.E), 2018. Available: http://www.rne.ro/rne/informatii/genunchi/.
64 The Canadian Joint Replacement Registry. Available: https://www.cihi.ca/en/canadian-joint-replacement-registry-cjrr.
65 Kaiser Permanente National Implant Registry. 2019 Annual Report; 2019. %%%https://national-implantregistries.kaiserpermanente.org/Media/Default/documents/2019%20External%20Annual%20Report.pdf.
66 The National Joint Registry for England, Wales, Northern Ireland, and Isle of Man and the Royal College of Surgeons of England (UK-NJR). Available: http://www.njrcentre.org.uk/njrcentre/default.aspx.
67 Levašič V, Savarin D, Milošev I, Valdoltra Arthroplasty Registry. Valdoltra KNEE Arthroplasty Registry 2018 Valdoltra Orthopaedic Hospital; 2019. https://www.ob-valdoltra.si/sites/www.ob-valdoltra.si/files/upload/files/valdoltra_knee_arthroplasty_registry_2002-2018.pdf.
68 Domingo L, Arias J, Martínez O, Espallargues M, Executive Commitee and the Advisory Commitee of the RACat. Catalan Arthroplasty Register. Third report (2005-2014). Barcelona Agency for Health Quality and Assessment of Catalonia. Catalan Health Ministry. Government of Catalonia; 2017. http://aquas.gencat.cat/web/.content/minisite/aquas/publicacions/2017/RACat_artroplasties_hip_knee_2005-2014.pdf.
69 Torre M, Laricchiuta P, Luzi I. Italian Arthroplasty Registry Project. Better data quality for better patient safety. Fourth Report 2017 – Addendum. Roma Il Pensiero Scientifico Editore; 2018. https://riap.iss.it/riap/en/activities/reports/2018/06/08/fourth-report-2017-english-addendum/.
70 Dutch Arthroplasty Register (LROI). Online LROI annual report 2019; 2019. https://www.lroi-report.nl/app/uploads/2020/10/PDF-Online-LROI-annual-report-2019-min.pdf.
71 Belgian Hip and Knee Arthroplasty Register. Annual Report 2014; 2015. https://www.ehealth.fgov.be/file/view/5fca367bad5fd36bf017d1363087849a.
72 Portuguese Arthroplasty Register. 2013 Annual Report; 2014. http://www.rpa.spot.pt/getdoc/c3d0a244-c056-4949-a50b-07d0fdeac2b9/RPA-Report-2013.aspx.
73 Endoprothesenregister Deutschland (EPRD). Jahresbericht 2019; 2019. https://www.eprd.de/fileadmin/user_upload/Jahresbericht_2019_doppelseite_2.0.pdf.
74 Executive summary of 2019 annual report. Arthroplast Today 2019;5:532–3. https://doi.org/10.1016/j.artd.2019.11.004.
75 Šarūnas Tarasevičius, Čebatorius A, Valavičienė R, et al. First outcome results after total knee and hip replacement from the Lithuanian arthroplasty register. Medicina 2014;50:87–91. https://doi.org/10.1016/j.medici.2014.06.004.
76 Terteliene E, Grigaitis K, Robertsson O, et al. Validation of Lithuanian arthroplasty register telephone survey of 2769 patients operated for total knee replacement. Medicina 2019;55:310. https://doi.org/10.3390/medicina55060310. http://www.ncbi.nlm.nih.gov/pubmed/31242685.
77 Swiss Arthroplasty Register (SIRIS). Available: https://www.siris-implant.ch/de.
78 Lynch TS, Parker RD, Patel RM, et al. The impact of the multicenter orthopaedic outcomes network (moon) research on anterior cruciate ligament reconstruction and orthopaedic practice. J Am Acad Orthop Surg 2015;23:154–63. https://doi.org/10.5435/JAAOS-D-14-00005. http://www.ncbi.nlm.nih.gov/pubmed/25667401.
79 Norwegian National Advisory Unit on Arthroplasty and Hip Fractures. Report June 2019; 2019. http://nrlweb.ihelse.net/eng/Rapporter/Report2019_english.pdf.
80 The Swedish National Knee Ligament Registry. Annual report 2018; 2018. https://www.aclregister.nu/media/uploads/Annual%20reports/annual_report_swedish_acl_registry_2018.pdf.
81 Kaiser permanente anterior cruciate ligament reconstruction registry (KP ACLRR). Available: %%%https://national-implantregistries.kaiserpermanente.org/Media/Default/documents/2019%20External%20Annual%20Report.pdf.
82 Lind M, Menhert F, Pedersen AB. Incidence and outcome after revision anterior cruciate ligament reconstruction: results from the Danish Registry for knee ligament reconstructions. Am J Sports Med 2012;40:1551–7. https://doi.org/10.1177/0363546512446000. http://www.ncbi.nlm.nih.gov/pubmed/22562791.
83 Danish Ligament Reconstruction Register (DKRR). Available: https://www.danishhealthdata.com/find-health-data/Dansk-Korsbaandsregister.
84 New Zealand ACL Registry Annual Report 2019. Available: https://www.aclregistry.nz/reports/.
85 UK Knee Osteotomy Registry (UKKOR) Annual Report. Available: https://secure.amplitude-registry.com/UKKOR/Content/Ukkor_AnnualReport_RGB.pdf.
86 Danish National Patient Register (DNPR). Available: https://www.danishhealthdata.com/find-health-data/Landspatientregisteret.
87 The German Cartilage Registry (KnorpelRegister DGOU - German Society for Orthopedics and Trauma Surgery). Available: https://zks-internet.ukl.uni-freiburg.de/autoreports/Knorpelregister/KnorpelregisterKnie/graphs/Knorpelregister_Report.pdf.