

# Australian Orthopaedic Association National Joint Replacement Registry

2022 Hip, Knee and Shoulder  
Replacement Lay Summary



**AOA**  
AUSTRALIAN  
ORTHOPAEDIC  
ASSOCIATION

Australian  
Orthopaedic  
Association  
National  
Joint  
Replacement  
Registry

Director: Professor Stephen Graves

E: [admin@aoanjrr.org.au](mailto:admin@aoanjrr.org.au)

Manager: Ms Kathy Hill

E: [khill@aoanjrr.org.au](mailto:khill@aoanjrr.org.au)

AOANJRR

SAHMRI,

North Terrace

ADELAIDE SA 5000

T: +61 8 8128 4280

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# Australian Orthopaedic Association National Joint Replacement Registry

## 2022 Hip, Knee and Shoulder Replacement Lay Summary

# Acknowledgements

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The Registry acknowledges the cooperation and support provided by those undertaking the surgery and completing the data forms, in particular, all orthopaedic surgeons, registrars and nursing staff.

The Registry acknowledges the ongoing support of all hospitals, both public and private, that undertake arthroplasty surgery nationally. The support provided by each hospital through their nominated coordinator(s) is appreciated. A complete list of participating hospitals and coordinators is presented at the end of the Hip, Knee and Shoulder Arthroplasty Annual Report.

The Registry greatly appreciates the participation of all joint replacement patients throughout Australia. Their contribution allows ongoing improvements in arthroplasty outcomes to be achieved.

## AOA Registry Clinical Director

Professor Stephen Graves

## Deputy Clinical Directors

Professor Richard de Steiger

Mr Peter Lewis

Professor Ian Harris

## Assistant Deputy Clinical Director

Mr James D Stoney

## Clinical Advisors

Professor Richard Page

Mr Peter Stavrou

## PROMs Advisor

Professor Ilana Ackerman

## AOA Registry Committee

Neil Bergman

Annette Holian

Chris Morrey

Stephen Graves

Richard de Steiger

Peter Lewis

James Stoney

Bill Walter

Richard Page

Peter Stavrou

Rob Kuru

Peter McEwen

Paul Smith

Michael Schuetz

Joshua Petterwood

David Wysoki

Committee Chair

AOA President

AOA Vice President

Director

Deputy Director (Victoria)

Deputy Director (South Australia)

Assistant Deputy Director

Arthroplasty Society of Australia

Shoulder & Elbow Society

Foot & Ankle Society

Spine Society

Knee Society

Australian Capital Territory

Queensland

Tasmania

Western Australia

## AOA NATIONAL JOINT REPLACEMENT REGISTRY

### Registry Executive Manager

Kathy Hill

### Clinical Studies Manager

Durga Bastiras

### PROMs Manager

Pablo Flores Figuera

### Publications Manager

Sophie Corfield

### Administrative Coordinator

Rianne Thompson

### Clinical Studies Team

Tania Alland

Libby Poole

Dianne Buranyi-Trevarton

Laura Busk

### PROMs Team

Nea Ryan

David Metherell

Marta Jasinska

### Data Linkage

Katherine Duszynski  
(UNISA)

## SOUTH AUSTRALIAN HEALTH AND MEDICAL RESEARCH INSTITUTE (SAHMRI)

### Project Manager

Emma Heath

### Statisticians

Michelle Lorimer

Alana Cuthbert

Carl Holder

Dylan Harries

Kara Cashman

### Data Managers

Janey Barrow

Robert Armitage

Primali De Silva

### Data Entry

Georgina Daynes

Kirsty Modystach

Anh Pham

Jacinta Greer

Anna Fergusson

Vivien Do

Jeremy Durward

Michael Crame

Andrew Loakim

Anita Wright

Courtney Cullen

Natalie Morrall

### ICT

Andrew Brock

Christian Boyd

Jennifer Coleman

Nazia Dilnaz

Daina Ross

Vincent Talladira

Anu Bakshi

Peter Weston

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# AOANJRR Data Snapshot 2021



**1,853,452**

Total number of joint replacement procedures reported by the Registry at the end of 2021



**81**

Conference Presentations

Joint Replacement Procedures Reported in 2021

**52,787**  
Hips

**68,466**  
Knees

**8,733**  
Shoulders



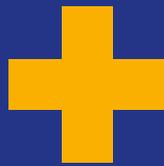
**293**

Ad Hoc Reports



**2,249**

Automated Industry Reporting System (AIRS)



**42**

Hospital Audit Reports



**1,033**

Individual Surgeon Reports



**31**

Journal Articles Published

## COVID-19 Impact on Joint Replacement in Australia



In 2020-2021 there were **19,595** fewer procedures than expected had the 2008-2019 trend in joint replacement procedures continued.

Public Hospital joint replacement procedures decreased by **14.9%** in 2021 compared to 2019.

Private Hospital joint replacement procedures increased by **10.9%** in 2021 compared to 2019.

## PROMs National Rollout

June 2022 Update

Participating Hospitals

**217**

Pre-Op PROMs

**55,120**

Post-Op PROMs

**33,686**

Pre-Op Completion Rate

**77.5%**

Post-Op Completion Rate

**66.1%**

% patient-reported change following hip, knee, or shoulder joint replacement as "much better"

**84.7%**

% patients very satisfied or satisfied following hip, knee, or shoulder joint replacement

**85.9%**



Total number of Hospitals onboard per state:

- ACT: 6
- SA: 29
- NSW: 60
- TAS: 7
- NT: 3
- VIC: 50
- QLD: 43
- WA: 19



**733**

Total number of surgeons participating



**57,896**

Patient participation through AOANJRR patient dashboards

## Introduction

This summary is an explanation of the major findings of the Australian Orthopaedic Association National Joint Replacement Registry 2022 Annual Report for Hip, Knee and Shoulder Arthroplasty (replacement). This is the major clinical report produced by the Registry each year. The full version of the 2022 Annual Report on Hip, Knee and Shoulder Arthroplasty is available in the 'Publications' section of the Registry website <https://aoanjrr.sahmri.com/annual-reports-2022>.

The Lay Summary is provided to ensure that a clear, concise, and easily understood explanation of the published findings are available to all those who may be interested. The Lay Summary also provides guidance for those who may wish to further review the full extent of the data published by the Registry in the Annual Report. The Australian Orthopaedic Association (AOA) believes this is especially important because of the high level of community interest in the Registry and the need to ensure that reports are accessible to all.

This year's report involved the analysis of 1,853,452 primary and revision procedures (796,686 hips, 980,419 knees and 76,347 shoulders). This is the total number of hip, knee and shoulder replacement operations recorded by the Registry with a procedure date up to and including 31 December 2021. This is 129,986 additional hip, knee and shoulder procedures compared to the number reported in the 2021 Annual Report. Some of the prosthesis designs reported since the Registry first began collecting data in 1999 are now no longer used. Understandably, the performance of many of these older designs is not quite at the same standard as the currently used prostheses (described as 'modern prostheses'). To ensure that the relevance and currency of AOANJRR data are maintained, almost all analyses (unless specifically stated) have been limited in this year's report to modern hip, knee and shoulder prostheses i.e. those prostheses that were still being used in 2021. Most of the operations that have been reported to the Registry over the years have used modern prostheses. The effect of not including prostheses that are no longer used is that overall outcomes reported for the different device classes are better and a smaller number of individual prostheses/prosthesis combinations are listed in the report.

In addition to the Annual Report and this Lay Summary, there are a further 14 supplementary reports published by the Registry on the website: <https://aoanjrr.sahmri.com/annual-reports-2022/supplementary>.

## A Brief History of the Registry Origins

The AOA started the National Joint Replacement Registry in 1999. It was initially for hip and knee replacement only. This was a complex system to set up and therefore it took almost 3 years to fully implement the Registry across Australia. Since mid-2002, the Registry has received information on almost all hip and knee replacements undertaken in Australia. The Registry receives this information from over 300 hospitals.

In November 2007, the Registry commenced national data collection on a number of additional types of joint replacement. This included shoulder joint replacement procedures, the analysis of which is presented along with hip and knee replacement in the main report. The other additional types of joint replacement that the Registry collects information on include elbow, wrist, ankle, and spinal disc replacement. The analysis of these procedures is presented in the supplementary reports available on the Registry website.

In 2018, the Registry started collecting information directly from patients. These are known as patient-reported outcome measures (PROMs). The Registry collects this information from people happy to provide it, both before and 6 months after their operation. The purpose is to better understand the results of joint replacement by having good information from patients on the extent of problems that they have, not only with the joint being operated on, but also their general health and then how these change after the operation.

PROMs data are collected directly from patients invited by the Registry to answer a number of electronic survey questions. The questions are designed to provide an overview of a patient's general health, their ability to complete everyday activities and how much pain they are getting from the joint. By asking these questions before and after surgery as well as additional questions about how happy they are with the joint replacement, the Registry is able to better understand the extent of problems that patients are having before their operation and then how much this has changed after it. This data provides really important new information that the Registry has not previously had, which is the patient's opinion on the benefit or otherwise of the joint replacement.

### The Purpose of the Registry

The AOA started the Registry to improve the results of joint replacement surgery in Australia. Generally, this type of surgery is very successful but, as with all areas of healthcare, there is always room for improvement. Since the Registry commenced data collection there has been an improvement in the outcomes of this surgery.

One of the most serious consequences of a less than successful operation is the need to have a revision (redo) operation. The Registry provides information to assist surgeons to keep the number of these operations to a minimum. It does this by identifying those things that work best and highlighting what can be improved.

### Supplementary Reports

The Registry publishes data in addition to that included in the Annual Report, in the following Supplementary Reports:

- 1. Partial Hip Arthroplasty**  
Detailed information on Partial Hips is available in this supplementary report. A summary of Partial Hips is provided in the main report.
- 2. Patella/Trochlea Partial Knee Arthroplasty**  
Detailed information on Patella/Trochlea Partial Knee Replacement is provided in this supplementary report.
- 3. Partial Shoulder Arthroplasty**  
Detailed information on Partial Shoulder Replacement is available in this supplementary report. A summary of Partial Shoulders is provided in the main report.
- 4. Demographics of Hip, Knee and Shoulder Arthroplasty**  
This report details the age and gender profile of people receiving hip, knee or shoulder replacement and includes information on the reasons for undergoing replacement surgery.
- 5. Cement in Hip and Knee Arthroplasty**  
This report details the use of the different types of cement in hip and knee replacement surgery.
- 6. Mortality of Hip and Knee Arthroplasty**  
This report details the risk of dying following the different types of hip and knee replacement surgery.
- 7. Revision of Hip and Knee Arthroplasty**  
This report details the outcome of revisions of hip and knee replacements.

Prior to establishing the Registry, Australian orthopaedic surgeons felt they had a lack of detailed information on the results of the many different procedures and types of joint replacement available. In particular, the surgeons required information to compare the impact of the many different factors known to influence the results for their patients.

Surgeons have a large choice of different types of artificial joints that they can use to replace damaged and painful joints. There are also different techniques, which can be used to put these artificial joints in place. Surgeons know that there is variation in the results depending on the patient, the nature of the patient's problem, which joint is being replaced, the way the operation is performed, and the type of artificial joint replacement used.

The Registry is able to compare all of these different factors simultaneously. In doing so, it provides information to assist surgeons to decide the best type of artificial joint replacement to use in any particular situation. The Registry can detail the results for different classes (or categories) of artificial joints and different individual types of artificial joints in each of the classes. It can also determine if patient age, gender, weight, general health, and/or the reason a joint replacement is performed, affects the result.

It is important to emphasise that this is not the only information that is used to determine what the best approach should be. When providing advice to patients, surgeons will also rely on their training and experience as well as information from medical journals, other registries elsewhere in the world, conferences, and courses they may attend, as well as learning from other surgeons.

**The Registry provides information to assist in deciding the best type of artificial joint replacement to use in any particular situation.**

When surgeons interpret information from the Registry, they use their knowledge and experience to put that information into context. The Registry does not decide or recommend the best joint replacement for a particular patient. This can only ever be decided by the surgeon in consultation with the patient. In this way, all factors relevant to each individual patient can be carefully taken into consideration.

## Supplementary Reports

### 8. Metal/Metal Bearing Surface in Total Conventional Hip Arthroplasty

This report details the outcome of metal/metal bearings when used with large (greater than 32mm) femoral heads.

### 9. Demographics and Outcomes of Elbow and Wrist Arthroplasty

This report details the age and gender profile of people receiving elbow and wrist surgery. It includes reasons for undergoing these different types of joint replacement as well as some early information on the outcome of these operations.

### 10. Demographics and Outcomes of Ankle Arthroplasty

This report details the age and gender profile of people receiving ankle joint replacement and reasons for undergoing ankle replacement as well as some early information on the outcome of this operation.

### 11. Demographics of Spinal Disc Arthroplasty

This report details the age and gender profile of people receiving spinal disc replacement and reasons for undergoing this operation.

### 12. Analysis of State and Territory Health Data – All Arthroplasty 1993/1994 – 2020/2021

Data presented in this report are for both the public and private hospital sector and have been obtained from State and Territory Health Departments for specific ICD-10-AM codes relating to hip, knee, shoulder, elbow, wrist, ankle and spinal disc replacement.

## How the Registry Works

The Registry collects a small amount of confidential information on each joint replacement operation undertaken in Australia, with the exception of those people who choose not to have their information collected by the Registry.

The information collected includes age, gender, weight, height, general health, the reason for the surgery, the joint type, and if it was on the right or the left side. Information on the type of artificial joint and the components used in the operation are also collected.

**Currently the Registry monitors and has information on over 1.8 million joint replacement operations.**

As previously mentioned, if a problem occurs following a joint replacement one of the possible outcomes is that the operation is redone. This is referred to as a revision procedure. The Registry is notified about the revision, records this information and links it to the first (or primary) operation. The Registry can then determine how many primary procedures have been revised, the reason for the revision, how long after the original surgery, and can also record which of the components (if any) were replaced.

## Who Funds the Registry?

The Commonwealth Government, through the Department of Health, funds the Registry. The Government and the Department have been very supportive of the Registry. They provided the initial funding to establish the Registry and have maintained its core funding since the Registry commenced.

## Supplementary Reports

### 13. Prosthesis Types with No or Minimal Use

This report details the outcomes of classes of hip and knee replacement that are no longer used or have minimal use and therefore do not appear in the main report.

### 14. Comparative Prosthesis Performance

This report provides summary data and outcomes for comparative prosthesis performance

### Investigations of Prostheses with Higher than Anticipated Rates of Revision

Each year the Registry identifies prostheses that have a higher than anticipated rate of revision. This is a series of reports providing detailed information on each of the prostheses identified in the 2022 Annual Report.

## How the Registry Presents the Results

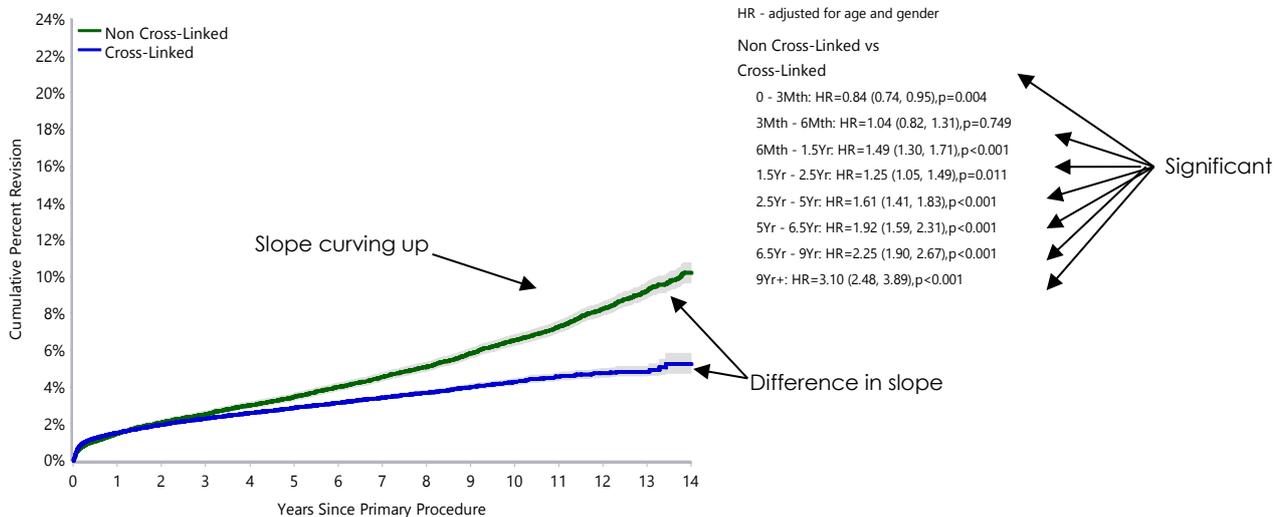
The fact that the Registry is a national database means it reports on the results of a very large number of operations, which improves the value and accuracy of the information. Currently, the Registry monitors and has information on over 1.8 million joint replacement operations.

The Registry presents the results in different ways. The clearest and most important way is by graphs and tables. We know the time until the redo (revision) operation and so we can calculate the percent of procedures that have been revised at 1, 2, and 3 years after the original procedure. This is known as the cumulative percent revision. There are many things that can affect this i.e. make it lower or higher. The aim is to identify what things make the cumulative revision rate lower, which means that there is less chance of needing to have the operation again. This is done by comparing results of surgery undertaken in different types of patients (young vs older, male vs female, heavy vs normal weight, etc.), different types of joint replacement prostheses, and different techniques for implanting the device. Examples of different techniques include the use of different types of instruments, or robotic surgery, or the operative approach. By comparing these different groups, we are not only able to understand what works better in certain situations but also what does not work so well.

### GRAPHS

To assist in the interpretation of any difference, the Registry often graphs the results. Figure L1 is a typical example of a cumulative percent revision graph which is comparing two different types of plastic used in hip replacement. The cumulative percent revision which gets progressively greater as time progresses is plotted for each group at specific times since the original surgery. The time period scale is usually in years since the first operation.

**Figure L1** Example of a graph with Cumulative Percent Revision which compares the results of two different types of plastic commonly used in joint replacement surgery (cross-linked and non-cross-linked polyethylene).



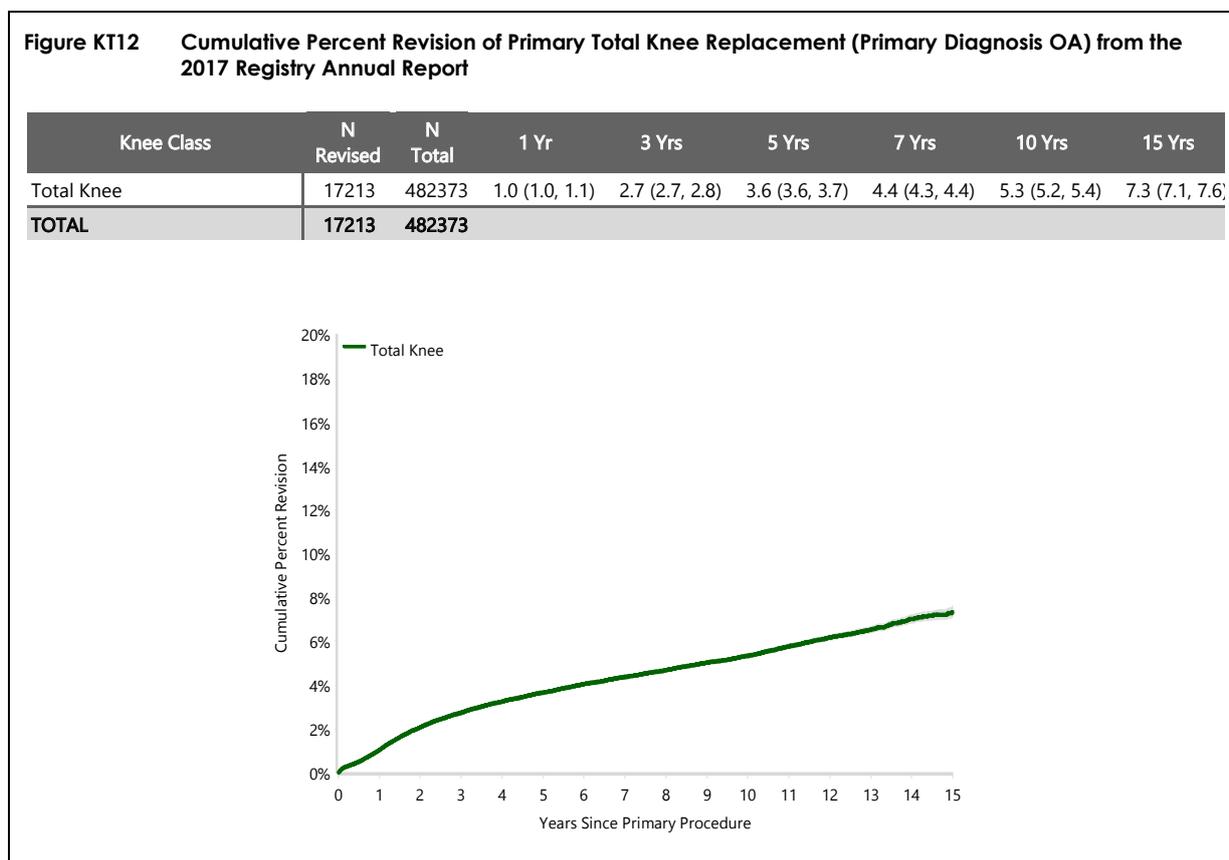
The lines on the graph represent the results for the factors being compared. The more the lines slope upwards the greater the number of revision (redo) operations that have been done. In general, the greater the difference in the slope of the lines the more important the difference. This graph shows that there are more revisions when non cross-linked polyethylene (the green line) is used compared to cross-linked polyethylene (the blue line).

The information on the right-hand side of each of these graphs is important. This gives a measure of the amount of difference, how this is changing with time, and how confident you can be that the difference is real. The most important information is the HR (hazard ratio) and the p (probability) value. These are explained a little further down.

## TABLES

The Registry also reports data in cumulative percent revision tables which accompany these graphs. These tables give the number of revisions as a percentage of the number of operations at particular times, i.e. 1 year, 3 years, etc. The numbers are simply the values on the graph at these specific time points and are listed to provide the actual number for each year so that the number does not need to be guessed at by looking at the graph.

Figure L2 Example of a table and corresponding graph



This table also shows some values in brackets after the main number i.e. at 10 years the main number is 5.3%, which means that at 10 years if you are still alive you have a 5.3% chance of having a revision. The reason that there are numbers in brackets afterward (in this case 5.2 and 5.4) is that 5.3% is not an exact number, it is an estimate based on the analysis of all the data. The numbers in the brackets represent the 95% confidence interval. This means that the estimate is 5.3% and there is 95% confidence that the actual or real number is somewhere between 5.2% and 5.4%. This is a small confidence interval which is usually when the number of operations is large. When the confidence interval is small the estimate is likely to be accurate.

On occasion, the Registry provides only cumulative percent revision tables and does not provide the graphs. This is usually when the results of many different replacements in one category are being presented. The reason the graphs are not provided for each of the different replacements is simply a space issue. It would make the report too large.

When examining the tables, it can be seen that there is variation in the outcome of the different prostheses that are listed. It is important to understand that just because a prosthesis combination has a higher cumulative percent revision than other prosthesis combinations, it does not necessarily mean that the combination is not as good. It is possible that this difference in the number of revisions between the prostheses has occurred by chance rather than being a true difference. In reality, most but not all prostheses have equally good results.

## HAZARD RATIOS

Hazard Ratios (HR) are used to compare 2 different factors such as non cross-linked poly (non XLPE) compared to cross-linked poly (XLPE). The HR is an indication of the difference in the risk of revision for non XLPE compared to XLPE. For example, if the HR=3, this means that there is a three times greater risk of being revised. If the HR=1, then this means that there is no difference. If the HR=0.5 then this means that that risk of revision is half.

The p value is a measure of the likelihood that a difference observed between groups being compared is real, rather than occurring by chance. In statistical terms, this is called significance. The difference is regarded as significant (in other words likely to be true) if a p value is smaller than 0.05. A p value of 0.05 means that there is a 1 in 20 chance that the difference is not true. A p value of 0.001 means that there is only a 1 in 1,000 chance that the difference is not true. In other words, it is more certain that the difference is real.

**Figure L3** Example of a hazard ratio from a Registry graph

HR adjusted for age and gender	
Non Cross-Linked vs Cross-Linked Polyethylene	
0-3Mth:	HR=0.84 (0.74, 0.95), p=0.004
3Mth-6Mth:	HR=1.04 (0.82, 1.31), p=0.749
6Mth-1.5Yr:	HR=1.49 (1.30, 1.71), p<0.001
1.5Yr-2.5Yr:	HR=1.25 (1.05, 1.49), p=0.011
2.5Yr – 5Yr:	HR=1.61 (1.41, 1.83), p<0.001
5Yr – 6.5Yr:	HR=1.92 (1.59, 2.31), p<0.001
6.5Yr – 9Yr:	HR=2.25 (1.90, 2.67), p<0.001
9Yr+:	HR=3.10 (2.48, 3.89), p<0.001

Quite often different hazard ratios (HRs) are listed for different time periods as above. The time period is the number that is on the left. The values in the brackets after the HR number are the possible lower and upper limits of the HR. The reason that these numbers are given is that the HR number is an estimate just like the revision estimate and the numbers in the brackets indicate that there is a 95% degree of certainty that the actual HR falls within this range. Again, in the same manner as the revision estimate. For instance, the first entry in Figure L3 above referring to the 0-3 month period has a lower limit of 0.74 and an upper limit of 0.95. The HR value of 0.84 is the arithmetic mean (average) value of the upper and lower limit but because this is an estimate there is a possibility that the actual HR is not this figure but there is a 95% likelihood that it falls within the range identified by the numbers in the brackets.

When the Registry compares two different factors, such as non cross-linked to cross-linked polyethylene, to see if there is a difference, it also tests whether that difference changes with time. That is why all the different time periods are listed. With this particular comparison, it can be clearly seen that the difference between the two different polyethylene types is increasing as the time after the original operation increases i.e., the HR is increasing with time after surgery.

The length of time after the initial operation when differences become evident is an important piece of information in helping to determine why there is a difference. Using Figure L3 as an example, the HRs have been divided into eight time periods, the time from the joint replacement to 3 months after the surgery, then 3 months following the surgery to 6 months, and so on. There are many reasons why some things may differ soon after surgery and these reasons often change as the time after surgery increases. What can also happen, as is the case in the example provided, is that the extent of difference can vary with time; sometimes the difference is greatest early, and other times the difference may increase as time progresses which is what has occurred with this example. In some graphs, the difference does not change with time but is the same from start to finish. When this occurs then instead of having a list of different time periods, only one HR will be given, and it will state that the HR is over the entire period.

# Impact of COVID-19 on Joint Replacement in Australia in 2021

## Introduction

In this chapter, we have mapped the number of procedures that occurred before the pandemic and have predicted the number of procedures that would have occurred in 2020 and 2021 had the pandemic not occurred. When we compare the predicted number to the actual number of procedures occurring in the past two years, we have found that there is a shortfall. In other words, in 2020-2021 there should have been an additional 19,595 procedures undertaken but these procedures did not go ahead due to the pandemic.

## Outcomes

Compared to the previous year, in 2021 joint replacement procedures increased by 7.0%. However, this increase only occurred in the private hospital system and particularly in the first half of the year. In the public hospital system, in the first 2 months, the number of procedures was as high as pre-pandemic levels before falling to the lowest number of procedures of the pandemic for the remainder of the year.

The impact varied depending on the type of joint replacement and the reason why the joint replacement needed to be done. The reduction was greatest for primary elective operations which are usually undertaken to manage joints with severe pain or disease. A proportion of hip and shoulder replacements are undertaken as emergency procedures, most often to treat fractures. There was no reduction in the emergency hip and shoulder replacements to treat fractures. The number of revision procedures declined, particularly during April and May. This reduction was not to the same extent as the primary elective procedures, but the evident rebound in primary procedures after June did not occur for revision operations.

**Figure L4 All Joint Replacement Hip, Knee and Shoulder (Primary and Revision)**

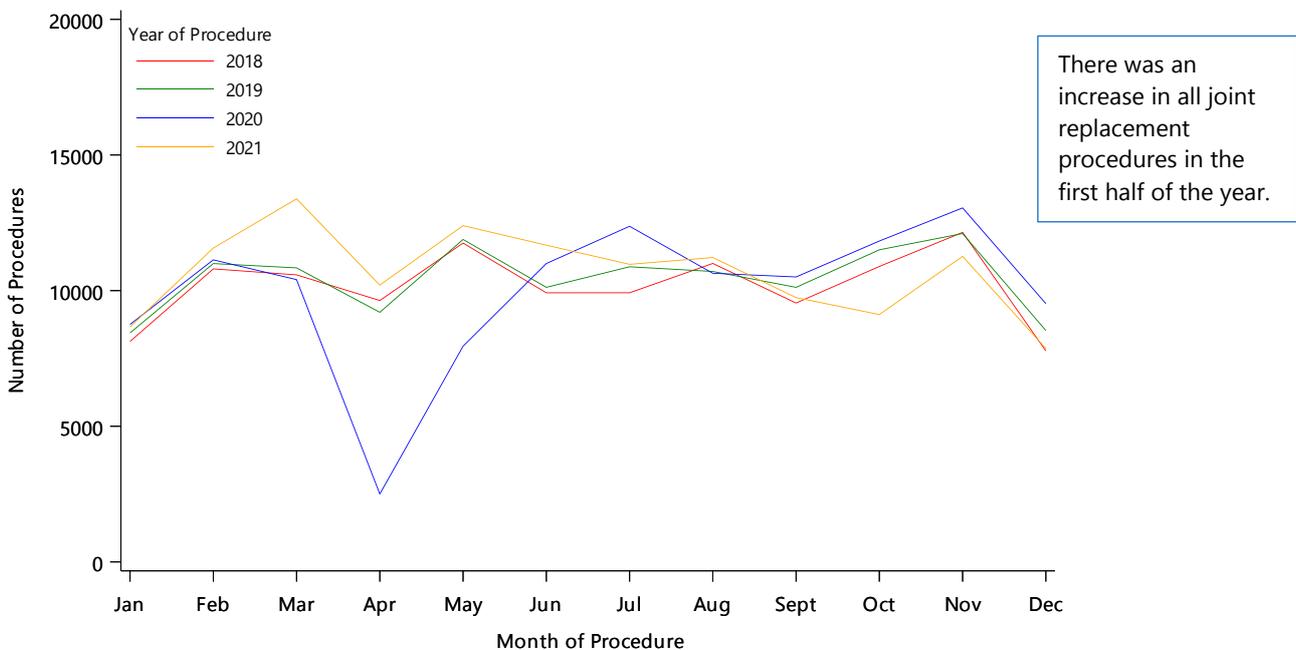




Figure L5 Primary Joint Replacement - By Hospital Type

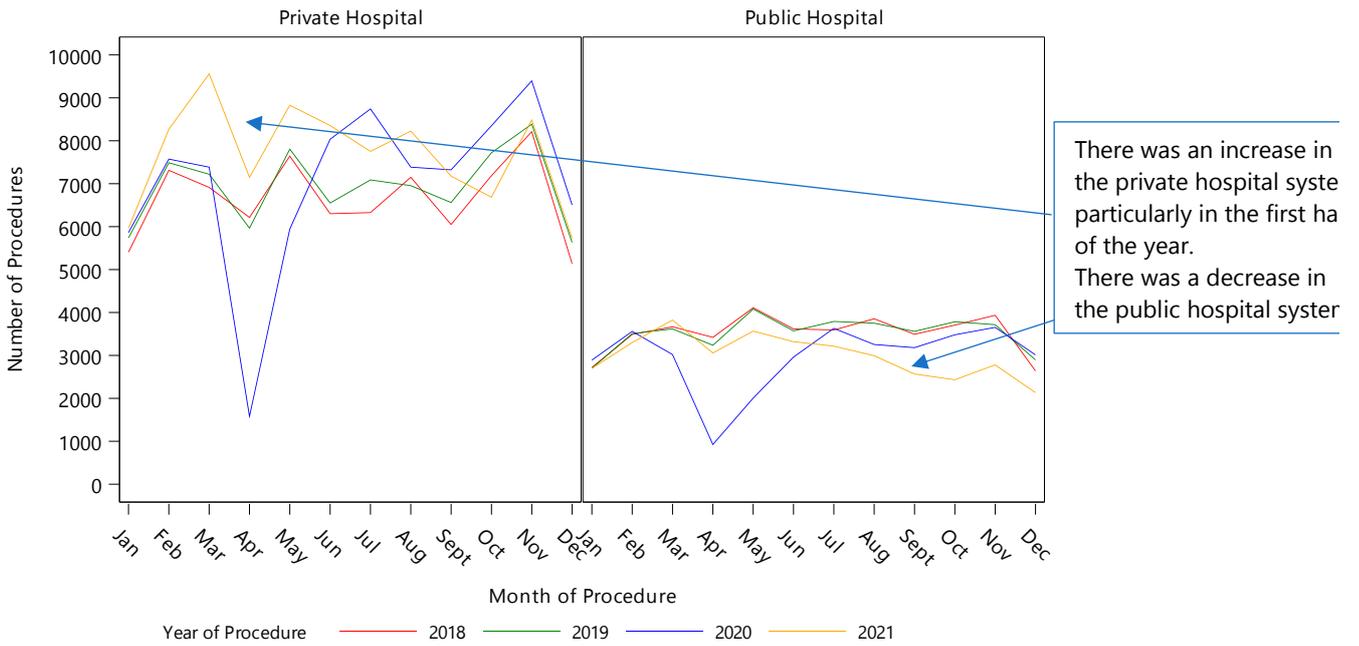
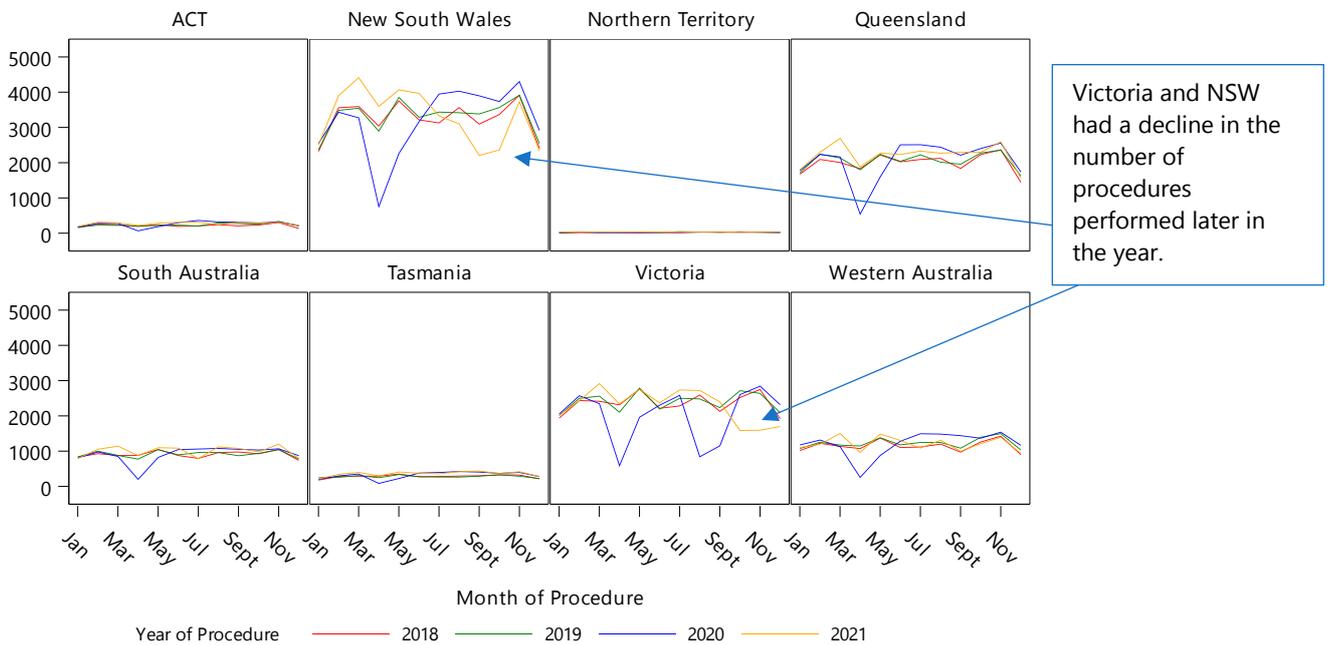
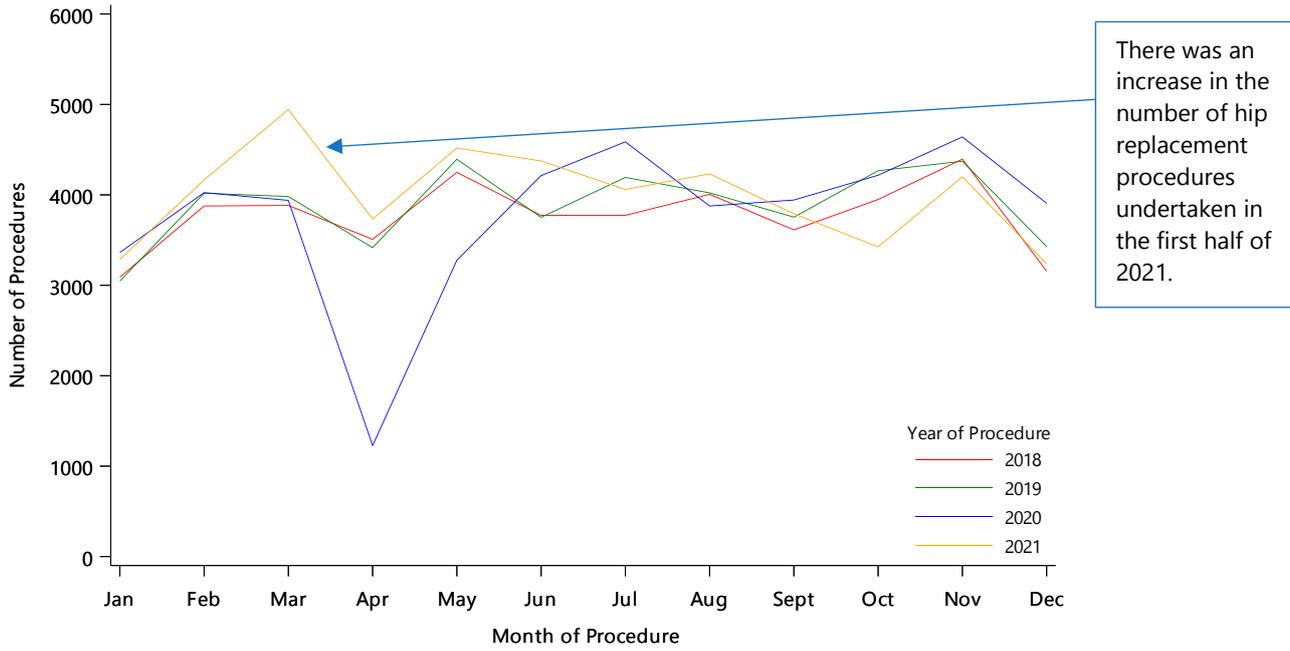


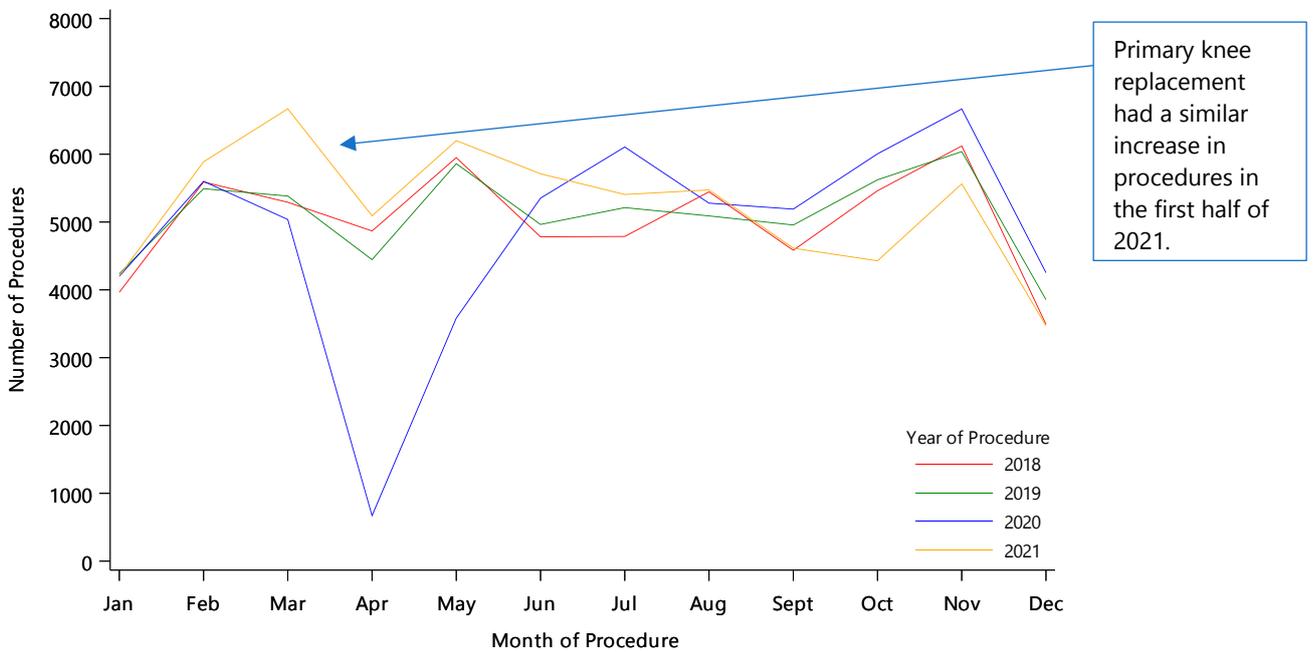
Figure L6 All Joint Replacement – By State and Territory



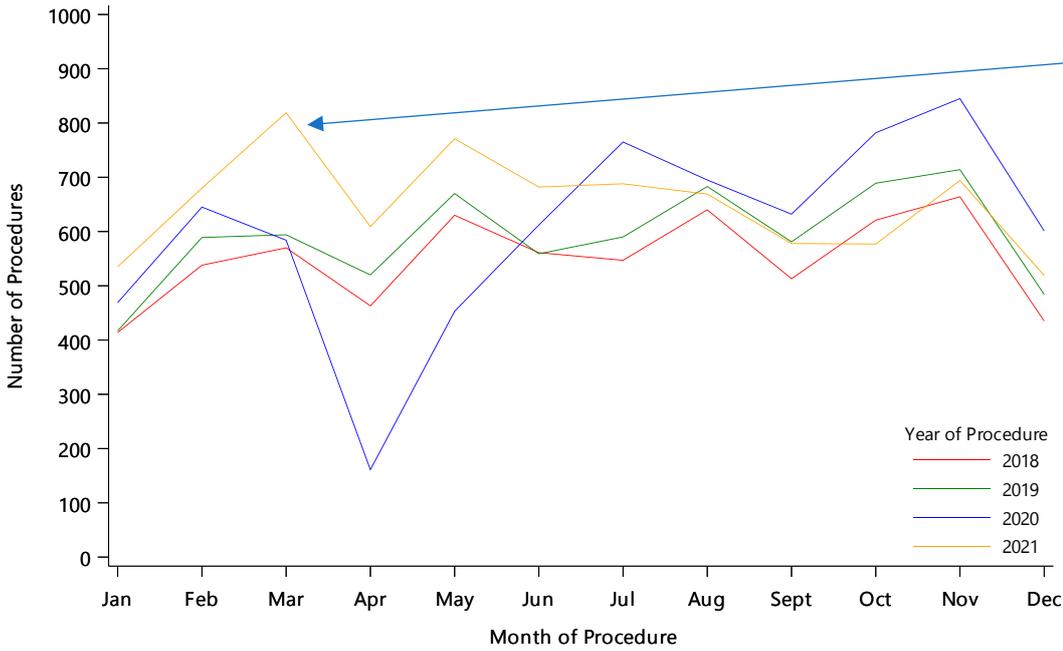
**Figure L7 All Primary Hip Replacement (All Diagnoses)**



**Figure L8 All Primary Knee Replacement (All Diagnoses)**

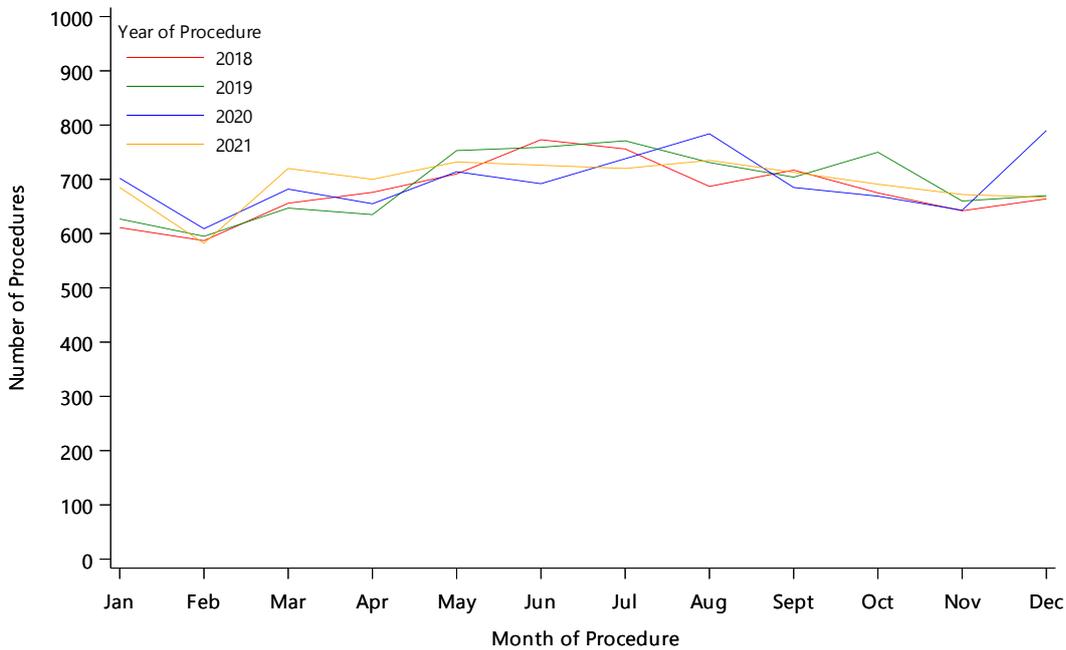


**Figure L9 All Primary Shoulder Replacement (All Diagnoses)**



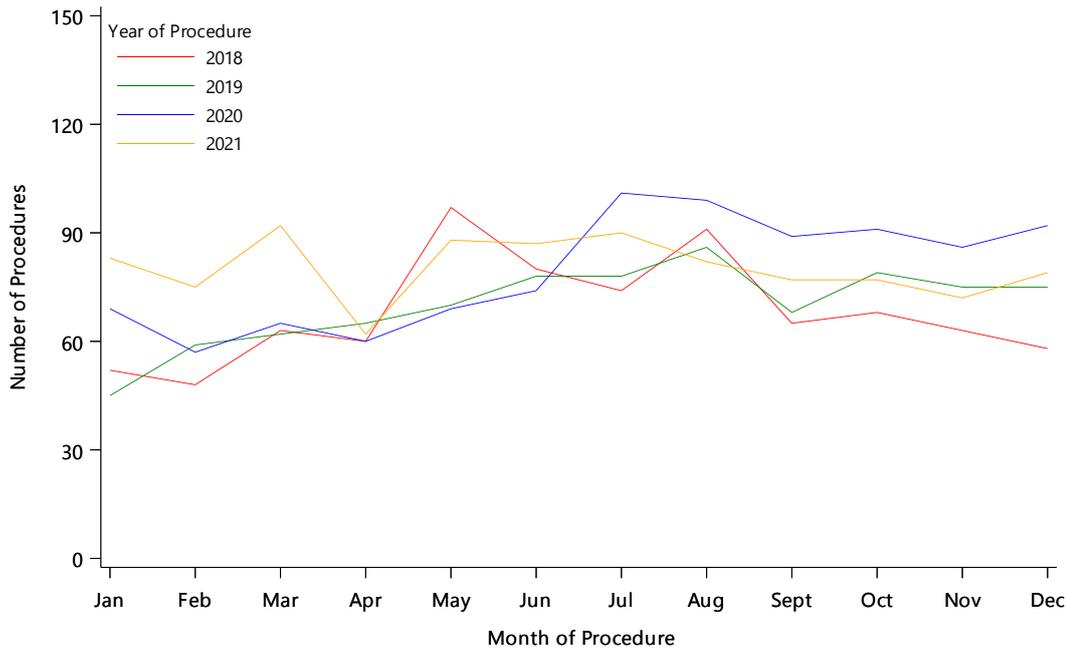
Similarly to hip and knee procedures, there was an increase in the number of shoulder replacement procedures undertaken in the first half of 2021.

**Figure L10 Primary Hip Replacement (Primary Diagnosis Fractured Neck of Femur)**



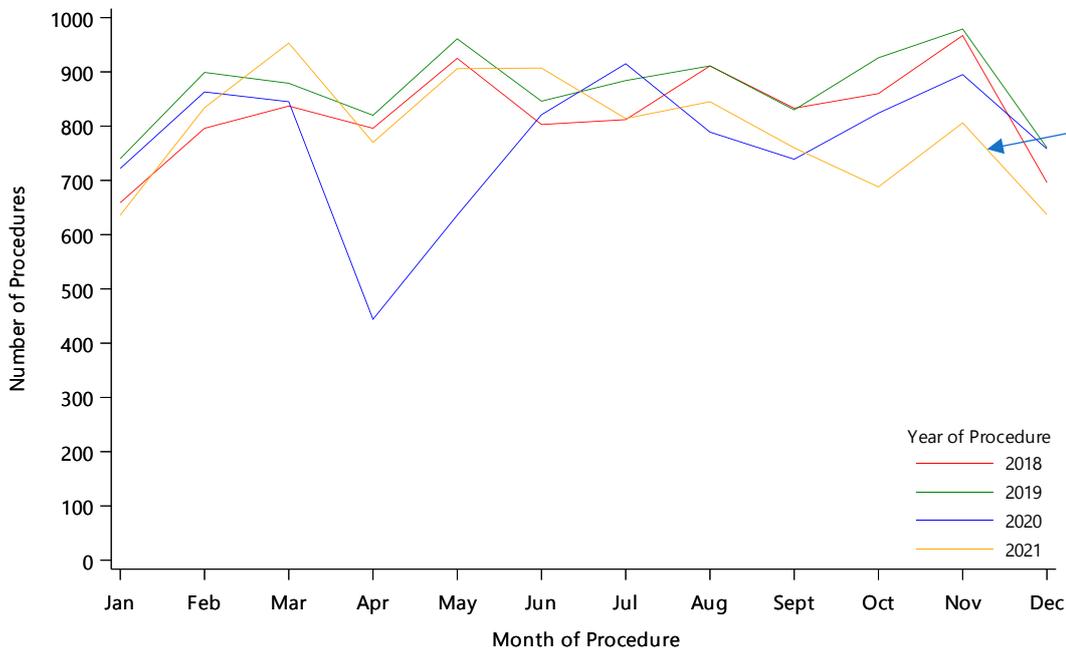
The number of hip replacements undertaken for the management of fracture in 2021 was similar to previous years.

**Figure L11 Primary Shoulder Replacement (Primary Diagnosis Fracture)**



The number of shoulder replacements undertaken for the management of fracture in 2021 was similar to previous years.

**Figure L12 Revision Hip, Knee and Shoulder Replacement**



Revision procedures declined in the last 3 months of 2021.

# Patient Reported Outcome Measures

## Introduction

As mentioned previously, the patient reported outcome measures (PROMs) used by the Registry are survey questions designed to assess, from the patient's perspective, their general health and wellbeing as well as the extent of problems including the amount of pain specifically related to the joint that is being operated on. PROMs are commonly used in research to measure the outcomes (effectiveness) of medical interventions, such as surgery. They are also frequently used in clinical practice to measure the quality of care and to guide decision-making for patients and surgeons.

After the success of a PROMs pilot program which started in 2018, the national roll-out of PROMs data collection by the Registry commenced in 2020. The Registry first provided information on PROMs in last year's Annual Report. These additional joint replacement outcomes are reported directly by patients through an electronic data capture system. The system is set up in such a way that in addition to the general information provided in the Annual Report, each patient can also see their pre-operative and post-operative responses compared to all other patients undergoing the same procedure through the secure password protected online system in real-time.

## Data Collection

This year, the Registry is again reporting PROMs data for primary total hip and primary total knee replacement undertaken for osteoarthritis, primary total stemmed and total reverse shoulder replacement for osteoarthritis, and primary reverse total shoulder replacement separately for rotator cuff arthropathy.

The data are presented overall for each category of joint replacement as well as for the two different shoulder diagnoses, and how this varies by age, gender, ASA score and BMI category.

Several different survey questionnaire tools are used to collect data on patients' experience of their quality of life and joint-specific pain and function. This data is asked of patients before their surgery and again 6 months after their surgery. This enables the change to be accurately assessed. In addition, after the surgery patients are also asked how satisfied they are with the results of the operation.

## PROM Instruments

The specific survey instruments used for AOANJRR PROMs are described below.

### OVERALL HEALTH

The EQ-5D (EuroQol five dimension survey instrument) provides a simple descriptive profile of a patient's health state. It is commonly used throughout the world. The EQ-5D is made up of what is referred to as five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each dimension has five response levels: no problems, slight problems, moderate problems, severe problems, extreme problems. The patient is asked to indicate their health state by checking the box next to the response level for each of the five dimensions that most accurately reflects how they feel.

The EQ-VAS (or EQ-VAS Health) is a measure of patient-reported health 'today' and provides an alternative way to understand an individual's rating of their own overall current health. It uses a visual scale so people can place themselves where they think they are for their overall health. The scale ranges from zero (worst health imaginable) to 100 (best health imaginable).

Changes in the EQ-5D and EQ-VAS scores from pre-operative to post-operative are analysed and reported on by the Registry. By comparing pre-operative and post-operative scores, the Registry can measure the extent of change.

Oxford Scores are questionnaires that are specifically designed to assess the function and pain of the joint that is to be operated on. They are used to understand the extent of the problem that patients are having with the joint. The score is used, not only to assess pain and joint function before surgery, but also after. There are 12 questions to answer with five choices each, giving an overall score. The

before and after scores are to see what changes there have been for individuals. These individual scores are also combined to assess the change that has occurred for the whole group.

Satisfaction is measured on a scale from one (very dissatisfied) to five (very satisfied) with the joint replacement procedure. Patient-reported change in joint function is measured on a scale from one (much better) to five (much worse).

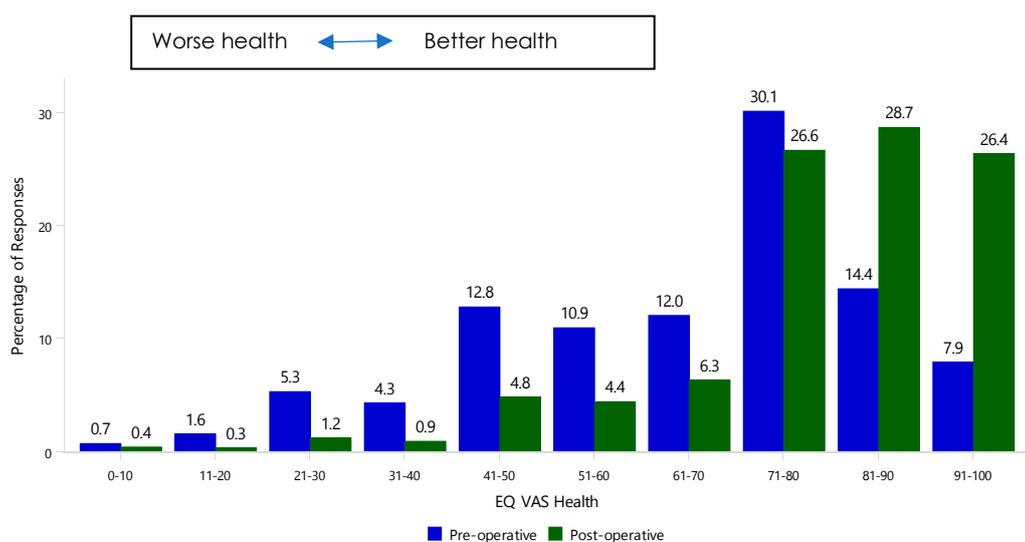
### Interpreting Patient Reported Outcomes

The PROMs chapter in the Annual Report provides a number of tables and graphs unique to reporting PROMs data. These have not been provided in the Annual Report previously as the information obtained from PROMs is presented in different ways to other Registry data. The explanations below are designed to assist you to review and interpret the charts used within this year's PROMs chapter.

#### BAR CHARTS

Bar charts illustrate the findings of scales (EQ-5D, EQ-VAS, and Oxford Hip and Knee Scores). The scale at the bottom of the graph ranges from 0 ('worst health imaginable') to 100 ('best health imaginable'). The numbers at the top of each coloured bar are the percentage of patients that have reported that selection within each of the 10 point scale groups listed at the bottom of the graph (Figure L13).

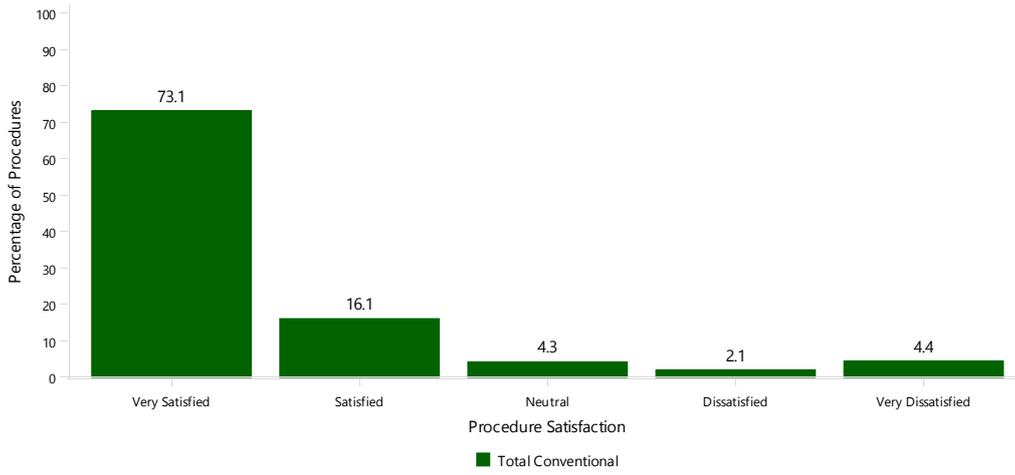
**Figure L13 Mean Pre-operative and Post-operative EQ-VAS Health in Primary Total Conventional Hip Replacement (Primary Diagnosis OA)**



This graph shows patient outcomes of their health before and after hip surgery (before in blue and after in green). There are more patients to the left-hand side of graphs in blue before surgery and more to the right-hand side in green indicating that many but not all patients felt their health had improved after surgery.

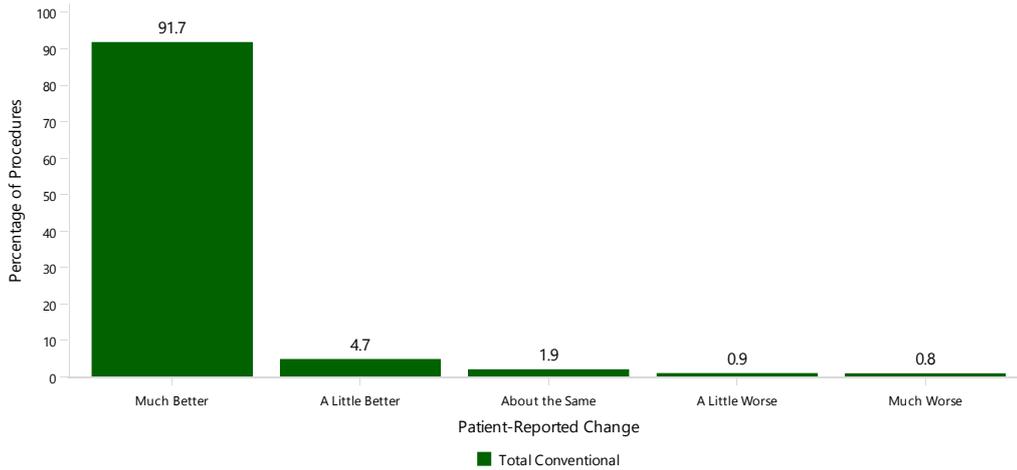
Patients were surveyed at 6 months post-operatively on how satisfied they were with their primary joint replacement, and on their perceived change in their joint replacement after surgery. Simple bar charts are provided that display the findings (Figure L14).

**Figure L14 Procedure Satisfaction in Primary Total Conventional Hip Replacement (Primary Diagnosis OA)**



This graph shows that most patients felt very satisfied with their joint replacement.

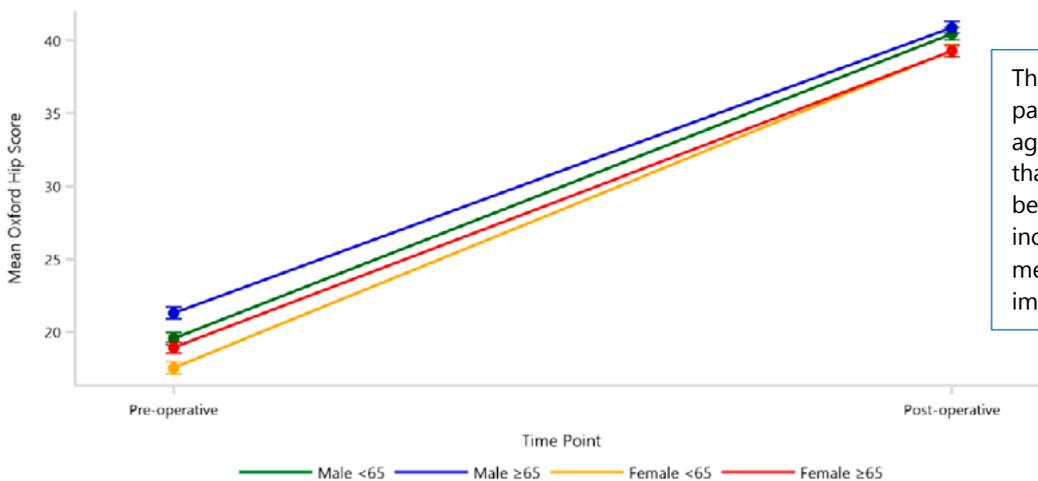
**Figure L15 Patient-Reported Change in Primary Total Conventional Hip Replacement (Primary Diagnosis OA)**



Most patients who had hip replacements felt their hip was much better after their surgery.

Another graph shown in the PROMs sections reports patient score of pain and function before surgery and at 6 months after surgery (Figure L16).

**Figure L16 Mean Pre-operative and Post-operative Oxford Hip Score in Primary Total Conventional Hip Replacement by Gender and Age (Primary Diagnosis OA)**



This graph shows the level of pain and function score by age and gender. The score that patients provided before their surgery has increased after their surgery meaning that they have improved.

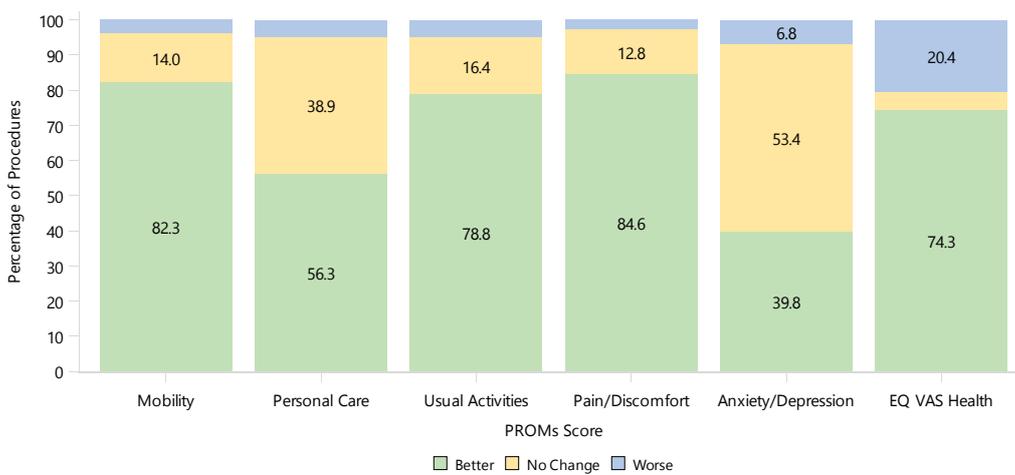
**STACKED BAR CHARTS**

These illustrate the changes before and after surgery that a patient experiences, against different aspects of a patient’s life (mobility, personal care, etc.) using the different measurement tools shown at the bottom of the chart.

The following figures show the percentage of people who feel better, the same, or worse after their joint replacement surgery. The only scale on which most people feel no difference is for anxiety and depression, although up to four in 10 (hip surgery) people do feel less anxiety and depression after their procedure.

The results for patient-reported reductions in pain are positive for up to almost 9 out of 10 people undergoing hip surgery.

**Figure L17 Percent Change in PROMs Scores from Pre-Operative to Post-Operative Primary Total Conventional Hip Replacement (Primary Diagnosis OA)**



The 'stacked' aspect of the chart shows the percentage of patients who experience:

- feeling 'better' (green),
- having 'no change' (yellow)
- feeling 'worse' (blue) after surgery.

## SUMMARY OF PROMS RESULTS

We hope that the above information on how to interpret the PROMs data presented in the main report helps those who are interested to look at that information in more detail. It is important to understand that the reporting of this information is at a very early stage. Much more comprehensive information will become available as additional data is collected over the coming years.

The initial findings are not surprising and indicate that most patients have large improvements in quality of life, joint pain and function 6 months after their operation. These improvements were seen no matter the age, gender, ASA score or BMI category of the patients operated on. It is well known that joint replacement surgery is a very successful operation, and this information confirms that.

PROMs information can also be used to understand whether there are variations in patient groups having joint replacement surgery across the Australian community. In particular, the variations in the general health or the severity of problems with the joint being operated on. The early data on this indicates that there is not a big difference in patients having this surgery.

What is more important to understand is why some patients do not get the benefit that is hoped for. There could be all sorts of reasons for this, and it will be a major focus of the Registry going forward to understand why this occurs and how the results from a patient's perspective can be made even better. To do this effectively, the Registry needs more information than it has at the moment. Currently, the Registry is working hard to increase the number of patients that are providing PROMs data. Collecting this information in the coming years will help the Registry to make important findings that can be used to continually improve the results of these very valuable operations.

## Ten, Fifteen and Twenty Year Prosthesis Outcomes

This chapter provides information on hip and knee prostheses that have the longest follow-up in the Registry. It is very important to understand what the revision rates for different types of joint replacement are in the long term. The aim of joint replacement surgery is to relieve pain and restore function for as long as possible. Those prostheses with the lowest rates of revision over many years achieve this best.

Since the Registry commenced data collection the risk of a revision operation has gone down. A major reason for this has been the improvement in the prostheses used. Since the Registry started collecting data over 20 years ago many of the prostheses being used back then are no longer available. When considering which are the best prostheses to use, there is little point in considering the results of devices that are no longer available. It is for this reason that only procedures using prostheses that have been available and used in 2021 (described as modern prostheses) are included in these analyses.

### Ten Year Outcomes

This year, the Registry is reporting on the outcome of 41 different modern hip prostheses (combinations of femoral and acetabular prostheses with at least 10 years of follow-up). Prostheses with 10 years of follow-up data account for 78% of all primary total conventional hip procedures being undertaken in Australia. The cumulative percent revision of primary total hip procedures that have 10 years of follow-up data varies from 2.8% to 8.8%. In this analysis, two groups of devices have been identified that have performed to a high standard, i.e. they are revised less often than other devices. There are prostheses with what is referred to as a 'superior benchmark' and then a second group which have been identified as having a 'non-inferior benchmark'.

All of these devices have proven low revision rates at 10 years. The superior benchmark devices have either a slightly lower revision rate than the non-inferior benchmark devices or the certainty of the lower revision rate is higher. Both of these groups have what is regarded as low revision rates at 10 years. The Registry identified 9 hips with a superior benchmark and an additional 6 hips with a non-inferior benchmark. In other words, of the 41 different modern hip prosthesis combinations, 15 (36.6%) are identified as having low revision rates at 10 years. This is regarded as a very good result for these 15 different hip replacements.

It is important to appreciate that many factors that contribute to the revision rates of different prostheses and many of the prostheses not identified as having a superior or non-inferior performance are likely to give excellent results. Surgeons are always happy to discuss the choice of prostheses with patients as it is a chance to alleviate any concerns around this.

A similar analysis was undertaken for primary total knee replacement. The Registry identified 42 modern total knee replacement combinations with data for 10 years or more. This group accounts for 82.2% of all the total knee procedures reported to the Registry. The percentage of knee replacement procedures that have 10 years of follow-up data and have been revised varies from 2.8% to 9.7%.

The Registry identified 7 knee prostheses with a superior benchmark and an additional 12 prostheses with a non-inferior benchmark. In other words, of the 42 different modern knee prostheses combinations, 19 (45.2%) are regarded as having a very good result.

### Fifteen Year Outcomes

The Registry also has information on currently used prostheses (20 hips and 28 knees) that extends out to 15 years. Many of the devices have performed well.

The percentage of hip procedures that have 15 years of follow-up data and have been revised varies between 4.5% and 19.2%. The Registry identified 4 hip prostheses with a superior benchmark and an additional 4 prostheses with a non-inferior benchmark. In other words, of the 20 different modern hip prosthesis combinations, 8 (40.0%) are identified as having low revision rates at 15 years.



For knee replacements, the percentage of procedures that have 15 years of data and have been revised varies between 3.4% to 11.8%. The Registry identified 6 knee prostheses with a superior benchmark and an additional 8 prostheses with a non-inferior benchmark.

In other words, of the 28 different modern knee prostheses combinations, 14 (50.0%) are regarded as having a very good result at 15 years.

## Twenty Year Outcomes

The Registry can report 20 year outcome data for 8 hip and 9 knee combinations of prostheses that are currently being used. The hip prosthesis combinations have been used in 30.3% of all primary total conventional hip replacement procedures performed for osteoarthritis. The 20 year cumulative percent revision ranges from 5.4% to 17.8%.

The knee prosthesis combinations were used in 18.4% of all primary total knee replacement procedures performed for osteoarthritis. All 9 combinations were used in 2021. The 20 year cumulative percent revision ranges from 6.0% to 10.5%.

## Hip Replacement

The Registry considers three different categories of hip replacement. These are primary partial, primary total and revision hip replacement. Each of these categories is divided into a number of different classes. These are described in the Annual Report at the start of the section on hip replacement.

There were 52,787 hip replacements reported to the Registry in 2021. This is an increase of 2,699 procedures (5.5%) compared to the number undertaken in 2020.

Primary partial hips account for 14.3% of all hip replacements reported to the Registry since it commenced data collection. Primary total hips account for 75.3% and revision hips 10.4%.

The proportion of hip replacement procedures that are undertaken each year that are revision operations is called the revision burden. The aim of any intervention to improve the outcome of joint replacement is to reduce the revision burden. The revision burden has declined since 2003 with the exception of 2011. In that year, the Registry reported an increase in the revision burden. This was largely due to the high revision rate of large head metal on metal hip replacements and in particular the ASR XL prostheses. In 2012, the revision burden again declined and has continued to decrease since that time. In 2011, the revision burden was 12.6%, in 2012 it was 11.9%, in 2013 it was 10.7%, and in 2021 it has decreased to 7.6%. This is the lowest revision burden for hip replacement ever reported by the Registry. However, the impact of COVID-19 makes the interpretation of this finding uncertain.

The Registry data continues to show that in general, Australian surgeons have increasingly used approaches to hip replacement and hip replacement prostheses that the Registry has identified as being associated with an improved result. This is particularly evident in recent years with the increased use of prostheses known to have excellent outcomes over a long period and the decreased use of those that are known to have a less satisfactory result. It is anticipated that the effect of these changes will have a progressively beneficial impact on the revision burden in the coming years.

### Primary Partial Hip Replacement

Most partial hip replacements are used to treat broken hips. Elderly patients with a broken hip involving a complete fracture at the base of the femoral head (ball of the hip joint) which is significantly displaced (moved out of position). This is commonly referred to as a sub-capital fractured neck of femur.

The Registry has previously reported that the risk of further revision surgery following the treatment of broken hips with primary partial hip replacement is dependent on a number of factors. These include the age at the time of surgery, class of partial hip replacement, method of fixation, and the type of prosthesis used.

There are three main classes of partial hip replacement: unipolar monoblock prostheses, unipolar modular prostheses, and bipolar prostheses. Each has its place in the management of broken hips.

When the Registry first started collecting data, unipolar monoblock prostheses were the most common type of partial hip prostheses used. Of the three types of partial hip replacement, this has the highest rate of revision. The use of these devices, however, has continuously declined over the years and it is now rarely used.

Unipolar modular and bipolar replacement have a lower risk of revision in the 'younger' elderly population (below 85 years). Bipolar prostheses are revised less frequently than unipolar modular prostheses when individuals are less than 75 years of age.

The use of cement fixation reduces the risk of revision by approximately half, regardless of the class of partial hip replacement. Consequently, in recent years there has been a dramatic increase in the use of cement fixation when partial hips are used. However, the vast majority of partial hip replacements will do well, whether they are cemented or not.

More information regarding partial hip procedures is available in the 'Partial Hip Arthroplasty Supplementary Report' on the AOANJRR website: <https://aoanjrr.sahmri.com/annual-reports-2022>.

### Primary Total Hip Replacement

There are two main classes of primary total hip replacement. The first and most common is total conventional hip replacement, which involves replacing the femoral head (ball of the hip joint) as

well as the acetabulum (socket of the hip joint). The second is a total resurfacing hip replacement. Although the socket is replaced in a similar way to a conventional hip, it differs in that only the surface of the femoral head is replaced rather than the whole head.

Overall, resurfacing hip replacement has a higher rate of revision compared to primary total conventional hip replacement. In recent years, the use of total resurfacing hip replacement has continued to decline. In 2021, it was used in only 1.1% of all hip replacements performed.

Factors that affect the outcome of primary total resurfacing hip replacement include the type of prostheses used, as well as the gender, age, and size of the patient. Women have a significantly higher rate of revision. This difference has resulted in this procedure now being done almost exclusively in males. Men have an age-related rate of revision. Males over the age of 65 years have a much higher rate of revision in the first 6 months after surgery and consequently, this surgery is almost never done in patients above this age.

It appears that there are a number of reasons for the difference in outcomes related to gender. The first relates to the size of the patient. Smaller femoral head sizes do not do as well in a resurfacing procedure and women on average have smaller femoral head sizes. It also appears that women still have a higher rate of revision following a resurfacing hip replacement when a larger head size is used, but the reason for this is not clear. Males with a smaller femoral head size also have an increased risk of revision when compared to males with larger femoral head sizes. The use of this type of hip replacement is now largely confined to men younger than 65 years who have larger femoral heads.

The Registry has identified many factors that affect the outcome of primary total conventional hip replacement. These can be divided into patient and prosthesis factors.

Patients with osteoarthritis have better outcomes compared to patients having a total hip replacement for a different reason. Generally, it can be said that women have a slightly lower risk of revision compared to men. In the long term, the rate of revision decreases as the age at the time of the initial surgery increases. This is more apparent in women than in men.

The Registry is again reporting on the impact of ASA score and BMI for all patients. The impact of ASA score and BMI is only reported for the first few years after surgery as the Registry only commenced collection of ASA data in 2012 and BMI data in 2015. The ASA score is a measure of general health. The score increases with the number of health problems. The higher the ASA score, the higher the risk of revision, this is due in part to an increased risk of revision for infection. This is because the general health of patients with a higher ASA score at the time of surgery is not as good. There are six categories of BMI which include underweight, normal, pre-obese and then obese 1, 2, and 3. The revision rate is increased in patients with a BMI that is categorised as obese 1, 2, or 3. The most common reason for the increased rate of revision is infection.

The Registry is again reporting on the effect of surgical approach. The Registry only commenced collecting data on approach in 2015 so this analysis is only relevant to early outcomes. There are three main operative approaches used for hip replacement. They are posterior, lateral and anterior. As was reported last year, there is no difference in the risk of a revision when the three approaches are compared. However, there are differences in the reasons why a revision is undertaken. The anterior approach has a higher rate of revision for loosening and early fracture compared to the posterior and lateral approach and a lower rate of revision for infection and dislocation.

As has been done in previous years, important prosthesis characteristics that influence outcomes have been highlighted in this year's report. These include the method of fixation, the type of bearing surface of the artificial hip joint, and some special design features of both the femoral and acetabular prostheses.

Primary total conventional hip replacements vary in the method used to fix the prosthesis to bone. There are three main types of fixation, cemented, cementless and hybrid fixation. Cemented fixation is when the femoral and acetabular prostheses are fixed to bone using a hard setting plastic called methyl methacrylate (bone cement). Cementless fixation is when the femoral and acetabular prostheses are fixed directly to bone without using cement. Initially, the fixation is achieved by fitting the device tightly into the bone. This tight fit then allows bone to grow into specially designed roughened surfaces on both the femoral and acetabular components to permanently fix the device in place. Prostheses are designed to be specifically used with cemented or cementless fixation. The other main approach to fixation is hybrid fixation. This involves cementing the femoral component and using a cementless acetabular component.

For many years, the Registry has reported that age has a major influence on the outcome of the different types of fixation. In general, older patients do better with hybrid or cement fixation and younger patients do better with hybrid or cementless fixation. The likely reason for this is that cementless fixation particularly of the femoral component does better when the quality of a patient's bone is good. It is known that bone quality declines as we get older. With the analysis restricted to modern prostheses, there is little difference in outcomes based on fixation except for patients aged  $\geq 75$  years where the revision rate is lower when either hybrid or cement fixation is used.

The Registry is again reporting on the outcomes related to the use of different bearing surfaces. The bearing surface is the articulating surface i.e. the artificial ball and socket of the hip joint. It varies depending on the material used to make the femoral head and the acetabular socket. The socket may be plastic, ceramic, or metal. The type of plastic used is called polyethylene, it may be non cross-linked (non XLPE) or cross-linked (XLPE). XLPE means that an additional manufacturing process has been used that increases the bonding of the molecules within the polyethylene. It has been shown in laboratory testing that increasing the cross-linking, reduces the wear of this material as the hip replacement moves. The femoral head (ball) may be made of metal, ceramic, or a third option called ceramicised metal, which is available mainly from one company. The bearing surface is made up of the combination of materials used to make both the ball and the socket. Consequently, there are a number of possible combinations that make up the different bearing surfaces. These include metal on polyethylene (non XLPE and XLPE), ceramic on polyethylene (non XLPE and XLPE) and ceramic on ceramic. Ceramicised metal femoral heads are only used with polyethylene (XLPE and non-XLPE). Metal on metal bearings were used in the past but this bearing is now largely confined to resurfacing hip replacements. The reason that metal on metal is not used in other types of hip replacements, is because it does not work as well as other available artificial joint surfaces.

In recent years, the type of polyethylene used has been almost entirely XLPE. The use of this material has been associated with a significant reduction in the rate of revision in primary total conventional hip replacement for dislocation, loosening, and lysis. The reduced rate of revision for dislocation is due to an increased use of larger head sizes (32mm or greater) in XLPE procedures. It is possible to use these larger head sizes because this type of polyethylene is more resistant to wear. When a larger head size is used, the hip replacement is more stable and so there is a lower rate of revision for dislocation. The reduced rate of revision for loosening and lysis is thought to be due to the reduced wear rate. Loosening and lysis are most often due to an inflammatory reaction, that occurs following the production of small wear particles. Theoretically, a reduced wear rate means fewer particles and therefore less inflammation.

The lower rate of revision for XLPE compared to non XLPE occurs, regardless of whether a metal, ceramic or ceramicised metal femoral head is used. No matter what type of femoral head is combined with an XLPE socket the results are very similar.

The Registry has undertaken a detailed analysis of ceramic on ceramic bearings. Although the Registry has information on three different ceramics, only one of these ceramics (mixed ceramic) is in current use. It is the best of the three ceramics. The revision rate of mixed ceramic varies slightly with femoral head sizes less than 32mm having a slightly higher rate of revision. Compared to the different femoral heads used with XLPE the results are very much the same. On occasion in the main report, you may see that the Registry has referred to modern bearings, these include ceramic on ceramic bearings as well as metal, ceramic and ceramicised metal femoral heads combined with XLPE.

The Registry also reports the results of a number of different types of hip replacements that have special features. These include exchangeable neck femoral components, mini femoral stems, as well as constrained and dual mobility acetabular components. The Registry is reporting on the results of these devices again this year.

Exchangeable neck femoral stems have a neck that is modular and includes different lengths and angles that can be fitted into the femoral stem. This differs from most other femoral stems where the neck and the stem are attached. The purpose of exchangeable necks was to give the surgeon greater choice to replicate the desired anatomy and the optimum position of the femoral component. Unfortunately, these devices generally do not work as well as fixed neck stems and they have largely been abandoned. Information on exchangeable necks is no longer provided in the main Annual Report. Detailed information on femoral stems with exchangeable necks is available in the supplementary report 'Prosthesis Types with No or Minimal Use' on the AOANJRR website: <https://aoanjrr.sahmri.com/annual-reports-2022>

Mini stems are very short cementless femoral stems, where fixation to the bone is over a smaller area entirely in the top of the femur. This contrasts with the standard femoral stem that usually extends almost halfway down the length of the inside of the femur. Currently, mini femoral stems remain a relatively new technology and are not commonly used. They represent less than 1.9% of all total conventional hip procedures. Mini stems have a reduced rate of revision after 6 months compared to standard femoral stems. There is a difference in the reasons for revision, with the mini stems requiring revision because they were more likely to become loose or fracture at 1 year compared to the standard stem. The rate of revision also varies depending on the type of mini stem used.

A constrained acetabular prosthesis is a special prosthesis. Unlike normal acetabular prostheses, it has a mechanism to lock the femoral head inside the acetabular socket so that there is a reduced chance of dislocation but at the same time allowing almost normal movement of the hip joint. It is not surprising to find they are used in different types of clinical situations to usual acetabular prostheses. In particular, they have been used more commonly in situations known to have a higher risk of dislocation. Constrained acetabular prostheses compared to modern non-constrained acetabular prostheses when used to treat patients with osteoarthritis have a higher rate of revision. When they are used to treat patients with a broken hip there is no difference.

Another type of special acetabular prosthesis is the dual mobility acetabular prosthesis. The reason it is called dual mobility is because the femoral head articulates with a polyethylene liner, but unlike the common situation where the polyethylene liner is fixed to the acetabular shell, in the dual mobility the liner is designed to move or articulate with the metal shell (i.e. there is dual mobility). The purpose of the dual mobility design is similar to the constrained acetabular prosthesis, in that it is designed to reduce the risk of dislocation. Similar to constrained acetabular prostheses, the proportion of dual mobility acetabular prostheses used for unusual reasons is high compared to standard acetabular prostheses. There has been increasing use of dual mobility devices in recent years. There is no difference in the revision rate of dual mobility acetabular prostheses compared to standard modern acetabular prostheses when the patient is being treated for osteoarthritis. However, revision specifically for dislocation is reduced when a dual mobility prosthesis is used. There is no difference between dual mobility and standard modern acetabular prostheses when used to treat a broken hip.

## Knee Replacement

As with hips, the Registry considers three different categories of knee replacement: primary partial, primary total, and revision knee replacement. Each of these categories is further divided into a number of different classes. These are described in the Annual Report at the start of the section on knee replacement.

There were 68,466 knee replacements undertaken and reported to the Registry in 2021. This is an increase of 5,141 procedures (8.2%) compared to the number reported in 2020.

Primary partial knee replacement accounts for 7.4% of all knee replacements reported to the Registry since it commenced data collection. Primary total knees account for 84.6% and revision knees 8.0%. Almost all primary knee replacements, whether they are partial or total, are undertaken for osteoarthritis.

The proportion of knee procedures that are revision procedures, has been decreasing since the Registry was implemented. The percentage of knee replacements that are revisions decreased from 8.8% in 2004 and 8.0% in 2019 to 7.4% in 2021. However, the impact of COVID-19 makes the interpretation of this finding uncertain.

### Primary Partial Knee Replacement

A partial knee replacement is a replacement that only replaces part of the knee joint. The Registry identifies five classes of primary partial knee replacement. Most are used in small numbers and two are no longer used in Australia. The main report provides information on unicompartmental knee replacements and patella/trochlea partial knee replacements are reported in the Patella/Trochlea Partial Knee Arthroplasty Supplementary Report. The results of the two classes of partial knee replacement that are no longer used are available in the supplementary report on the AOANJRR website called Prosthesis Types with No or Minimal or Use.

The most used partial knee replacement is the unicompartmental knee. This replaces the femoral and tibial joint surfaces on either the inner or outer side of the knee (most commonly the inner side of the knee), its use accounts for 92.7% of all primary partial knees. Primary unicompartmental knee replacement has a higher rate of revision than primary total knee replacement. Age is a major factor affecting the outcome of unicompartmental knee replacement. The younger the patient, the more likely it is that the procedure will be revised early. At 20 years following a unicompartmental knee replacement, 28.4% have been revised. Almost 43.5% of patients less than 55 years of age at the time of their surgery have been revised within 20 years.

Unicompartmental knee replacement may be undertaken on the medial (inner), or lateral (outer) side of the knee. Medial unicompartmental knee replacement is much more common and accounts for 96.0% of all unicompartmental knee replacements. There is no difference in the revision rate when medial and lateral unicompartmental knee replacements are compared. The revision rate of unicompartmental knee replacement varies depending on the type of prosthesis used. The Registry has been following and reporting on the outcomes of unicompartmental knee replacement that is placed in position using robotic surgery. Most commonly this is used with one device. The early results of this type of surgery appear to be satisfactory.

More information regarding patella/trochlea partial knee procedures is available in the 'Patella/Trochlea Partial Knee Arthroplasty Supplementary Report' on the AOANJRR website: <https://aoanjrr.sahmri.com/annual-reports-2022>.

### Primary Total Knee Replacement

A primary total knee involves the removal and replacement of the joint surface of the femur and the tibia on both the medial (inner) and lateral (outer) sides. A single femoral prosthesis and a single tibial prosthesis are used. The tibial prosthesis may be one component, but it is more commonly two that are put together at the time of surgery. Usually, a metal tray fits over the cut surface of the tibia with a plastic insert (tibial insert) that fits inside the tray to make the tibial prosthesis. This then articulates with the single femoral replacement. A primary total knee replacement may or may not have the under-surface of the patella replaced.

Primary total knee replacement has the lowest rate of revision compared to all other types of primary knee replacement. Men have a slightly higher rate of revision compared to women. The most

important patient factor identified by the Registry that influences the rate of revision is age at the time of surgery, the younger the patient the higher the subsequent rate of revision. Patients less than 55 years of age at the time of surgery have a 16.6% chance of being revised at 20 years. However, the rate of revision is less for older patients.

An important difference between hip and knee replacement is what keeps the artificial joint surfaces from moving out of position. This is referred to as the stability of the joint. An unstable joint has additional unnatural movements between the joint articulating surfaces. The very extreme example of this is when the articulating surfaces come apart. This is referred to as dislocation which unlike hip replacement is very rare following knee replacement. There can also be lesser degrees of unnatural movement that can cause problems with the function of an artificial joint without the joint actually dislocating. In general, the stability of the joint is dependent on the shape of the joint as well as the soft tissues (muscles and ligaments) around the joint. If everything is working correctly, the combination of these factors allows normal movement and prevents unnatural movements (sideways or back and forward) between the joint surfaces. As the hip is a ball inside a socket joint, there is a lot of stability simply because of the shape. This is not the case with knee replacement where the tibial surface is relatively flat. The stability of the knee joint is much more dependent on surrounding soft tissues and in particular ligaments that hold these joint surfaces in place and in the correct alignment. Quite often in patients receiving a knee replacement, one or more of these ligaments may already be damaged. In order to address this issue, primary total knee replacement can vary depending on the additional built in stability that may be required. In certain circumstances, it is necessary to use a replacement that is designed to substitute for one or more of the damaged ligaments.

Most knee replacements used do not require any additional stabilising, other than substituting for the anterior cruciate ligament. These are referred to as minimally stabilised knee replacements. The next most common group is posterior stabilised. These have additional stability built into the knee replacement so that the prosthesis substitutes for both the posterior and anterior cruciate ligaments. The vast majority of knee replacements used are either minimally or posterior stabilised prostheses. Minimally stabilised prostheses have a slightly better outcome than posterior stabilised prostheses. However, there is some difficulty in being too definite about this, as posterior stabilised prostheses may be used more often in difficult cases. If a case is more difficult, it has more potential to be revised.

There is only a small variation in the outcome of knee replacement related to the type of fixation used to hold the tibial and femoral components tightly to bone. Hybrid fixation has the lowest rate of revision, but the difference is not major. Cemented fixation has a lower rate of revision compared to cementless fixation, but this varies depending on whether the total knee replacement is minimally or posterior stabilised. Minimally stabilised knees do best if at the very least the tibial component is cemented. Posterior stabilised knees do best when both the tibial and femoral components are cemented to the bone.

Other important ligaments around the knee are the medial and lateral collateral ligaments. These can also be substituted by what is often referred to as constrained knee replacements. These are not often required in primary operations. There is one final group of knee replacement when considering stability and these are hinged knees. These are used mostly when there is absolutely no ligament stability left in the knee. Their use is very rare for primary knee replacement.

Another general difference in the design of primary total knee replacement is the way the tibial insert is designed to move on the surface of the tibial tray. It may either be fixed to the tray (fixed insert) or designed to move slightly in one or more specific directions (mobile insert). Mobile inserts either rotate, slide or do both. For a number of years, the Registry has reported that in general, fixed inserts have a lower rate of revision.

Unlike hip replacements, knee replacements only have two main types of bearings. They are a metal femoral component combined with polyethylene, either XLPE or non-XLPE. Comparing the outcome of XLPE to non-XLPE across all knee replacements, there appears to be a benefit when XLPE is used. There is a lot of variation between the type of prostheses and the type of polyethylene used. As a consequence, any difference seen when comparing the overall result of XLPE to non-XLPE may be in part due to the type of prosthesis, rather than the type of polyethylene. To try and overcome this problem, the Registry has undertaken analyses of specific designs of total knee replacement that have used both XLPE and non-XLPE. There does not appear to be any situation where XLPE performs worse than non-XLPE. Sometimes it is better and sometimes it is the same.

The Registry has also carefully monitored the use and outcomes of computer navigation in primary total knee replacement. Computer navigation is computer-assisted surgery, which was first used over

20 years ago. It involves the use of intraoperative computer monitoring in an attempt to more accurately place the knee prosthesis. It is known that accurate positioning of the prosthesis is a very important factor in determining the result of the operation. The current information from the Registry suggests that there may be a small advantage, particularly in younger patients, as there is a small reduction in the rate of revision for loosening in this group.

There are also other techniques that surgeons are using in an attempt to improve the positioning of knee prostheses. Image derived instrumentation (IDI) is a technique that involves obtaining accurate images of the knee joint pre-operatively so that the instruments used to achieve the required alignment can be specifically made for that patient. In general, when IDI is used it is associated with a higher rate of revision compared to when it is not used. However, this difference is dependent on the age of the patient. When patients are younger than 65 years at the time of surgery there is no difference between IDI and conventional instrumentation.

In recent years, there has been an increase in the use of robotic surgery to aid with the accurate implantation of knee prostheses. Generally, there is a reduction in the revision risk if robotic surgery is used. There is no difference in the revision rate when used in younger patients. Longer follow-up is required before an accurate assessment of the long-term impact of this technique can be determined.

## Shoulder Replacement

Shoulder replacement is also grouped into three different categories: primary partial, primary total, and revision shoulder replacement. Each of these categories is divided into a number of different classes. These are described in the Annual Report at the start of the section on shoulder replacement.

There were 8,733 shoulder replacements reported to the Registry in 2021. The number of shoulder procedures undertaken in 2021 increased by 562 (7.1%) compared to the number undertaken in 2020.

Primary total shoulders account for 80.7% of all shoulder replacements reported to the Registry since it commenced data collection. Primary partial shoulders account for 10.0% and revision shoulders 9.3%.

Due to the staged introduction of the Registry, the first year that the Registry recorded complete national shoulder data was 2007. Since that time, the number of shoulder replacements reported to the Registry has increased each year. The number of shoulder replacements undertaken in 2021 was 219.8% more than undertaken in 2008.

However, there are differences in the rate of increase depending on the category of shoulder replacement. The number of primary partial shoulder replacements has decreased by 69.5% since 2008. The number of primary total shoulders has increased by 397.6% and revision shoulder replacement has increased by 137.1% during the same time.

In 2021, the revision burden has declined and is lowest at 7.3%. However, the impact of COVID-19 makes the interpretation of this finding uncertain.

### Primary Partial Shoulders

The Registry subcategorises primary partial shoulder replacement into four main classes. These are defined by the type of prostheses used. The main report provides information on the two main classes of partial shoulder replacement.

The most used partial shoulder replacement is hemi stemmed. This replaces the humeral head with a prosthetic head mounted on a stem. Hemi stemmed accounts for 72.7% of all primary partial shoulder replacements.

The second most used partial shoulder replacement is hemi resurfacing that uses a humeral prosthesis to replace the humeral articular surface only, without replacing the humeral head. Hemi resurfacing accounts for 23.5% of all primary partial shoulder replacements.

Partial resurfacing involves the use of one or more button prostheses to replace part of the natural articulating surface on one or both sides of the shoulder joint. Partial resurfacing accounts for 2.6% of all primary partial procedures. Hemi mid head is the least used type of primary partial shoulder replacement, accounting for 1.2%. It involves the resection of the humeral head and replacement with a humeral head and a humeral stem prosthesis. A humeral stem prosthesis may have metaphyseal or diaphyseal fixation.

### Primary Total Shoulders

There are four types of primary total shoulder replacement: total reverse, total stemmed, total mid head, and total resurfacing.

Total reverse accounts for 69.0% of all primary total shoulder replacements. It involves glenoid replacement with a glenosphere prosthesis combined with resection of the humeral head and replacement with humeral cup and humeral stem prostheses. A humeral stem prosthesis may have metaphyseal or diaphyseal fixation.

Total stemmed is the second most used type of primary total shoulder replacement, accounting for 25.1% of primary shoulder procedures. This procedure involves glenoid replacement combined with resection of the humeral head and replacement with humeral head and humeral stem prostheses. A humeral stem prosthesis may have metaphyseal or diaphyseal fixation. Cement fixation of the glenoid component in total stemmed shoulder replacement has a lower rate of revision.

Total mid head replacement is less frequently used accounting for 5.5% of all primary total shoulder replacements. This procedure involves glenoid replacement combined with resection of part of the humeral head and replacement with a humeral head and an epiphyseal fixation prosthesis.

Total resurfacing shoulder replacement is the least used type of primary total shoulder replacement accounting for 0.4%. This procedure involves glenoid replacement and the use of a humeral prosthesis that replaces the humeral articular surface without resecting the head.

Total reverse shoulder replacement has a higher rate of revision compared to total stemmed shoulder replacement for the first 3 months following surgery. After 3 months, total reverse shoulder replacement has a lower rate of revision compared to total stemmed shoulder replacement.

## Hip, Knee, Shoulder and Ankle Prostheses with a Higher than Anticipated Rate of Revision

The Registry reports on the results of individual prostheses in the different classes. There is variation in the revision rates for different types of prostheses in each class. Many of these differences are not statistically significant.

The Registry, however, does identify individual prostheses that have a statistically significant higher rate of revision. The threshold for that identification is that the revision rate is more than twice that of all other prostheses in the same class and the difference is statistically significant. In other words, the revision rate of these devices lies outside the expected norm. They are often referred to as outliers. These outliers are identified in the final chapter of the 2022 Annual Report.

This information highlights to surgeons, orthopaedic companies, and regulatory bodies worldwide, that something unexpected is happening with respect to the outcome of these prostheses. It enables consideration to be given as to the possible reasons for this difference and whether it is worthwhile or appropriate to continue to use these prostheses.

It is important to emphasise that there may be many reasons why the revision rate is twice that of other prostheses. Some of these may not necessarily be related or specific to the identified prostheses. The data relating to each of these prostheses have been carefully considered by an expert group of orthopaedic surgeons who have recommended these prostheses be identified and therefore be considered further as to whether or not they should continue to be used. When they undertake that consideration, all available data is reviewed and any subsequent investigation that they may request is undertaken and provided. The consequence of this process is that not all outliers are recommended for identification. One of the main reasons that an outlier is not identified is because it is a non-standard prosthesis that is used in unusual or complex clinical situations associated with a higher risk of revision. In this situation, it is not fair to compare the results of these special devices to that of standard prostheses used in standard clinical situations.

This year, the Registry has identified for the first time 4 prostheses or prosthesis combinations with a higher than anticipated rate of revision. These include 3 total conventional hips and 1 total knee.

Identified prostheses are listed in one of three groups. There are those that have a higher rate of revision that are being identified for the first time and are still in use in Australia. The second group includes prostheses that are being re-identified but are also still used. This list identifies that the prosthesis continues to have a higher than anticipated rate of revision and it provides updated information on its continued use. Most prostheses that are identified for the first time or re-identified prostheses decline in use with time. This is usually evident only after the first year because almost a full year of use has occurred prior to the identification in a previous Annual Report.

The third group are prostheses that are identified but are no longer used in Australia. Most of these have been previously identified. However, occasionally there is a prosthesis in this group that is identified for the first time. These are prostheses that are no longer available for use in Australia, and that as time progresses the Registry is able to identify that this device has a revision rate that is subsequently identified to be higher than anticipated.

The Registry identification of prostheses with a higher than anticipated rate of revision has resulted in many of these prostheses being withdrawn from national and international markets. Only summary information is provided in the Annual Report. However, the full detailed analysis for each of these prostheses is available from the Registry website (Investigations of Prostheses with Higher than Anticipated Rates of Revision).

## Conclusion

The purpose of the AOANJRR is to provide high-quality independent data on the results of joint replacement in Australia. The Registry provides this information to surgeons, and all other stakeholders to assist them to make informed judgments on the best approach to joint replacement surgery.

It is hoped that the information presented in this report is useful to people who are seeking additional information on joint replacement surgery, particularly those that are considering or have already undergone the operation. Registry information can be very complicated, as many factors interact to influence the outcome of the surgery. The intention of making this information available to everybody is to assist in promoting informed discussion about the outcome of joint replacement surgery, particularly between patients and their treating surgeons.