LROI Report 2014

Arthroplasty in the Picture

Annual Report of the Dutch Arthroplasty Register
(Landelijke Registratie Orthopedische Implantaten) 2014

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's-Hertogenbosch, the Netherlands

Netherlands Orthopaedic Association (NOV)
Dutch Arthroplasty Register (LROI)
www.lroi.nl

LROI

Preface

We are proud to present the fourth annual report of the Dutch Arthroplasty Register (LROI). We worked hard this year to offer you an interesting report with the most recent data from the LROI. The theme of this year's report is 'Arthroplasty in the Picture'. This theme can be addressed from various perspectives. First of all, this year the LROI linked up to the National Implant Register of the Ministry of Health, Welfare and Sports. Consequently, traceability of arthroplasty is now also ensured at government level. Besides, the quality indicators were delivered through the LROI to Zorginstituut Nederland (ZIN, Dutch National Health Care Institute) for the first time last year. Furthermore, this report will chart the survival rates of hip and knee arthroplasties for the first time. And finally we will shed more light on the numbers and types of ankle, shoulder and elbow arthroplasties that were performed in the Netherlands. These are true milestones for our LROI.

Traceability of arthroplasty ensured

The LROI was founded in 2007 with an aim to gain more insight in results of knee and hip arthroplasties that are performed in Dutch patients. These registrations will enable us to sooner identify prostheses that perform less well and, as such, registration will support continuous improvement of quality and safety of orthopaedic care, in particular by traceability of joint implants. This traceability of joint implants has played an important part in consultations with the Ministry of Health, Welfare and Sports (VWS). In January 2015, Minister Edith Schippers (VWS) decided that a National Implant Register would be founded to increase traceability of medical implants. The national register lists implants that will be traceable, if required, by the health care provider up to patient level. Meanwhile, the existing registers of orthopaedic surgeons (LROI), but also of cardiologists (NCDR), gynaecologists (POMT) and plastic surgeons (DBIR) have been linked to the National Implant Register.

As LROI, we are very glad to be able to immediately offer a well organised registration of arthroplasty with full coverage to the National Implant Register. About 60,000 hip and knee prostheses are registered annually, and we know that all Dutch hospitals participate with a completeness of no less than 96%. Consequently, we may conclude that all orthopaedic surgeons in the Netherlands consider quality, safety and traceability to be paramount.

Transparency through quality indicators

In 2015, the quality indicators were provided to Zorginstituut Nederland (ZIN, Dutch National Health Care Institute) through the indicator portal on the LROI dashboard for the very first time. All hospitals sent their data after approval to ZIN by means of this LROI portal. This saved a lot of time by automatic input through the LROI. Besides, the input is consistent because the data must be correct in the source (LROI). If this is not the case, it must be adjusted in the source. This input will enhance monitoring of quality of care in Dutch hospitals now and in the future. From this perspective, we still aim to include patients with a Dutch health insurance who have surgery abroad in the LROI. This is not just highly important to allow traceability of implants used on these patients, but also to verify quality of these foreign health care institutions.

Special survival of hip and knee prostheses

This year, besides providing traceability of implants and submitting quality indicators to ZIN, it was possible for the very first time to determine survival characteristics of a prosthesis. By using the patient's date of death that has recently been included in the register and with a maximal follow up of 8 years by now, it was possible to give more details on survival of hip and knee prostheses for the very first time. You will read more about this in the special paragraph at the end of the chapters on hip and knee prostheses. This also includes the average revision percentages within 1 year after primary surgery. And you will read about the revision percentages of hip and knee prostheses, broken down into the most relevant patient characteristics (such as gender and age). Furthermore, we will inform you about the survival of resurfacing hip prostheses that have been implanted in the Netherlands as of 2007. These results support the advice of the Netherlands Orthopaedic Association against implanting this type of prostheses. The advice can now be supported by Dutch statistics.

Ankle, shoulder and elbow prostheses are now also monitored

In 2014, the LROI was expanded with registration of ankle, shoulder and elbow arthroplasties. Although these arthroplasties are less often performed than hip and knee arthroplasties, this registration is just as important from the perspective of insight into care and traceability of prostheses. In this report, you will find descriptives of the prostheses that were implanted in 2014. Since 2014 was the first year to register these new prostheses, and because a new registration will always entail some logistical changes in hospitals, the completeness of this first registration year is not yet optimal. All hospitals will receive feedback with respect to completeness with an aim to optimize it. Support will be offered by the LROI head office if so required or desired.

Finally

We would like to thank all orthopaedic hospitals for the commitment they demonstrated over the past eight years with respect to registration in the LROI. This annual report could not have been prepared without their commitment. We hope for excellent cooperation in future years as well. Everyone's commitment is required to achieve valid results. Just like the 2013 LROI Annual Report 'Insight into Quality & Safety', this annual report will be published jointly with a patients' report, designed as a Z card. It goes without saying that feedback on the report and the Z card is very welcome and will only serve to improve registration and this annual report. We hope you will enjoy reading this report.

Drs. Henk Koot, *chairman LROI executive board*
Dr. Wim Schreurs, *chairman LROI scientific advisory board*

Definitions

Acetabular component
The part of a hip prosthesis that is implanted into the acetabulum – the socket part of a ball and socket joint

Allograft
Transplant of bone tissue from a different body

Amputation
Cutting off a part of the human body. Cutting off a limb with a joint prosthesis in it, is classified as revision surgery in the LROI

Ankle inlay
Intermediate component (inner layer), made of polyethylene that is placed between the tibial component and the talus component of an ankle prosthesis

Arthrodesis
A procedure in which a natural joint is fused together

Arthrofibrosis
Rigidity of the joint as a consequence of connective tissue adhesion

Arthroscopy
Keyhole surgery to examine and treat joint disorders

Arthrotomy
Opening a joint during surgery

Articulation
The two surfaces that move together (articulate) in a total joint replacement

ASA score
The American Society of Anaesthesiologists (ASA) score is a scoring system for grading the overall physical condition of the patient, as follows: I – fit and healthy; II – mild disease, not incapacitating; III – incapacitating systemic disease; IV – life threatening disease

Autograft
Transplant of bone tissue originating from the patient's own body

Benchmark
Comparing the performance at one's hospital to performances of other hospitals or those of hospitals throughout the Netherlands to learn from each other

Bilaterality
Replacing the same joint on both sides of the body (typically both hips or knees) by means of a prosthesis within a specific period

Body Mass Index
Index for weight compared to body length (kg/m^2); ≤18.5: underweight; >18.5-25: normal weight; >25-30: overweight; >30-40: obesity; >40: morbid obesity

Bonegraft
Bone transplant

Case mix
Term used to describe variation in the population, relating to factors such as diagnosis, patient age, gender and health condition

Cement
Material (polymethyl methacrylate) used to fixate joint replacements to bone

Charnley score
Clinical classification system; A: one joint affected; B1: both joints affected; B2: contralateral joint with a prosthesis; C: several joints affected or a chronic disease that affects quality of life

Competing risk survival analyse
Method to calculate survival taking into account various outcomes, in this case revision and death

Completeness
The completeness of the number of registered procedures in the LROI, based on a comparison with the hospital information system of every hospital that performs hip and/or knee arthroplasty in the Netherlands

Cuff arthropathy
Osteoarthritis of the shoulder joint as a consequence of the tendons around the shoulder joint being affected

Cuff rupture
Rupture of a tendon of the muscles that are around the shoulder joint

Cumulative incidence
The added up incidence over a specific period of an event (such as revision of a prosthesis or death of a patient)

Cumulative revision percentage
Added up revision percentage over a specific period

Distal hemihumeral prosthesis
Elbow prosthesis in which the distal part of the humerus (upper arm bone) is replaced

Dual mobility cup
Acetabular component that consists of a dual cup and, therefore, has two independent articulation points

Femoral component
Part of a hip or knee prosthesis that is implanted into the femur (thigh bone) of the patient

Femoral head component
Part of a hip prosthesis that is implanted on top of the femoral component of a hip prosthesis and moves inside the acetabular component or the cup of the hip joint

Flail elbow
Situation after removal of an elbow prosthesis in which no joint is present any more between the upper and lower arm

Girdlestone situation
Revision procedure to a hip in which the hip joint or hip prosthesis is removed and no new prosthesis is implanted (often because of a bacterial infection)

Glenoid baseplate
Part of a reversed shoulder prosthesis: a metal plate that is screwed into the glenoid (shoulder cup) of the shoulder blade, on which the glenosphere is fixed

Glenoid component
The part of a shoulder prosthesis that is placed in the glenoid; the cup-shaped notch of the shoulder blade

Glenoid liner
Intermediate component (inside layer) of a total anatomical shoulder prosthesis that will be placed in a glenoid component (most often a metal one)

Glenosphere
The part of a reversed shoulder prosthesis that is placed on the glenoid baseplate which is screwed into the glenoid and is spherical in shape

Hip inlay (insert)
Intermediate component (inner layer), made of polyethylene that is placed in the acetabular component

Hybrid fixation
Fixation of a prosthesis in which (most often) one of both parts of a prosthesis is cemented and the other one uncemented

Humeral component
The part of a shoulder or elbow prosthesis that replaces the humerus (upper arm bone). The humeral component of a shoulder prosthesis may consist of two parts: the humeral head and the humeral stem component

Humeral liner
Intermediate component (inside layer) of a reversed shoulder prosthesis that will be placed in a metaphysical component

Kaplan-Meier survival analysis
Method to calculate survival, in which only one end point is possible, in this case revision

Knee insert
Intermediate component (inner layer), made of polyethylene that is placed in the tibial component of a knee prosthesis

Lateral collateral ligament
Lateral (outer) knee ligament or elbow ligament

Lateral resurfacing arthroplasty
Elbow prosthesis in which only the lateral side of the joint is replaced

Malalignment
Strain on a part of the body due to an abnormal position of a joint component with respect to other components

Medial malleolus osteotomy
Surgical approach of the ankle in which the medial malleolus (protruding part of the tibia on the inside of the ankle) is incised and later re-fixed to be able to have better access to the inside of the joint

Meniscectomy
Meniscus removal

Metallosis
Deposition of metal debris in soft tissues of the body

Metaphysis component
The part of a shoulder prosthesis that replaces the metaphysis (upper part) of the humerus (upper arm bone)

Olecranon
The most proximal part of the ulna

Osteoarthritis
Disorder in which the cartilage of a joint is affected

Osteochondral bone defect
Defect of the joint surface in which both cartilage and underlying bone are affected

Osteonecrosis
Cellular death of bone tissue

Osteosynthesis
Securing broken bone parts together with plates, pins and/or screws

Osteotomy
Incise the bone in order to correct the position, to shorten or lengthen the bone

Patellar component
Part of a knee prosthesis that is implanted on the inner side of the knee cap

Patellofemoral prosthesis
Two-piece knee prosthesis that provides a prosthetic (knee) articulation surface between the patella and trochlea (furrow) of the thigh bone (femur)

Primary prosthesis
The first time (primary) a prosthesis is implanted to replace the original joint

PROMs
Patient Reported Outcome Measures

Radial head component
Part of an elbow prosthesis that replaces the head of the radius (spoke-bone)

Radial head prosthesis
Elbow prosthesis in which only the head of the radius (spoke-bone) is replaced

Radial stem component
Part of an elbow prosthesis that is implanted in the shaft of the patient's radius (spoke-bone)

Resurfacing hip arthroplasty
Hip prosthesis in which the cup (acetabulum) is replaced and a metal cap is implanted on top of the femoral head

Resurfacing shoulder arthroplasty
Shoulder prosthesis in which a metal cap is implanted on top of the humeral head

Reversed hybrid fixation hip prosthesis
Fixation of a hip prosthesis in which the acetabular component is cemented and the femoral component is uncemented

Reversed shoulder prosthesis
Adjusted type of total shoulder arthroplasty in which the parts are implanted in a reversed manner. A sphere (glenosphere) is implanted onto the glenoid and a stem with cup in the shaft of the shoulder head

Revision arthroplasty
Any change (insertion, replacement and/or removal) of one or more components of the prosthesis

Shoulder hemiarthroplasty
Shoulder hemiarthroplasty with humeral stem, stemless hemi shoulder prosthesis (without humeral stem) or resurfacing shoulder hemiarthroplasty

Synovectomy
Removal of inflamed mucosa in a joint

Talus component
Part of an ankle prosthesis that is inserted in the talus (ankle bone) of a patient

Tibial component
Part of a knee or ankle prosthesis that is inserted in the tibia (shin bone) of a patient

Total arthroplasty
Arthroplasty in which the entire joint of a patient is replaced

Ulnar component
Part of an elbow prosthesis that is inserted in the ulna of a patient

Ulnar nerve
One of the three nerves that runs along the elbow. This nerve largely runs along the ulna

Unicondylar knee arthroplasty
Replacement of half the knee (either inner or outer side) by a prosthesis

Validity
Level of accuracy and completeness of registered data

Walch score
Clinical classification system for level and type of wear of a shoulder joint; A1: humeral head centred, minimal erosion of shoulder cup; A2: humeral head centred, substantial erosion of shoulder cup; B1: Posterior subluxation of humeral head, posterior joint cavity narrow, subchondral sclerosis and osteophytes; B2: posterior subluxation of humerus head, retroversion of shoulder cup with posterior erosion; C: retroversion of shoulder cup over 25 degrees, irrespective of erosion

Abbreviations

ASA	American Society of Anaesthesiologists
BMI	Body Mass Index
BSN	Citizen Service Number
CI	Confidence Interval
DBC	Diagnosis Treatment Combination
DBIR	Dutch Breast Implant Registry
DOT	DBCs on the road to Transparency
HIS	Hospital Information System
IGZ	Dutch Health Inspectorate
KHP	Hemiarthroplasty
KM	Kaplan-Meier
LCL	Lateral Collateral Ligament
LROI	Dutch Arthroplasty Register
NCDR	National Cardiovascular Data Registry
NOV	Netherlands Orthopaedic Association
NVOG	Dutch Society for Obstetrics & Gynaecology
NVPC	Dutch Society for Plastic and Reconstructive Surgery
NVVC	Dutch Society of Cardiology
PE	Polyethylene
POMT	Patient Outcome Measurement Tool
PROMs	Patient Reported Outcome Measures
SD	Standard Deviation
THA	Total Hip Arthroplasty
TKA	Total Knee Arthroplasty
UMC	University Medical Centre
VWS	[Ministry of] Health, Welfare and Sports
WAR	Scientific Advisory Board
ZIN	Dutch National Health Care Institute

Summary

Introduction
The LROI (Dutch Arthroplasty Register) is a digital quality register of hip and knee joint replacement surgery in the Netherlands, established in 2007. As of 2014, ankle, shoulder and elbow arthroplasties have also been registered. Data from the LROI provide insight into orthopaedic implants in order to improve quality and safety of orthopaedic care. As such, the LROI dashboard provides reflective information and scientific research is performed. Due to a link with dates of death, this is the first year in which survival analysis could be performed. In case of a calamity or incident with a prosthesis, the implanted prosthesis can be traced to patients (through the hospitals). In order to achieve LROI's purposes, developments follow each other in rapid succession.

Traceability
The LROI plays an important role in monitoring safety of joint prostheses for the benefit of patients. In case of a calamity with a specific implant, the LROI can immediately provide an overview of patients that have had arthroplasty with the specific implant. Next, hospitals may contact patients with the specific implant. This guarantees patient safety. As of 2015, the National Implant Register of the Ministry of Health, Welfare and Sports also uses LROI data with regard to traceability of joint implants.

Data quality
The number of registrations of hip and knee arthroplasties has increased over the years. In 2014, 28,026 primary total hip arthroplasties (THAs) and 3,574 hip revision arthroplasties were registered. Additionally, 26,595 primary knee arthroplasties and 2,541 knee revision arthroplasties were registered in 2014. Newly to be registered joint prostheses are most often shoulder prostheses with 2,077 primary shoulder arthroplasties and 203 shoulder revision arthroplasties. The number of ankle arthroplasties is 122, of which 107 were primary arthroplasties and 15 ankle revision arthroplasties. The number of elbow arthroplasties is 146, of which 107 primary elbow arthroplasties and 38 elbow revision arthroplasties were registered. Primary hip arthroplasties are registered by all hospitals who implant these in accordance with Vektis (the organization of health insurance companies). Completeness of primary hip arthroplasties is 96% and 91% with respect to hip revision arthroplasties, which is based on a comparison with the hospital information system (HIS). With regard to primary knee arthroplasties the result is 97% and with regard to knee revision arthroplasties it is 92%. Newly to be registered arthroplasties are not yet as complete; with respect to primary ankle arthroplasties the number is 88% and 75% with respect to ankle revision arthroplasties; 82% with respect to primary shoulder arthroplasties and 79% with respect to shoulder revision arthroplasties; 69% with respect to primary elbow arthroplasties and 75% with respect to elbow revision arthroplasties. Completeness fluctuates considerably when hospitals are compared. Validity was high for most variables (>95%). Newly to be registered variables (postal code, body mass index (BMI), smoking and Charnley/Walch score) are lagging somewhat behind in this respect.

Hip arthroplasty
The number of registered THAs increased in 2014 up to 28,026 when compared to earlier years. The number of hip revision arthroplasties stayed nearly the same at 3,574 registered hip revision arthroplasties. In case of hip arthroplasties, university medical centres (UMCs) relatively often performed hip revision arthroplasties (28%) when compared to the number of primary THAs. This, especially when compared to general hospitals (11%) and private hospitals (4%). The number of registered primary THAs varied per hospital from 5 to 759 (median: 263). The average age of patients who underwent a THA in 2014 was 68.9 (SD: 10.7) years. Two-thirds were women and two-thirds had an ASA score of II. The larger majority (87%) had a THA after being diagnosed with osteoarthritis. Two-thirds had overweight, obesity or morbid obesity (BMI>25) and 13% smoked. The case mix of patient populations varied largely from hospital to hospital. In 2014, the most frequently used surgical approach was posterolateral (62%). The use of straight lateral approach (20%) and anterolateral approach (5%) decreased. Use of anterior approach (12%) increased. Primary THAs were most often implanted without cement (61%). Acetabular components were most often press-fit (64%). Cemented acetabular components most often consisted of standard (58%) or

cross-linked (37%) polyethylene (PE), uncemented acetabular components consisted most often of titanium (91%). 81% of the inlays consisted of cross-linked PE. 63% of femoral heads consisted of ceramics and 31% of cobalt chrome and 53% had a diameter of 32mm. Two-thirds of femoral components consisted of titanium and a quarter of the components consisted of cobalt chrome. The most commonly used articulations were ceramics-on-PE (54%) and metal-on-PE (30%). Nearly all of the bone cement used contained gentamicin (93%) and often its viscosity was high (88%). The use of pre-packed bone cement in a vacuum mixing system increased from 5% in 2010 to 18% in 2014. Unipolar arthroplasty was used in 2014 on patients with an average age of 82.1 years (SD: 8.7), mainly in women (71%) and patients with an ASA score of II (38%) or III-IV (59%). Nearly all hemiarthroplasty was performed by general hospitals (97%) and often after the primary diagnosis of an (acute) fracture (92%). Patients who had unipolar arthroplasty in 2014 suffered from overweight or obesity in 39% of all cases. 67% of hip revision arthroplasties were partial revisions, 25% were total revisions and 6% Girdlestone situations. In partial revisions, in general two (47%) or three (45%) components were replaced. The femoral head was replaced in 91% of partial revisions. The inlay was replaced in 57% of partial revisions and the acetabular component was replaced in 54%. The most common reason for revision was loosening of the acetabular component (26%), followed by loosening of the femoral component (21%), inlay wear (20%) and dislocation (19%). The femoral head diameter was usually 32 mm or smaller (86%). Hip revision arthroplasties were often performed with cement (47%). Over the period 2010-2013 revision within 1 year was 1.4% after implanting the primary THA. The most common reasons for revision within 1 year were dislocation (37%), loosening of the femoral component (22%) and peri-prosthetic fracture (18%). The revision percentage for THAs after 5 years was 3.2%. The chances of needing a revision were higher for men, patients below 60 years of age and patients who had a THA following a diagnosis other than osteoarthritis. The revision percentage of resurfacing hip arthroplasties was significantly higher than that of THAs.

Knee arthroplasty

The number of registered primary knee arthroplasties increased to 26,754 and the number of knee revision arthroplasties increased to 2,514 in 2014. University medical centres (UMCs) relatively often performed revision arthroplasties in case of knee arthroplasties (23%) when compared to the number of primary arthroplasties. This, especially when compared to general hospitals (9%) and private hospitals (5%). The number of primary knee arthroplasties varied considerably from hospital to hospital in 2014, specifically from 6 to 739 (median: 240). Younger patients relatively often underwent unicondylar knee arthroplasties; 20% of the patients was under 50 years, compared to 2% of patients aged 80 years or more. Patients with primary arthroplasty had an average age of 67.5 (SD: 9.5) years; two-thirds of patients were women and two-thirds had ASA score II. The primary diagnosis leading to a primary knee arthroplasty was mainly osteoarthritis (96%). Eleven per cent of patients with primary knee arthroplasty smoked, 82% had overweight, obesity or morbid obesity (BMI>25). The case mix of patient populations varied largely from hospital to hospital. 38% of patients had had surgery before on the specific knee. Most often, this was a meniscectomy (30%), followed by arthroscopy (19%). The vast majority (94%) of primary knee arthroplasties was performed through a medial parapatellar arthrotomy (after a median incision). Over 90% was performed with cement. 97% of the femoral components used in primary knee arthroplasties was made of cobalt chrome. Inserts were always made of PE, with 91% of standard PE. About half of the tibial components consisted of titanium and the other half of cobalt chrome. Patellar components were always made of PE as well, with 97% of standard PE. Bone cement contained gentamicin in 92% and viscosity was either high (87%) or medium (13%). The use of pre-packed bone cement in a vacuum mixing system increased from 6% in 2010 to 23% in 2014. Of all knee revision arthroplasties registered in the LROI in 2014, nearly half was a total revision and 38% a partial revision. Removal of a prosthesis occurred quite often in a UMC (13%). A quarter of revision arthroplasties was a conversion to total knee arthroplasty. The most common reasons for revision were instability (25%), loosening of the tibial component (23%) and patellar pain (22%). In partial knee revision arthroplasty the insert was replaced in nearly three-quarters of all cases and in one-third the patella was replaced. One component was replaced in 63% of the cases and two components in 30%. The number of revision arthroplasties varied strongly from hospital to hospital (median: 18; range: 1-345). In two-thirds of knee revision arthroplasties in which bone cement was used, the bone cement contained gentamicin. Over the period 2010-2013 revision within 1 year was 0.9% after a primary knee arthroplasty. The most common reasons for revision within 1 year were patellar pain (29%), infection (26%) and instability (26%). The revision percentage for primary knee arthroplasties after 5 years was 4.1%. Patients under 60 years of age were more likely to require revision. The 5-year revision percentage of unicondylar knee prostheses was 9.7%. The risk of revision for patients with a patellofemoral knee prosthesis within 5 years was 17.4%.

Ankle arthroplasty

In total, 122 ankle arthroplasties were registered in the LROI in 2014. These included 107 primary ankle arthroplasties and 15 ankle revision arthroplasties. The number of ankle arthroplasties varied from hospital to hospital from 1 to 19 (median: 2). The average age of patients who underwent a primary ankle arthroplasty was 65.2 (SD: 9.9) years. The number of male and female patients was about equal and 72% had ASA score II. Nearly three-quarters of the patients had overweight, obesity

or morbid obesity. One-third has undergone a previous surgery to the relevant ankle, most often this had been osteosynthesis (19%). Primary ankle arthroplasties were always total ankle arthroplasties, performed with an anterior approach and nearly always without cement (99%). In 2014, 6 partial revisions, 4 removals and 3 total ankle revisions were registered. The most common reason for ankle revision arthroplasty was malalignment (64%), followed by loosening of the talus component (42%) and arthrofibrosis (42%).

Shoulder arthroplasty

In 2014, 2.077 primary shoulder arthroplasties and 2.013 shoulder revision arthroplasties were registered in the LROI, performed on 2.044 patients. The spread of the number of shoulder arthroplasties varied considerably from hospital to hospital (median: 20; range: 1-152). Nearly all shoulder arthroplasties were performed in a general hospital (93%). 59% of all primary shoulder arthroplasties were reversed shoulder arthroplasties. Twenty per cent were total shoulder arthroplasties and 21% were shoulder hemiarthroplasties. The average age of patients with a primary shoulder arthroplasty was 71.3 (SD: 9.9) years. Patients with a shoulder hemiarthroplasty (66.5 (SD: 11.1) years) or total shoulder arthroplasty (65.6 (SD: 10.3) years) were younger than patients with a reversed shoulder arthroplasty (74.7 (SD: 7.5) years). The most registered primary diagnosis of patients with a reversed prosthesis was cuff arthropathy (33%), followed by osteoarthritis (28%). In shoulder hemiarthroplasties (44%) the most registered primary diagnoses were osteoarthritis (44%) and fracture (30%). In total shoulder arthroplasties it was osteoarthritis (83%). Seventy per cent of patients with primary shoulder arthroplasties had overweight (BMI>25). Younger patients often had hemi or total shoulder arthroplasty, with 45% of patients being younger than 50 who had total shoulder arthroplasty and 42% who had shoulder hemiarthroplasty. Older patients more often underwent a reversed arthroplasty; 80% of the patients of 80 years and older had reversed arthroplasty. Reversed shoulder arthroplasties were performed by means of a deltopectoral (53%) or anterosuperior (46%) approach. This varied highly from hospital to hospital. Humeral stem components consisted of titanium in 80% of the reversed shoulder arthroplasties. Humeral liners consisted of standard PE in 95% of the cases and metaphyses were made of titanium in 85% of the cases. Two-thirds were performed without cement and in 26% of reversed arthroplasties only the humerus was cemented. This varied highly from hospital to hospital as well. The bone cement used mostly contained gentamicin (87%) and commonly had a high viscosity (86%). A humeral stem was registered in 71% of shoulder hemiarthroplasties. The deltopectoral approach was often used in shoulder hemiarthroplasties (88%). Two-thirds were placed without cement and one-third with cement. Also in shoulder hemiarthroplasties the bone cement commonly contained gentamicin (89%) and had a high viscosity (91%). Total shoulder arthroplasties were nearly always performed by means of a deltopectoral approach (99%). Humeral stems most often consisted of titanium (74%), followed by cobalt chrome (20%). The glenoid component often consisted of PE, with 64% standard PE and 29% cross-linked PE. When performing total shoulder arthroplasties, often only the glenoid component was cemented (62%) or the prosthesis was implanted fully cemented (29%). The bone cement used mostly contained gentamicin (88%) and had a high viscosity (88%). Shoulder revision arthroplasties were total revisions in 47% of the cases and partial revision in 39% of the cases. In partial revisions, the humeral liner was most often (44%) replaced, followed by glenosphere (41%) and humeral head (28%). The number of shoulder revision arthroplasties varied from hospital to hospital in 2014 from 1 to 50 (median: 3). The most common reasons for revision were progressive osteoarthritis (24%) and infection (19%). In 39% of revision arthroplasties cement was not used, while both glenoid and humeral component were cemented in 22%.

Elbow arthroplasty

In total, 144 elbow arthroplasties were registered in the LROI in 2014. This included 107 primary arthroplasties and 38 revision arthroplasties. The number of elbow arthroplasties varied from hospital to hospital from 1 to 29 (median: 4). Seventy per cent of primary elbow arthroplasties were total arthroplasties, 22% radial head arthroplasties. The average age of patients who underwent a primary elbow arthroplasty in 2014 was 60.6 (SD: 13.0) years. Three quarters were women and sixty per cent had ASA score II. The most common diagnosis was late post-traumatic (31%), followed by rheumatoid arthritis (27%). 43% of patients who underwent primary elbow arthroplasty had undergone a previous surgery to the relevant elbow. This was most often a lateral arthrotomy (31%). The posterior approach was most often used for performing a primary elbow arthroplasty (39%). Seventy per cent was performed with cement. The bone cement either contained gentamicin (62%), or erytromycin and colistin (35%). Elbow revision arthroplasty was just as often partial revision (30%) as total revision (30%). The prosthesis was removed in 9 (24%) elbow revision arthroplasties. The most common reason for revision was metallosis (29%), followed by infection (25%).

New developments in the LROI

In order to achieve LROI targets, the LROI will continue to develop. As such, the LROI will switch to Reports, a new software system, in 2016. This software system can meet all LROI's demands and desires and offers a future perspective on further expansion of registration. This LROI Annual Report is accompanied by a patient edition, designed as a Z card. Moreover, a patient letter was developed with specific information concerning patient and implant characteristics, so patients will have a better insight in the type of prosthesis that was implanted in their body. LROI's legal structure was improved. As a consequence, the first research proposals could be approved and these are currently

in progress. Furthermore, implant traceability is now covered nationally, and the LROI served as a blueprint. The LROI is also used for tripartite provision of quality indicators of hip and knee prostheses to Zorginstituut Nederland by caregivers, health insurers and patients. Finally, Dutch orthopaedics will get even better insight in their own results, now that LROI's dashboard has been expanded with a graphic image of the revision percentage after 1 year and new reports with an option to compare one's own hospital's quality against that of other hospitals.

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1 Introduction

The Dutch Arthroplasty Register (LROI) is a digital quality register. Since 2007, patient and prosthesis characteristics of hip and knee arthroplasties have been registered in the LROI. In 2014, registration of ankle, shoulder and elbow prostheses were added. Moreover, Patient Reported Outcome Measures (PROMs) of patients with hip and knee arthroplasties are registered in the LROI.

LROI's data enables early detection of less well-performing prostheses and, in case of calamities, these implants can be traced to patients (through the hospitals). Registration of joint prostheses that were implanted in the Netherlands, the implant techniques used, and patient characteristics, provide national reflective information to which a hospital can compare its own details. This allows orthopaedic departments to improve their weak points, if any. Finally, the LROI organization allows scientific research aimed at improving quality of orthopaedic care. The LROI promotes quality control and, as such, innovations in the field of implants and the LROI organization informs the general public, orthopaedic patients and other stakeholders about LROI results. In order to achieve these purposes, the LROI continues to develop. This 2014 LROI Annual Report 'Arthroplasty in the Picture' provides all information about the results that were achieved in 2014.

Insight in orthopaedic implants

The more information becomes available, the more insight the LROI will provide in arthroplasties. In September 2014, the LROI was expanded with death dates – if any – of people with joint arthroplasties. The death dates are necessary to be able to calculate an accurate life span of prostheses (see paragraph: Methodology of survival analyses). This is a key milestone in LROI's history, as it created the opportunity to meet one of LROI's primary purposes, which is identifying less well-performing prostheses and, consequently, improving quality and safety of orthopaedic care. Currently, this is possible for hip arthroplasty (Chapter 4.5) and knee arthroplasty (Chapter 5.4), since these joints have been registered ever since 2007 in the LROI and, as such, a sufficient follow-up is available. Only in a few years' time we will be able to carry out these analyses with respect to ankle, shoulder and elbow arthroplasties.

Reflective information

Data in the LROI gives all orthopaedic departments the opportunity to reflect upon themselves compared to any other orthopaedic department in the Netherlands. This also provides insight in the department's operations when compared to others (benchmarking). In order to continuously provide this option, the on-line LROI dashboard was developed. To enhance validity of data in the LROI an option was recently added to monitor quality reports of various key variables to be registered for each surgery. These reports will show whether completeness in registration of specific variables is increasing. Since this year, this parameter is one of the quality indicators for health care insurers. Subsequently, reports in the LROI dashboard will specify clearly which types of procedures have variables that are less complete. All of this strongly enhances the quality of data in the LROI (see Chapter 3 Data quality in the LROI).

Traceability

Besides insight in arthroplasty in the Netherlands, the LROI aims to organise traceability of implanted prostheses. Currently, ankle, shoulder and elbow prostheses are also registered in the LROI. In case of calamities, traceability of these types of registered implants is now also possible. Furthermore, the increased completeness of hip and knee arthroplasty registrations has also contributed to traceability of these implants. Read more about LROI's contribution to traceability and the relevance thereof in Chapter 2.

Scientific research

The LROI data set can be used for scientific research. Insight into arthroplasties that were performed in the Netherlands, may be shared internationally by means of scientific publications. Due to the increase of data in the LROI, such as ankle, shoulder and elbow arthroplasties, the link with death data and the opportunity to carry out survival analyses and enhanced completeness and validity of the database, LROI data are highly suitable to conduct scientific research. The first scientific article with LROI data was published in the Acta Orthopaedica in 2015.[1] In order to regulate scientific research in a proper manner, the legal structure was improved and scientific regulations were drawn up.

New developments in the LROI

The LROI will continue to develop. As such, the LROI will switch to a more user-friendly input software next year. It is also expected that the initial results of PROMs measurements will be available next year. Consequently, the next annual report will focus largely on patient characteristics and results from a patients' perspective. You will read all about new developments at and around the LROI in Chapter 9.

[1]Steenbergen, LN van, Denissen, GAW, Spooren, A, Rooden, SM van, Oosterhout, FJ van, Morrenhof, JW, Nelissen, RGHH, 2015. *More than 95% completeness of reported procedures in the population-based Dutch Arthroplasty Register. External validation of 311,890 procedures.* Acta Orthopaedica 86 (4): 498-505).

Methodology of survival analyses

The life span of a joint prosthesis is the time between implantation of a primary prosthesis and the time of the first revision. However, patients may die before the prosthesis needs to be revised (Figure 1.1).

Link between primary and revision arthroplasties

In order to assess a prosthesis' life span, follow-up time of all primary prostheses was examined. This was done by linking revision arthroplasties to the primary arthroplasties in the LROI by means of the encrypted Citizen Service Number (BSN). In this way, the correct revision arthroplasty can be linked anonymously to a primary arthroplasty. In about 7% of the arthroplasties, the encrypted BSN was not entered into the system, mainly in the first years of registration. Links between these primary and revision arthroplasties were established based on the LROI hospital number and the LROI patient number. As such, revision arthroplasties have been linked to primary arthroplasties of a patient when the patient underwent primary and revision arthroplasty on the same joint in the same hospital.

Kaplan-Meier survival analysis

Survival of a prosthesis may be determined in various ways. Traditionally, the Kaplan-Meier (KM) method is often used. This method was developed for situations with one possible end point (such as death of the patient). However, in order to calculate survival of a prosthesis at least two end points are important: revision of the prosthesis and death of the patient. The KM method estimates the proportion of failed prostheses if patients would live on forever. However, a number of patients dies before the prosthesis requires revision. Consequently, fewer revisions are carried out than could be expected based on the model. That is why this method overrates the chance of revision.

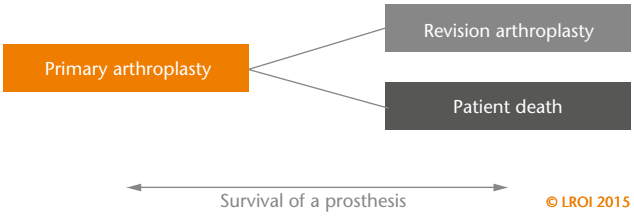


Figure 1.1 Survival of a prosthesis.

Competing risk survival analysis

The competing risk method allows monitoring for several end points. When an end point occurs (such as death), other end points will no longer be available (such as prosthesis revision). The cumulative incidence (summed occurrence of an end point) will be calculated. Death of a patient is a final end point, the prosthesis will no longer be revised and this finalizes the period that a prosthesis lasts. The time at risk will be the period from primary implantation to death.

Method comparison

Orthopaedic professionals are currently debating what method is most adequate to calculate the survival of prostheses. In order to get a clearer picture of the difference in results between Kaplan-Meier method and competing risk method we have calculated the revision percentage within 5 years using both methods. The revision percentage was calculated for men who underwent a total hip arthroplasty or resurfacing hip arthroplasty over the period 2007-2014.

This comparison shows that the revision percentage calculated by means of the KM method results in a slightly higher chance of revision within 5 years (Table 1.1). This difference is now minor, but will increase as follow-up extends. Consequently, this Annual Report estimates the chance of revision of a prosthesis by means of the competing risk method.

Table 1.1 Revision percentage of primary total hip arthroplasties and resurfacing hip arthroplasties in men. A comparison between competing risk and Kaplan-Meier estimates.

	N	Competing risk method Revision percentage after 5 years (95% CI)	Kaplan-Meier method 1-KM survival after 5 years (95% CI)
Total hip arthroplasty	55,582	3.5 (3.3-3.7)	3.6 (3.4-3.8)
Resurfacing hip arthroplasty	1,795	5.3 (4.3-6.4)	5.3 (4.2-6.4)

Please note: The primary outcome in a Kaplan-Meier analysis is prosthesis survival, while this is the revision percentage of prostheses in the competing risk method. In order to compare methods, survival as determined by means of the Kaplan-Meier analysis is converted into the revision percentage (100% - survival% = revision%).
KM: Kaplan-Meier; CI: confidence interval.


REF 1 2 40 0
LOT 18 90 8
TM
STEM

2 Traceability of joint implants

The fundamental idea for registration of joint implants is to achieve a continuous feedback process on results of implants used in the Netherlands. Hospitals may compare the results of their joint implants to national figures and prepare an improvement plan, if so required. Furthermore, registration is highly important for monitoring implant safety. The LROI may identify implants that perform less well and they can be traced to patients who may be summoned, if so required.

All required details for traceability of hip, knee, ankle, shoulder and elbow arthroplasties are registered. In order to guarantee traceability, it is of the essence to know which prosthesis was implanted in which patient, in which hospital, and at what time. All of these factors have been registered in the LROI since 2007 by using the batch number (LOT number), implant code (REF number), patient identification through the encrypted Citizen Service Number (BSN), the hospital patient number and date of birth. Furthermore, characteristics of the surgery are registered, such as hospital and date of surgery. This results in full traceability of implants to hospitals and patients.

Traceability arranged nationally

The Ministry of Health, Welfare and Sports (VWS) put the National Implant Register into use on 30 January 2015. The main function of this national register for VWS is the opportunity to trace all implants in the Netherlands. This register includes high-risk implants that were inserted in the Netherlands. Primarily, arthroplasties, cardiac implants (including pacemakers and ICDs), and implants in plastic surgery (breast implants) and gynaecology (pelvic floor meshes).

The National Implant Register is exclusively accessible to the Health Inspectorate (IGZ). The National Implant Register will provide IGZ with a tool that can offer insight in the number of patients involved and, therefore offer insight into the consequences for Dutch health care and patient safety in case of an alert with respect to a specific implant or type of implant. IGZ will also be able to trace patients, exclusively by means of the hospitals concerned. For reasons of privacy, IGZ does not have insight in personal details of patients.

LROI adequacy

Input for the National Implant Register is derived from existing implant registrations. By using national implant registrations, in which medical specialists have already listed information about implants within the framework of quality improvement, the administrative burden is limited. This leads to a win/win situation.

In order to assess if the LROI would be a suitable source for VWS, RIVM simulated a recall in five hospitals in 2014 to investigate traceability of arthroplasties through the LROI. The simulated recall was executed for four different types of knee prostheses. In each hospital two types of knee prostheses were selected that had been implanted these hospitals. This investigation demonstrated the following:

- Data available from the LROI allow quick traceability at present and provide high national coverage;
- The minimal dataset for traceability is available in the LROI and stored in a central national database;
- The implants that have already been registered in the LROI can easily be traced to hospitals and patients;
- Tracing the selected implants to patients and consulting the patients' details in the relevant departments proved to be very simple acts that could be executed quickly.

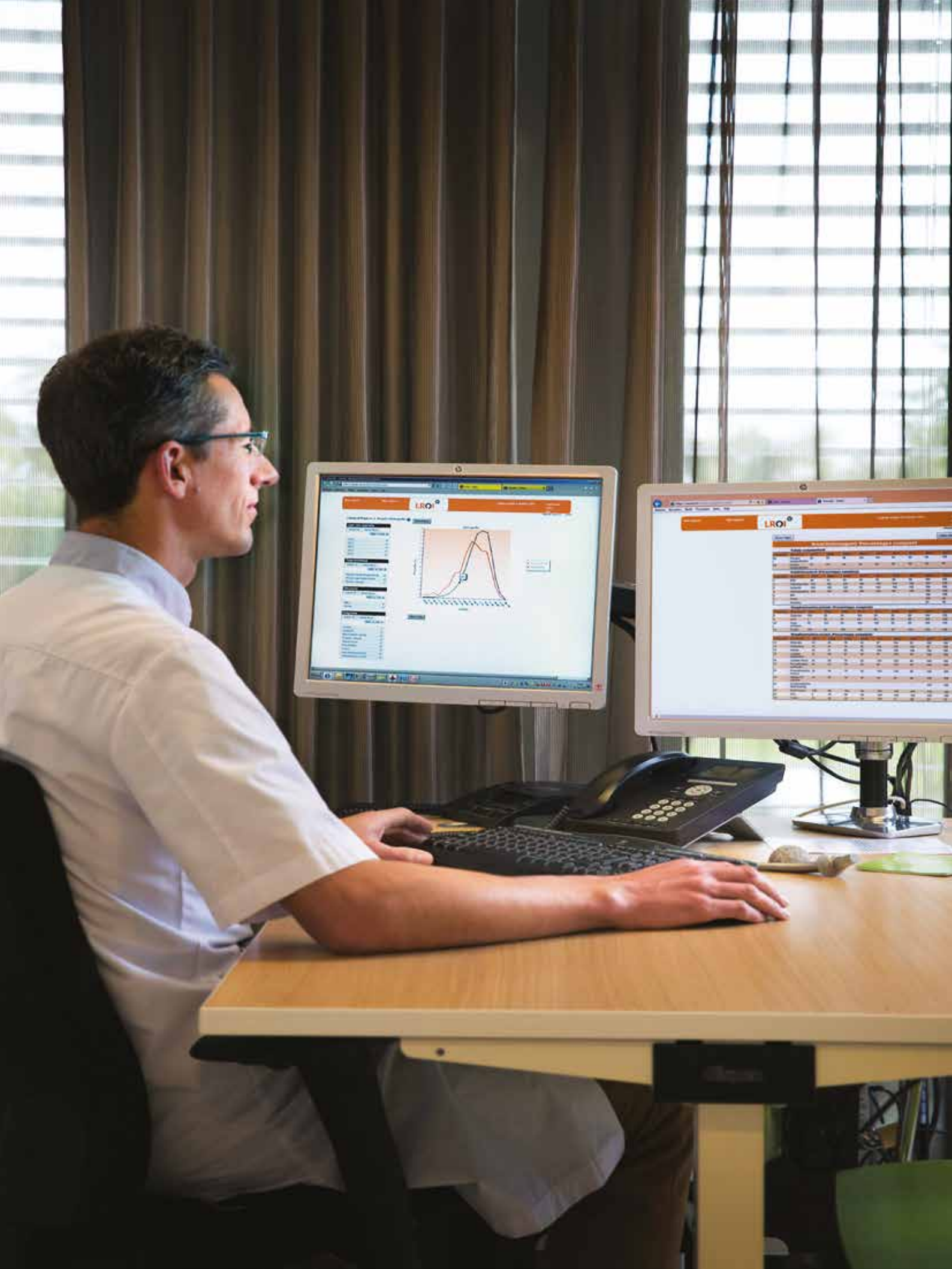
It was concluded that the LROI is very suitable for direct application in the National Implant Register. This is because all information that is required for implant traceability (REF and LOT number) has already been registered in the LROI for a number of years.
With respect to traceability it is essential that the relevant register offers national coverage. Although national coverage of the LROI is already high (96%), the legal obligation to register implants will further increase coverage of LROI.

Moreover, it is important that patients who died need no longer be traced. In order to find out if patients have died or not, a link was established between LROI data and death records in the Netherlands.

Strategic alliance

The four scientific associations that have already established their own implant registration and are also the source for the national VWS register aimed at traceability (NOV's LROI, NVVC's NCDR, NVPC's NBIR, and NVOG's POMT), are having the ambition to cooperate in a network within the Federatie Medisch Specialisten (Federation of Medical Specialists). Other scientific associations that also manage implant registers are expected to join a network of the Federatie Medisch Specialisten.

This network not only aims to share expertise and liaise, but also to advise VWS about policy with respect to registration, submission of data, traceability, organisation and functionality of the implant register.



3 LROI data quality

3.1 Number of registrations

The LROI lists 220,170 hip arthroplasty registrations that were performed between 1 January 2007 and 31 December 2014. 78% (n=169,628) pertain to insertion of a primary total hip arthroplasty and 10% (n=22.795) to hip revision arthroplasties (Table 3.1). The LROI contains 170,825 knee arthroplasty registrations that were performed between 1 January 2007 and 31 December 2014. 92% (n=157,661) pertain to insertion of a primary total knee arthroplasty and 8% (n=13,164) to knee revision arthroplasties (Table 3.2).

The LROI is nearly complete as of 2010. Therefore, a dotted line was inserted between 2009 and 2010 in both Table 3.1 and Table 3.2. The number of arthroplasties registered in the LROI for 2007-2013 is slightly higher than described in previous annual reports since hospitals are still completing their registrations.

Table 3.1 Number of registered hip arthroplasties per year of surgery.

	Type of hip arthroplasty				
Surgery year	Total hip arthroplasty (n)	Hemiarthroplasty (n)	Resurfacing arthroplasty (n)	Other (n)	Revision arthroplasty (n)
2007	8,526	937	448	782	1,269
2008	14,724	1,365	727	1,069	1,856
2009	20,987	2,048	845	1,458	2,679
2010	22,935	2,346	601	1,237	2,948
2011	23,510	2,391	225	902	3,194
2012	25,002	2,784	10	632	3,763
2013	25,918	3,012	1	171	3,512
2014	28,026	3,727	0	29	3,574
Total	169,628	18,610	2,857	6,280	22,795

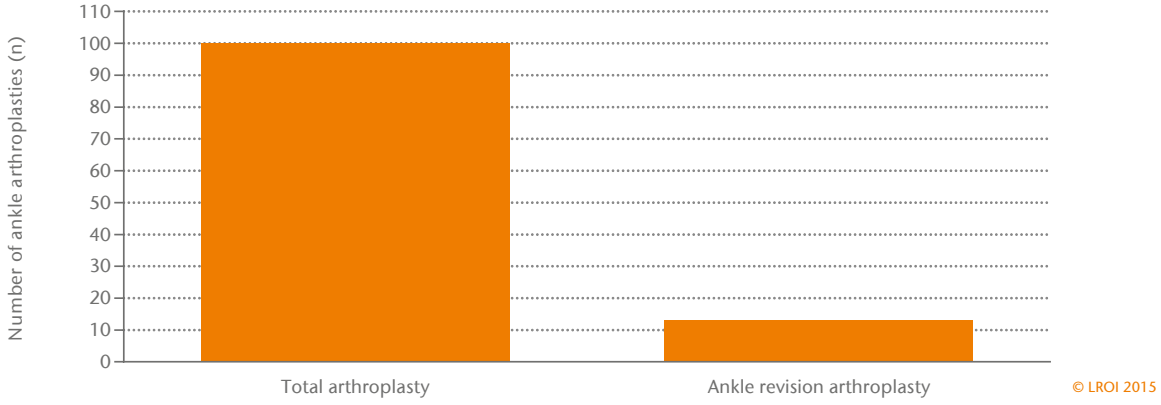
Please note: In 2.7% (n=5,304) of primary hip arthroplasties the type of hip prosthesis has not been registered.

Table 3.2 Number of registered knee arthroplasties per year of surgery.

	Type of knee arthroplasty				
Surgery year	Total knee arthroplasty (n)	Unicondylar knee arthroplasty (n)	Patellofemoral knee arthroplasty (n)	Other (n)	Revision arthroplasty (n)
2007	6,688	678	49	306	596
2008	11,107	1,127	94	324	908
2009	16,042	1,527	141	468	1,300
2010	17,887	1,697	160	502	1,619
2011	18,906	1,598	149	418	1,791
2012	21,107	1,595	189	365	2,110
2013	21,966	1,830	158	139	2,299
2014	24,057	2,351	127	60	2,541
Total	137,760	12,403	1,067	2,582	13,164

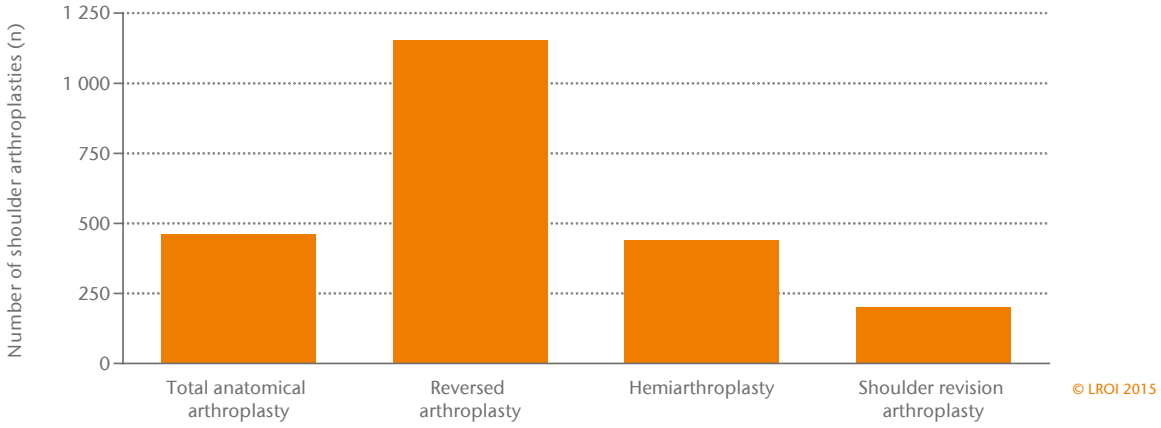
Please note: In 2.5% (n=3,849) of primary knee arthroplasties the type of knee prosthesis has not been registered.

Table 3.1 and Table 3.2 demonstrate that clearly more hip and knee arthroplasties were registered in 2014 than in previous years.
As of mid-2013, ankle, shoulder and elbow arthroplasties have been registered in the LROI besides hip and knee arthroplasties. This 2014 Annual Report covers a full registration year for these joints and therefore we are able to display the first results. 122 ankle arthroplasties were registered in 2014. 87% (n=107) pertain to primary ankle arthroplasty and 12% (n=15) to ankle revision arthroplasties (Table 3.2). The type of one arthroplasty (<1%) was not registered. All primary ankle arthroplasties were total ankle arthroplasties (Figure 3.1).



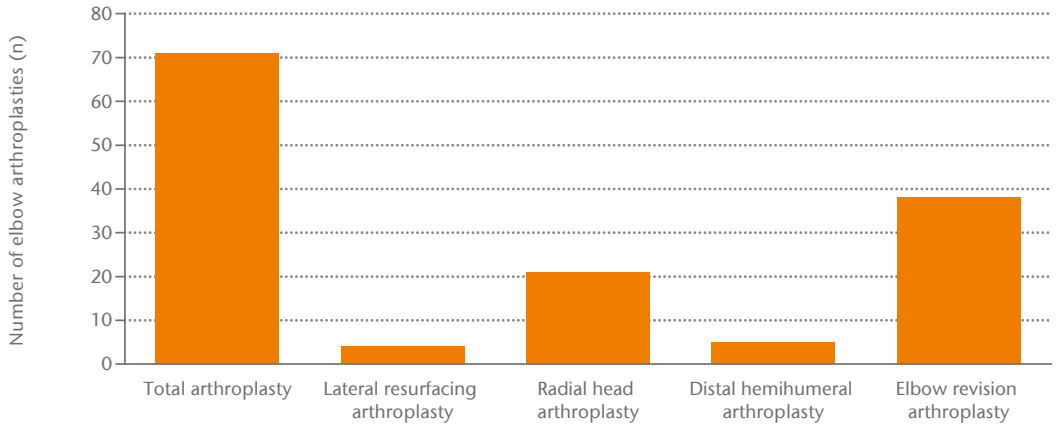
Type of ankle arthroplasty		
Number (n)	103	15
Proportion (%)	83.7	12.2

Figure 3.1 Number of registered ankle arthroplasties in 2014 (n=122).
Please note: In 0.8% (n=1) of the ankle arthroplasties the type of arthroplasty – primary or revision – has not been registered.
Please note: In 3.3% (n=4) of primary ankle arthroplasties the type of ankle prosthesis has not been registered.



Type of shoulder arthroplasty				
Number (n)	406	1,225	428	203
Proportion (%)	17.7	53.4	18.7	8.8

Figure 3.2 Number of registered shoulder arthroplasties in 2014 (n=2,293).
Please note: In 0.6% (n=13) of the shoulder arthroplasties the type of arthroplasty – primary or revision – has not been registered.
Please note: In 0.8% (n=18) of primary shoulder arthroplasties the type of shoulder prosthesis has not been registered.



Type of elbow arthroplasty					
Number (n)	71	4	22	5	38
Proportion (%)	48.7	2.7	14.4	3.4	26.0

Figure 3.3 Number of registered elbow arthroplasties in 2014 (n=145).
Please note: In 0.7% (n=1) of the elbow arthroplasties the type of arthroplasty – primary or revision – has not been registered.
Please note: In 4.7% (n=5) of primary elbow arthroplasties the type of elbow prosthesis has not been registered.

A total of 2,293 shoulder arthroplasties were registered in 2014. 91% (n=2,077) pertain to primary (first) shoulder arthroplasty and 9% (n=203) to shoulder revision arthroplasties (Table 3.2). The type of 13 arthroplasties (<1%) was not registered. Most often reversed shoulder arthroplasties were performed during a primary shoulder arthroplasty (n=1,225) (Figure 3.2).

A total of 146 elbow arthroplasties were registered for 2014. 74% (n=107) pertain to primary elbow arthroplasty and 26% (n=38) to elbow revision arthroplasties (Table 3.2). The type of one arthroplasty (<1%) was not registered. Most often total elbow arthroplasties were performed during a primary elbow arthroplasty (n=71) (Figure 3.3).

3.2 Completeness of registering hospitals and registered arthroplasties

All hospitals that performed primary hip and knee arthroplasties registered in the LROI in 2014 (based on a comparison of Vektis data [see text box]). This has been the case for three consecutive years (as of 2012). 96% of all primary total hip arthroplasties carried out were registered in the LROI and 97% of all primary total knee arthroplasties carried out. In 2013, completeness of these arthroplasties was 96% for both hip and knee arthroplasties (see 2013 LROI Annual Report 'Insight into Quality and Safety'). The median number of registrations of primary total hip arthroplasties per hospital was 263 (range: 5-759). The median number of registrations of primary total knee arthroplasties per hospital was 240 (range: 6-739). The percentage of revision arthroplasties of hip and knee in the LROI has largely increased when compared to the year before. The completeness of registered hip revision arthroplasties increased from 88% in 2013 to 91% in 2014 (median number

Vektis is a care information centre. Vektis collects and analyses data on the costs and quality of health care in the Netherlands. Vektis data mainly originates from reimbursement files of health care insurers. Therefore, Vektis has national data on medication use and use of aiding devices, data on primary health care and data on Diagnosis Treatment Combinations (DBCs/DOT) in hospitals and any other types of insured care in the Netherlands. In addition, Vektis collects demographic data, based on surveys among insurers and results of quality studies[1].

[1] www.vektis.nl

per hospital: 29; range: 1-177). The completeness of registered knee revision arthroplasties increased from 90% in 2013 to 92% in 2014 (median number per hospital: 18; range: 1-345) (Table 3.3). Completeness fluctuated from hospital to hospital for both hip (Figure 3.4) and knee arthroplasties (Figure 3.5).
Since mid-2013, ankle, shoulder and elbow arthroplasties have also been registered in the LROI. Completeness of these newly to be registered arthroplasties is lower than completeness of

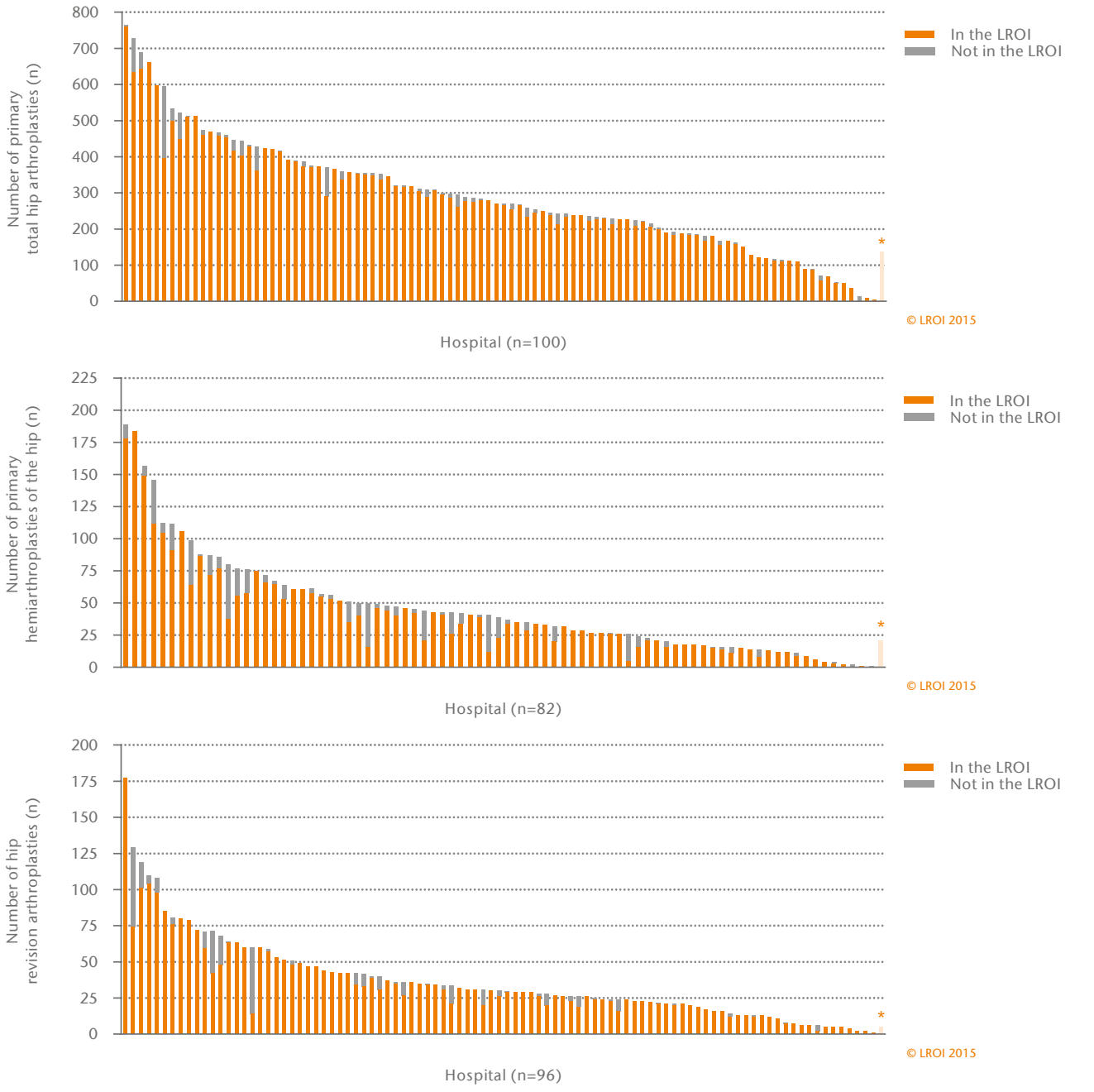


Figure 3.4 Number of procedures performed (based on the hospital information system) and the number of registered procedures in the LROI per hospital for primary total hip arthroplasties, primary hemiarthroplasties to the hip and hip revision arthroplasties in 2014. *No data provided for comparison by the hospital.
Please note: 1 hospital registered a primary total hip arthroplasty in the hospital information system, but not in the LROI.
Please note: 7 hospitals registered a hemiarthroplasty to the hip in the LROI but not in the hospital information system, 2 hospitals registered a hemiarthroplasty to the in the hospital information system but not in the LROI.
Please note: 1 hospital registered a hip revision arthroplasty in the LROI but not in the hospital information system.

Table 3.3 Completeness of registering hospitals and completeness of registered arthroplasties in the LROI based on the hospital information system in 2014.

	Number of hospitals in LROI[1]	Completeness of registering hospitals[2]	Median [range] number of registrations	Completeness registrations[3]
Hip arthroplasty		100		
Primary total hip arthroplasties (THAs)	100		263 [5-759]	96
Primary hemiarthroplasties hip (orthopaedic surgeons)	87		34 [1-197]	87
Hip revision arthroplasties	97		29 [1-177]	91
Knee arthroplasties		99		
Primary knee arthroplasties	104		240 [6-739]	97
Knee revision arthroplasties	101		18 [1-345]	92
Ankle arthroplasties		79		
Primary ankle arthroplasties	21		2 [1-17]	88
Ankle revision arthroplasties	6		2 [1-3]	75
Shoulder arthroplasties		94		
Primary shoulder arthroplasties	88		17 [1-102]	82
Shoulder revision arthroplasties	51		3 [1-50]	79
Elbow arthroplasties		96		
Primary elbow arthroplasties	21		3 [1-27]	69
Elbow revision arthroplasties	11		1 [1-15]	75

[1] Number of hospitals that performed arthroplasties in accordance with their hospital information system in 2014.

[2] Proportion of total number of hospitals that performed arthroplasties in 2014 (based on Vektis data).
[3] Completeness of number of registered arthroplasties in the LROI on 21 April 2015, compared to the total number of arthroplasties performed (based on the hospital information system) in 2014. This pertains only to hospitals that submitted data for comparison.

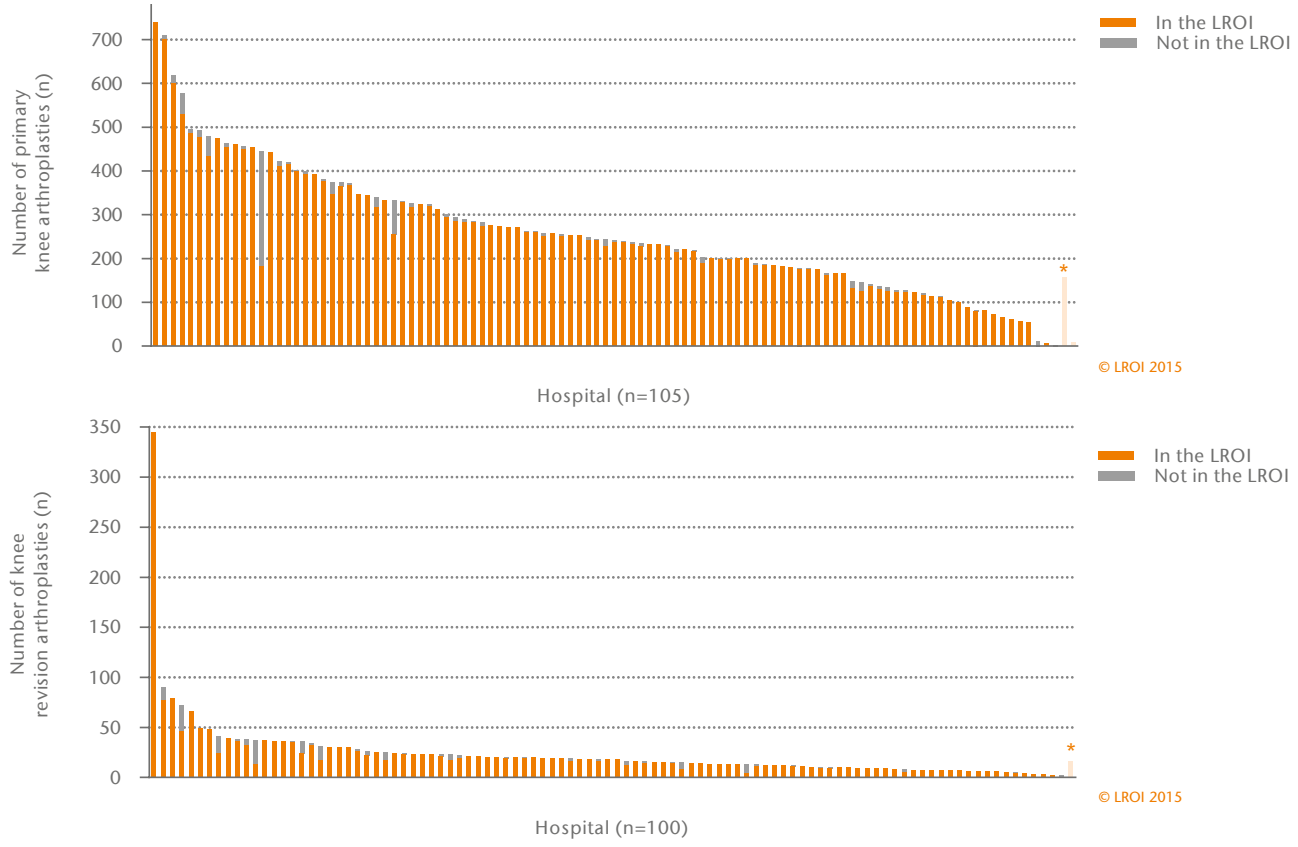


Figure 3.5 Number of procedures performed (based on the hospital information system) and the number of registered procedures in the LROI per hospital for primary knee arthroplasties and knee revision arthroplasties in 2014. *No data provided for comparison by the hospital.
Please note: 1 hospital registered a primary knee arthroplasty in the hospital information system, but not in the LROI.
Please note: 1 hospital registered a knee revision arthroplasty in the LROI but not in the hospital information system.

hip and knee arthroplasties. It is expected that completeness of newly to be registered arthroplasties, similar to that of hip and knee arthroplasties will increase over time.
Based on a comparison with Vektis data (see text box on page 31), 94% of the hospitals that perform shoulder arthroplasties registered in the LROI in 2014. In total, 88 hospitals registered primary shoulder arthroplasties and 51 hospitals registered shoulder revision arthroplasties. The median number of registrations of primary shoulder arthroplasties per hospital was 17 (range: 1-102) and with regard to shoulder revision arthroplasties it was 3 per hospital (range 1-50). Completeness of registered primary shoulder arthroplasties was 82% and of

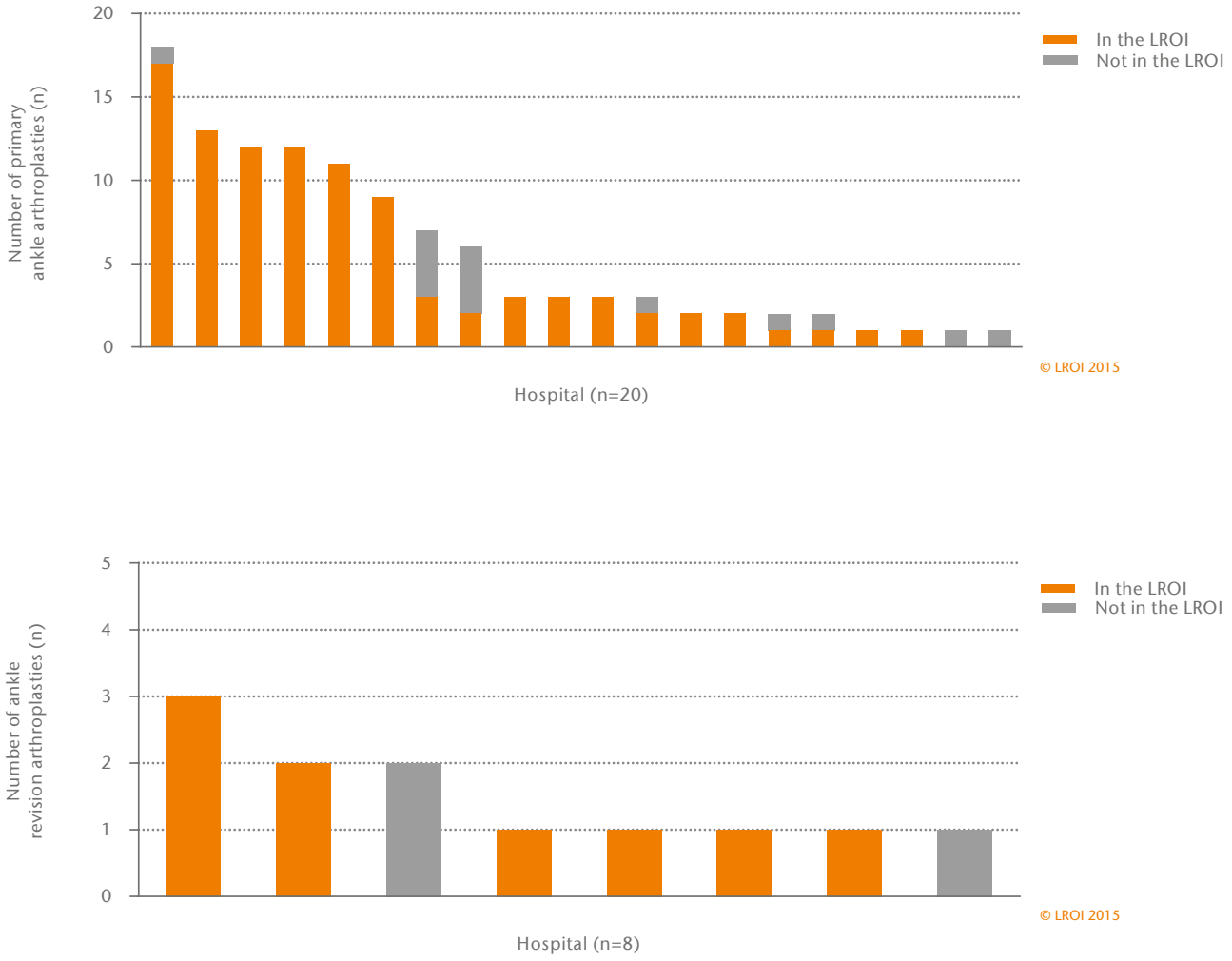


Figure 3.6 Number of procedures performed (based on the hospital information system) and the number of registered procedures in the LROI per hospital for primary ankle arthroplasties and ankle revision arthroplasties in 2014.
Please note: 3 hospitals registered a primary ankle arthroplasty in the LROI but not in the hospital information system, 2 hospitals registered a primary ankle arthroplasty in the hospital information system but not in the LROI.
Please note: 2 hospitals registered an ankle revision arthroplasty in the hospital information system but not in the LROI.

shoulder revision arthroplasties it was 79% (Table 3.3). With respect to shoulder arthroplasties, completeness also varied from hospital to hospital (Figure 3.7).

Elbow and ankle revision arthroplasties clearly occurred less frequently than hip, knee and shoulder arthroplasties in 2014. Both primary elbow and primary ankle arthroplasties were registered by a total of 21 hospitals. Elbow revision arthroplasties were registered by 11 hospitals. Ankle revision arthroplasties were registered by 6 hospitals. Based on a comparison to Vektis data (see text box) this was 96% of all hospitals that performed elbow arthroplasties and 79% of hospitals that performed ankle

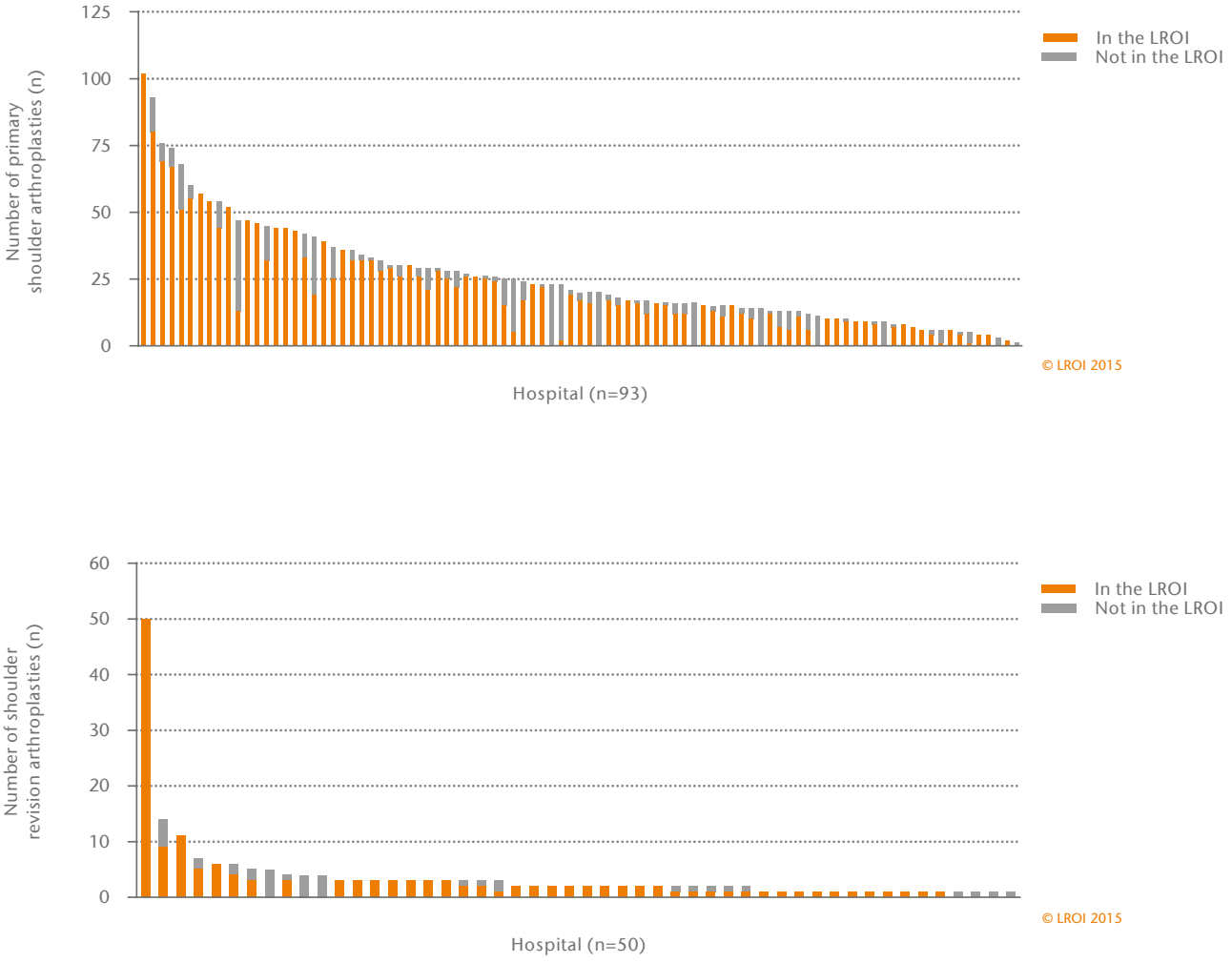


Figure 3.7 Number of procedures performed (based on the hospital information system) and the number of registered procedures in the LROI per hospital for primary shoulder arthroplasties and shoulder revision arthroplasties in 2014.
Please note: 3 hospital registered a primary knee arthroplasty in the LROI but not in the hospital information system, 8 hospitals registered a primary shoulder arthroplasty in the hospital information but not in the LROI.
Please note: 8 hospitals registered a shoulder revision arthroplasty in the LROI but not in the hospital information system, 7 hospitals registered a shoulder revision arthroplasty in the hospital information system but not in the LROI.

arthroplasties. Completeness of the number of registrations in the LROI with respect to primary elbow arthroplasties was 69% (median per hospital: 3; range: 1-27) and with respect to elbow revision arthroplasties 75% (median per hospital: 1; range: 1-15). Completeness of the number of registrations in the LROI with respect to primary ankle arthroplasties was 88% (median per hospital: 2; range: 1-17) and with respect to ankle revision arthroplasties 75% (median per hospital: 2; range: 1-3) (Table 3.3). In spite of the small number of registrations, completeness for ankle (Figure 3.6) and elbow arthroplasties (Figure 3.8) also varied from hospital to hospital.

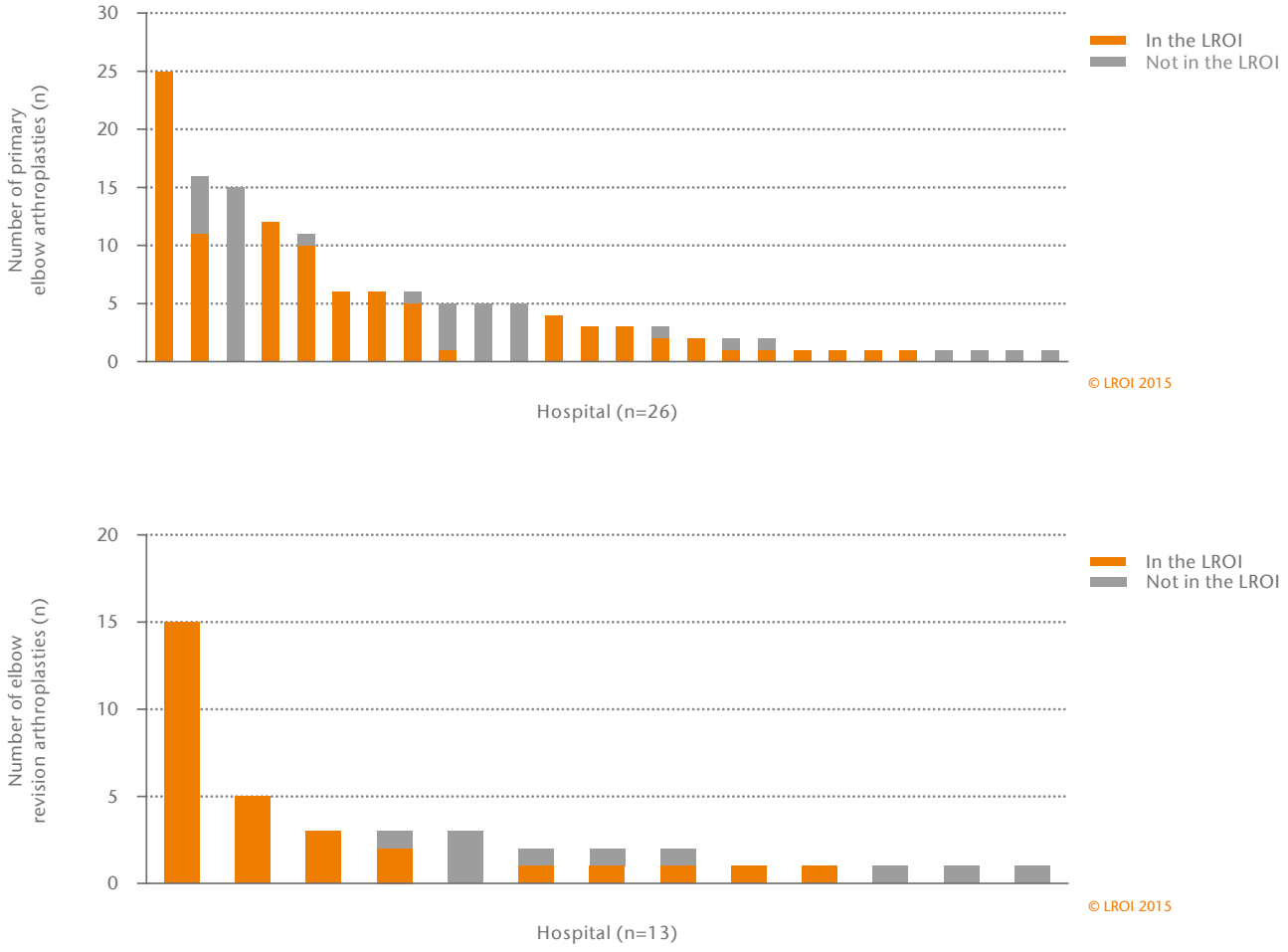


Figure 3.8 Number of procedures performed (based on the hospital information system) and the number of registered procedures in the LROI per hospital for primary elbow arthroplasties and elbow revision arthroplasties in 2014.

Please note: 2 hospitals registered a primary elbow arthroplasty in the LROI but not in the hospital information system, 7 hospitals registered a primary elbow arthroplasty in the hospital information system but not in the LROI.

Please note: 2 hospitals registered an elbow revision arthroplasty in the LROI but not in the hospital information system, 4 hospitals registered an elbow revision arthroplasty in the hospital information system but not in the LROI.

3.3 Validity of registered arthroplasties

Besides cooperation of all hospitals in the Netherlands in the LROI registration and completeness of the number of registrations in the LROI, the completeness of specific essential variables (validity) was also monitored this year. In May 2015, all hospitals received an overview of validity for arthroplasties performed in their hospital. Moreover, completeness can be monitored for each hospital on the LROI dashboard anytime.

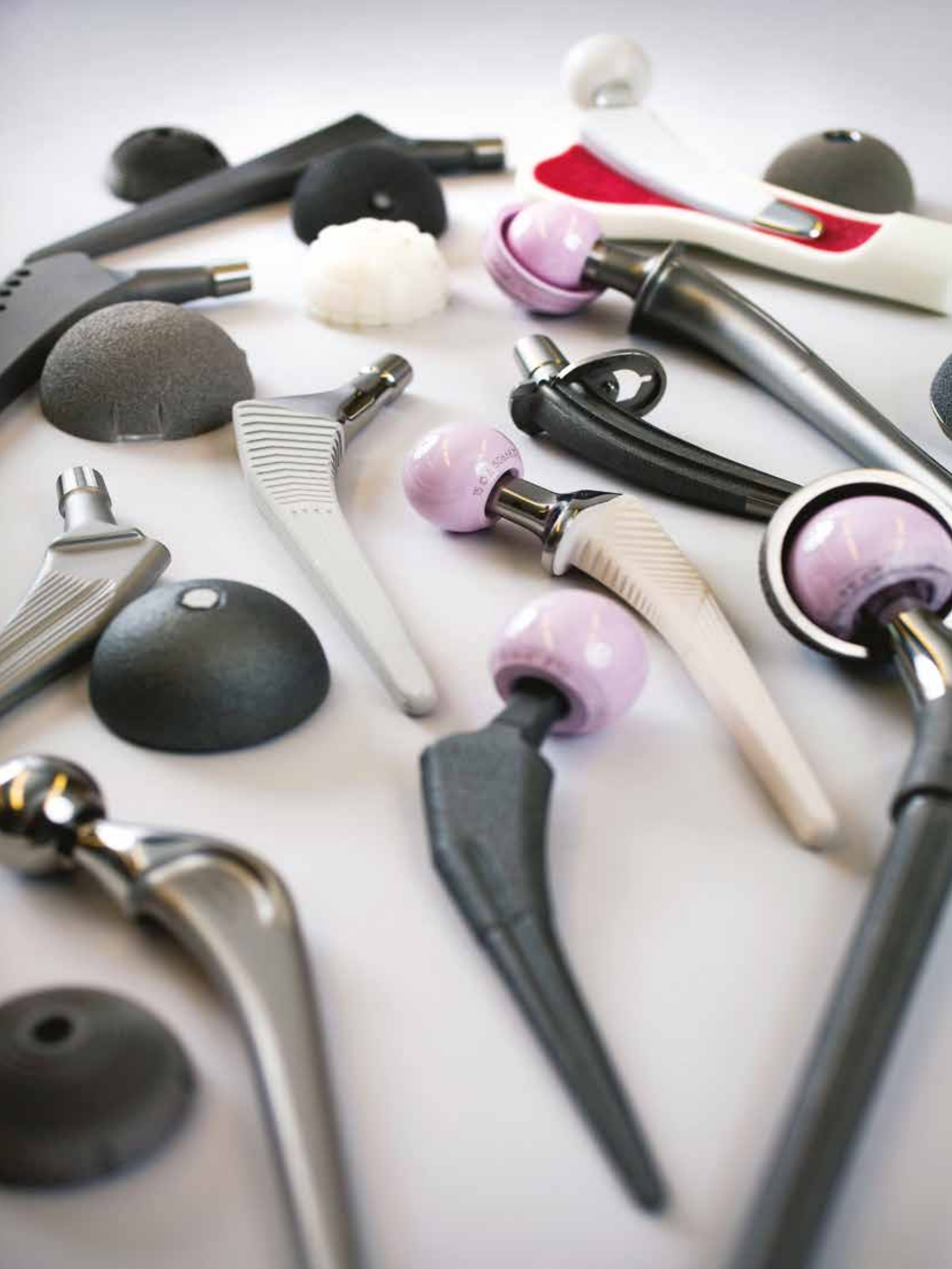
Table 3.4 describes validity of the LROI per joint for 2014 as it was registered on 16 June 2015. In particular the new variables (postal code, BMI, smoking and Charnley/Walch score) showed a lower completeness percentage at that stage. Validity of newly registered joints (ankle, shoulder and elbow arthroplasties) is also somewhat lagging behind, in general, when compared to validity in hip and knee arthroplasties. This inspires confidence that validity will increase over time.

Table 3.4 Overview of validity by variable for each joint of hip, knee, ankle, shoulder and elbow arthroplasties registered in the LROI in the Netherlands for 2014.

	Hip	Knee	Ankle	Shoulder	Elbow
Number of arthroplasties[1] (n)	35,586	29,295	123	2,293	146
Number of primary arthroplasties (n)	32,011	26,754	107	2,077	107
Number of revision arthroplasties (n)	3,574	2,541	15	203	38
General characteristics	%	%	%	%	%
Gender	100.0	99.8	100.0	99.3	100.0
Encrypted BSN	97.7	97.7	93.5	94.2	85.6
HIS patient number	100.0	99.9	100.0	99.6	100.0
Date of birth	99.8	99.9	100.0	99.5	100.0
Type of arthroplasty	100.0	100.0	99.2	99.4	99.3
Type of arthroplasty	100.0	100.0	99.2	99.4	99.3
Postal code	95.8	93.7	91.1	96.0	97.2
BMI	87.7	87.2	89.4	88.6	89.1
Smoking	77.3	78.7	92.9	86.5	89.0
Fixation	98.8	98.8	92.9	96.8	87.7
Primary arthroplasty characteristics	%	%	%	%	%
Diagnosis	98.7	98.5	96.3	97.7	92.5
ASA score	98.8	99.1	97.2	98.0	93.5
Charnley/Walch score	90.2	93.7	95.3	83.8	n.a.
Prosthesis	99.3	99.4	96.3	98.6	95.3
Surgical approach	98.9	98.9	95.3	97.4	93.5
Revision arthroplasty characteristics	%	%	%	%	%
Type of revision	97.9	98.1	100.0	98.0	97.4
ASA score	97.2	97.0	100.0	94.1	94.7
Charnley/Walch score	86.0	85.8	n.a.	n.a.	n.a.
Reason for revision	97.6	97.6	100.0	96.1	94.7

Please note: Validity by variable as determined on 16 June 2015.

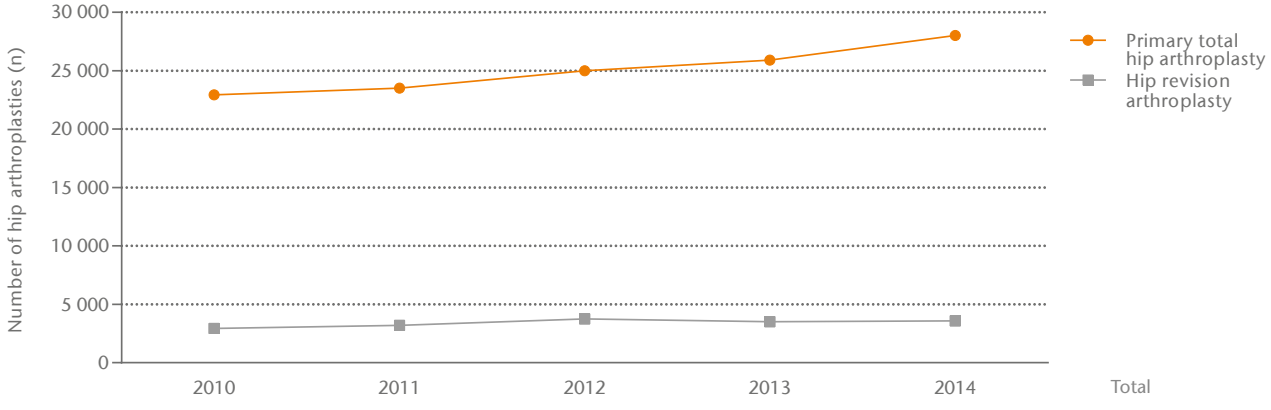
[1] All arthroplasties by joint; so, including arthroplasties of which the type of surgery (primary or revision) was not registered.



4 Hip arthroplasties

4.1 Trends and associations of primary hip and hip revision arthroplasties

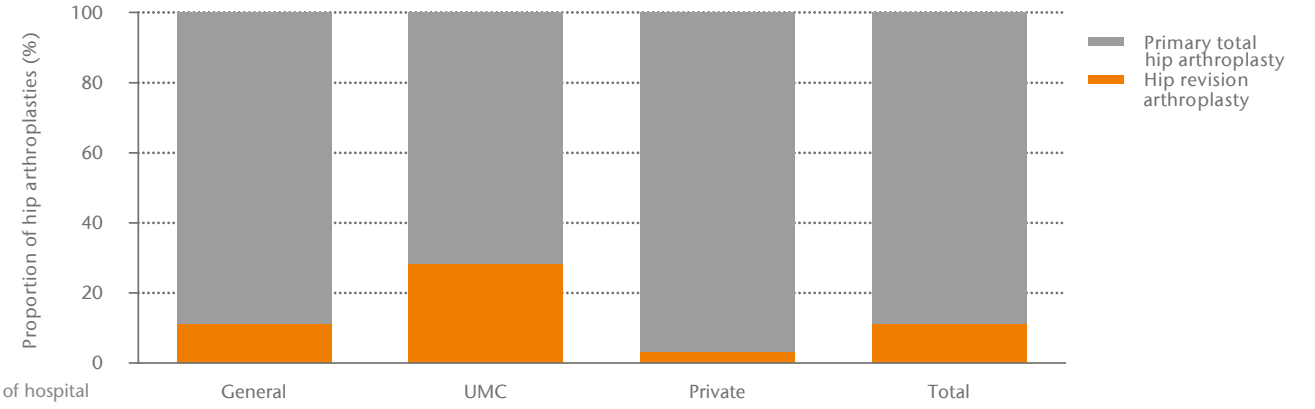
In the period 2010-2014, 125,391 primary total hip arthroplasties (THAs) and 16,991 hip revision arthroplasties were registered in the LROI. The number of registered THAs increased in 2014 when compared to previous years, though the number of revision arthroplasties stayed nearly the same (Figure 4.1). Out of 28,026 primary THAs that were performed in 2014, 4% (n=1,039) was performed bilaterally in 2014. This varied from 0% in four hospitals to 8% in one hospital.



Year	2010	2011	2012	2013	2014	Total
Type of procedure						
Primary total hip arthroplasties (n)	22,935	23,510	25,002	25,918	28,026	125,391
Hip revision arthroplasties (n)	2,948	3,194	3,763	3,512	3,574	16,991
Total (n)	25,883	26,704	28,765	29,430	31,600	142,382

Figure 4.1 Number of primary total hip arthroplasties and hip revision arthroplasties registered in the LROI in the Netherlands in 2010-2014.

A distinction was made between general hospitals, university medical centres (UMCs) and private hospitals. University medical centres (UMCs) relatively more often performed revision arthroplasties (28%) compared to the overall number of primary THAs; especially compared to the proportion in general hospitals (11%) and private hospitals (4%). In 2014, 83 general hospitals, 8 UMCs and 9 private hospitals performed hip arthroplasties. The number of primary THAs varied largely between hospitals from 5 to 759, with a median of 263 (Figure 4.3).



Type of hospital	General	UMC	Private	Total
Type of procedure				
Primary total hip arthroplasty (%)	89.2	72.1	96.5	88.7
Hip revision arthroplasty (%)	10.8	27.9	3.5	11.3
Total (n)	28,939	1,445	1,216	31,600

Figure 4.2 Primary total hip arthroplasties and hip revision arthroplasties (proportion [%] per category) by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital.

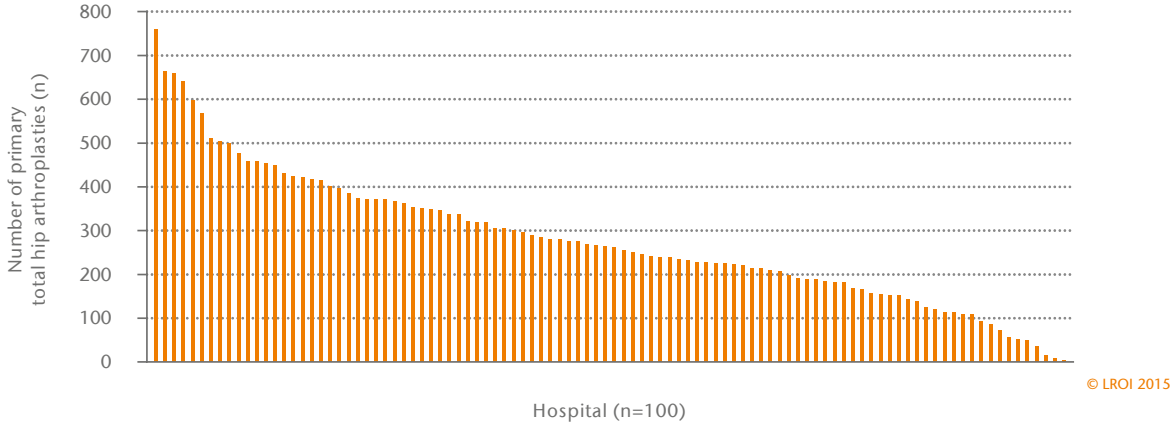


Figure 4.3 Number of primary total hip arthroplasties per hospital in the Netherlands in 2014 (n=28.026).

4.2 Primary total hip arthroplasties

4.2.1 Demographic data

The mean age of patients who underwent a THA in 2014 was 68.9 (standard deviation (SD): 10.7) years. Two-thirds were women and two-thirds had an ASA score of II (moderately ill, not disabling). Nearly 70% was 60 to 79 years of age. The large majority (87%) received a THA after being diagnosed – primarily – with osteoarthritis. Half of the patients who underwent a primary THA in 2014 had only one affected hip joint. Two-thirds of the patients who underwent a primary THA in 2014 suffered from overweight, obesity or morbid obesity (BMI>25) and on average, 13% smoked. Completeness of registration of primary THAs was 96% (Table 4.1). The number of private hospitals that performed primary THAs increased from 6 in 2013 to 9 in 2014. The number of general hospitals that performed primary THAs increased from 81 in 2013 to 83 in 2014.

Characteristics of patients who underwent a primary THA in 2014 strongly depend on the primary diagnosis. As such, over three-quarters of patients who underwent a primary THA after a primary diagnosis of post Perthes' disease were male, when only one-third is male on average. Consequently, Table 4.2 lists all patient characteristics according to diagnosis. The results for 2014 match the results for 2013 (see 2013 LROI Annual Report 'Insight into Quality & Safety'). Furthermore, patients who received a primary THA after the primary diagnosis of rheumatoid arthritis often have a higher Charnley score and post-Perthes' disease patients most often have a higher BMI. Patients who suffer from post-Perthes' disease smoke more often, which also applies to patients who had a primary THA after the diagnosis osteonecrosis (Table 4.2). Five per cent of all patients who had a THA in 2014 underwent surgery before on the relevant hip. In most cases, this was osteosynthesis (Table 4.3).

Table 4.1 Patient characteristics of all patients with a registered primary total hip arthroplasty (THA) in the Netherlands in 2014.

	Patients with primary THA in 2014 (n=26,987)
Completeness (%)	96
Mean age (years) (SD)	68.9 (10.7)
Age (years) (%)	
<50	5
50-59	14
60-69	34
70-79	35
≥80	12
Gender (%)	
Men	34
Women	66
ASA score (%)	
I	20
II	66
III-IV	14
Type of hospital[1] (%)	
General	92
UMC	4
Private	4
Diagnosis (%)	
Osteoarthritis	87
Dysplasia	2
Rheumatoid arthritis	1
Fracture (acute)	4
Osteonecrosis	3
Post-Perthes	0
Tumour	0
Late post-traumatic	3
Other	0
Charnley score (%)	
A One hip joint affected	50
B1 Both hip joints affected	28
B2 Contralateral hip joint with a total hip prosthesis	20
C Multiple joints affected or chronic disease that affects quality of life	2
Body Mass Index (kg/m²) (%)	
Underweight (≤18.5)	1
Normal weight (>18.5-25)	33
Overweight (>25-30)	43
Obesity (>30-40)	22
Morbid obesity (>40)	1
Smoking (%)	
No	87
Yes	13

[1]In 2014, 83 general hospitals, 8 UMCs and 9 private hospitals performed primary THAs.

THA: total hip arthroplasty; General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

Table 4.3 Previous surgery to the same joint in patients with a primary total hip arthroplasty in the Netherlands in 2014 (n=25,989).

	Proportion[1] (%)
Previous surgery to the relevant hip (total)	5.0
Osteosynthesis	3.5
Osteotomy	0.9
Arthrodesis	0.1
Girdlestone situation	0.1
Other	1.0

Please note: With regard to 1 patient it was unknown if earlier surgery had taken place on the relevant hip.

[1] A patient may have undergone multiple previous surgeries to the same joint. As such, the total proportion is more than 5.0% (proportion of patients with one or more previous surgeries to the same joint).

Characteristics of a hospital's patient population (also referred to as case mix) largely determine the results of hospitals as presented in this Annual Report. The case mix of patient populations varied largely from hospital to hospital. The 2013 LROI Annual Report 'Insight into Quality & Safety' listed this practice variation with respect to various characteristics. Three new relevant characteristics are now showed, specifically Body Mass Index (BMI), smoking and Charnley score. The distribution of BMIs differed considerably. The proportion of normal or underweight varied between hospitals from two-thirds to just below 20% (Figure 4.4). The proportion of smoking patients varied between hospitals from 0 to nearly 30% (Figure 4.5). Of these variables, the variation in Charnley score was the largest, with a difference in proportion of Charnley score A (one hip affected by osteoarthritis) of nearly 80% in one hospital to 20% in another (Figure 4.6).

Table 4.2 Patient characteristics of all patients with a registered primary total hip arthroplasty by diagnosis in the Netherlands in 2014.

	Osteoarthritis (n=23,246)	Dysplasia (n=535)	Rheumatoid arthritis (n=213)	Fracture (n=1,037)	Osteonecrosis (n=756)	Post-Perthes' disease (n=88)	Tumour (n=69)	Late post-traumatic (n=643)	Total (n=26,987)
Mean age (years) (SD)	69.7 (9.7)	55.6 (14.1)	64.3 (14.0)	70.3 (9.6)	61.5 (14.9)	52.5 (13.8)	61.9 (12.8)	65.5 (13.5)	68.8 (10.8)
Age (years) (%)									
<50	4	38	15	3	22	47	16	13	5
50-59	13	24	17	10	22	25	28	20	14
60-69	34	22	31	38	27	19	29	29	34
70-79	36	14	28	35	19	8	22	23	35
≥80	13	2	9	14	10	1	5	15	12
Gender (%)									
Men	33	33	20	30	49	78	31	40	34
Women	67	67	80	70	51	22	69	60	66
ASA-score (%)									
I	20	45	5	16	18	48	4	20	20
II	67	47	69	59	58	45	44	60	66
III-IV	13	8	26	25	24	7	52	20	14
Type of hospital (%)									
General	93	86	91	94	86	91	74	89	92
UMC	3	7	7	6	11	5	26	9	4
Private	4	7	2	0	3	4	0	2	4
Charnley-score (%)									
A One hip joint affected	47	53	33	77	64	76	83	84	50
B1 Both hip joints affected	30	29	31	11	18	15	5	8	28
B2 Contralateral hip joint with a total hip prosthesis	21	16	19	9	15	8	6	5	20
C Multiple joints affected or chronic disease that affects quality of life	2	2	17	3	3	1	6	3	2
Body Mass Index (kg/m²) (%)									
Underweight (≤18.5)	0	1	2	4	3	1	0	3	1
Normal weight (>18.5-25)	32	37	38	49	42	25	46	45	33
Overweight (>25-30)	44	41	40	36	33	45	36	36	43
Obesity (>30-40)	23	20	17	11	20	28	16	16	22
Morbid obesity (>40)	1	1	3	0	1	1	2	0	1
Smoking (%)									
No	88	87	85	83	73	68	90	77	87
Yes	12	13	15	17	27	32	10	23	13

Please note: In 2014, 38 (0.1%) patients received a primary total hip arthroplasty after a diagnosis that is not listed in the table.
The diagnosis of 362 (1.3%) patients was not registered.
General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

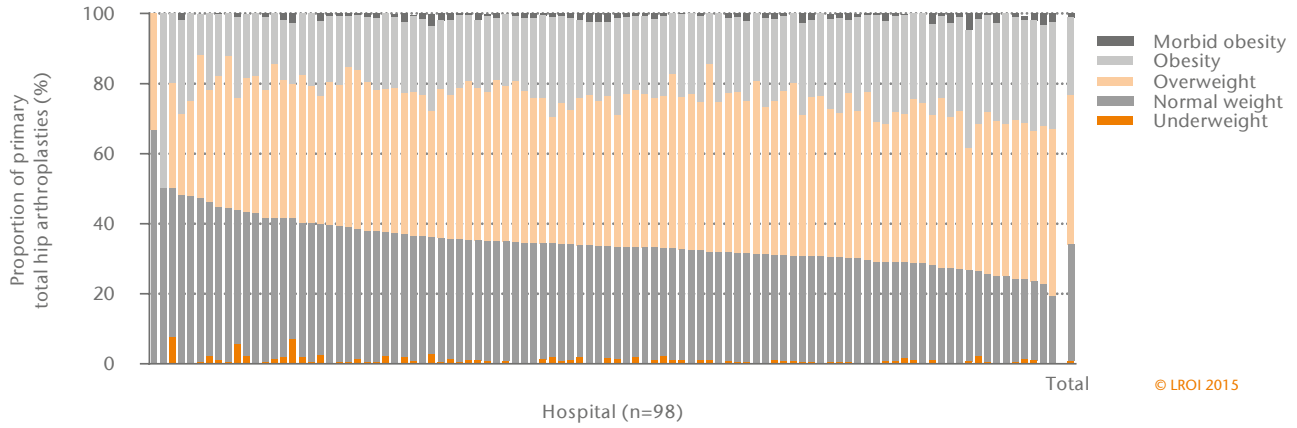


Figure 4.4 Distribution of body mass index (kg/m²) of patients who underwent a primary total hip arthroplasty for the first time per hospital in the Netherlands in 2014 (n=24,764).

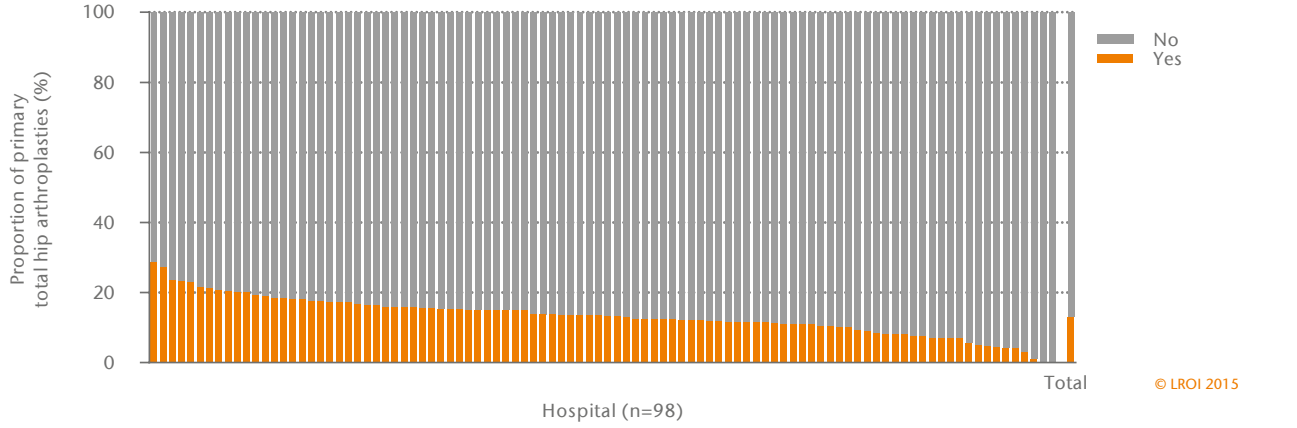


Figure 4.5 Distribution of smoking by patients who underwent a primary total hip arthroplasty for the first time per hospital in the Netherlands in 2014 (n=21,378).

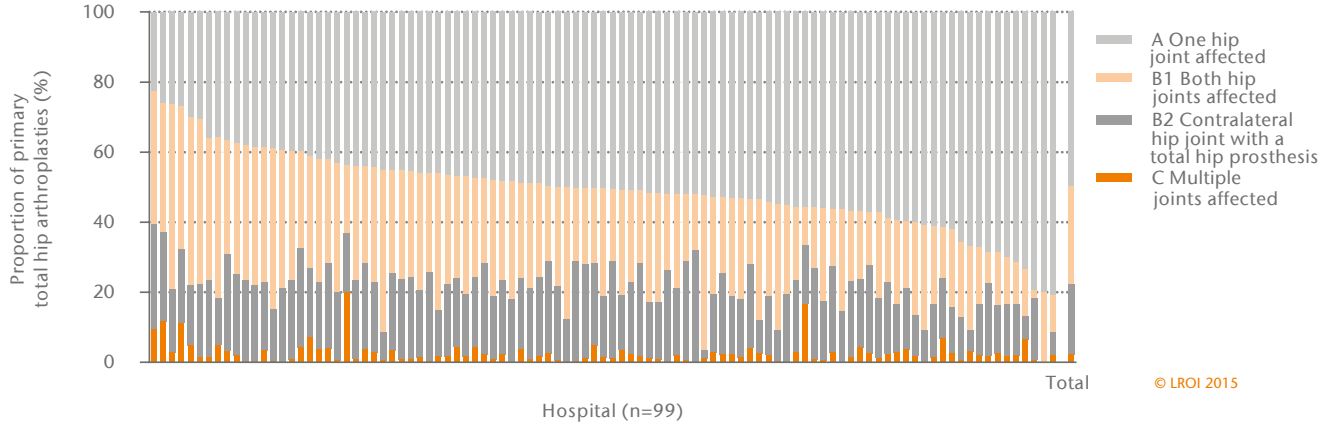
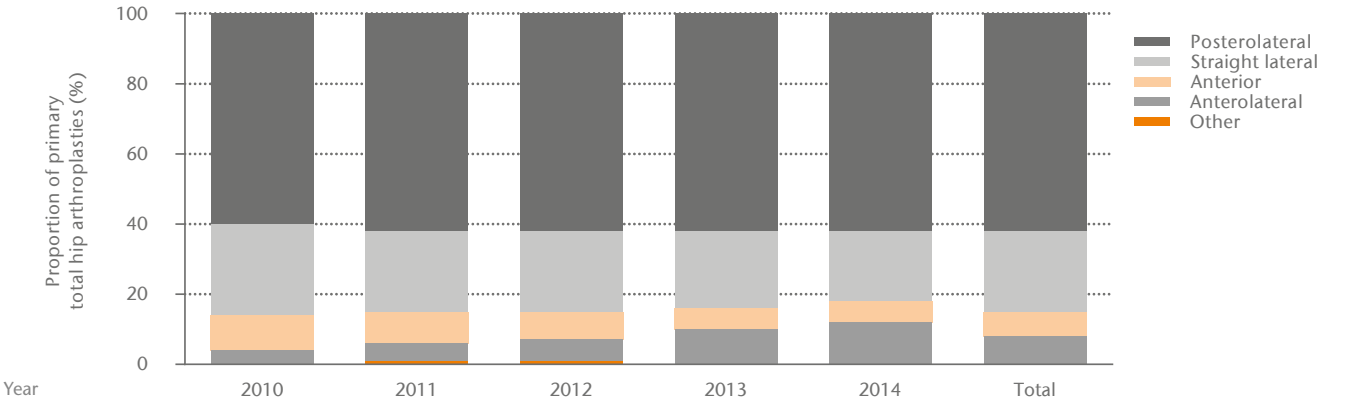


Figure 4.6 Distribution of Charnley score of patients who underwent a primary total hip arthroplasty for the first time per hospital in the Netherlands in 2014 (n=25,355).
THA: total hip arthroplasty.

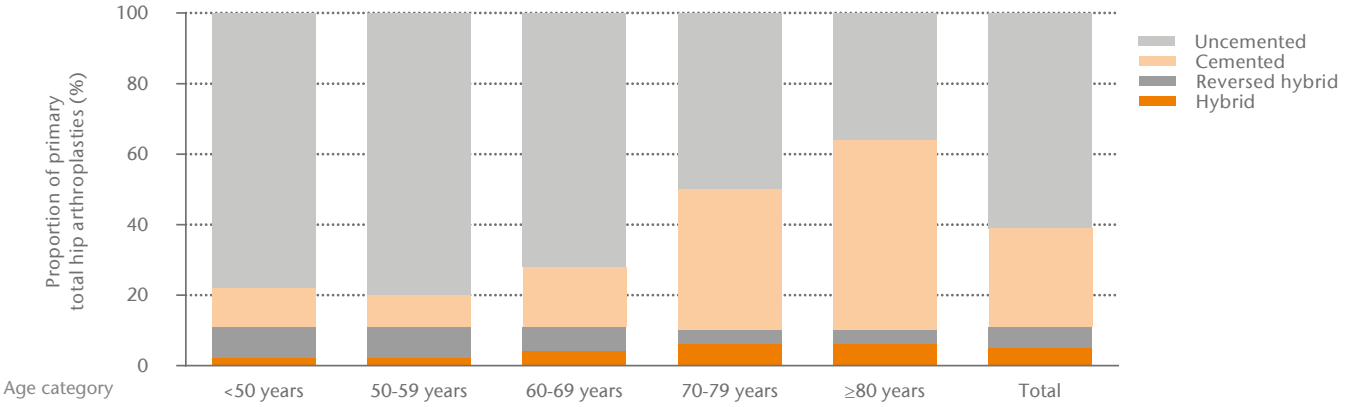
4.2.2 Prosthesis characteristics and surgical techniques

The most commonly used surgical approach was posterolateral (62%) for primary THAs. Use of the direct lateral approach decreased from 22% in 2013 to 20% in 2014. This is a trend that has continued since 2010 (26%). A similar decrease is visible with respect to the anterolateral approach, from 10% in 2010 to 5% in 2014. The use of the anterior approach increased even further, from 4% in 2010 and 10% in 2013 to 12% in 2014 (Figure 4.7). Similar to 2013, primary THAs were mainly performed without cement in 2014 (61%). Nearly 30% was



Year	2010	2011	2012	2013	2014	Total
Surgical approach						
Posterolateral (%)	60.2	62.4	62.3	61.6	61.9	61.7
Straight lateral (%)	25.6	23.3	23.1	21.8	20.2	22.7
Anterior (%)	4.2	4.9	6.0	9.8	12.3	7.7
Anterolateral (%)	9.7	8.7	7.9	6.6	5.4	7.5
Other (%)	0.3	0.7	0.7	0.2	0.2	0.4
Total (n)	22,801	23,341	24,829	25,792	27,900	124,663

Figure 4.7 Trend (proportion [%] per year) in surgical approach for performing a primary total hip arthroplasty in the Netherlands in 2010-2014.

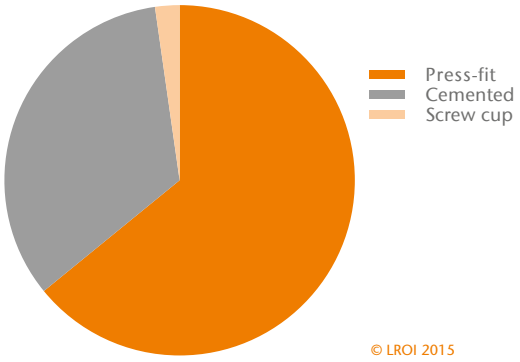


Age category	<50 years	50-59 years	60-69 years	70-79 years	≥80 years	Total
Fixation						
Uncemented (%)	77.6	79.5	72.2	49.9	36.0	61.4
Cemented (%)	11.4	9.0	17.1	39.5	54.0	27.9
Reversed hybrid (%)	9.2	9.3	6.6	4.2	3.6	5.9
Hybrid (%)	1.8	2.2	4.1	6.4	6.4	4.8
Total (n)	1,550	3,831	9,502	9,574	3,437	27,894

Figure 4.8 Type of fixation (proportion [%] per category) in primary total hip arthroplasties by age category in the Netherlands in 2014.
Please note: For 3 (<0.01%) primary total hip arthroplasties the type of fixation was unknown.

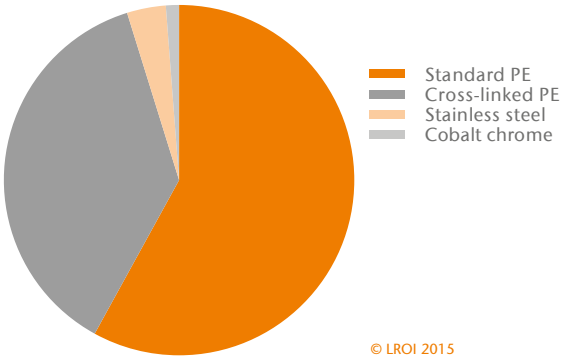
performed with cement and in over 10% either the acetabulum or femur was cemented. THAs were more often performed with cement in elderly patients (≥80 years: 54%), while THAs were more often performed without cement in younger patients (<50 years: 78%) (Figure 4.8). Cemented acetabular components were most often monoblocks (98%). 81% of uncemented acetabular components that were used in a primary THA had mobile backing and 18% were monoblocks. About two-thirds of the acetabular components used in primary THAs were clamped into the acetabulum (press-fit) and one-third was intended for fixation with cement. Only 2% of acetabular components were screw cups (Figure 4.9).

The vast majority of cemented acetabular components was made of polyethylene (PE), specifically 58% of standard PE and 37% of cross-linked PE in primary THAs performed in 2014 (Figure 4.10). Over ninety per cent of the acetabular components intended for uncemented implantation was made of titanium (Figure 4.11). Figure 4.12 displays the material of inlays used in primary THAs in 2014. The trend in material of inlays used in primary THAs continued. Since 2010, the use of inlays made of cross-linked PE increased (45% in 2010 to 81% in 2014) and the use of inlays made of standard PE (36% in 2010 to 8% in 2014), ceramics (18% in 2010 to 10% in 2014) and cobalt chrome (6% in 2010 to 0% in 2014) decreased.



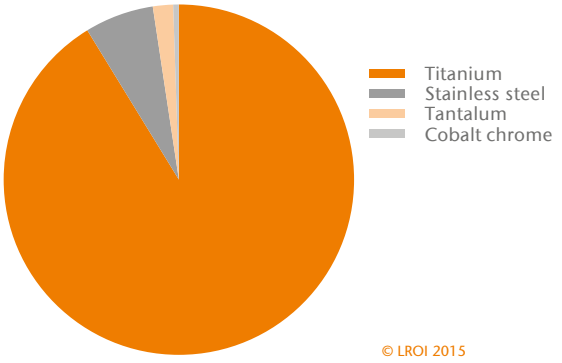
Type of acetabulum	Number (n)	Proportion (%)
Press-fit	17,789	64.3
Cemented	9,252	33.5
Screw cup	618	2.2

Figure 4.9 Type of acetabular component in primary total hip arthroplasties in the Netherlands in 2014 (n=27,659).



Material cemented acetabular component	Number (n)	Proportion (%)
Standard PE	5,366	58.0
Cross-linked PE	3,442	37.2
Stainless steel	332	3.6
Cobalt chrome	112	1.2

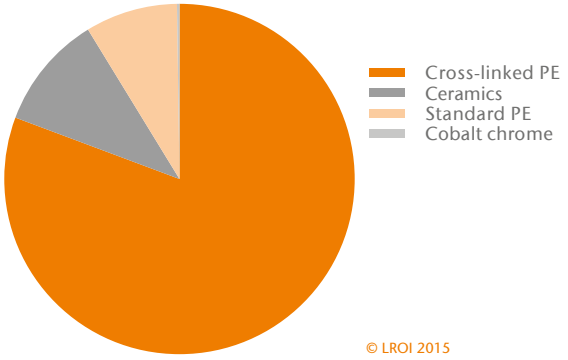
Figure 4.10 Material cemented acetabular component in primary total hip arthroplasties in the Netherlands in 2014 (n=9,253).
Please note: In 1 (0.01%) of primary total hip arthroplasties the material of the cemented acetabular component was titanium.
PE: polyethylene.



Material uncemented acetabular component	Number (n)	Proportion (%)
Titanium	16,796	91.2
Stainless steel	1,172	6.4
Tantalum	343	1.9
Cobalt chrome	96	0.5

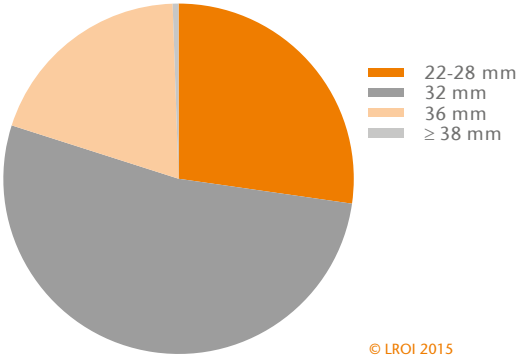
Figure 4.11 Material uncemented acetabular component in primary total hip arthroplasties in the Netherlands in 2014 (n=18,407).

The use of femoral heads with a 32 mm diameter increased from 34% in 2010 to 53% in 2014 (Figure 4.13). Six per cent of femoral heads with a 22-28 mm diameter in primary THAs was placed with a dual mobility cup. The femoral head mainly consists of ceramics (63%), followed by cobalt chrome (31%) (Figure 4.14). This is similar to 2013. Two-thirds of femoral components were made of titanium and over one quarter of cobalt chrome; 7% were made of stainless steel (Figure 4.15). Ceramics-on-PE was the most frequently used type of articulation in 2014, specifically in 54% of primary THAs in the Netherlands. Metal-on-PE THAs were more often used in elderly patients, when ceramics-on-PE and ceramics-on-ceramics THAs were more often used in younger patients (Figure 4.16).



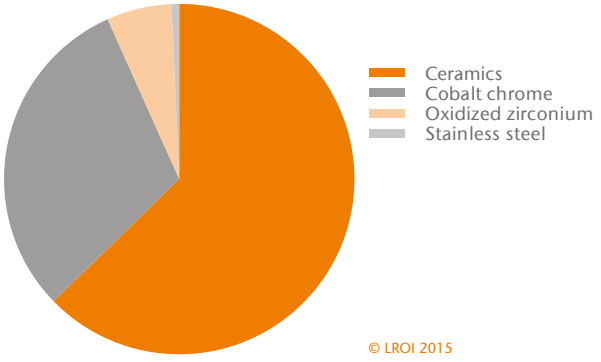
Inlay material	Number (n)	Proportion (n)
Cross-linked PE	13,658	80.7
Ceramics	1,787	10.6
Standard PE	1,441	8.5
Cobalt chrome	39	0.2

Figure 4.12 Inlay material in primary total hip arthroplasties in the Netherlands in 2014 (n=16,925).
PE: polyethylene.



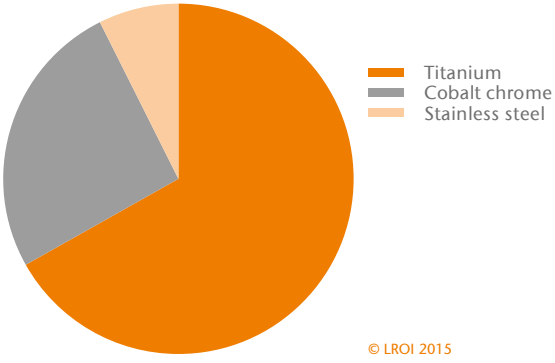
Femoral head diameter	Number (n)	Proportion (%)
22-28 mm	7,506	27.1
32 mm	14,625	52.9
36 mm	5,393	19.5
≥ 38 mm	148	0.5

Figure 4.13 Femoral head component diameter in primary total hip arthroplasties in the Netherlands in 2014 (n=27,672).



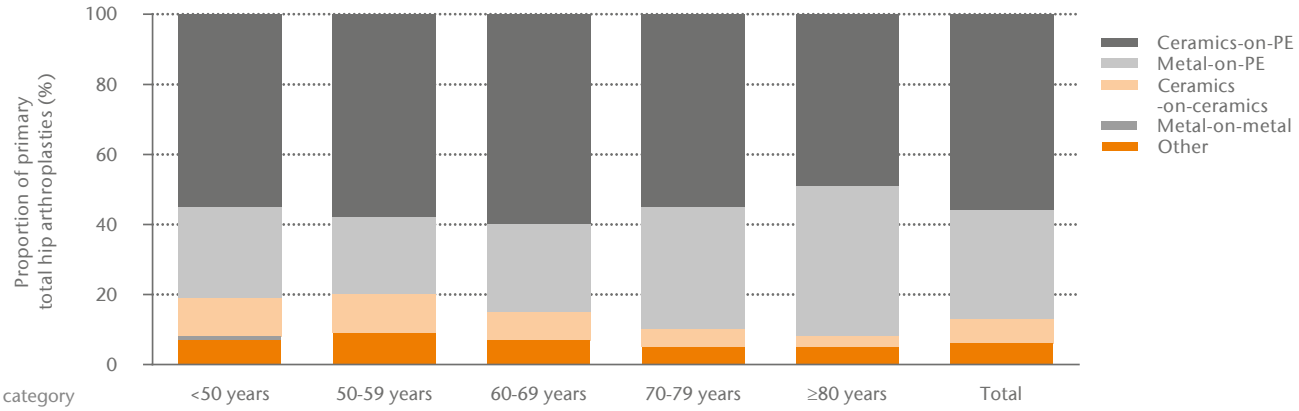
Femoral head material	Number (n)	Proportion (%)
Ceramics	17,349	62.7
Cobalt chrome	8,459	30.6
Oxidized zirconium	1,661	6.0
Stainless steel	194	0.7

Figure 4.14 Femoral head component material in primary total hip arthroplasties in the Netherlands in 2014 (n=27,672).
Please note: In 9 (0.03%) primary total hip arthroplasties a titanium femoral head component was implanted, of which one had a hardened layer.



Femur material	Number (n)	Proportion (%)
Titanium	18,569	67.0
Cobalt chrome	7,105	25.6
Stainless steel	2,035	7.4

Figure 4.15 Femur component material in primary total hip arthroplasties in the Netherlands in 2014 (n=27,709).

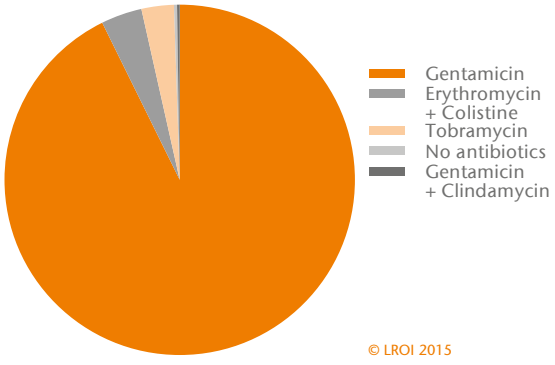


Articulation						
Ceramics-on-PE (%)	53.2	55.1	57.7	52.9	46.0	54.0
Metal-on-PE (%)	24.6	21.8	24.8	35.3	42.4	30.2
Ceramics-on-ceramics (%)	10.6	10.0	7.6	4.4	3.1	6.4
Metal-on-metal (%)	0.7	0.3	0.2	0.1	0.3	0.2
Other (%)	10.9	12.8	9.7	7.3	8.2	9.2
Total (n)	1,555	3,838	9,530	9,617	3,448	27,988

Figure 4.16 Articulation (proportion [%] per category) in primary total hip arthroplasties in the Netherlands in 2014.
Please note: No articulation could be determined in 549 primary total hip arthroplasties, since not all components (femoral head and inlay/acetabulum) were implanted and/or registered.
PE: polyethylene.

In 2014, 9,312 cemented (46 different types) and 18,264 uncemented (53 different types) acetabular components were registered for primary THAs. In total, 9,021 cemented (37 different types) and 18,610 uncemented (53 different types) femoral components were registered. Table 4.4 lists an overview of the ten most registered acetabular and femoral components. Components that were implanted cemented and those that were implanted uncemented (as registered by the orthopaedic department) were distinguished.

The use of bone cement was registered in 9,931 primary THAs in 2014. There were 15 different types of bone cement used, with the five most registered types of bone cement listed in Table 4.5. The bone cement used to perform primary THAs nearly always contained antibiotics in 2014. This was gentamicin in the vast majority of cases (93%) (Figure 4.17). Viscosity of bone cement was generally high (88%), or in other cases medium (12%) (Figure 4.18). Although these were most often separately packed bone cement components, the use of bone cement pre-packed in a vacuum mixing system increased over the period 2010-2014 from 5% in 2010 to 18% in 2014 (Figure 4.19).



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	9,206	92.7
Erythromycin + Colistin	375	3.8
Tobramycin	297	3.0
No antibiotics	28	0.3
Gentamicin + Clindamycin	24	0.2

Figure 4.17 Antibiotics in bone cement in primary total hip arthroplasties in the Netherlands in 2014 (n=9,931).
Please note: Bone cement with gentamicin and vancomycin was used in 1 (<0.01%) primary total hip arthroplasty.

Table 4.4 The ten most frequently registered acetabular (both cemented and uncemented) and femoral (both cemented and uncemented) components in primary total hip arthroplasties implanted in the Netherlands in 2014.

Acetabulum (n=27,660)

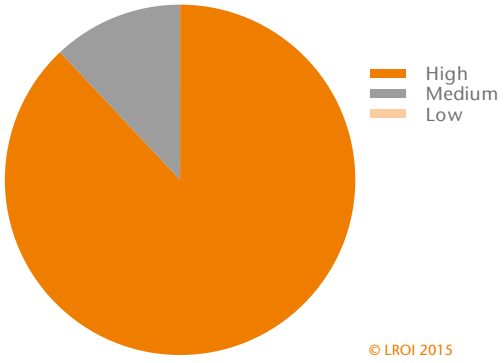
Cemented (n=9,312)		Uncemented (n=18,264)	
Name	Proportion (%)	Name	Proportion (%)
IP Cup	19.6	Allofit	20.3
Müller Low Profile	16.2	Pinnacle	20.2
Reflection All Poly	9.8	Mallory Head	11.1
Exeter Rimfit	8.2	Exceed ABT	9.1
Stanmore	5.1	RM Pressfit cup	6.3
FAL Cup	5.1	Trident Tritanium	5.6
SHP	4.3	R3	5.0
Contemporary Hooded	3.9	Trident	4.8
CCB cup	3.7	Reflection	4.7
Exeter	3.4	Bicon Plus	2.0

Femur (n=27,714)

Cemented (n=9,021)		Uncemented (n=18,610)	
Name	Proportion (%)	Name	Proportion (%)
Lubinus SPII	32.4	Corail	19.5
Exeter	19.6	Taperloc	17.3
Original ME Muller	16.8	Alloclassic SL	11.2
Spectron EF	11.2	CLS Spotorno	10.0
Stanmore	10.7	Accolade	7.9
CCA stem	2.2	SL Plus	6.1
Taperloc	1.4	Mallory Head Stems	5.5
Twinsys stem	0.8	Twinsys Stem	4.3
Synergy	0.7	Synergy	2.9
Charnley Mod	0.6	CBH stem	1.8

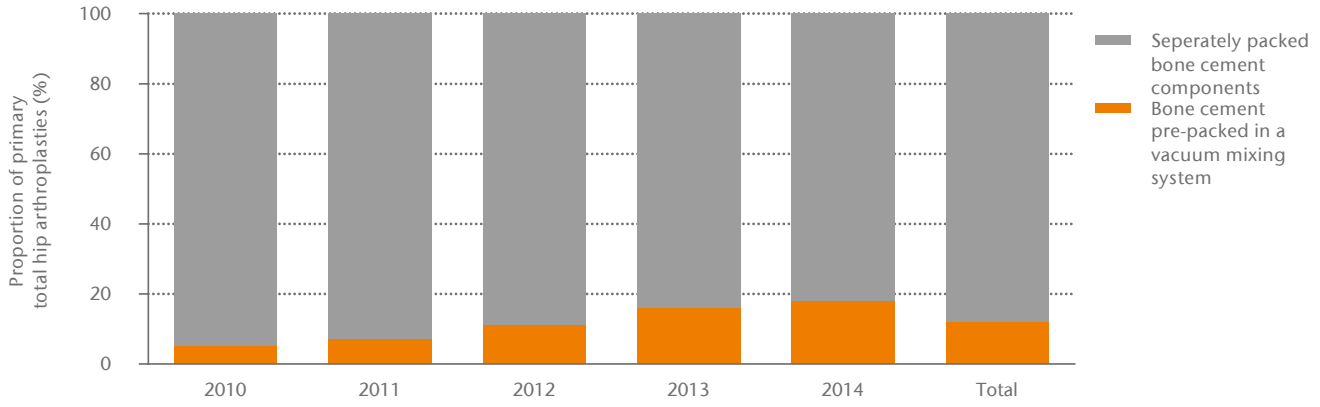
Table 4.5 The five most frequently registered types of bone cement used during primary total hip arthroplasties in the Netherlands in 2014 (n=9,931).

Name	Proportion (%)
Palacos R+G	65.7
Refobacin Bone Cement R	14.5
Refobacin Plus Bone Cement	5.4
Palacos MV+G	5.2
Simplex ABC EC	3.8



Bone cement viscosity	Number (n)	Proportion (%)
High	8,739	88.0
Medium	1,191	12.0
Low	1	0.0

Figure 4.18 Viscosity of bone cement in primary total hip arthroplasties in the Netherlands in 2014 (n=9,931).



Year	2010	2011	2012	2013	2014	Total
Vacuum mixing system						
Separately packed bone cement components	94.6	92.7	88.7	83.6	82.2	88.0
Bone cement pre-packed in a vacuum mixing system	5.4	7.3	11.3	16.4	17.8	12.0
Total (n)	7,809	8,286	8,910	9,256	9,930	44,191

Figure 4.19 Trend (proportion [%] by year) in use of bone cement pre-packed in a vacuum mixing system in primary total hip arthroplasties in the Netherlands in 2010-2014.

4.3 Hip hemiarthroplasties

The number of registered hip hemiarthroplasties in the LROI increased from 2,358 in 2010 to 3,727 in 2014. However, the number of registered hip hemiarthroplasties in the LROI is not complete, since these procedures are also performed by trauma surgeons. In the fall of 2013, an agreement was reached with the trauma surgeons, so they can also register hemiarthroplasties in the LROI. This was started in 2014. Unfortunately, the registration of hemiarthroplasties performed by trauma surgeons is not yet complete. In total, 17 hospitals registered primary hip hemiarthroplasties that were performed by trauma surgeons in the LROI in 2014. The completeness of hemiarthroplasties performed by orthopaedic surgeons was 87%. In 2014, orthopaedic surgeons performed hip hemiarthroplasties in 79 hospitals.

The average age of patients who received a hip hemiarthroplasty in 2014 was 82.1 years (SD: 8.7). That is nearly 13 years higher than the average age of patients who received a THA in the same

year. The proportion of patients with ASA scores of III-IV is nearly 60%, while this proportion is 14% in patients with THAs. The vast majority of hip hemiarthroplasties (94%) was performed after a fracture (including a post-traumatic ground) (Table 4.6).

Table 4.6 Patient characteristics of all patients with a registered primary hip hemiarthroplasty in the Netherlands in 2014.

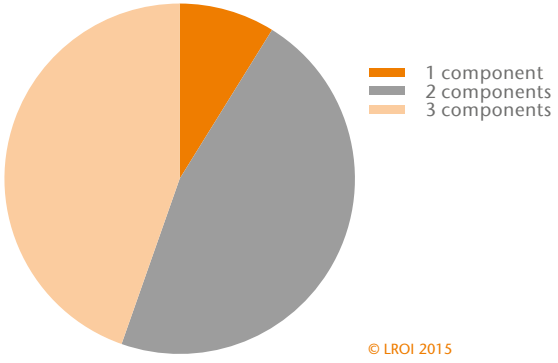
	Patients with hemiarthroplasty in 2014 (n=3,651)
Completeness (%)	87
Mean age (years) (SD)	82.1 (8.7)
Age (years) (%)	
<50	0
50-59	2
60-69	6
70-79	28
≥80	64
Gender (%)	
Men	29
Women	71
ASA score (%)	
I	3
II	38
III-IV	59
Type of hospital[1] (%)	
General	97
UMC	3
Private	0
Diagnosis (%)	
Fracture (acute)	92
Osteoarthritis	4
Late post-traumatic	2
Tumour	1
Osteonecrosis	1
Dysplasia	0
Rheumatoid arthritis	0
Post-Perthes' disease	0
Inflammatory arthritis	0
Body Mass Index (kg/m²) (%)	
Underweight (≤18.5)	5
Normal weight (>18.5-25)	56
Overweight (>25-30)	30
Obesity (>30-40)	9
Morbid obesity (>40)	0
Smoking (%)	
No	91
Yes	9

[1] In 2014, 76 general hospitals, 7 UMCs and 3 private hospitals performed primary hip hemiarthroplasties.
General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

4.4 Hip revision arthroplasties

Hip revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of a hip prosthesis. Patients may undergo multiple procedures for one revision. This may be the case when an implant is removed during one surgery due to an infection, and a new prosthesis is implanted during a next surgery. This results in multiple revision arthroplasties, but it still relates to the revision of a single primary prosthesis. Furthermore, the majority of hip revision arthroplasties in the LROI are revisions of primary hip arthroplasties performed before the start of the LROI in 2007. Since data have only been registered from 2007 on, only a part of the revision arthroplasties can be linked to a primary arthroplasty. Therefore, this chapter does not list patient characteristics.

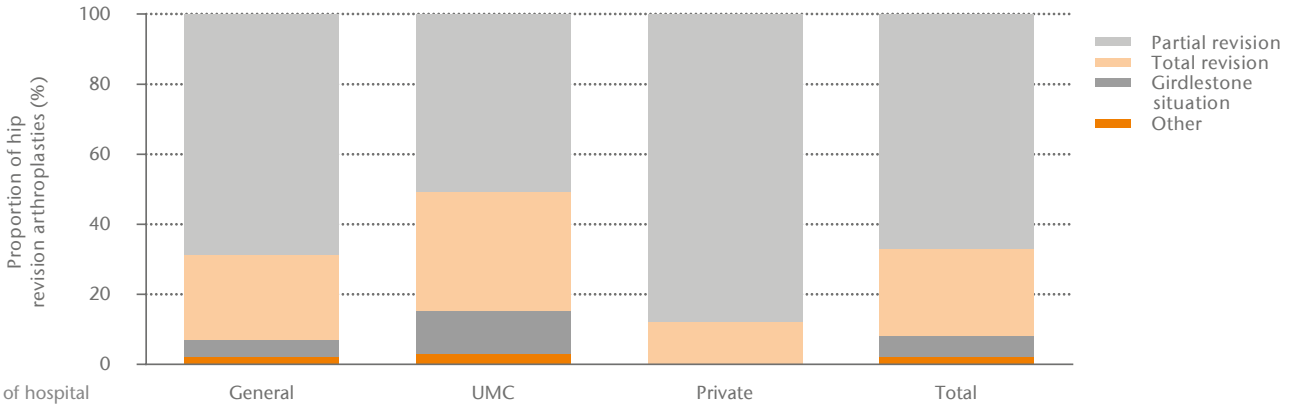
In total, 3,574 hip revision arthroplasties were registered for 2014. This is similar to the number of hip revision arthroplasties in 2013 (n=3,512). Completeness of the registration of hip revision arthroplasties in the LROI is 91% for 2014, based on a comparison to the hospital information system (HIS).



Number of revised components	Number (n)	Proportion (%)
1 component	193	8.8
2 components	1,016	46.6
3 components	974	44.6

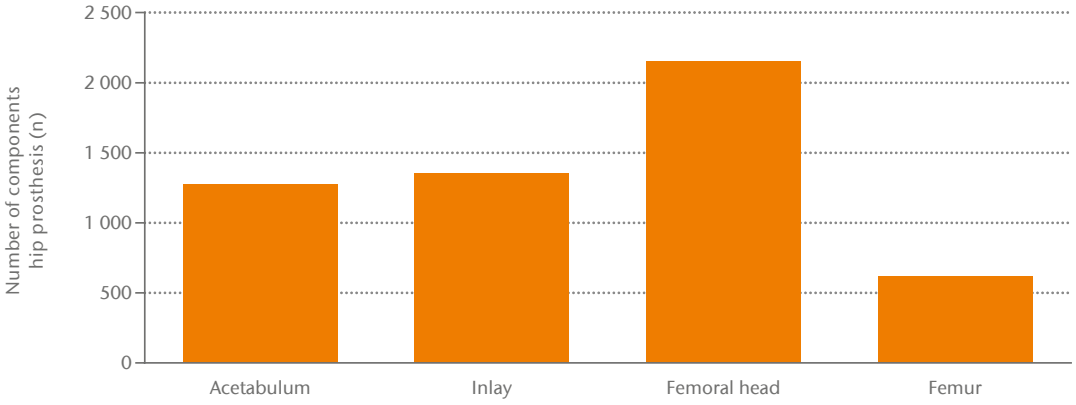
Figure 4.21 Number of revised components in partial hip revision arthroplasties in the Netherlands in 2014 (n=2,183).

In 2014, 2,358 (67%) partial revisions and 861 (25%) total hip revision arthroplasties were performed. A Girdlestone situation was registered for 205 procedures (6%). This is more than in 2013 (n=120; 4%). These proportions vary by type of hospital. UMCs would quite often perform total hip revision arthroplasties, while revision arthroplasties in private hospitals would be partial revisions in nearly all cases (90%) (Figure 4.20). Twelve per cent of revision arthroplasties were conversions to a total hip arthroplasty. In partial revisions carried out in 2014, generally two (47%) or three (45%) components were replaced (Figure 4.21). In 91% of all cases the femoral head was replaced and in 54% of all cases the acetabulum. Inlays were replaced in 57% of revision procedures (Figure 4.22).



Type of hospital	General	UMC	Private	Total
Type of hip revision				
Partial revision (%)	69.1	51.5	88.4	67.3
Total revision (%)	23.5	34.2	11.6	24.6
Girdlestone situation (%)	5.2	11.8	0.0	5.9
Other (%)	2.2	2.5	0.0	2.2
Total (n)	3,060	398	43	3,501

Figure 4.20 Type of revision (proportion [%] per category) of hip revision arthroplasties by hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital.



	Acetabulum	Inlay	Femoral head	Femur
Number (n)	1,275	1,352	2,151	621
Proportion[1] (%)	54.1	57.3	91.2	26.3

Figure 4.22 Revised components in partial hip revision arthroplasties in the Netherlands in 2014 (n=2,358).
[1] More than one component can be replaced during a procedure. As such, the total proportion is over 100%.

The number of hip revision arthroplasties varied strongly between hospitals in 2014; from fewer than ten revision arthroplasties in eleven hospitals to 177 revision arthroplasties in one hospital. The median number of hip revision arthroplasties per hospital was 29 in 2014 (Figure 4.23). The most common reason for revision was loosening of the acetabular component (26%). Next came loosening of the femoral component (21%), inlay wear (20%) and dislocation (19%) (Table 4.7). In 47% of revision arthroplasties cemented fixation was used, while 44% was performed without cement. Hybrid fixation was used in 10% of hip revision arthroplasties (Figure 4.24). In nearly half of all revision arthroplasties in which a femoral head was implanted, it had a diameter of 22-28 mm (Figure 4.25). 74% of femoral heads of 22-28 mm that were implanted together with an acetabular component were implanted with a dual mobility cup in hip revision arthroplasties. In primary total hip arthroplasties this percentage was 6%.

In 2014, 1,484 cemented (40 different types) and 599 uncemented (39 different types) acetabular components were registered as being revised. 621 cemented (34 different types) and 810 uncemented (48 different types) femoral components

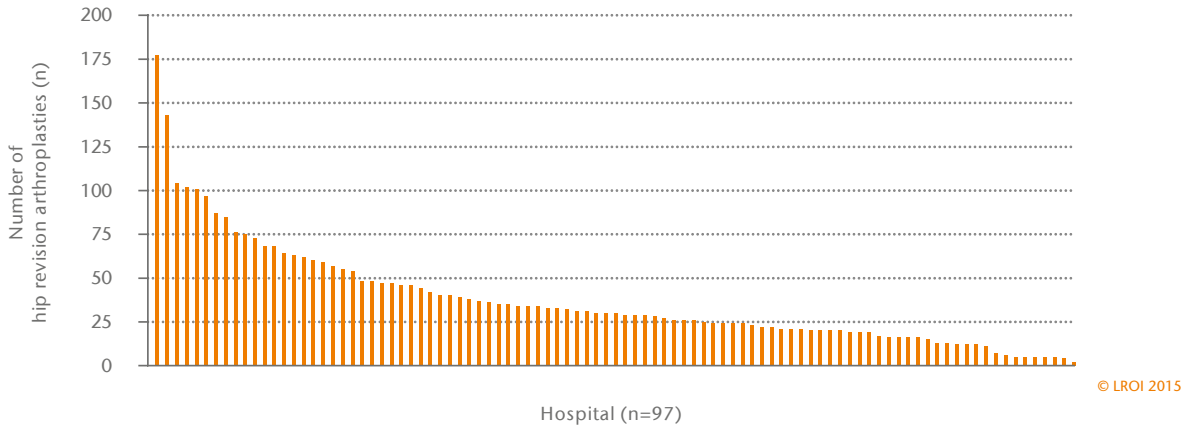
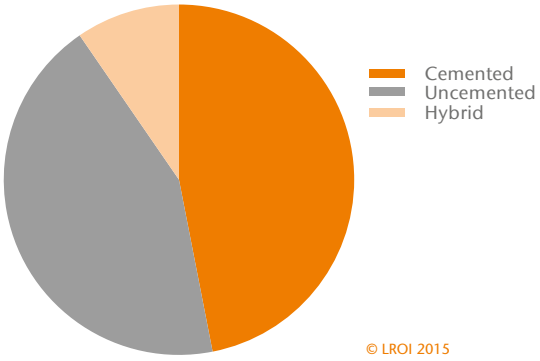
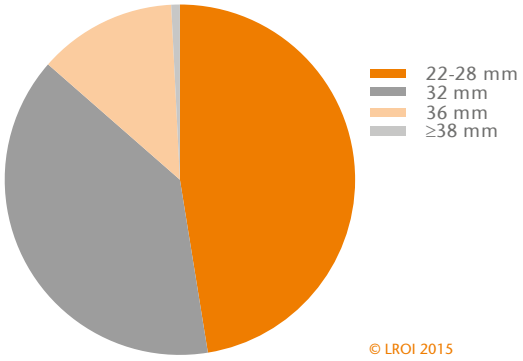


Figure 4.23 Number of hip revision arthroplasties per hospital in the Netherlands in 2014 (n=3,574).



Fixation	Number (n)	Proportion (%)
Cemented	1,556	46.9
Uncemented	1,442	43.5
Hybrid	318	9.6

Figure 4.24 Type of fixation in hip revision arthroplasties in the Netherlands in 2014 (n=3,316)



Femoral head diameter	Number (n)	Proportion (%)
22-28 mm	1,431	47.4
32 mm	1,176	39.0
36 mm	385	12.8
>38 mm	24	0.8

Figure 4.25 Femoral head diameter in hip revision arthroplasties in the Netherlands in 2014 (n=3,016)

were registered as being revised. Table 4.8 lists the ten most frequently registered acetabular and femoral components that were used in hip revision arthroplasties in the Netherlands in 2014. Although many different types of components were registered in hip revision arthroplasties in 2014, the vast majority of types was used in less than 3% of the procedures. This represents 1 to 50 times per year throughout the Netherlands. Components may obviously also be used in many cases as components for primary hip arthroplasties.

Table 4.7 Reasons for revision or re-surgery in patients that underwent a hip revision arthroplasty in the Netherlands in 2014 (n=3,574).

Reason for revision	Proportion[1] (%)
Loosening of acetabular component	26.3
Loosening of femoral component	20.8
Inlay wear	20.4
Dislocation	19.0
Infection	12.3
Peri-prosthetic fracture	11.7
Girdlestone situation	6.3
Symptomatic MoM inlay	5.8
Peri-articular ossification	2.6
Other	11.6

[1] A patient may have more than one reason for revision of re-surgery. As such, the total proportion is over 100%.

Table 4.8 The ten most frequently registered acetabular (both cemented and uncemented) and femoral components (both cemented and uncemented) in hip revision arthroplasties, implanted in the Netherlands in 2014.

Acetabulum (n=2,100)

Cemented (n=1,484)		Uncemented (n=599)	
Name	Proportion (%)	Name	Proportion (%)
Avantage	38.2	Continuum	14.9
Exeter Rimfit	9.2	Pinnacle	11.7
Müller low profile	7.7	Allofit	11.2
Reflection All Poly	7.7	Mallory Head	8.0
IP Cup	5.2	Trident	7.5
Polarcup	4.4	Delta-One TT	5.3
Saturne	3.5	Trident Tritanium	5.2
FAL Cup	2.8	RM Pressfit cup	4.0
SeleXys DS cup	2.4	Delta-TT	3.8
Exeter Contemporary Flanged	2.4	Reflection	3.5

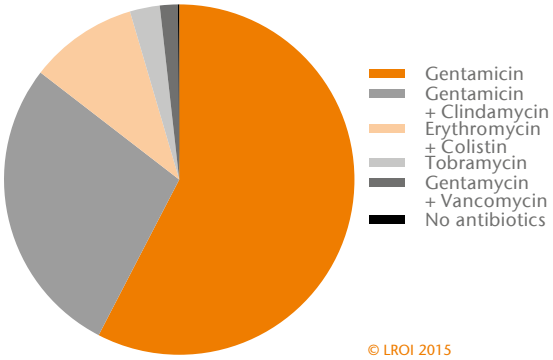
Femur (n=1,445)

Cemented (n=621)		Uncemented (n=810)	
Name	Proportion (%)	Name	Proportion (%)
Exeter	31.4	Restoration Modular	18.4
Lubinus SPII	24.0	Revitan	9.8
Spectron EF	14.0	MP Reconstruction Prosthesis	8.5
Stanmore	9.3	Corail	7.7
Original ME Muller	6.0	Arcos	7.3
CS Plus	2.1	SLR Plus	4.9
MP Reconstruction Prosthesis	1.9	Alloclassic SLL	4.4
Synergy	1.6	Mallory Head Stems	4.1
Restoration Modular	1.3	Wagner Cone	3.7
Taperloc	1.0	CLS Spotorno	3.1

Please note: often not all components are replaced in revision arthroplasties. This accounts for the difference in number of registered components.
Please note: Cemented and uncemented prosthesis components do not account for 100% of all components that were implanted, since fixation methods are not always known.

Table 4.9 The five most frequently registered types of bone cement used during hip revision arthroplasties in the Netherlands in 2014 (n=1,630).

Name	Proportion (%)
Palacos R+G	40.4
Copal G+C	16.2
Refobacin Revision	11.7
Simplex ABC EC	10.0
Refobacin Bone Cement R	7.7



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	939	57.6
Gentamicin + Clindamycin	454	27.9
Erythromycin + Colistin	163	10.0
Tobramycin	45	2.8
Gentamicin + Vancomycin	27	1.7
No antibiotics	2	0.1

Figure 4.26 Antibiotics in bone cement used in hip revision procedures in the Netherlands in 2014 (n=1,630).

In more than half of cemented hip revision arthroplasties, bone cement with gentamicin was used and in 28% of hip revision arthroplasties bone cement with gentamicin and clindamycin was used in 2014 (Figure 4.26). With respect to hip revision arthroplasties, 14 different types of bone cement were registered in the Netherlands for 2014. Table 4.9 lists the five most registered types of bone cement.

4.5 Survival of hip prostheses

In September 2014, the LROI was expanded with dates of death – if any – of people with joint prostheses, in order to determine survival and revision percentages of prostheses properly. The link that was required to incorporate the date of death in the database is achieved in a way that guarantees patient privacy and meets the requirements of Dutch legislation and regulations. The LROI is the first registry in the Netherlands to achieve such a link.

Data from the LROI with regard to 2007-2014 was used for survival analyses with a follow-up until 1 January 2015. This means that the maximum follow-up is 8 years. However, the number of prostheses with a 6-8 year follow-up is limited. Therefore, a follow-up of up to 6 years after the primary procedure is shown. A hip revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of a hip prosthesis, irrespective of the reason for revision. Revision for any reason is taken as end point. This chapter lists the chance of revision within 1 year for THAs performed in the period 2010-2013, as well as the variation between hospitals and reasons for revision within 1 year. Furthermore, the cumulative short-term (5-year) revision percentage after a primary THA is listed,

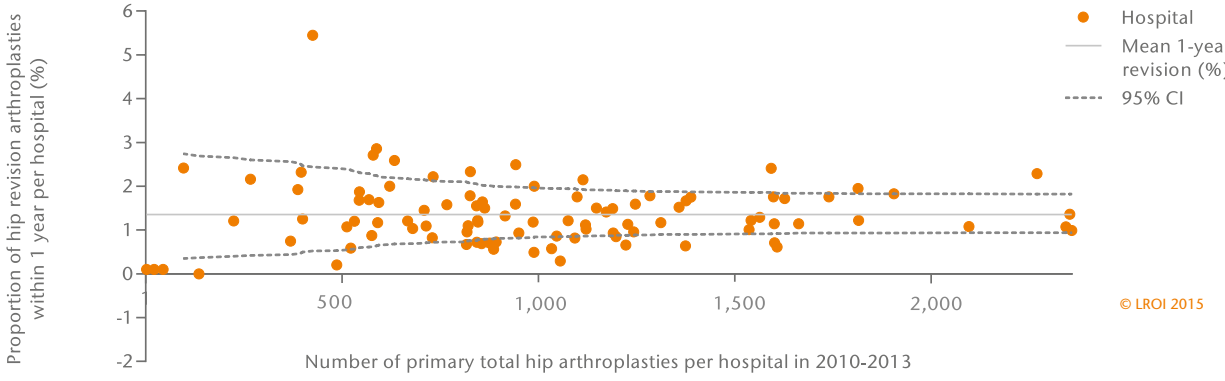


Figure 4.27 Funnel plot of discrepancies between hospitals in proportion of hip revision arthroplasties after a primary total hip arthroplasty within one year in the Netherlands is 2010-2013 (adjusted for case mix factors age, gender, ASA score and diagnosis (osteoarthritis versus other)) (n=98,260).

divided for several case mix factors. The revision percentage of resurfacing hip arthroplasties was also monitored as well as the occurrence of variation in revision percentages by type of resurfacing hip arthroplasties. The results were obtained using competing risk analyses, taking into account the chance of dying of patients (see 'Methodology of survival analyses' in Chapter 1 on page 23 for an explanation).

4.5.1 Revision within 1 year of total hip prostheses

This paragraph focusses on the revision percentages within one year after the primary procedure. A total of 98,260 primary THAs were performed in the period 2010-2013, of which 1,331 (1.4%) arthroplasties were revised within 1 year. In the same period, 1,280 (1.3%) THAs were performed in patients that died within a year after the primary procedure (Table 4.10).
Variation exists in the 1-year revision percentage of THAs, adjusted for case mix variables, between hospitals in the Netherlands. The case mix adjusted 1-year revision percentage of THAs exceeds the 95% confidence interval (CI) in 11 hospitals (Figure 4.27). The most common reasons for revision arthroplasties within 1 year were dislocation (37%), loosening of the femoral component (22%) and peri-prosthetic fracture (18%) (Table 4.11).

4.5.2 Short-term revision of total hip prostheses

This paragraph determines the 5-year revision percentage (for any reason) of THAs, according to gender, age and diagnosis (osteoarthritis versus non-osteoarthritis). The revision percentage for THAs after 5 years was 3.2% (95% CI: 3.1-3.3%) (Figure 4.28). The risk of needing a revision within 5 years after the primary arthroplasty was higher for men, patients below 60 years of age and patients who received a THA following a diagnosis other than osteoarthritis. THAs in elderly patients (≥75 years) had a lower risk of their prosthesis being revised (Figure 4.29 to Figure 4.31 and Table 4.12).

Table 4.10 Revision percentage within 1 year after the primary total hip arthroplasty over the period 2010-2013 with a follow-up of at least 365 days.

	Number (n)	Proportion (%)
No revision within 1 year	96,929	98.6
Revision within 1 year	1,331	1.4

Please note: Over the period 2010-2013, 1,280 (1.3%) total hip arthroplasties were implanted in patients that died within 1 year after the primary procedure.

Table 4.11 Reasons for revision or re-surgery in patients that underwent a hip revision arthroplasty within 1 year after the primary total hip arthroplasty in the Netherlands in 2010-2013 (n=1,331).

Reason for revision	Number (n)	Proportion (%)
Dislocation	498	37.4
Loosening of femoral component	229	22.1
Peri-prosthetic fracture	244	18.3
Infection	148	11.1
Loosening of acetabular component	139	10.4
Girdlestone	42	4.2
Peri-articular ossification	17	1.7
Inlay wear	16	1.2
Symptomatic MoM inlay	5	0.4

Please note: A patient may have more than one reason for revision or re-surgery. As such, the total proportion is over 100%.

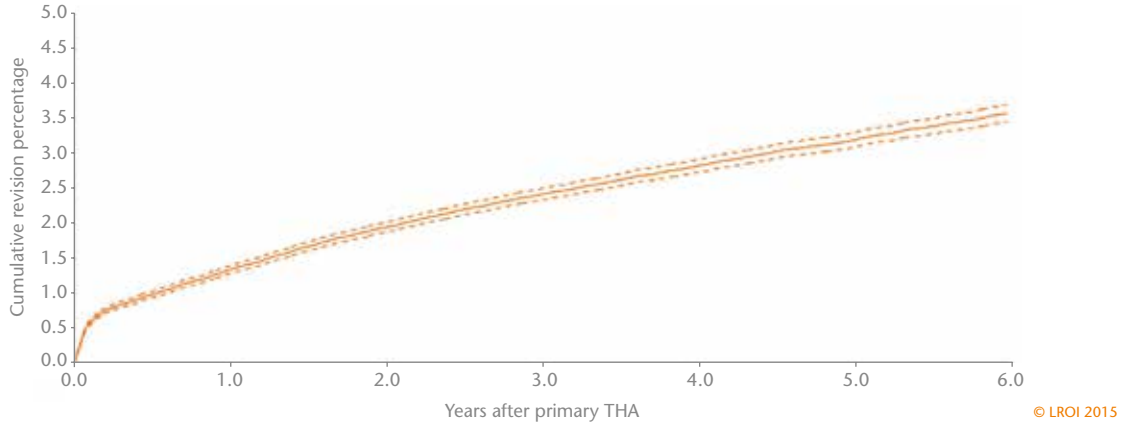


Figure 4.28 Cumulative revision percentage of total hip arthroplasties in the Netherlands in 2007-2014 (n=171,288).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

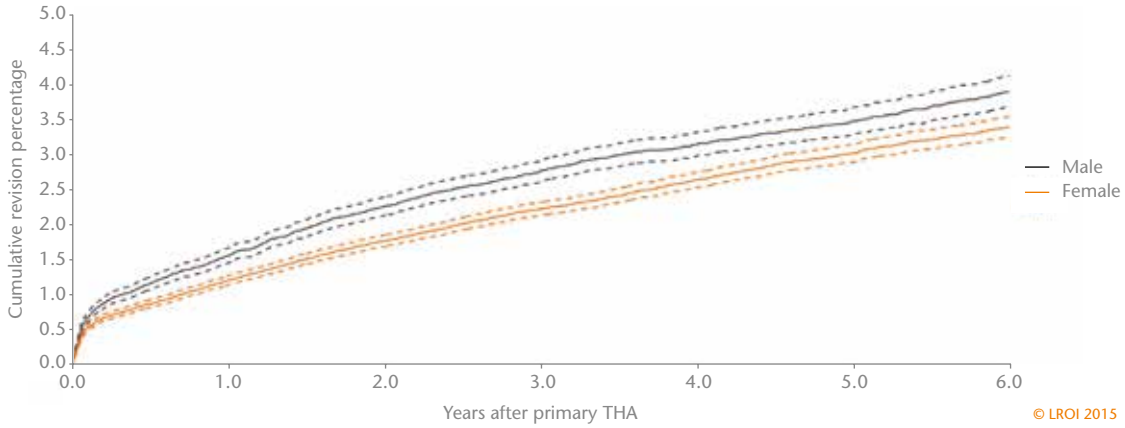


Figure 4.29 Cumulative revision percentage of total hip arthroplasties by gender in the Netherlands in 2007-2014 (n=170,105).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

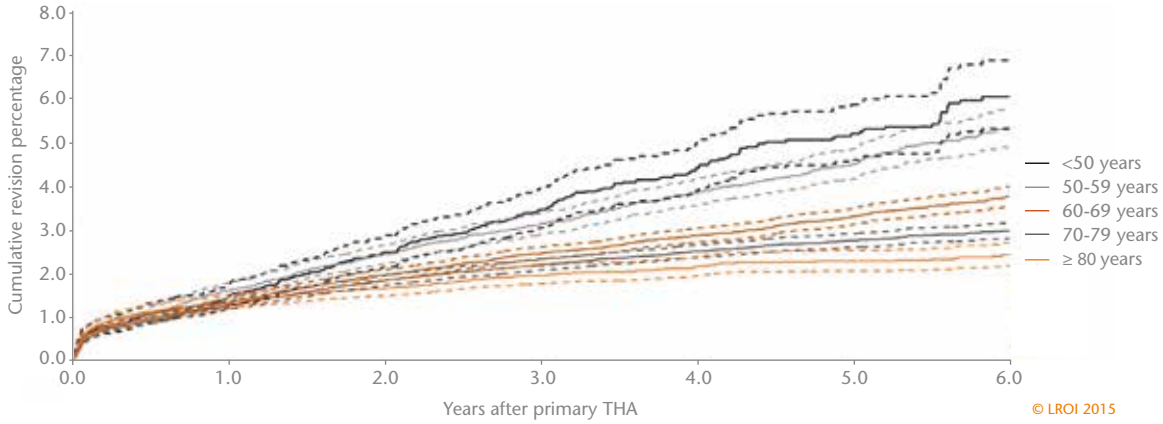


Figure 4.30 Cumulative revision percentage of total hip arthroplasties by age category in the Netherlands in 2007-2014 (n=170,849).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

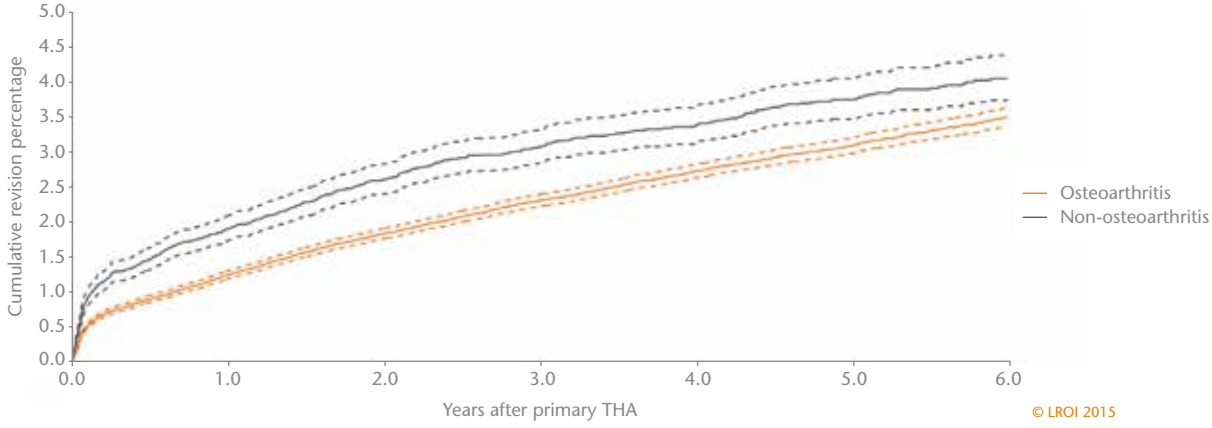


Figure 4.31 Cumulative revision percentage of total hip arthroplasties by diagnosis (osteoarthritis versus other) in the Netherlands in 2007-2014 (n=171,288).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

Table 4.12 Cumulative 5-year revision percentage of total hip arthroplasties in the Netherlands in 2007-2014 (n=171,288).

	n	Cumulative 5-year revision percentage (95% CI)
Total	171,288	3.2 (3.1-3.3)
Gender		
Men	55,582	3.5 (3.3-3.7)
Women	114,523	3.0 (2.9-3.2)
Age (years)		
<50	8,713	5.1 (4.6-5.8)
50-60	23,680	4.5 (4.1-4.8)
60-69	56,668	3.3 (3.1-3.5)
70-79	60,757	2.7 (2.6-2.9)
≥80	21,086	2.3 (2.0-2.5)
Diagnosis		
Osteoarthritis	147,510	3.1 (3.0-3.2)
Other	23,778	3.8 (3.5-4.1)

CI: confidence interval.

4.5.3 Short-term revision of resurfacing hip prostheses

Based on scientific literature and other national arthroplasty registers it is known that resurfacing hip arthroplasties have worse survival rates than THAs. Since data from the LROI is now available to determine the revision percentage of arthroplasties, this was investigated for the Dutch situation. The figures below demonstrate that the revision percentage for resurfacing hip arthroplasties is significantly higher than for THAs. There is a clear difference in revision percentages between men and women. Therefore their revision percentages are shown separately. The risk for men with a resurfacing hip arthroplasty to undergo a revision of this prosthesis within 5 years is 5.3% (95% CI: 4.3-6.4%); for women the risk of revision within 5 years is 13.5% (95% CI: 11.4-15.9%). In THAs the risk of revision within 5 years is 3.5% (95% CI: 3.3-3.7%) for men and 3.0% (95% CI: 2.9-3.2%) for females (Figure 4.32a and 4.32b, Table 4.13). Revision percentages vary considerable from one type of resurfacing

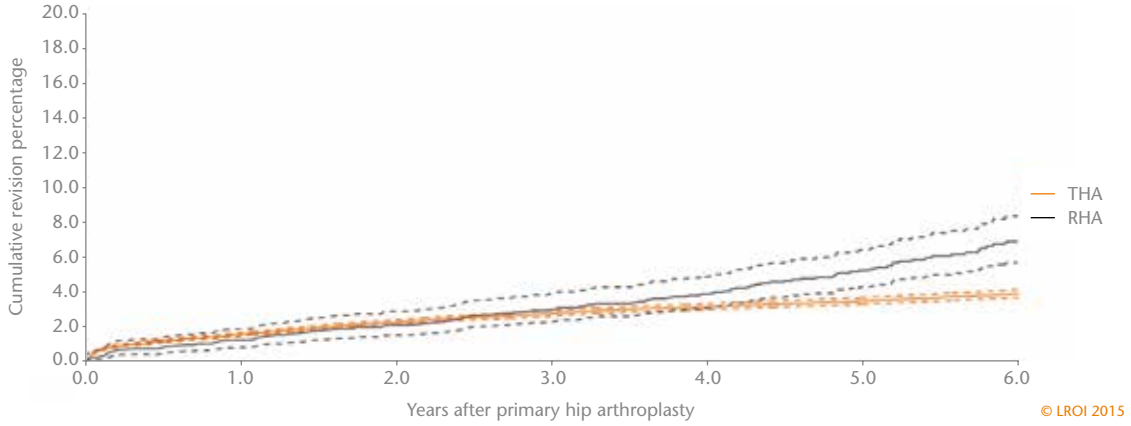


Figure 4.32a Cumulative revision percentage of total hip arthroplasties or resurfacing hip arthroplasties in men in the Netherlands in 2007-2014 (n=57,378).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.
THA: total hip arthroplasty; RHA: resurfacing hip arthroplasty.

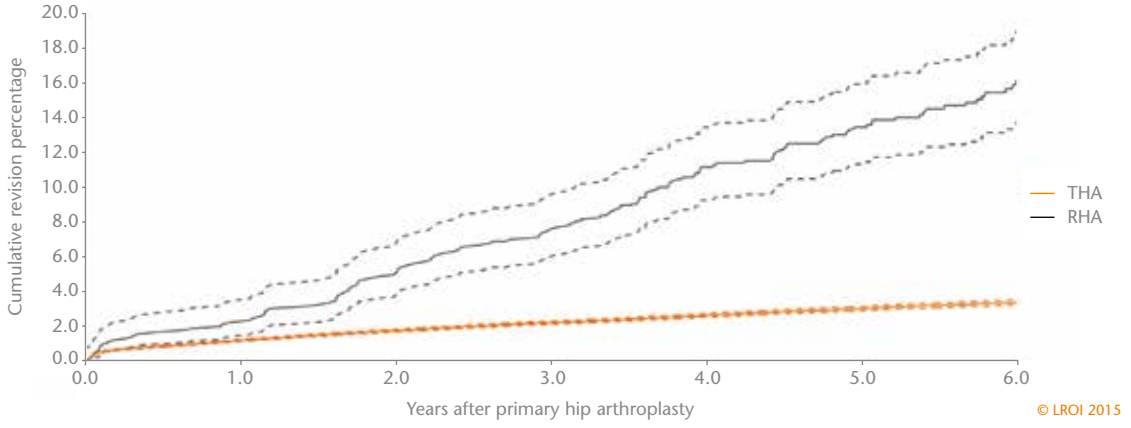


Figure 4.32b Cumulative revision percentage of total hip arthroplasties or resurfacing hip arthroplasties in women in the Netherlands in 2007-2014 (n=115,404).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.
THA: total hip arthroplasty; RHA: resurfacing hip arthroplasty.

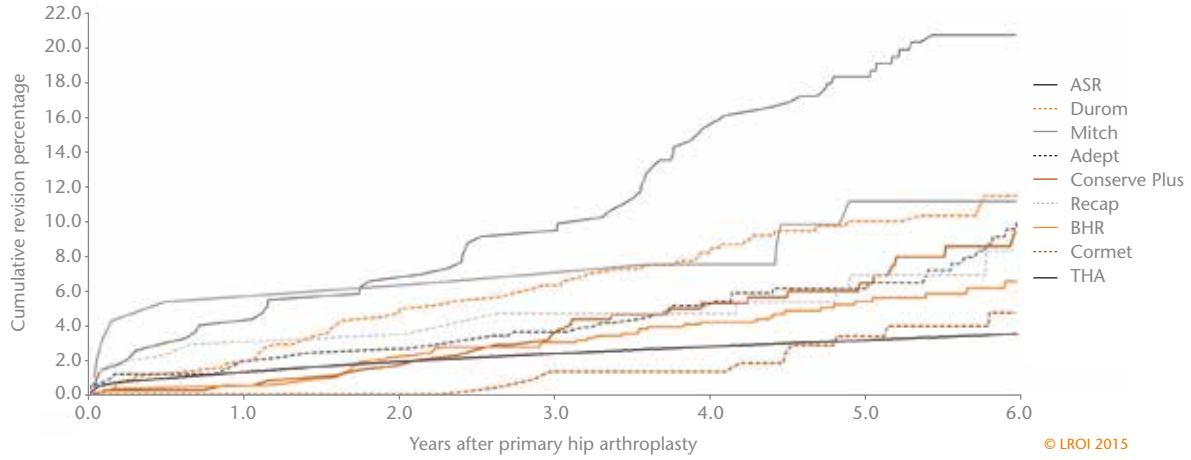


Figure 4.33 Cumulative revision percentage of resurfacing hip arthroplasties per type and total hip arthroplasties in the Netherlands in 2007-2014 (n=172,784).
THA: total hip arthroplasty.

hip arthroplasty to another. The revision percentage of ASR resurfacing hip arthroplasties is significantly higher than that of other types of resurfacing hip arthroplasties (Figure 4.33). Chances of revision within 7 years after a resurfacing hip arthroplasty other than ASR resurfacing hip arthroplasties is 6.4% (95% CI: 5.1-7.9%) for men and 15.3% (95% CI: 12.5-18.6%) for women. This is clearly lower than the revision percentage of the entire group of resurfacing hip arthroplasties (men: 7.5% (95% CI: 6.1-9.1%); women: 18.4 (95% CI: 15.6-21.7).

Table 4.13 Cumulative 5-year revision percentage of total hip arthroplasties or resurfacing hip arthroplasties by gender in the Netherlands in 2007-2014.

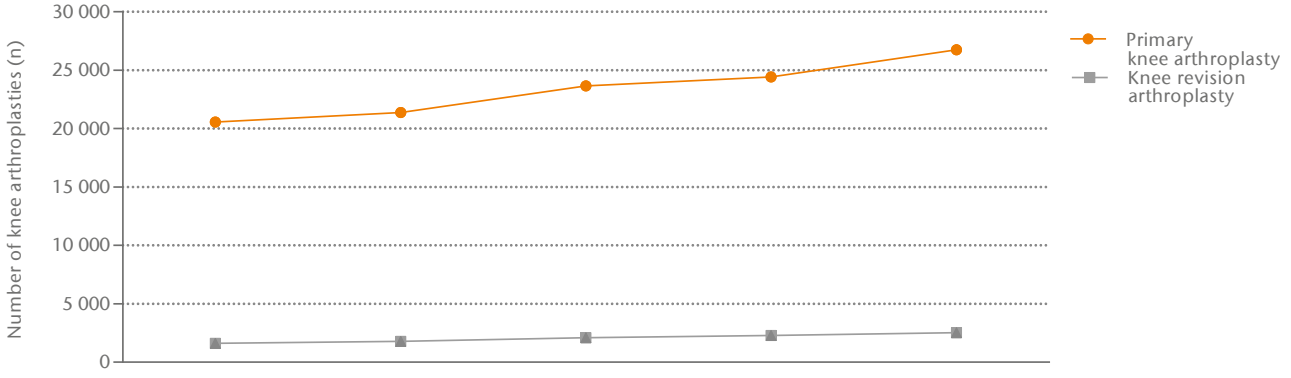
Type of hip arthroplasty	Men (n=57,378)		Women (n=115,404)	
	n	Cumulative 5-year revision percentage (95% CI)	n	Cumulative 5-year revision percentage (95% CI)
THA	55,582	3.5 (3.3-3.7)	114,119	3.0 (2.9-3,2)
RHA	1,795	5.3 (4.3-6.4)	881	13.5 (11.4-15.9)

THA: total hip arthroplasty; RHA: resurfacing hip arthroplasty; CI: confidence interval.

5 Knee arthroplasties

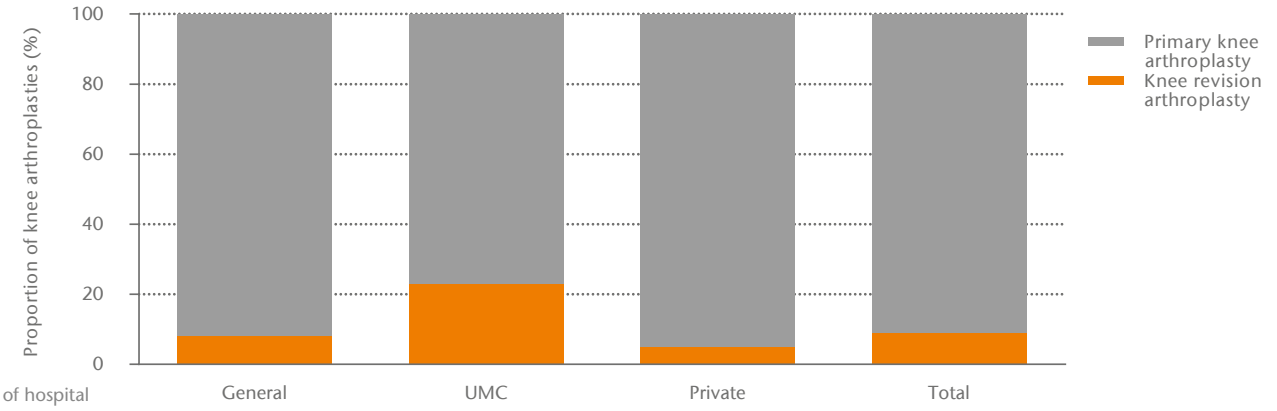
5.1 Trends and associations of primary knee arthroplasties and knee revision arthroplasties

Over the period 2010-2014, 116,780 primary knee arthroplasties (TKAs) and 10,360 knee revision arthroplasties were registered in the LROI. The number of registered primary knee arthroplasties increased from 20,558 in 2010 to 26,754 in 2014 and the number of registered knee revision arthroplasties increased from 1,619 in 2010 to 2,541 in 2014 (Figure 5.1). In 2014, 83 general hospitals, 8 UMCs and 13 private hospitals performed knee arthroplasties. The proportion of knee revision arthroplasties was higher in UMCs (23%) than in general hospitals (9%) or private hospitals (5%) (Figure 5.2). Out of 26,754 primary knee arthroplasties that were performed in 2014, 15% (n=4,006) was performed bilaterally in 2014.



Year	2010	2011	2012	2013	2014	Total
Type of procedure						
Primary knee arthroplasty (n)	20,558	21,372	23,660	24,4436	26,754	116,780
Knee revision arthroplasty (n)	1,619	1,791	2,110	2,299	2,541	10,360
Total (n)	22,177	23,163	25,770	26,735	29,295	127,140

Figure 5.1 Number of primary knee arthroplasties and knee revision arthroplasties registered in the LROI in the Netherlands in 2010-2014.

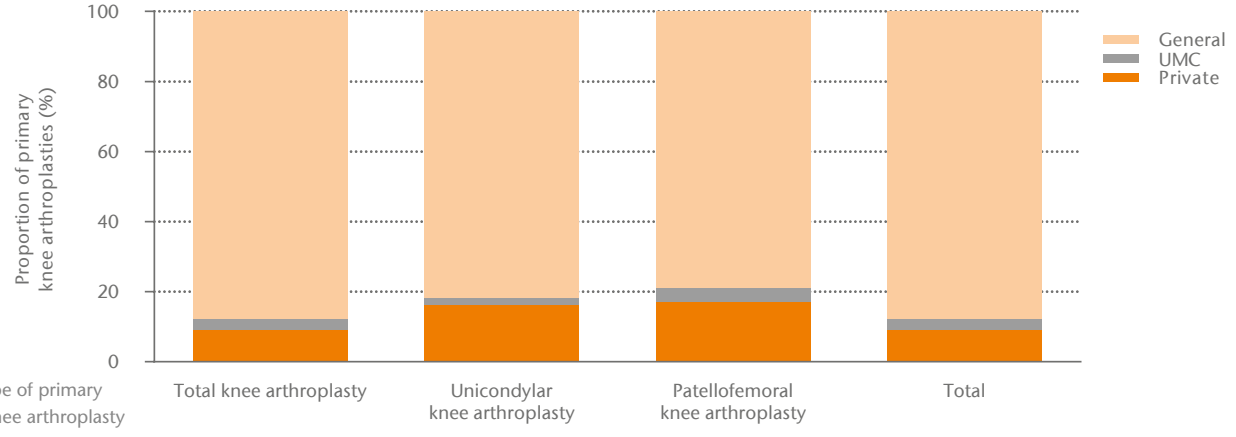


Type of hospital	General	UMC	Private	Total
Type of procedure				
Primary knee arthroplasty (%)	91.5	76.7	94.7	91.3
Knee revision arthroplasty (%)	8.5	23.3	5.3	8.7
Total (n)	25,727	941	2,627	29,295

Figure 5.2 Primary knee arthroplasties and knee revision arthroplasties (proportion [%] per category) by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital.

5.2 Primary knee arthroplasties

Primary knee arthroplasties are distinguished between total knee prostheses (TKA), unicondylar knee prostheses and patellofemoral knee prostheses. Unicondylar (16%) and patellofemoral (17%) knee prostheses were performed proportionally often in private hospitals when compared to TKAs (9%) in 2014 (Figure 5.3). The number of primary total knee arthroplasties varied a great deal from hospital to hospital, specifically from 6 to 739, with a median of 240 (Figure 5.4).

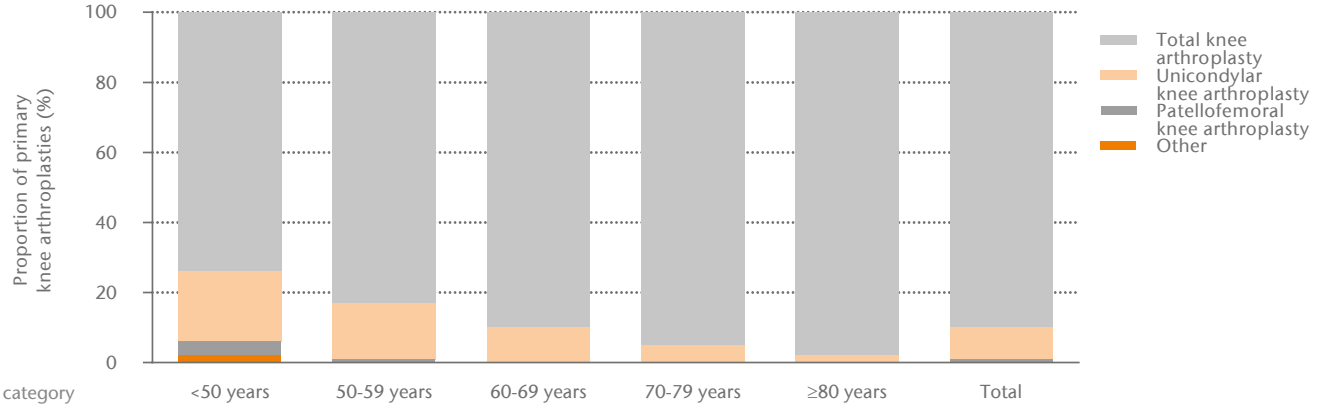


Type of primary knee arthroplasty	Total knee arthroplasty	Unicondylar knee arthroplasty	Patellofemoral knee arthroplasty	Total
Type of hospital				
General (%)	88.6	82.0	78.8	88.0
UMC (%)	2.8	1.8	3.9	2.7
Private (%)	8.6	16.2	17.3	9.3
Total (n)	24,052	2,351	127	26,590

Figure 5.3 Type of hospital (proportion [%] per category) by type of primary knee arthroplasty in the Netherlands in 2014.
Please note: In 2014, 60 (0.2%) procedures were registered in the LROI as other type of primary knee arthroplasty.
General: general hospital; UMC: university medical centre; Private: private hospital.

Unicondylar and patellofemoral knee arthroplasties were proportionally often performed in younger patients, when elderly patients mainly received a TKA in 2014. About 90% of primary knee arthroplasties was a TKA and 9% was a unicondylar knee arthroplasty. The number of patellofemoral knee arthroplasties was 127 (0.5%) in 2014 (Figure 5.5). In 2013, 156 (0.7%) patellofemoral knee arthroplasties were performed.

Figure 5.4 Number of primary knee arthroplasties per hospital in the Netherlands in 2014 (n=26,754).



Age category	<50 years	50-59 years	60-69 years	70-79 years	≥80 years	Total
Type of knee arthroplasty						
Total knee arthroplasty (%)	74.0	83.0	89.9	95.2	97.8	90.3
Unicondylar knee arthroplasty (%)	20.2	15.7	9.7	4.6	2.0	9.0
Patellofemoral knee arthroplasty (%)	4.4	1.0	0.2	0.1	0.0	0.5
Other (%)	1.4	0.3	0.2	0.1	0.2	0.2
Total (n)	928	4,200	8,626	6,918	1,917	22,589

Figure 5.5 Type of primary knee arthroplasty (proportion [%] per category) of patients who underwent a primary knee arthroplasty for the first time by age category in the Netherlands in 2014.

5.2.1 Demographic data

Patient characteristics of patients with a primary knee arthroplasty were nearly similar in 2014 to these characteristics in 2013 (see 2013 LROI Annual Report 'Insight into Quality & Safety'). Moreover, about half of the patients that underwent a TKA had a Charnley score of A (one knee joint affected) in 2014 and 38% had a Charnley score of B1 (both knee joints affected). With respect to unicondylar knee arthroplasties 70% had a Charnley score A and 25% Charnley score B1. In 2014, over 80% of patients with a TKA or unicondylar knee arthroplasty had

Table 5.1 Patient characteristics of all patients with a registered primary knee arthroplasty by type of primary knee arthroplasty in the Netherlands in 2014.

	Total knee arthroplasty (n=20,411)	Unicondylar knee arthroplasty (n=2,053)	Patellofemoral knee arthroplasty (n=107)	Total (n=22,748)
Completeness (%)				97
Mean age (years) (SD)	68.1 (9.3)	62.4 (8.8)	53.4 (10.8)	67.5 (9.5)
Age (years) (%)				
<50	4	9	38	4
50-59	17	32	37	19
60-69	38	41	20	38
70-79	32	16	5	31
≥80	9	2	0	8
Gender (%)				
Men	35	42	27	36
Women	65	58	73	64
ASA score (%)				
I	16	26	35	17
II	70	67	62	69
III-IV	14	7	3	14
Type of hospital[1] (%)				
General	87	79	76	86
UMC	3	1	4	3
Private	10	20	20	11
Diagnosis (%)				
Osteoarthrosis	96	98	93	96
Post-traumatic	2	1	6	2
Rheumatoid arthritis	1	0	0	1
Osteonecrosis	1	1	0	1
Other	0	0	1	0
Charnley score (%)				
A One knee joint affected	52	70	65	53
B1 Both knee joints affected	38	25	28	37
B2 Contralateral knee joint with a total knee prosthesis	8	4	6	7
C Multiple joints affected or chronic disease that affects quality of life	3	1	1	3
Body Mass Index (kg/m²) (%)				
Underweight (≤18.5)	0	0	0	0
Normal weight (>18.5-25)	18	19	34	18
Overweight (>25-30)	43	44	37	43
Obesity (>30-40)	36	35	32	36
Morbid obesity (>40)	3	2	2	3
Smoking (%)				
No	90	87	79	89
Yes	10	13	21	11

Please note: Also contains 48 (0.2%) primary knee arthroplasties that were registered as other and 127 primary knee arthroplasties of which the type of prosthesis had not been registered.

[1] In 2014, 83 general hospitals, 8 UMCs and 13 private hospitals performed knee arthroplasties.

General: general hospital; UMC: university medical centre; Private: private hospitals; SD: standard deviation.

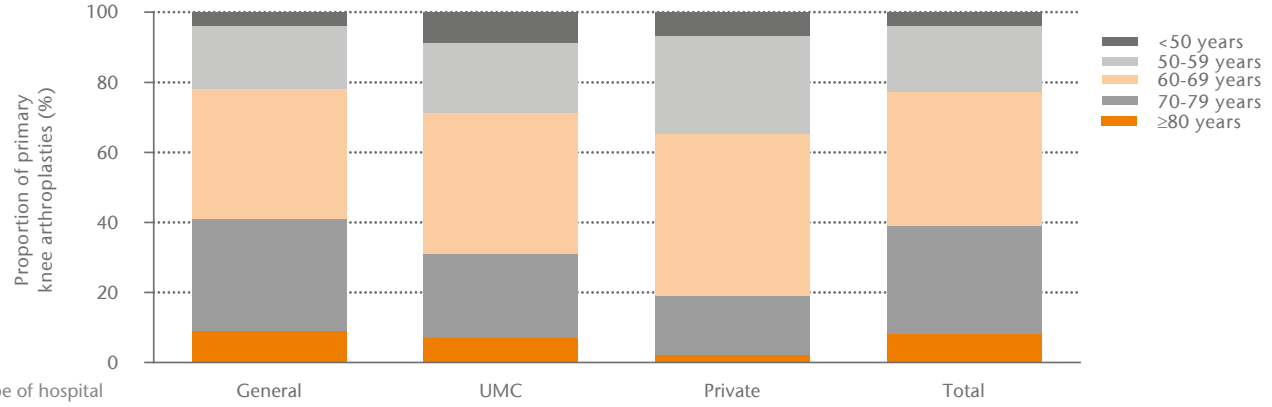
overweight with a Body Mass Index (BMI) equal to or higher than 25. In patellofemoral knee arthroplasties this percentage was lower, specifically 66%. The percentage of smoking patients was higher in patellofemoral knee arthroplasties (21%) than in TKAs (10%) or unicondylar knee arthroplasties (13%) (Table 5.1). The age at which patients had primary knee arthroplasties, the type of hospital where they had surgery, BMI and Charnley score strongly depended on the diagnosis. Completeness of registration of primary TKAs was 97% (Table 5.2).

Table 5.2 Patient characteristics of all patients with a registered primary knee arthroplasty by diagnosis in the Netherlands in 2014.

	Osteoarthritis (n=21,557)	Post-traumatic (n=396)	Rheumatoid arthritis (n=269)	Osteonecrosis (n=104)	Total (n=22,748)
Mean age (years) (SD)	67.7 (9.4)	62.5 (11.2)	64.3 (10.1)	67.3 (11.5)	67.5 (9.5)
Age (years) (%)					
<50	4	16	8	9	4
50-59	18	26	25	15	19
60-69	38	33	37	29	38
70-79	31	20	26	38	31
≥80	9	5	4	9	8
Gender (%)					
Men	36	37	23	33	36
Women	64	63	77	67	64
ASA-score (%)					
I	17	27	5	10	17
II	70	63	69	69	69
III-IV	13	10	26	21	14
Type of hospital (%)					
General	87	83	84	86	86
UMC	2	8	12	6	3
Private	11	9	4	8	11
Charnley-score (%)					
A One knee joint affected	53	81	27	79	54
B1 Both knee joints affected	37	16	39	15	36
B2 Contralateral knee joint with a total knee prosthesis	7	2	12	3	7
C Multiple joints affected or chronic disease that affects quality of life	3	1	22	3	3
Body Mass Index (kg/m²) (%)					
Underweight (≤18.5)	0	1	2	0	0
Normal weight (>18.5-25)	18	25	27	33	18
Overweight (>25-30)	43	41	41	32	43
Obesity (>30-40)	36	31	28	34	36
Morbid obesity (>40)	3	2	2	1	3
Smoking (%)					
No	89	82	88	83	89
Yes	11	18	12	17	11

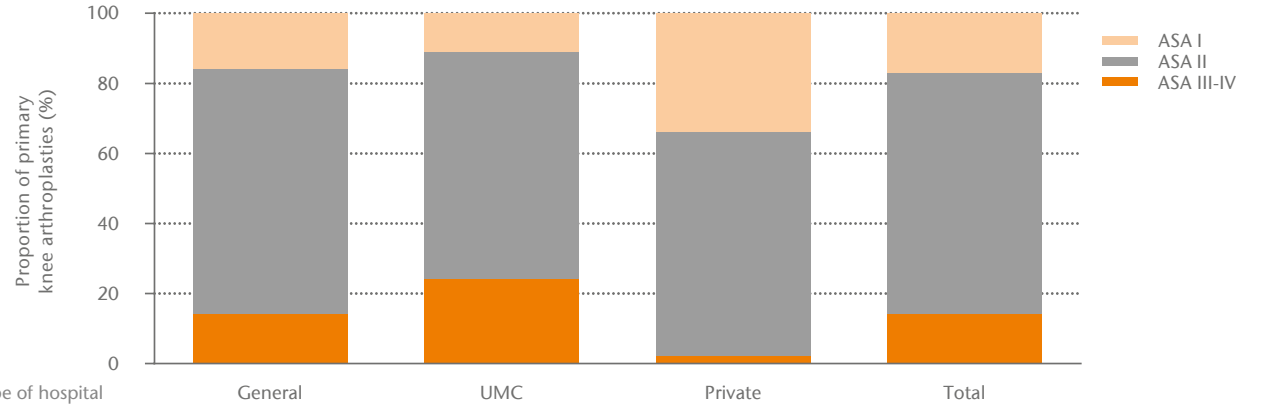
Please note: In 2014, 94 (0.4%) patients had a primary knee arthroplasty after a diagnosis that is not listed in the table.
The diagnosis of 328 (1.4%) patients had not been registered.
General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

Patients who had a primary knee arthroplasty in general hospitals in 2014 were often older; some 42% of the patients were 70 years or older. This percentage is lower in UMCs (30%) and private hospitals (19%) (Figure 5.6). The ASA score was often higher in UMCs (ASA III: 25%) and often lower in private hospitals (ASA I: 34%) in patients that underwent a primary knee arthroplasty in 2014 (Figure 5.7). Over 37% of patients who underwent a primary knee arthroplasty in 2014 had undergone a previous surgery to the relevant knee before. These were mainly meniscectomies (Table 5.3).



Type of hospital	General	UMC	Private	Total
Age (years)				
<50 (%)	3.6	9.0	7.4	4.1
50-59 (%)	17.4	20.4	27.7	18.6
60-69 (%)	37.1	40.1	46.2	38.2
70-79 (%)	32.5	24.1	16.9	30.6
≥80 (%)	9.4	6.5	1.8	8.5
Total (n)	19,675	602	2,438	22,715

Figure 5.6 Age distribution (proportion [%] per category) of patients who underwent a primary knee arthroplasty for the first time by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital.



Type of hospital	General	UMC	Private	Total
ASA score				
ASA I (%)	15.5	10.7	33.8	17.3
ASA II (%)	70.1	64.7	63.8	69.3
ASA III-IV (%)	14.4	24.6	2.4	13.4
Total (n)	19,512	601	2,431	22,544

Figure 5.7 Distribution of ASA score (proportion [%] per category) of patients who underwent a primary knee arthroplasty for the first time by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital.

Characteristics of a hospital's patient population (also referred to as case mix) largely determine the results of hospitals as presented in this Annual Report. The case mix of patient populations varies largely from hospital to hospital. The 2013 LROI Annual Report 'Insight into Quality & Safety' listed this variation in practice with respect to various characteristics. Three new relevant characteristics have now been classified, specifically Body Mass Index (BMI), smoking and Charnley. The proportion of patients with normal or underweight compared to patients with overweight (BMI>25) varied considerably from hospital to hospital, specifically from 7% to 33%, with two outliers of 0% and 100%. In both cases this pertained to just one patient (Figure 5.8). The proportion of smokers varied from 0% to 23% (Figure 5.9). The proportion of patients with Charnley score A compared to patients with Charnley score B1 or higher varied tremendously, specifically from 21% in one hospital to 100% in three hospitals (Figure 5.10).

Table 5.3 Previous surgeries to the same joint in patients who underwent a primary knee arthroplasty in the Netherlands in 2014 (n=22,748).

	Proportion[1] (%)
Previous surgery to the relevant knee (total)	37.5
Meniscectomy	29.6
Arthroscopy	18.6
Osteotomy	3.1
Osteosynthesis	1.9
ACL reconstruction	1.5
Synovectomy	1.2
Other	3.5

Please note: For 2 patients (<0.01%) it was unknown if they had undergone a previous surgery to the relevant knee.

[1] A patient may have undergone multiple previous surgeries to the same joint. As such, the total proportion is more than 37.5% (proportion of patients with one or more previous surgeries to the same joint).

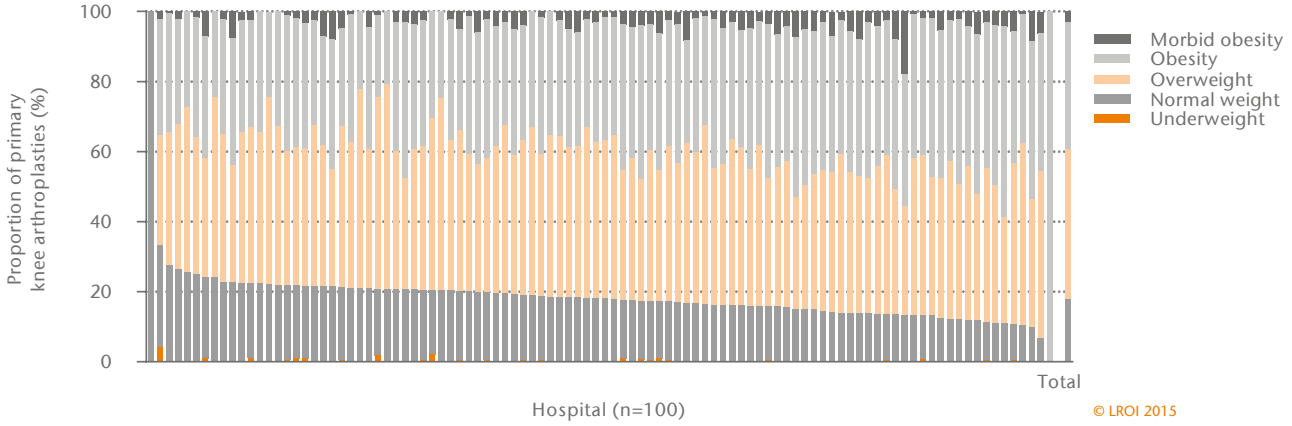


Figure 5.8 Distribution of body mass index (kg/m²) of patients who underwent a primary knee arthroplasty for the first time per hospital in the Netherlands in 2014 (n=19,897).

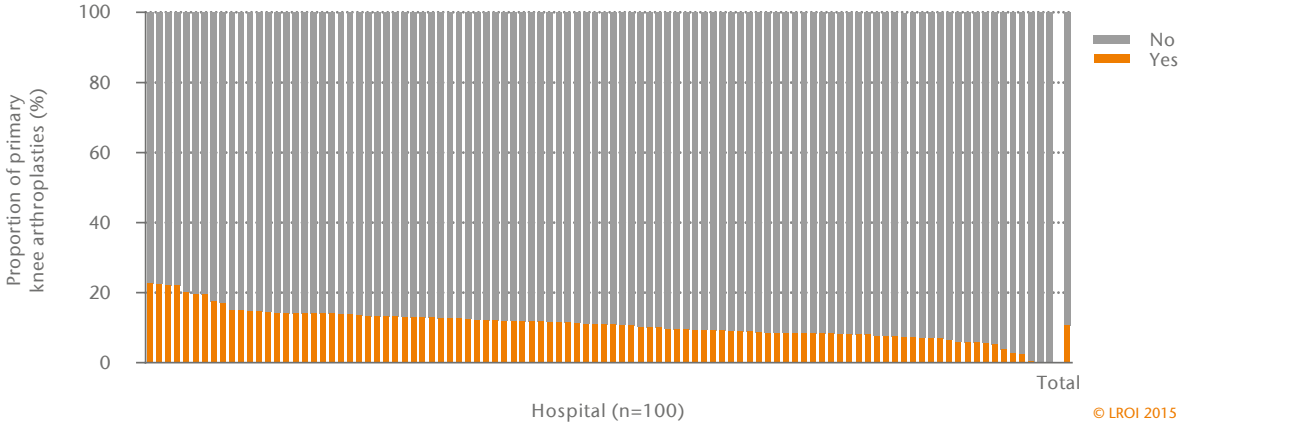


Figure 5.9 Distribution of smoking by patients who underwent a primary knee arthroplasty for the first time per hospital in the Netherlands in 2014 (n=17,859).

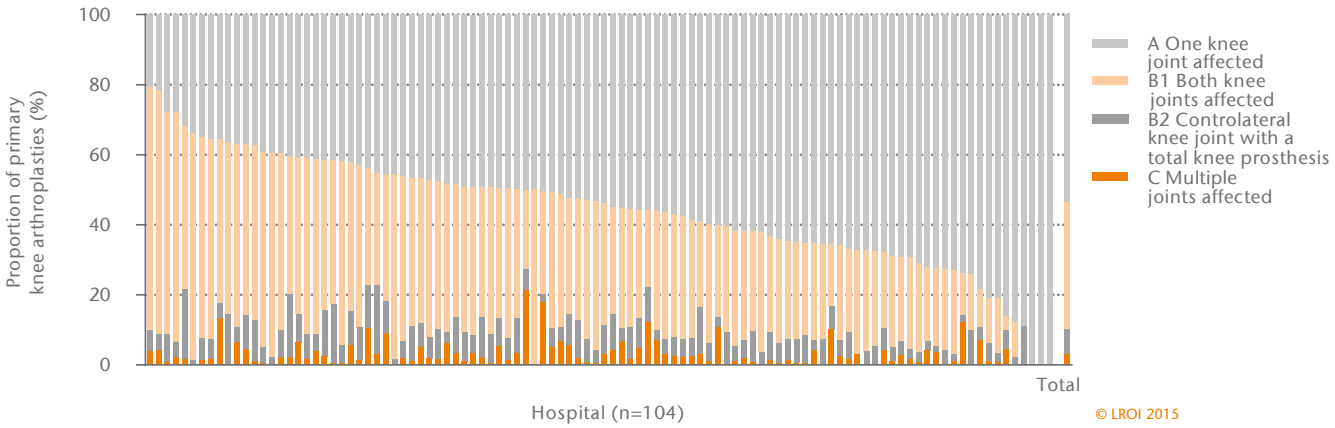
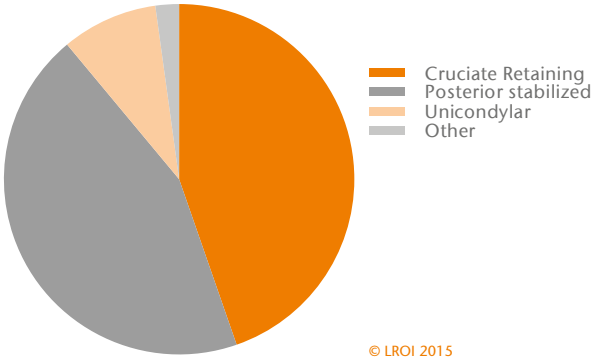


Figure 5.10 Distribution of Charnley score of patients who underwent a primary knee arthroplasty for the first time per hospital in the Netherlands in 2014 (n=21,289).
TKA: total knee arthroplasty.

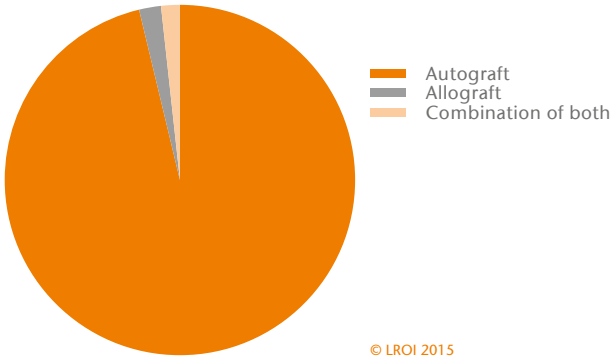
5.2.2 Prosthesis characteristics and surgical techniques

In 2014, the proportion of femoral components implanted with retention of the posterior cruciate ligament (cruciate retaining: 45%) and the proportion of femoral components implanted at the sacrifice of the posterior cruciate ligament (posterior stabilized: 44%) was nearly equal (Figure 5.11). The vast majority (94%) of primary knee arthroplasties was performed through a medial parapatellar arthrotomy (after a median incision). In only one per cent of primary knee arthroplasties a bone transplant (bonegraft) was used. This was most often an autograft (Figure 5.12). Over 90% of primary knee arthroplasties was performed with cement. No cement was used in nearly 6% (Figure 5.13). A



Type of femoral component	Number (n)	Proportion (%)
Cruciate retaining	11,561	44.7
Posterior stabilized	11,458	44.2
Unicondylar	2,295	8.9
Other (including patellofemoral)	563	2.2

Figure 5.11 Type of femoral component in primary knee arthroplasties in the Netherlands in 2014 (n=25,918)

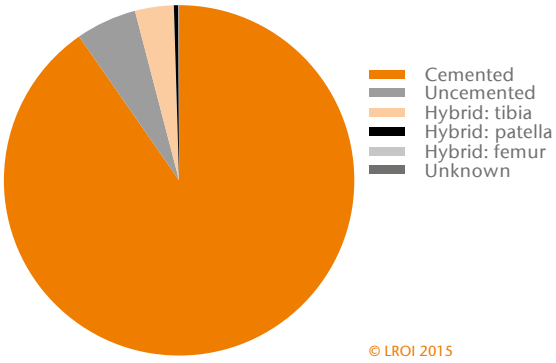


Type of bonegraft	Number (n)	Proportion (%)
Autograft	334	96.3
Allograft	7	2.0
Combination of both	6	1.7

Figure 5.12 Type of bonegraft in primary knee arthroplasties in the Netherlands in 2014 (n=347).

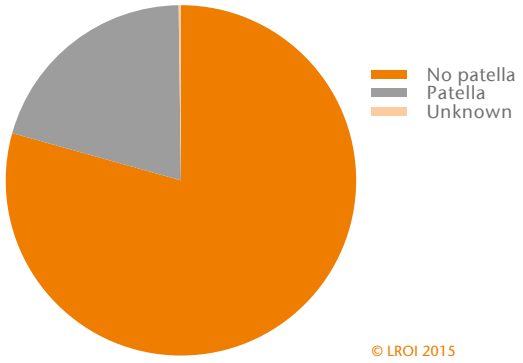
patellar component was implanted in 20% of primary total knee arthroplasties in 2014 (Figure 5.14).

In 2014, 97% of the implanted femoral components in primary knee arthroplasties was made of cobalt chrome (Figure 5.15). The inserts of primary knee arthroplasties were made of polyethylene (PE); the vast majority of standard PE (Figure 5.16). Registered tibial components consisted of titanium in nearly half of all cases and in nearly as many cases of cobalt chrome (Figure 5.17). The patellar components of primary knee arthroplasties were made



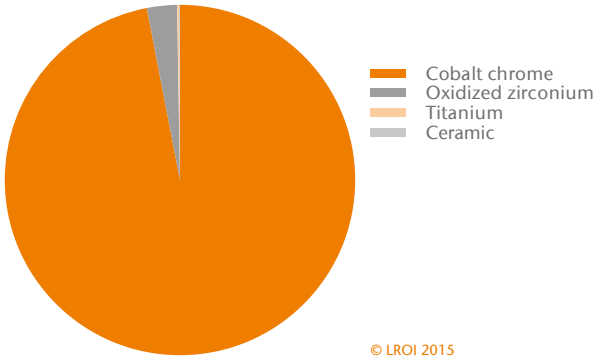
Fixation	Number (n)	Proportion (%)
Cemented	23,992	90.3
Uncemented	1,489	5.6
Hybrid: tibia cemented	951	3.6
Hybrid: patella cemented	109	0.4
Hybrid: femur cemented	14	0.1
Unknown	4	0.0

Figure 5.13 Type of fixation in primary knee arthroplasties in the Netherlands in 2014 (n=26,559).



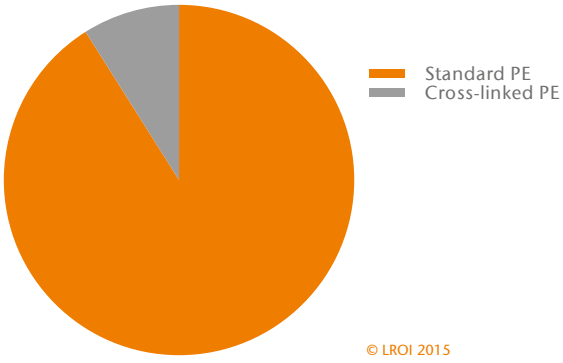
Patellar component	Number (n)	Proportion (%)
No patella	18,966	79.4
Patella	4,886	20.4
Unknown	50	0.2

Figure 5.14 Implantation of patellar component in primary knee arthroplasties in the Netherlands in 2014 (n=23,902).



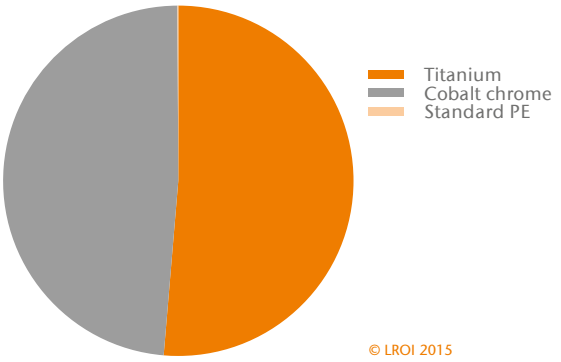
Femur material	Number (n)	Proportion (%)
Cobalt chrome	25,131	97.0
Oxidized zirconium	718	2.7
Titanium	47	0.2
Ceramics	21	0.1

Figure 5.15 Femoral component material in primary knee arthroplasties in the Netherlands in 2014 (n=25,917).



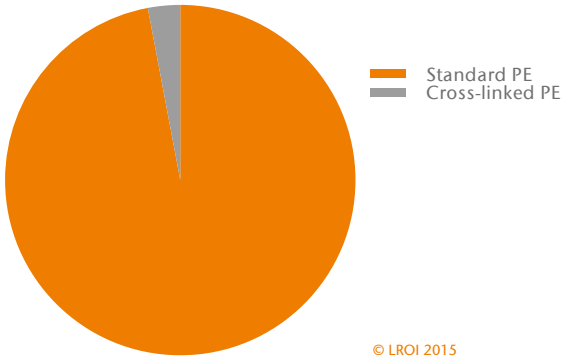
Insert material	Number (n)	Proportion (%)
Standard PE	23,386	91.0
Cross-linked PE	2,300	9.0

Figure 5.16 Insert material in primary knee arthroplasties in the Netherlands in 2014 (n=25,686).
PE: polyethylene



Tibia material	Number (n)	Proportion (%)
Titanium	13,451	51.3
Cobalt chrome	12,731	48.6
Standard PE	21	0.1

Figure 5.17 Tibial component material in primary knee arthroplasties in the Netherlands in 2014 (n=26,203).
PE: polyethylene.



Patella material	Number (n)	Proportion (%)
Standard PE	4,771	97.0
Cross-linked PE	146	3.0

Figure 5.18 Patellar component material in primary knee arthroplasties in the Netherlands in 2014 (n=4,917).
PE: polyethylene.

Table 5.4 The five most frequently registered total knee arthroplasties, unicondylar knee arthroplasties and patellofemoral knee arthroplasties performed in the Netherlands in 2014.

Total knee arthroplasty (n=23,435)		Unicondylar knee arthroplasty (n=2,308)		Patellofemoral knee arthroplasty (n=95)	
Name	Proportion (%)	Name	Proportion (%)	Name	Proportion (%)
Genesis II	23.7	Oxford PKR	78.5	Gender Solutions® Patello-Femoral	37.9
NexGen	20.4	Unicompartmental High Flex	7.7	Journey PFJ	20.0
Vanguard Complete Knee	17.7	Genesis Uni	6.2	Vanguard PFR	12.6
PFC / Sigma	12.3	BalanSys	2.0	PFC / Sigma	11.6
LCS	11.4	U-KneeTec	0.9	NexGen	6.3

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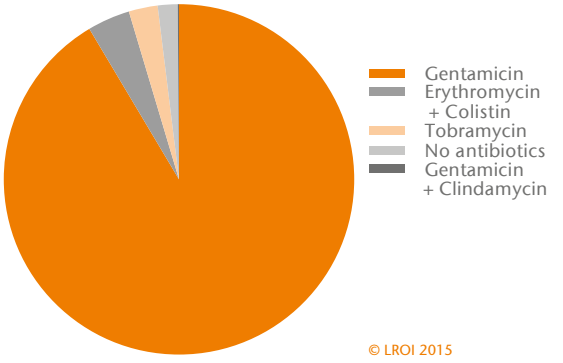
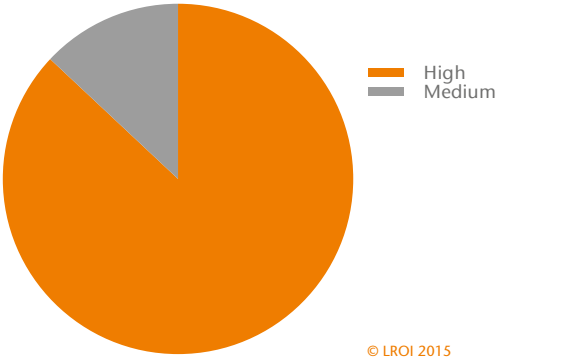


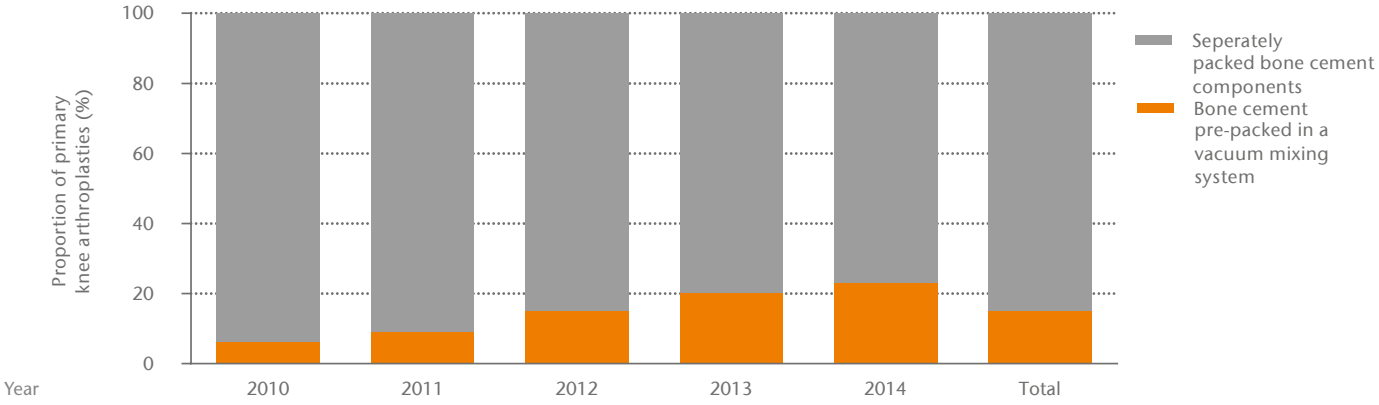
Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	20,999	91.5
Erythromycin + Colistin	902	3.9
Tobramycin	613	2.7
No antibiotics	422	1.8
Gentamicin + Clindamycin	26	0.1

Figure 5.19 Antibiotics in bone cement in primary knee arthroplasties in the Netherlands in 2014 (n=22,925).



Bone cement viscosity	Number (n)	Proportion (%)
High	19,974	87.0
Medium	2,988	13.0

Figure 5.20 Viscosity in bone cement in primary knee arthroplasties in the Netherlands in 2014 (n=22,962).



Year	2010	2011	2012	2013	2014	Total
Vacuum mixing system						
Separately packed bone cement components (%)	93.7	91.2	85.3	79.6	77.1	84.6
Bone cement pre-packed in a vacuum mixing system (%)	6.3	8.8	14.7	20.4	22.9	15.4
Total (n)	14,888	16,536	18,686	19,816	21,319	91,245

Figure 5.21 Trend (proportion [%] by year) in use of bone cement pre-packed in a vacuum mixing system in primary knee arthroplasties in the Netherlands in 2010-2014.

of PE, of which 97% of standard PE (Figure 5.18). Table 5.4 lists the five most registered primary knee arthroplasties per type of knee arthroplasty for 2014.

Bone cement with gentamicin (92%) was used in the vast majority of cemented or hybrid cemented primary knee arthroplasties in 2014. Only 2% did not contain antibiotics (Figure 5.19). Viscosity of bone cement was generally high (87%) and sometimes medium (13%) (Figure 5.20). Although most often separately packed bone cement components were used, the use of bone cement pre-packed in a vacuum mixing system increased from 6% in 2010 to 23% in 2014 (Figure 5.21). Table 5.5 lists the five most registered types of bone cement used in primary knee arthroplasties in 2014.

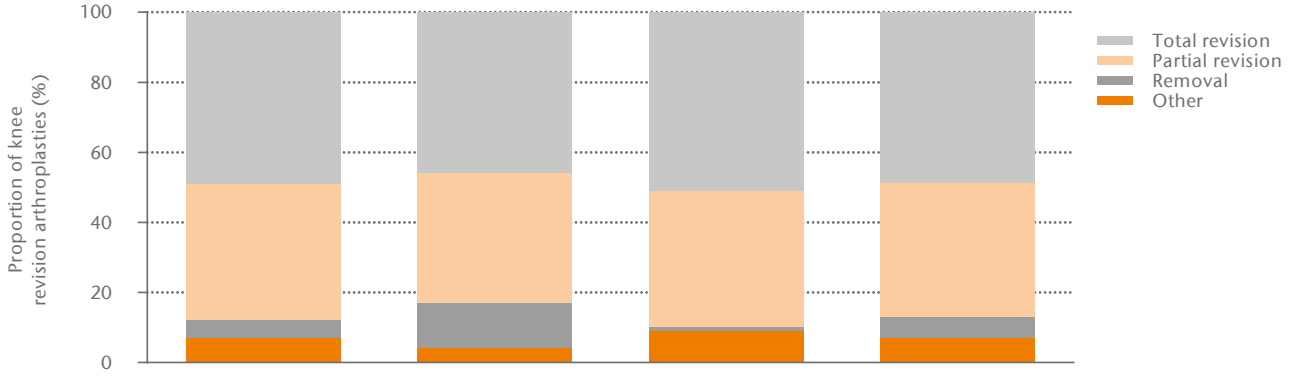
Table 5.5 The five most frequently registered types of bone cement used during primary knee arthroplasties in the Netherlands in 2014 (n=22,962).

Name	Proportion (%)
Palacos R+G	59.6
Refobacin Bone Cement R	13.2
Refobacin Plus Bone Cement	9.9
Palacos MV+G	6.4
Simplex ABC EC	3.9

5.3 Knee revision arthroplasties

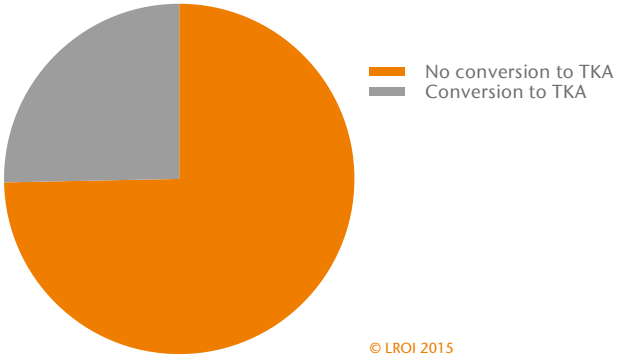
Knee revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of a knee prosthesis. Patients may undergo multiple procedures for one revision. This may be the case when an implant is removed during one surgery due to an infection, and a new prosthesis is implanted during a next surgery. This results in multiple revision arthroplasties, but it still relates to the revision of a single primary prosthesis. In addition, the majority of revision arthroplasties in the LROI are revisions of primary knee prostheses implanted before the start of the LROI in 2007. Since data have only been registered from 2007 on, only part of the revision arthroplasties can be linked to a primary arthroplasty. Therefore, this chapter does not list patient characteristics.

In total, 2,541 knee revision arthroplasties are registered in the LROI for 2014. This is slightly more than the number of



Type of hospital	General	UMC	Private	Total
Type of knee revision				
Total revision (%)	49.3	45.9	50.9	49.1
Partial revision (%)	38.5	36.7	39.4	38.4
Removal (%)	5.3	12.8	1.2	5.7
Other (%)	6.9	4.6	8.5	6.8
Total (n)	2,109	218	165	2,492

Figure 5.22 Type of revision arthroplasty (proportion [%] per category) of knee revision arthroplasties by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital.



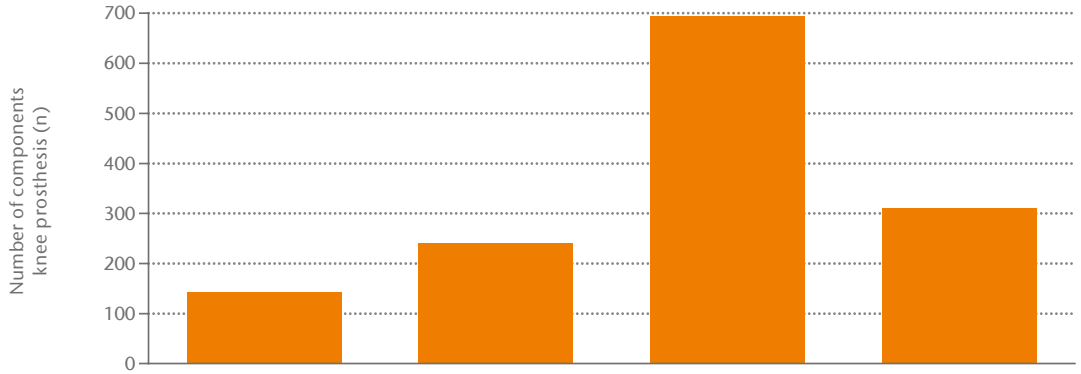
Conversion to TKA	Number (n)	Proportion (%)
No	1,531	74.6
Yes	519	25.4

Figure 5.23 Conversion of unicondylar or patellofemoral knee arthroplasty to a total knee arthroplasty in the Netherlands in 2014 (n=2,051).
TKA: total knee arthroplasty

Table 5.6 Reasons for revision or re-surgery in patients who underwent a knee revision arthroplasty in the Netherlands in 2014 (n=2,541).

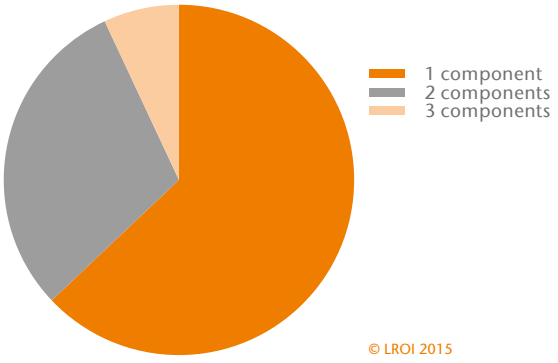
Reason for revision	Proportion[1] (%)
Instability	25.3
Loosening of tibial component	22.8
Patellar pain	22.3
Malalignment	15.7
Infection	14.8
Loosening of femoral component	9.0
Progression of osteoarthritis	8.3
Insert wear	8.1
Arthrofibrosis	6.9
Revision after knee removal	4.8
Patellar dislocation	2.5
Peri-prosthetic fracture	2.2
Loosening of patellar component	2.0

[1] A patient may have more than one reason for revision or re-surgery. As such, the total proportion is over 100%.



Number (n)	143	242	695	311
Proportion[1] (%)	14.9	25.3	72.5	32.5

Figure 5.24 Revised components in partial knee revision arthroplasties in the Netherlands in 2014 (n=958).
[1] More than one component can be replaced during a procedure. As such, the total proportion is over 100%.



Number of revised components	Number (n)	Proportion (%)
1 component	506	62.9
2 components	242	30.1
3 components	56	7.0

Figure 5.25 Number of revised components in partial knee revision arthroplasties in the Netherlands in 2014 (n=804).

registrations for 2013 (n=2,299). Completeness of the registration of knee revision arthroplasties in the LROI is 92% for 2014, based on a comparison to the hospital information system (HIS).

Nearly half of the knee revision arthroplasties were total revisions and 958 (38%) cases were partial revisions of the knee arthroplasty. Removal of a prosthesis was more often performed in UMCs (13% of knee revision arthroplasties) than in general hospitals (5%) or private hospitals (1%) (Figure 5.22). A quarter of the cases pertained to a conversion of a unicondylar or patellofemoral knee arthroplasty to a total knee arthroplasty (Figure 5.23). 129 patients (5%) underwent two or more knee revision arthroplasties in the same hospital in 2014. Over 70% of the partial knee revision arthroplasties performed in 2014 pertained to insert replacements. The patella was replaced in one-third of the cases and the tibia was replaced in a quarter of partial knee revision arthroplasties (Figure 5.24). Only the insert was replaced or added in 339 (13%) knee revision arthroplasties. Only the patella was implanted in 194 (8%) knee revision arthroplasties. Figure 5.25 displays how many components were revised per partial revision procedure.

The number of knee revision arthroplasties varied strongly from hospital to hospital, with fewer than 10 registered knee revision arthroplasties in twenty hospitals to 99 arthroplasties and one hospital with 345 registered knee revision arthroplasties in 2014. The median is 18 (range: 1-345) revision arthroplasties per hospital (Figure 5.26). The most common reason for knee revision arthroplasty was instability (25%), followed by loosening of the tibial component (23%) and patellar pain (22%) (Table 5.6). Table 5.7 lists the most registered types of components for knee revision arthroplasties, performed in the Netherlands in 2014. A large number of different components were registered in the LROI, of which the vast majority was used in fewer than 3% of revision procedures. This represents 1 to 55 times per year throughout the Netherlands. Except for knee revision arthroplasties, components may obviously also be used in many cases as components for primary knee arthroplasties.

In two-thirds of knee revision arthroplasties in which bone cement was used, the bone cement contained gentamicin. Bone cement without antibiotics was used in only one per cent of the cemented and hybrid cemented knee revision arthropalasties (Figure 5.27). Table 5.8 lists the five most registered types of bone cement in knee revision arthroplasties performed in the Netherlands in 2014.

Table 5.7 The ten most frequently registered femoral, tibial, insert and patellar components in knee revision arthroplasties in the Netherlands in 2014.

Femur (n=1,304)		Tibia (n=1,371)	
Name	Proportion (%)	Name	Proportion (%)
Legion	21.8	Legion	22.5
NexGen	18.3	NexGen	17.8
Genesis II	9.3	S-Rom	8.8
LCS	8.0	Genesis II	7.7
PFC / Sigma	7.7	Vanguard Complete Knee	7.0
Vanguard Complete Knee	6.1	PFC / Sigma	5.0
Vanguard 360	4.6	RT Plus	4.4
RT Plus	3.0	Vanguard 360	4.3
Triathlon	2.8	LCS	3.4
Legion Hinged	1.9	Triathlon	2.6

Insert (n=1,835)		Patella (n=1,003)	
Name	Proportion (%)	Name	Proportion (%)
Genesis II	27.7	Genesis II	38.0
NexGen	16.5	NexGen	19.9
LCS	9.7	Vanguard	13.8
Vanguard Complete Knee	7.5	PFC / Sigma	10.4
PFC / Sigma	7.3	LCS	3.5
ACS	3.5	Triathlon	3.3
Vanguard SSK	3.4	Optetrak	2.5
RT Plus	3.4	Scorpio	2.0
Scorpio	2.8	Journey BCS	1.8
Rotating Hinge Knee	2.5	AGC	1.2

Please note: often not all components are replaced in revision arthroplasties. This accounts for the difference in number of registered components.

Table 5.8 The five most frequently registered types of bone cement used during knee revision arthroplasties in the Netherlands in 2014 (n=1,617).

Name	Proportion (%)
Palacos R+G	41.9
Copal G+C	13.6
Refobacin Bone Cement R	10.3
Refobacin Revision	9.2
Refobacin Plus Bone Cement	7.9

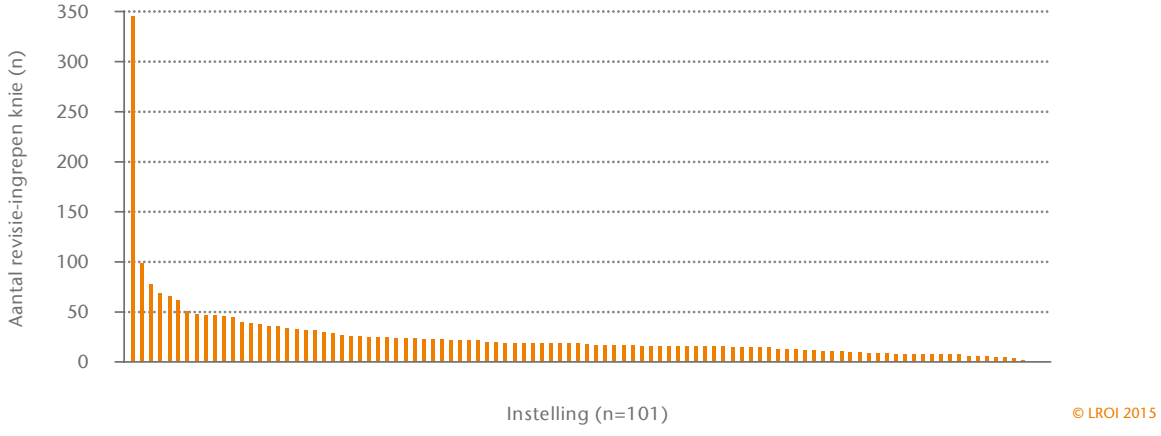
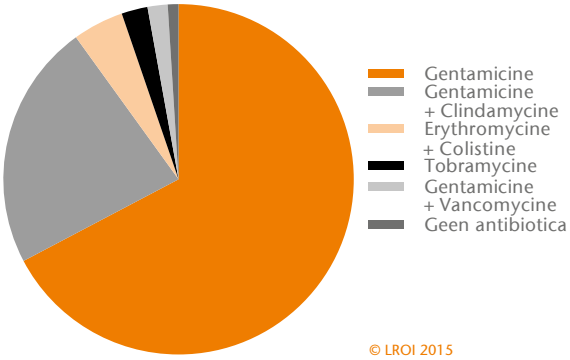


Figure 5.26 Number of knee revision arthroplasties per hospital in the Netherlands in 2014 (n=2.534).



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	1,088	67.3
Gentamicin + Clindamycin	368	22.8
Erythromycin + Colistin	76	4.7
Tobramycin	39	2.4
Gentamicin + Vancomycin	30	1.9
No antibiotics	16	1.0

Figure 5.27 Antibiotics in bone cement used in knee revision arthroplasties in the Netherlands in 2014 (n=1,617).

5.4 Survival of knee prostheses

In September 2014, the LROI was expanded with dates of death – if any – of people with joint prostheses, in order to determine survival and revision percentages of prostheses properly. The link that was required to incorporate the date of deathin the database is achieved in a way that guarantees patient privacy and meets the requirements of legislation and regulations. The LROI is the first registry in the Netherlands to achieve such a link.

Data from the LROI with regard to the 2007-2014 was used for survival analyses with a follow-up until 1 January 2015. This means that the maximum follow-up is 8 years. However, the number of prostheses with a 6-8 year follow-up is limited. Therefore, a follow-up is indicated up to 6 years after the primary procedure. A knee revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of a knee prosthesis, irrespective of the reason for revision. Revision for any reason is taken as end point. This chapter lists the chance of revision within 1 year for TKAs performed over the period 2010-2013. This also addresses the variation between hospitals and reasons for revision within 1 year. Furthermore, the cumulative short-term (5-year) revision percentage after a primary TKA is listed, divided over some case mix factors. The revision percentage of unicondylar and patellofemoral knee arthroplasties was also monitored. The results were obtained by means of competing risk analyses, taking into account the chance of dying of patients (see 'Methodology of survival analyses' in Chapter 1 on page 23 for an explanation).

5.4.1 Revision within 1 year of total knee prostheses

This paragraph focusses on revisions within one year after the primary procedure. A total of 79,689 primary TKAs were performed over the period 2010-2013, of which 739 (0.9%) prostheses were revised within 1 year. Over the same period, 588 (0.7%) TKAs were performed in patients that died within a year after the primary procedure (Table 5.9).
Variation in the 1-year revision percentage of TKAs is adjusted for case mix variables between hospitals in the Netherlands. The case mix adjusted 1-year revision percentage of TKAs exceeds the 95% confidence interval (CI) in 19 hospitals (Figure 5.28). The most common reasons for revision of TKAs within 1 year were patellar pain (29%), infection (26%), instability (26%) and malalignment (19%) (Table 5.10).

Table 5.9 Revision percentage within 1 year after the primary total knee arthroplasty over the period 2010-2013 with a follow-up of at least 365 days.

	Number (n)	Proportion (%)
No revision within 1 year	78,950	99.1
Revision within 1 year	739	0.9

Please note: over the period 2010-2013, 588 (0.7%) total knee arthroplasties were performed in patients that died within one year after the primary procedure.

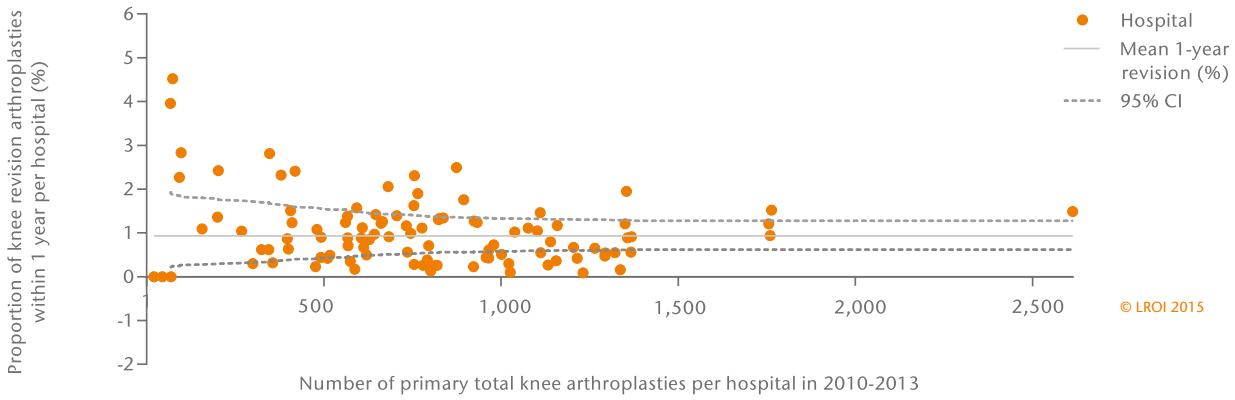


Figure 5.28 Funnel plot of discrepancies between hospitals in proportion of knee revision arthroplasties after a primary total knee arthroplasty within one year in the Netherlands in 2010-2013 (adjusted for case mix factors age, gender, ASA score and diagnosis (osteoarthritis versus other)) (n=79,689).

Table 5.10 Reasons for revision or re-surgery in patients that underwent a knee revision arthroplasty within 1 year after the primary knee arthroplasty in the Netherlands in 2010-2013 (n=739)

Reason for revision	Number (n)	Proportion (%)
Patellar pain	170	28.6
Infection	146	25.8
Instability	144	25.6
Malalignment	107	18.6
Loosening of tibial component	81	14.3
Revision after knee removal	41	7.6
Peri-prosthetic fracture	33	5.9
Patellar dislocation	29	5.1
Loosening of femoral component	27	4.8
Insert wear	13	2.3
Loosening of patellar component	4	0.7

Please note: A patient may have more than one reasons for revision of re-surgery. As such, the total proportion is over 100%.

5.4.2 Short-term revision of total knee prostheses

This paragraph determines the 5-year revision percentage (for any reason) of TKAs, according to gender, age and diagnosis (osteoarthritis versus non-osteoarthritis). The revision percentage for TKAs after 5 years was 4.1% (95% CI: 3.9-4.2%) (Figure 5.28). Patients below 60 years of age, in particular patients under 50 years, stand a larger chance of undergoing a revision within 5 years after the primary TKAs. The revision percentage after 5 years in patients under 50 years is 9.5% (95% CI: 8.5-10.6%). The chances of needing a revision within 5 years after the primary procedure were higher for patients who received a TKA following a diagnosis other than osteoarthritis. There is no difference in the 5-year revision percentage between men and women with a TKA (Figure 5.29 to Figure 5.32 and Table 5.11).

Table 5.11 Cumulative 5-year revision percentage of total knee arthroplasties in the Netherlands in 2007-2014 (n=137,433).

	n	Cumulative 5-year revision percentage (95% CI)
Total	137,433	4.1 (3.9-4.2)
Gender		
Men	45,694	4.1 (3.9-4.4)
Women	90,965	4.1 (3.9-4.2)
Age (years) (%)		
<50	4,682	9.5 (8.5-10.6)
50 -60	23,470	6.4 (6.0-6.9)
60 -69	49,520	4.1 (3.9-4.3)
70 -79	45,370	3.1 (2.9-3.3)
≥80	14,114	1.7 (1.5-2.0)
Diagnosis		
Osteoarthritis	130,265	4.1 (3.9-4.2)
Other	5,314	4.6 (3.9-5.3)

CI: confidence interval.

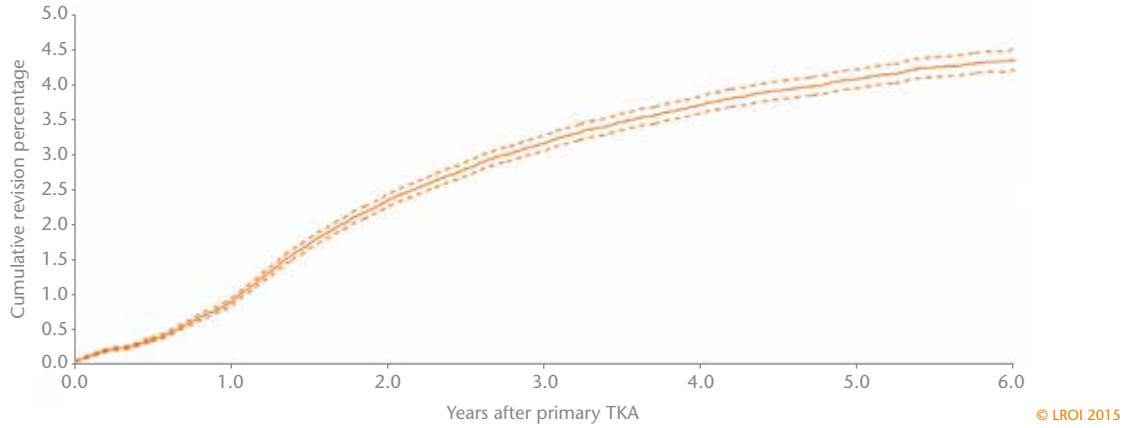


Figure 5.29 Cumulative revision percentage of total knee arthroplasties in the Netherlands in 2007-2014 (n=137,433).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

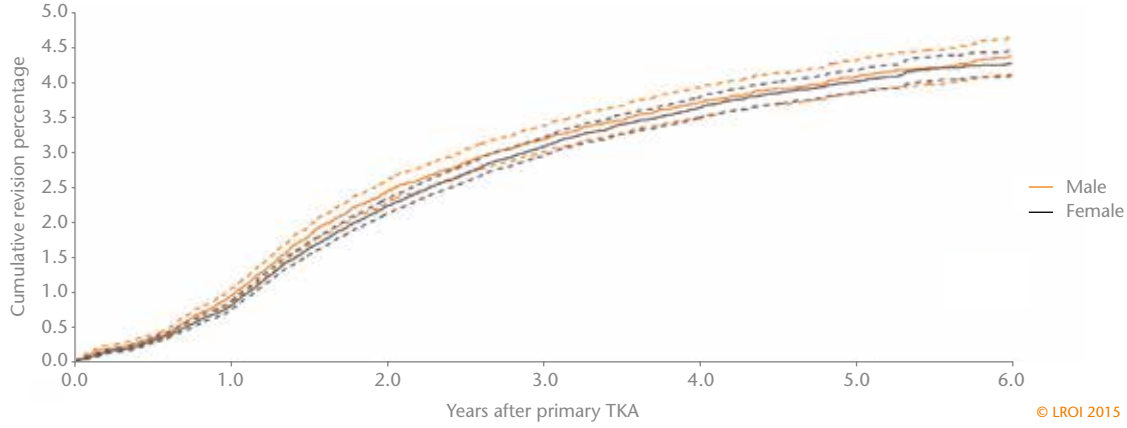


Figure 5.30 Cumulative revision percentage of total knee arthroplasties by gender in the Netherlands in 2007-2014 (n=136,659).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

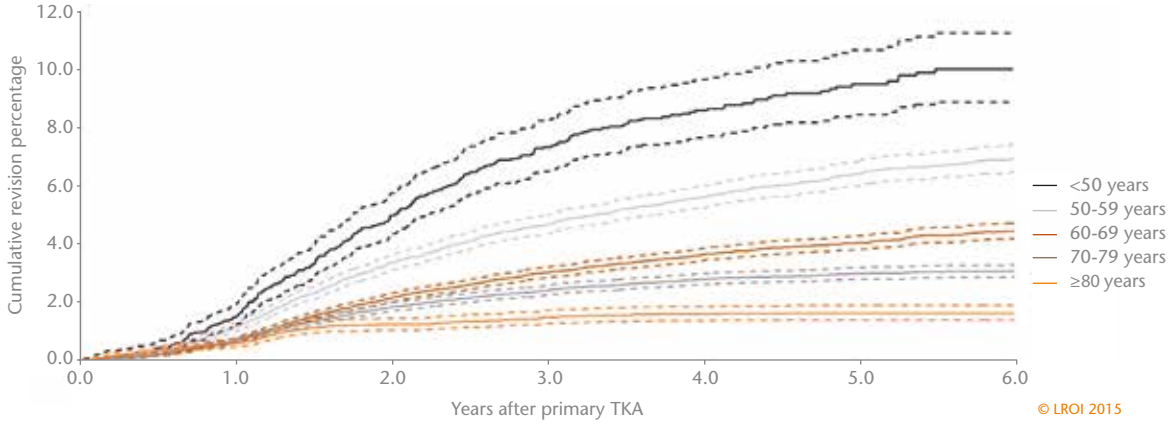


Figure 5.31 Cumulative revision percentage of total knee arthroplasties by age category in the Netherlands in 2007-2014 (n=137,156).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

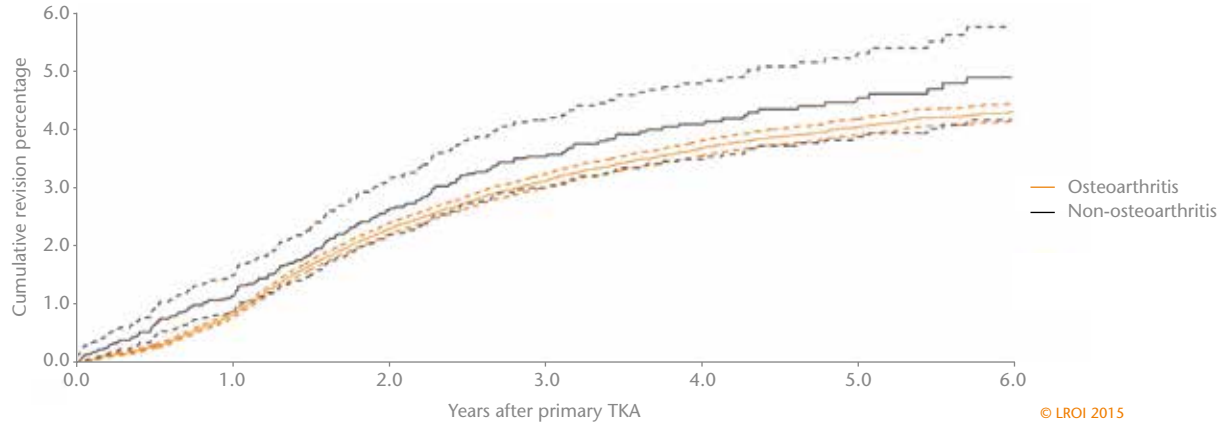


Figure 5.32 Cumulative revision percentage of total knee arthroplasties by diagnosis (osteoarthritis versus other) in the Netherlands in 2007-2014 (n=135,579).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

5.4.3 Short-term revision of primary unicondylar and patellofemoral knee prostheses

Primary knee arthroplasties are distinguished between total knee prostheses (TKA), unicondylar knee prostheses and patellofemoral knee prostheses. Unicondylar and patellofemoral knee arthroplasties are proportionally more often performed in younger patients (see paragraph 5.2). The 5-year revision percentage of unicondylar knee prostheses was 9.7% (95% CI: 9.0-10.4%). This means that chances for a patient with a unicondylar knee arthroplasty to have to undergo a revision of this prosthesis within 5 years are 9.7% (95% CI: 9.0-10.4%). Chances of revision for patients with a patellofemoral knee prosthesis within 5 years are 17.4% (95% CI: 14.5-20.9%) (Figure 5.33 and Table 5.12).

Table 5.12 Cumulative 5-year revision percentage of primary total, unicondylar and patellofemoral knee arthroplasties in the Netherlands in 2007-2014 (n=150,832).

Type of knee arthroplasty	n	Cumulative 5-year revision percentage (95% CI)
Total knee arthroplasty	137,433	4.1 (3.9-4.2)
Unicondylar knee arthroplasty	12,362	9.7 (9.0-10.4)
Patellofemoral knee arthroplasty	1,037	17.4 (14.5-20.9)

CI: confidence interval

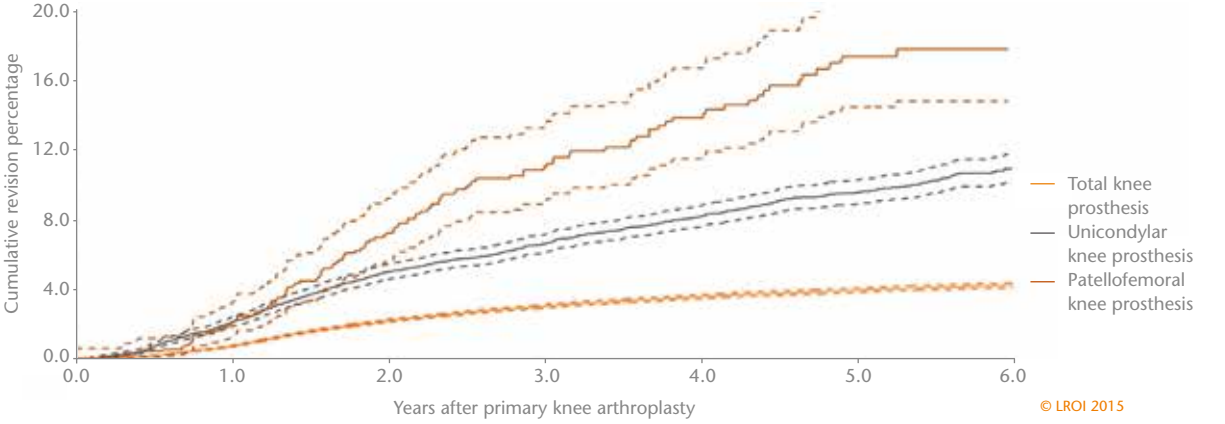


Figure 5.33 Cumulative revision percentage of primary knee arthroplasties by type of knee arthroplasties in the Netherlands in 2007-2014 (n=150,832).
Please note: Dotted lines represent the upper and lower limits of the 95% confidence interval.

6 Ankle arthroplasties

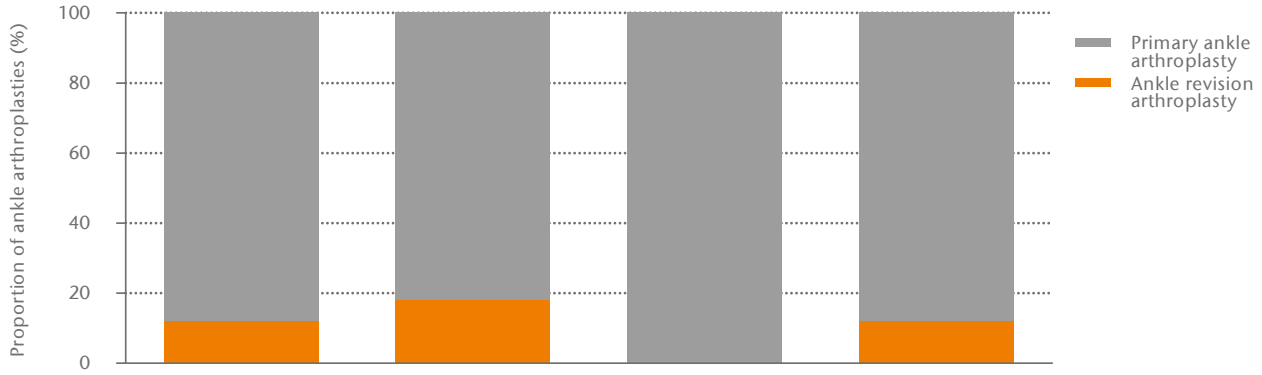
6.1 Trends and associations of primary ankle arthroplasties and ankle revision arthroplasties

In total, 122 ankle arthroplasties were registered in the LROI in 2014. 107 (88%) of these arthroplasties were primary ankle arthroplasties and 15 (12%) were ankle revision arthroplasties. In 2014, 21 hospitals registered ankle arthroplasties in the LROI. 13% of all ankle arthroplasties were revision arthroplasties in general hospitals. In university medical centres (UMCs) this was 18%. Private hospitals did not register ankle revision arthroplasties (Figure 6.1). The number of ankle arthroplasties varied from hospital to hospital in 2014 from one ankle arthroplasty in seven hospitals to 19 arthroplasties in one hospital (median: 2; range: 1-19) (Figure 6.2). Three primary ankle arthroplasties (3%) were performed bilaterally in 2014.

6.2 Primary ankle arthroplasties

6.2.1 Demographic data

In two-thirds of patients who received a primary ankle arthroplasty in 2014, this happened after the diagnosis osteoarthritis (osteoarthritis as primary diagnosis). Other registered diagnoses in patients with a primary ankle arthroplasty were mainly post-traumatic (n=17) and rheumatoid arthritis (n=14). Patients who received their primary ankle arthroplasty after another diagnosis but osteoarthritis were often younger than patients suffering from osteoarthritis. 20% of the patients who were diagnosed with osteoarthritis were younger than 60 years, when 58% of the patients with another diagnosis but osteoarthritis were younger than 60 years. Patients who received a primary ankle arthroplasty after the diagnosis osteoarthritis more often had an ASA score of II (mild disease, not incapacitating). Patients who received a primary ankle arthroplasty after another diagnosis smoked



Type of procedure				
Primary ankle arthroplasty (%)	87.5	81.8	100.0	87.7
Ankle revision arthroplasty (%)	12.5	18.2	0.0	12.3
Total (n)	88	22	12	122

Figure 6.1 Primary ankle arthroplasties and ankle revision arthroplasties (proportion [%] per category) by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital

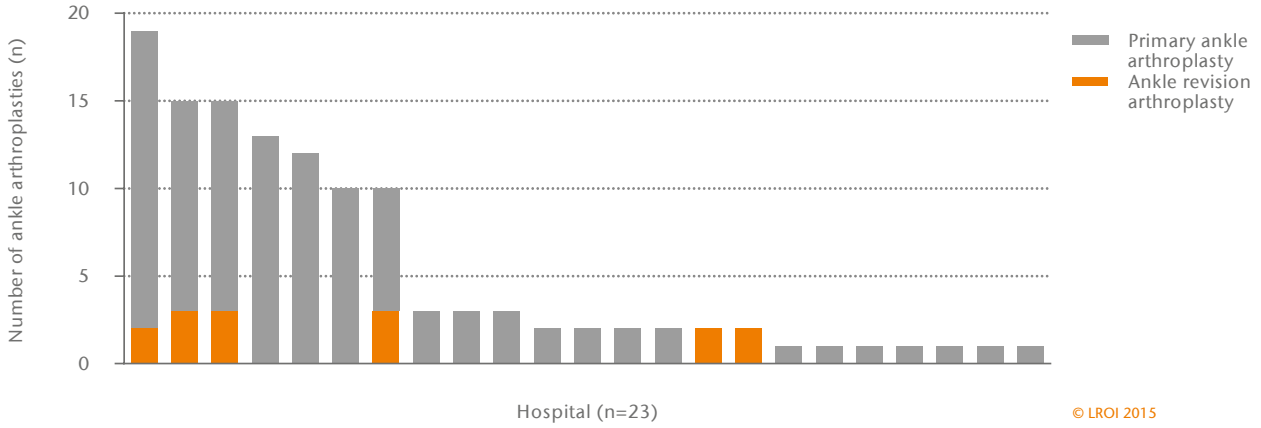


Figure 6.2 Number of primary ankle arthroplasties and ankle revision arthroplasties per hospital in the Netherlands in 2014 (n=122).

more often (16%) than patients who received this prosthesis after being diagnosed with osteoarthritis (5%). Completeness of registration of primary ankle arthroplasties was 88% (Table 6.1). One-third of the patients had undergone previous surgery to the same ankle. In most cases this was osteosynthesis (19%), followed by an arthroscopy (9%) and hindfoot surgery (7%) (Table 6.2).

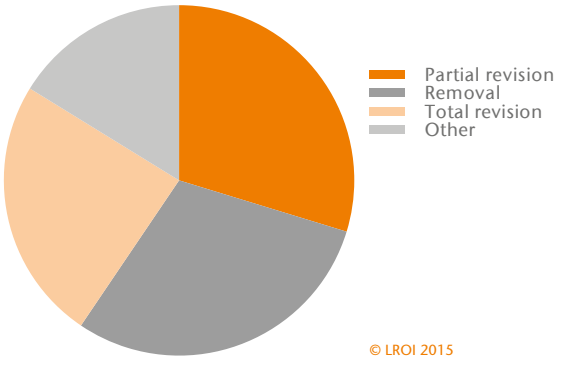
6.2.2 Prosthesis characteristics and surgical techniques

All primary ankle arthroplasties registered for 2014 in the LROI were total arthroplasties. All primary ankle arthroplasties were performed with an anterior approach. Nearly always (99%), primary ankle arthroplasties were fixated without cement. A bonegraft was used in six primary ankle arthroplasties (6%). Besides performing the ankle arthroplasty also the heel cord was extended surgically in one-third (n=32) of the procedures. A medial malleolus osteotomy was performed in 6% of the cases. The material of tibial components was nearly always (97%) cobalt chrome, as were the talus components (98%). The inlay was always (100%) made of standard polyethylene. Table 6.3 lists the three most registered types of primary total ankle arthroplasties.

6.3 Ankle revision arthroplasties

Ankle revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of the ankle joint. Patients may undergo multiple procedures for one revision. This may be the case when an implant is removed during one surgery due to an infection, and a new prosthesis is implanted during a next surgery. This results in multiple revision arthroplasties, but it still relates to the revision of a single primary prosthesis. Since presently only data on 2014 are registered, we cannot yet link one or more revision procedures to a primary procedure or other revision procedure. Therefore, this chapter does not list patient characteristics.

In total, fifteen ankle revision arthroplasties were registered for 2014. Completeness of the registration of ankle revision arthroplasties in the LROI is 75% for 2014, based on a comparison to the hospital information system (HIS). These revision arthroplasties were performed in six hospitals. Two or three revision procedures were performed in each hospital in 2014 (median: 3; range: 2-3). Six revision arthroplasties were partial revisions, four procedures were removals of ankle prostheses and three were total revisions of ankle arthroplasties. Two arthroplasties were different types of revisions (Figure 6.3). Arthrodesis was performed during four revision arthroplasties and in one revision arthroplasty it pertained to an amputation. Only the inlay was revised in all partial ankle revision arthroplasties. An allograft was used in six ankle revision arthroplasties. The most common reason for ankle revision arthroplasty was malalignment (64%), followed by loosening of the talus component (42%) and arthrofibrosis (42%) (Table 6.4).



Type of revision	Number (n)	Proportion (%)
Partial revision	6	40.0
Removal	4	26.7
Total revision	3	20.0
Other	2	13.3

Figure 6.3 Type of revision in ankle revision arthroplasties in the Netherlands in 2014 (n=15).

Table 6.1 Patient characteristics of all patients with a registered primary ankle arthroplasty by diagnosis in the Netherlands in 2014.

	Osteoarthritis (n=64)	No osteoarthritis[1] (n=36)	Total[2] (n=104)
Completeness (%)			88
Mean age (years) (SD)	67.8 (8.7)	59.9 (10.2)	65.2 (9.9)
Age (years) (%)			
<50	3	16	7
50-59	17	42	25
60-69	38	25	34
70-79	39	17	32
≥80	3	0	2
Gender (%)			
Men	56	47	51
Women	44	53	49
ASA score (%)			
I	16	30	21
II	81	56	72
III-IV	3	14	7
Type of hospital[3] (%)			
General	84	56	74
UMC	12	22	15
Private	4	22	11
Body Mass Index (kg/m²) (%)			
Underweight (<18.5)	0	7	2
Normal weight (>18.5-25)	27	27	26
Overweight (25-30)	50	43	47
Obesity (>30-40)	22	23	24
Morbid obesity (>40)	2	0	1
Smoking (%)			
No	95	81	88
Yes	5	16	11
Unknown	0	3	1

[1] Another diagnosis than osteoarthritis registered as primary diagnosis, specifically post-traumatic (17%), rheumatoid arthritis (14%), inflammatory arthritis (1%) or other primary diagnosis (3%).
[2] The primary diagnosis of 4 (3.8%) patients was not registered.
[3] In 2014, 17 general hospitals, 2 UMCs and 2 private hospitals performed primary ankle arthroplasties.
General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

Table 6.2 Previous surgery to the same joint in patients with primary ankle arthroplasties in the Netherlands in 2014 (n=104).

	Proportion[1] (%)
Previous surgery to the relevant ankle (total)	33.7
Osteosynthesis	19.2
Arthroscopy	8.7
Hindfoot surgery	6.7
Synovectomy	3.8
Forefoot surgery	2.9
Arthrodesis	2.9
Ligament reconstruction	1.0
Treatment of osteochondral bone defect	1.0
Osteotomy	0.0
Other	7.7

[1] A patient may have undergone multiple previous surgeries to the same joint. As such, the total proportion is more than 33.7% (proportion of patients with one or more previous surgeries to the same joint).

Table 6.3 The three most frequently registered types of primary total ankle arthroplasties implanted in the Netherlands in 2014 (n=107).

Name	Proportion (%)
Salto	37.6
CCI	34.4
Hintegra Regular	14.0

Table 6.4 Reasons for revision or re-surgery in patients who underwent an ankle revision arthroplasty in the Netherlands in 2014 (n=15).

Reason for revision	Proportion[1] (%)
Malalignment	64.3
Loosening of talus component	41.7
Arthrofibrosis	41.7
Loosening of tibial component	38.5
Peri-prosthetic fracture	33.3
Instability	33.3
Dislocation	16.7
Infection	7.7
Other	11.1

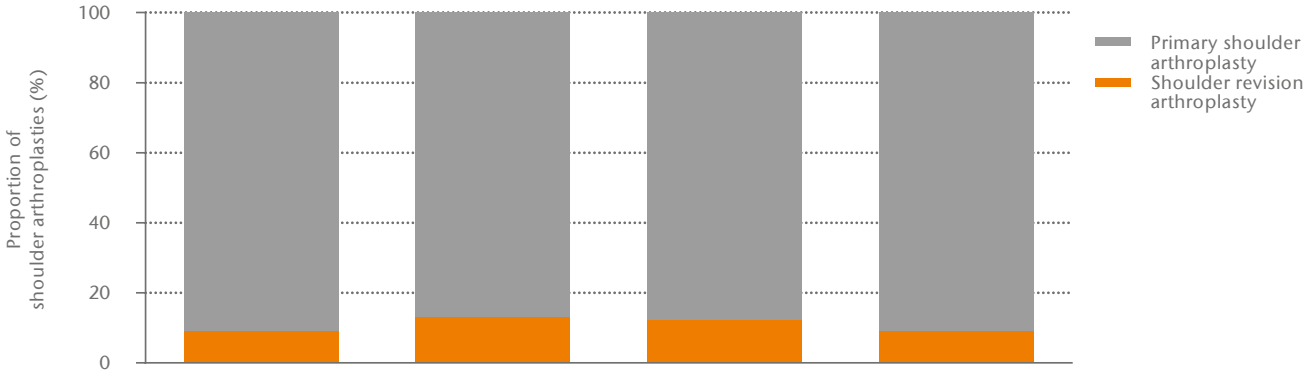
[1] A patient may have more than one reason for revision or re-surgery. As such, the total proportion is over 100%.


30 20 10 0

7 Shoulder arthroplasties

7.1 Trends and associations of primary shoulder arthroplasties and shoulder revision arthroplasties

In 2014, 2,077 primary shoulder arthroplasties and 203 shoulder revision arthroplasties were registered in the LROI. Primary shoulder arthroplasties were performed in 2,044 patients. 2% (n=33) of the primary shoulder arthroplasties were performed bilaterally in 2014. A distinction was made between general hospitals, university medical centres (UMCs) and private hospitals. In 2014, 73 general hospitals, 7 UMCs and 8 private hospitals performed shoulder arthroplasties. University medical centres (UMCs) and private hospitals (12%) more often performed revision arthroplasties in case of shoulder arthroplasties (13%) in proportion to general hospitals (9%) although the vast majority of all shoulder arthroplasties was performed in general hospitals (Figure 7.1). The number of shoulder arthroplasties varied considerably from hospital to hospital. As such, twenty hospitals registered fewer than ten shoulder arthroplasties; however, one hospital registered 152 shoulder arthroplasties. The median number of registrations of primary shoulder arthroplasties per hospital was 20 (range: 1-152) (Figure 7.2).



Type of hospital	General	UMC	Private	Total
Type of procedure				
Primary shoulder arthroplasty (%)	91.4	86.7	88.3	91.1
Shoulder revision arthroplasty (%)	8.6	13.3	11.7	8.9
Total (n)	2,105	98	77	2,280

Figure 7.1 Primary shoulder arthroplasties and shoulder revision arthroplasties (proportion [%] per category) by type of hospital in the Netherlands in 2014.
Please note: In 0.6% (n=13) of the shoulder arthroplasties the type of arthroplasty – primary or revision – has not been registered.
General: general hospital; UMC: university medical centre; Private: private hospital.

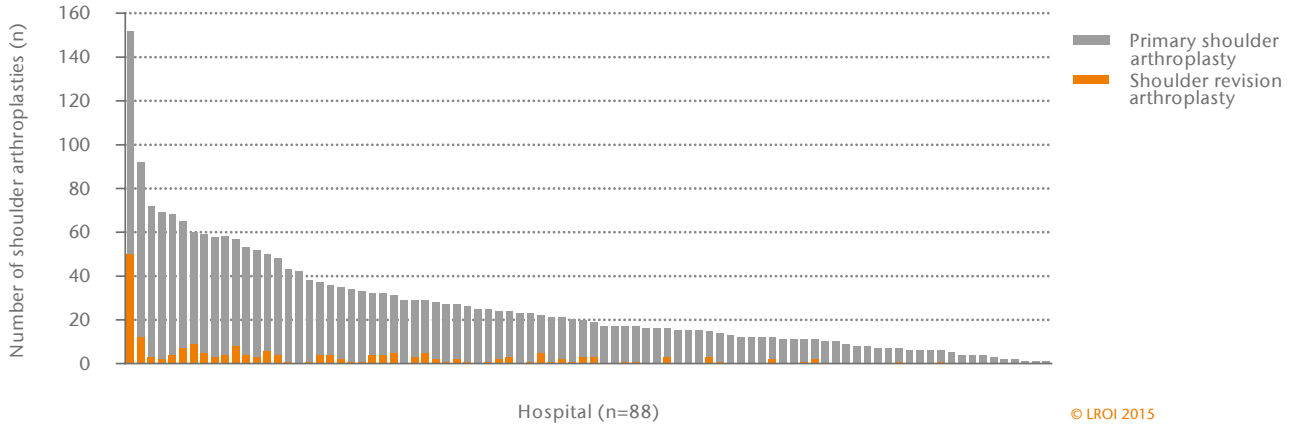
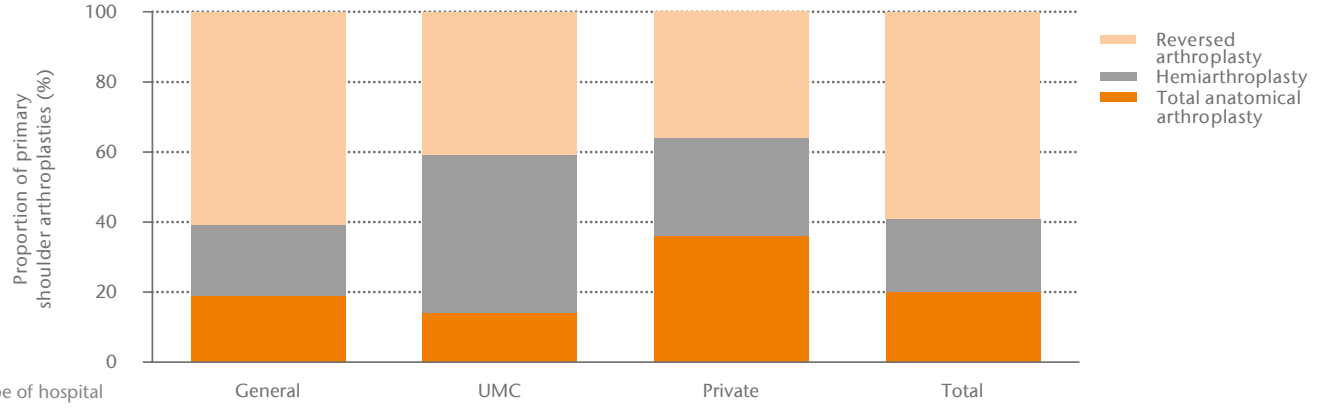


Figure 7.2 Number of primary shoulder arthroplasties (n=2.077) and shoulder revision arthroplasties (n=203) per hospital in the Netherlands in 2014.
Please note: In 0.6% (n=13) of the shoulder arthroplasties the type of arthroplasty - primary or revision - has not been registered.

7.2 Primary shoulder arthroplasties

Primary shoulder arthroplasties are distinguished between reversed shoulder arthroplasties, total anatomical shoulder arthroplasties and shoulder hemiarthroplasties (shoulder hemiarthroplasty with humeral stem, stemless shoulder hemiarthroplasty and resurfacing shoulder hemiarthroplasty). Shoulder prostheses with a humeral stem were implanted in 71% of shoulder hemiarthroplasties. In 2014, 60% (n=1,225) of primary shoulder arthroplasties were reversed arthroplasties. A hemiarthroplasty was performed in 21% of all primary shoulder arthroplasties and in 20% a total anatomical shoulder arthroplasty was performed. However, the number of registered shoulder hemiarthroplasties in the LROI is not complete, since these procedures are also performed by trauma surgeons. For 2014, only shoulder hemiarthroplasties that were carried out by orthopaedic surgeons were registered in the LROI. A vast majority of primary shoulder arthroplasties was performed in



Type of primary shoulder arthroplasty				
Reversed arthroplasty (%)	61.1	41.2	35.8	59.5
Hemiarthroplasty (%)	19.5	44.7	28.4	20.8
Total anatomical arthroplasty (%)	19.4	14.1	35.8	19.7
Total (n)	1,907	85	67	2,059

Figure 7.3 Type of primary shoulder arthroplasty (proportion [%] per category) by type of hospital in the Netherlands in 2014.
General: general hospital; UMC: university medical centre; Private: private hospital

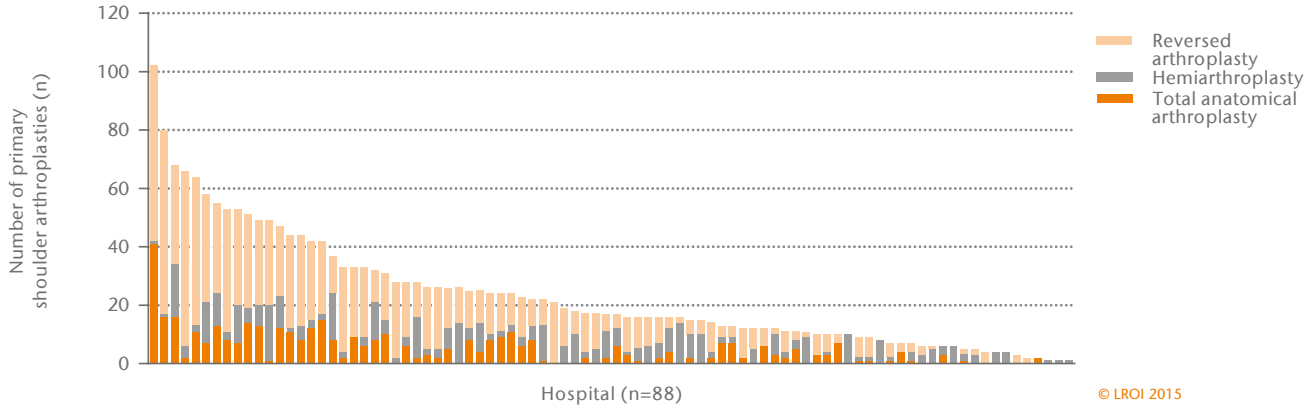
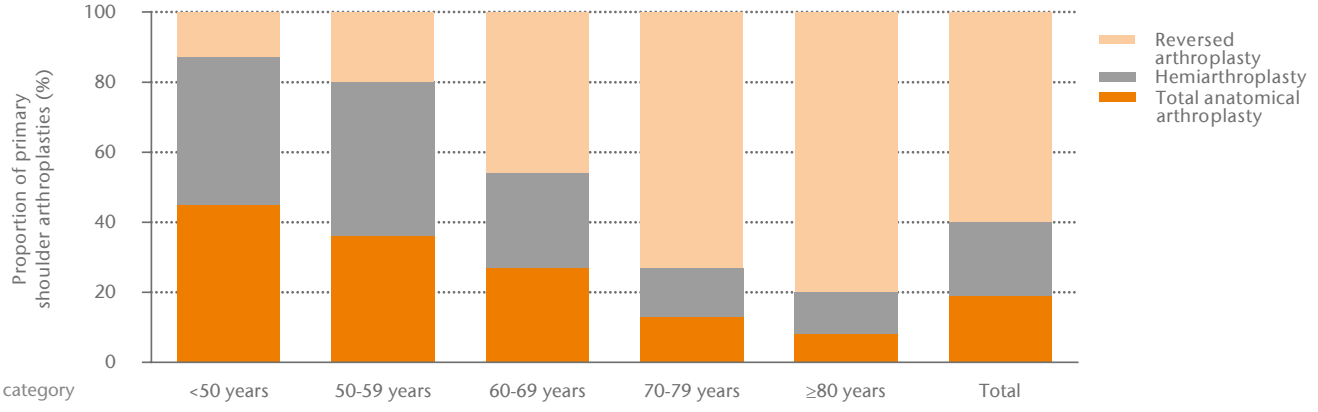


Figure 7.4 Number of primary shoulder arthroplasties by type of arthroplasty per hospital in the Netherlands in 2014 (n=2,059).

general hospitals (93%). Shoulder hemiarthroplasties were proportionally often registered in UMCs in 2014 (45%). Over half (n=21) were performed after a fracture (acute or post-traumatic). Private hospitals performed the various types of shoulder arthroplasties nearly as often (Figure 7.3). Figure 7.4 shows the number of primary shoulder arthroplasties by type of arthroplasty per hospital in the Netherlands, as these were registered in the LROI in 2014.

7.2.1 Demographic data

Patients who received a reversed shoulder arthroplasty were clearly older on average (74.7 years (SD: 7.5)) than patients who received a hemiarthroplasty (66.5 years (SD: 11.1) years) or total shoulder arthroplasty (65.6 (SD: 10.3)) (Table 7.1). Figure 7.5 shows that only 13% of patients up to the age of 50 who received a primary shoulder arthroplasty in 2014 received a reversed shoulder arthroplasty. Patients as of 80 years mainly received a reversed shoulder prosthesis in 2014 (80%). However,



Age category	<50 years	50-59 years	60-69 years	70-79 years	≥80 years	Total
Type of primary shoulder arthroplasty						
Reversed arthroplasty (%)	12.7	19.9	46.3	73.6	79.9	59.6
Hemiarthroplasty (%)	42.2	43.9	26.4	13.7	12.3	21.0
Total anatomical arthroplasty (%)	45.1	36.2	27.3	12.7	7.8	19.4
Total (n)	71	196	568	847	333	2,027

Figure 7.5 Type of primary shoulder arthroplasty (proportion [%] per category) by age category in patients with a primary shoulder arthroplasty in the Netherlands in 2014.
Please note: age had not been registered in 12 (0.6%) primary shoulder arthroplasties.

Table 7.1 Patient characteristics of all patients with a registered primary shoulder arthroplasty by type of arthroplasty in the Netherlands in 2014.

	Reversed arthroplasty (n=1,209)	Hemi arthroplasty (n=425)	Total anatomical arthroplasty (n=393)	Total[1] (n=2,044)
Completeness (%)				82
Mean age (years) (SD)	74.7 (7.5)	66.5 (11.1)	65.6 (10.3)	71.3 (9.9)
Age (years) (%)				
<50	1	7	8	3
50-59	3	20	18	10
60-69	22	36	39	28
70-79	52	27	28	42
≥80	22	10	7	17
Gender (%)				
Men	20	27	31	23
Women	80	73	69	77
ASA score (%)				
I	6	12	17	10
II	64	64	68	64
III-IV	30	24	15	26
Type of hospital[2] (%)				
General	95	87	92	93
UMC	3	9	3	4
Private	2	4	5	3
Diagnosis (%)				
Osteoarthritis	28	44	83	42
Rheumatoid arthritis	3	3	6	3
Fracture	14	30	1	15
Osteonecrosis	4	8	4	5
Post-traumatic	11	11	4	10
Cuff arthropathy	33	1	1	20
Cuff rupture	5	0	0	3
Other	2	2	1	2
Walch score (%)				
A1 Humeral head centered, minor erosion glenoid	58	73	46	58
A2 Humeral head centered, major erosion glenoid	23	13	28	22
B1 Humeral head subluxed posteriorly, posterior joint space narrow, subchondral sclerosis and osteophytes	13	10	19	14
B2 Humeral head subluxed posteriorly retroverted glenoid with posterior rim erosion	4	3	5	4
C Glenoid retroversion more than 25 degrees regardless of erosion	2	1	2	2
Body Mass Index (kg/m²) (%)				
Underweight (≤18.5)	1	1	1	1
Normal weight (>18.5-25)	31	28	28	29
Overweight (25-30)	38	36	38	38
Obesity (>30-40)	28	30	29	29
Morbid obesity (>40)	2	5	4	3
Smoking (%)				
No	89	80	86	87
Yes	11	20	14	13

[1] The type of shoulder prosthesis had not been registered in 18 (0.8%) primary shoulder arthroplasties.

[2] In 2014, 73 general hospitals, 7 UMCs and 8 private hospitals implanted primary shoulder arthroplasties.

General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

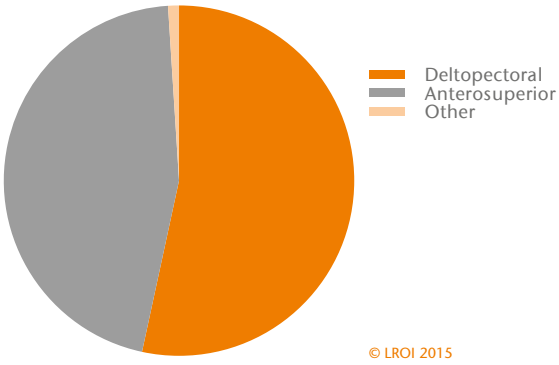
the proportion of total anatomical shoulder arthroplasties or hemiarthroplasties indeed decreased as age increased (Figure 7.6). Patients who received a hemiarthroplasty (27%) or total anatomical arthroplasty (31%) were more often male than patients who received a reversed arthroplasty (20%). ASA scores of patients who received a reversed shoulder arthroplasty were more often higher (ASA score III-IV: 30%) than those of patients who received a total (15%) or hemiarthroplasty (24%). Primary shoulder arthroplasties were mainly performed in general hospitals in 2014 (93%). Hemiarthroplasties were more often performed in UMCs than total or reversed shoulder arthroplasties. Furthermore, patients undergoing a hemiarthroplasty smoked more often (20%). Completeness of registration of primary shoulder arthroplasties was 82% (Table 7.1).

7.2.2 Prosthesis characteristics and surgical techniques

7.2.2.1 Reversed shoulder arthroplasties

In total, 78 hospitals performed reversed shoulder arthroplasties in 2014. These included 68 general hospitals, five UMCs and five private hospitals. The number of performed reversed shoulder arthroplasties varied between hospitals, from 33 hospitals that performed fewer than ten reversed shoulder arthroplasties to 24 hospitals that performed over twenty reversed shoulder arthroplasties (range: 1-63). The median number of arthroplasties per hospital was 11.

The most common surgical approach for performing a primary reversed shoulder arthroplasty was deltopectoral (53%), followed by the anterosuperior approach (46%) in 2014 (Figure 7.6). The proportion of approaches used varied strongly from hospital to hospital, with 31 hospitals that only used the deltopectoral approach and 22 hospitals that used this approach in less than 10% of the primary reversed shoulder arthroplasties (Figure 7.7).



Surgical approach	Number (n)	Proportion (%)
Deltopectoral	638	53.4
Anterosuperior	545	45.6
Other	12	1.0

Figure 7.6 Surgical approach for performing a primary reversed shoulder arthroplasty in the Netherlands in 2014 (n=1,195).

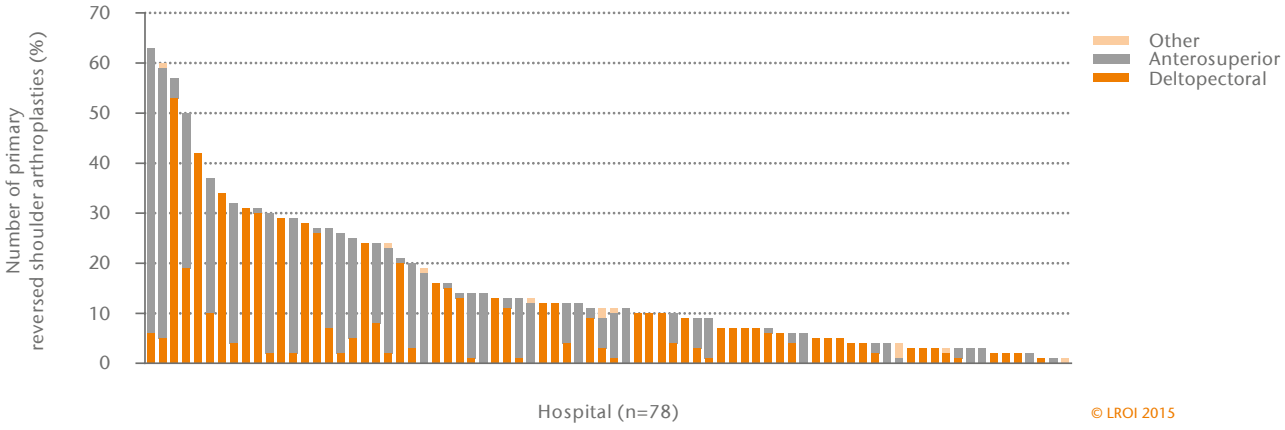
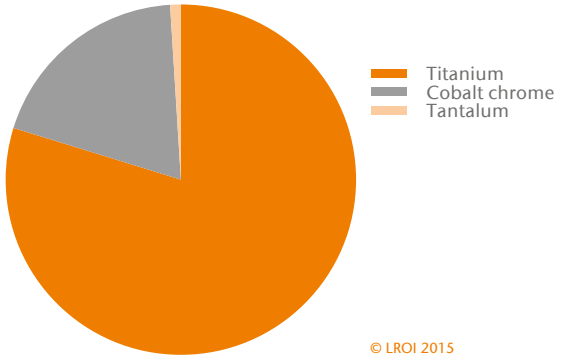


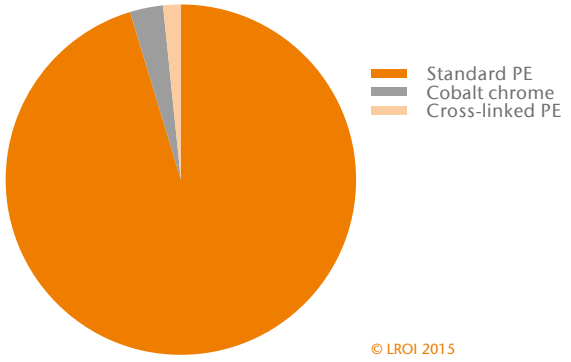
Figure 7.7 Surgical approach for performing a primary reversed shoulder arthroplasty per hospital in the Netherlands in 2014 (n=1,120).
Please note: surgical approach had not been registered by one hospital.

Humeral stems that were implanted in primary reversed shoulder arthroplasties in 2014, consisted of titanium (80%) and of cobalt chrome (19%) (Figure 7.8). Nearly always – in 95% of these procedures – humeral liners were made of standard polyethylene (Figure 7.9) and 85% of metaphyses were made of titanium. The other 15% were made of cobalt chrome (Figure 7.10). Glenospheres were nearly always (99%) made of cobalt chrome and glenoid baseplates always (100%) of titanium. Table 7.2 lists the five most registered humeral stems, humeral liners, glenospheres, glenoid baseplates and metaphyses that were



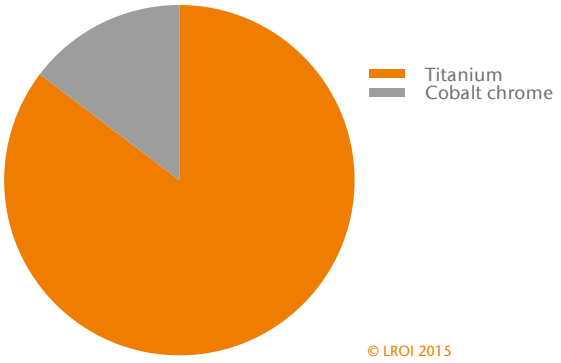
Humeral stem material	Number (n)	Proportion (%)
Titanium	891	79.8
Cobalt chrome	215	19.2
Tantalum	11	1.0

Figure 7.8 Humeral stem component material in primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=1,117).



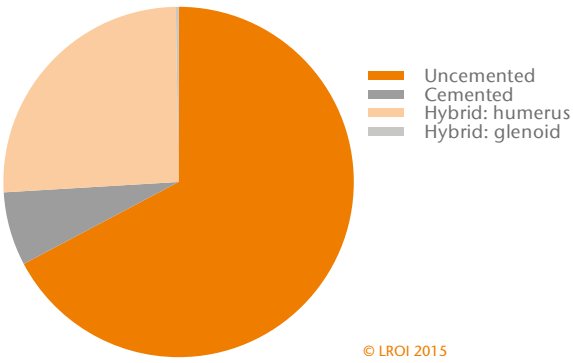
Humeral liner material	Number (n)	Proportion (%)
Standard PE	997	95.3
Cobalt chrome	32	3.1
Cross-linked PE	17	1.6

Figure 7.9 Humeral liner material in primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=1,046).
PE: polyethylene.



Metaphysis material	Number (n)	Proportion (%)
Titanium	663	85.3
Cobalt chrome	114	14.7

Figure 7.10 Metaphysis material in primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=777).



Fixation	Number (n)	Proportion (%)
Uncemented	801	67.3
Cemented	81	6.8
Hybrid: humerus cemented	306	25.7
Hybrid: glenoid cemented	3	0.3

Figure 7.11 Type of fixation in primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=1,191).

implanted in primary reversed shoulder arthroplasties in 2014. Two-thirds of primary reversed shoulder prostheses had uncemented fixation in 2014 (Figure 7.11). Twenty hospitals performed all reversed shoulder arthroplasties without cement. However, seven hospitals did not perform a single shoulder arthroplasty without cement (Figure 7.12). Separately packed bone cement components were used in 73% of all cemented arthroplasties and in 27% bone cement was used that was pre-packed in a vacuum mixing system. The bone cement contained antibiotics in most cases (94%). This was most often (87%)

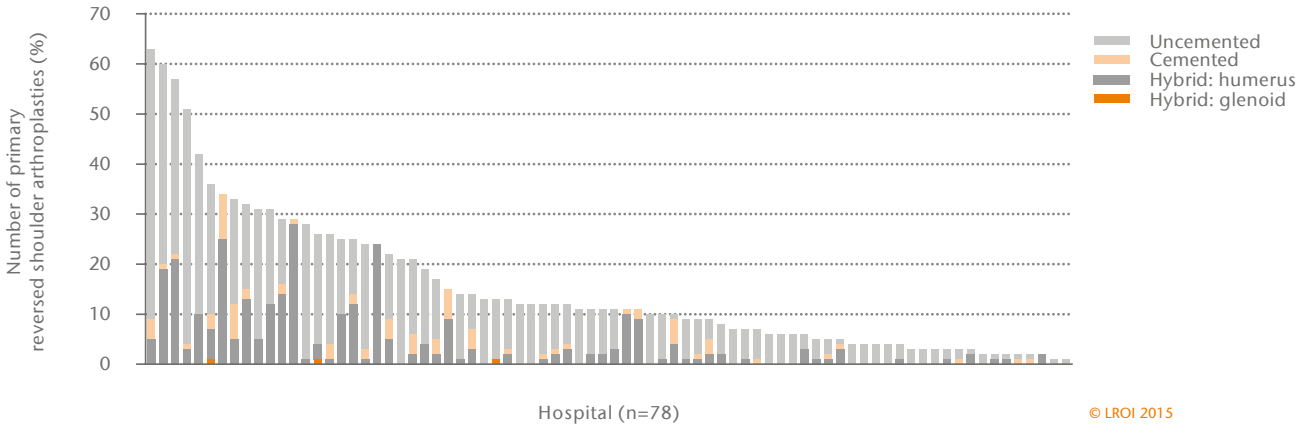


Figure 7.12 Type of fixation in primary reversed shoulder arthroplasties per hospital in the Netherlands in 2014 (1,191).

Table 7.2 The five most frequently registered humeral stems, humeral liners, glenospheres, metaphyses and glenoid baseplates in primary reversed shoulder arthroplasties performed in the Netherlands in 2014.

Humeral stem (n=1,162)

Name	Proportion (%)
Delta X-tend	32.5
Aequalis Reversed	32.3
Comprehensive	9.7
Aequalis Reversed Fractuur	7.5
Equinoxe	4.9

Humeral liner (n=1,047)

Name	Proportion (%)
Delta X-tend	34.3
Aequalis Reversed	33.0
Comprehensive	9.2
Aequalis Reversed Fractuur	6.9
Equinoxe	5.9

Glenosphere (n=1,098)

Name	Proportion (%)
Aequalis Reversed	41.8
Delta X-tend	33.2
Comprehensive	8.7
Equinoxe	5.2
TM Reverse Glenoid Heads	4.7

Metaphysis (n=826)

Name	Proportion (%)
Aequalis Reversed	42.5
Delta X-tend	28.6
Comprehensive	11.0
Equinoxe	5.6
Anatomical inverse Humeral Cups	4.1

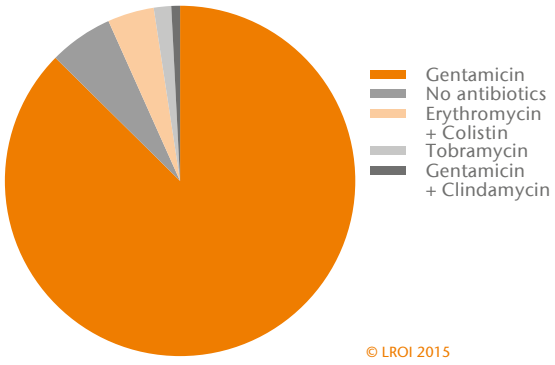
Glenoid baseplate (n=1,043)

Name	Proportion (%)
Aequalis Reversed	42.5
Delta X-tend	31.4
Comprehensive	9.4
Equinoxe	5.6
Affinis Inverse	4.1

gentamicin (Figure 7.13). Furthermore, it had a high viscosity in 86% of the cases and in 11% of the cases viscosity was medium (Figure 7.14). The five most registered types of bone cement are listed in Table 7.3.

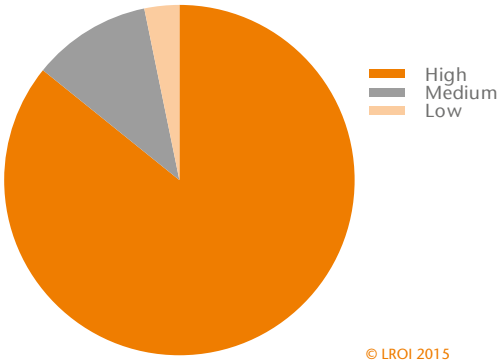
Table 7.3 The five most frequently registered types of bone cement used during primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=373).

Name	Proportion (%)
Palacos R+G	51.5
Refobacin Bone Cement R	26.5
Palacos MV+G	4.8
Simplex ABC EC	4.3
Palacos LV+G	3.2



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	326	87.4
No antibiotics	22	5.9
Erythromycin + Colistin	16	4.3
Tobramycin	6	1.6
Gentamicin + Clindamycin	3	0.8

Figure 7.13 Antibiotics in bone cement in primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=326).



Bone cement viscosity	Number (n)	Proportion (%)
High	320	85.8
Medium	41	11.0
Low	12	3.2

Figure 7.14 Bone cement viscosity in primary reversed shoulder arthroplasties in the Netherlands in 2014 (n=373).

7.2.2.2 Shoulder hemiarthroplasties

Shoulder hemiarthroplasties registered in the LROI may be shoulder hemiarthroplasties with humeral stem, stemless shoulder hemiarthroplasties or resurfacing shoulder hemiarthroplasties. Shoulder prostheses with a humeral stem were implanted in 71% of shoulder hemiarthroplasties. In total, 77 hospitals registered shoulder hemiarthroplasties in 2014. These included 64 general hospitals, seven UMCs and six private hospitals. The number of registered shoulder hemiarthroplasties varied between hospitals from one in 11 hospitals to over ten in 16 hospitals (range: 1-19). The median number of procedures per hospital was 4.

The deltopectoral surgical approach was used in 88% of the primary shoulder hemiarthroplasties. The other 12% of the hemiarthroplasties were performed by means of the anterosuperior approach. The approach used for performing a primary shoulder hemiarthroplasty varied from hospital to hospital. Four hospitals always performed these procedures with an anterosuperior approach, when 59 hospitals always used a deltopectoral approach (Figure 7.15).

Titanium humeral stems were implanted in most of the shoulder hemiarthroplasties, followed by cobalt chrome humeral stems (Figure 7.16). Humeral heads were nearly always (99%) made of cobalt chrome. Table 7.4 lists the most implanted humeral stems and humeral heads in 2014 as part of a primary shoulder hemiarthroplasty.

No cement was used in nearly two-thirds of primary shoulder hemiarthroplasties (Figure 7.17). The proportion of procedures in which cement was or was not used varied strongly from hospital to hospital. 13 hospitals used cement in each shoulder hemiarthroplasty, when 33 hospitals did not use cement in any of the shoulder hemiarthroplasties in 2014 (Figure 7.18). In 68% of these procedures separately packed bone cement

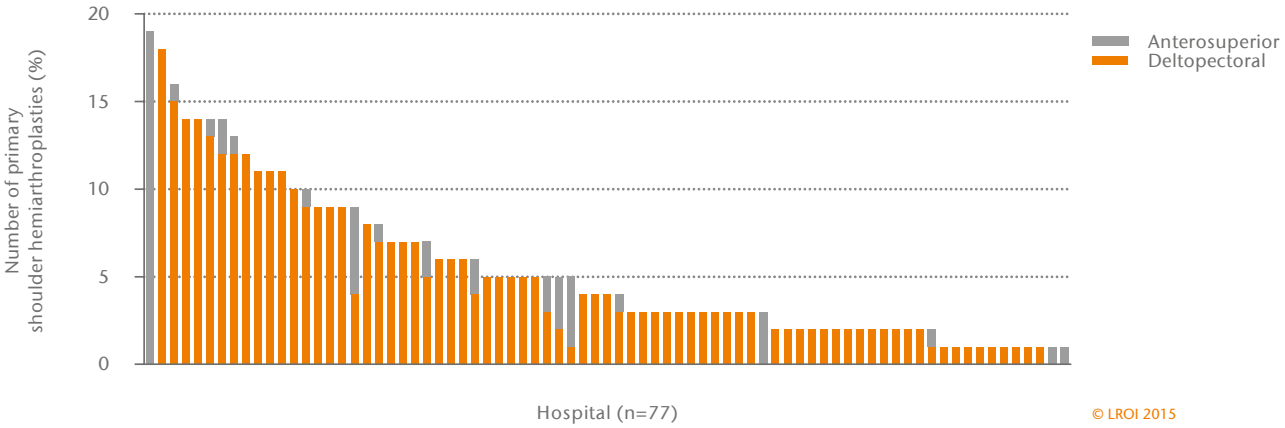


Figure 7.15 Surgical approach for performing a primary shoulder hemiarthroplasty per hospital in the Netherlands in 2014 (n=422).

Table 7.4 The five most frequently registered humeral stems and humeral heads in primary shoulder hemiarthroplasties implanted in the Netherlands in 2014.

Humeral stem (n=305)		Humeral head (n=359)	
Name	Proportion (%)	Name	Proportion (%)
Aequalis Fractuur hemi	23.9	Aequalis humeruskop	26.2
Comprehensive	14.4	Comprehensive	12.0
Global AP	5.9	Copeland	10.0
SMR stem	5.9	Global AP	5.8
Global Unite	5.2	Aequalis Resurfacing	5.8

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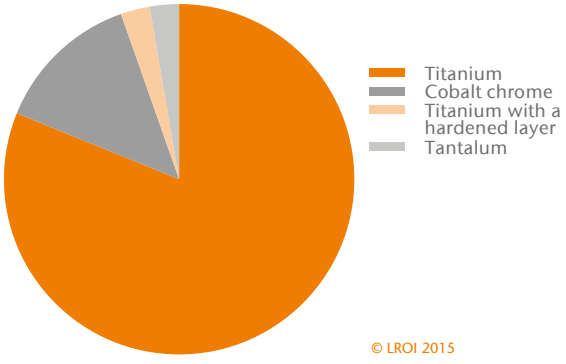
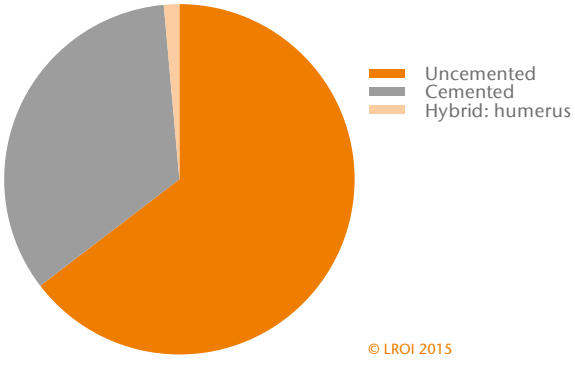


Humeral stem material	Number (n)	Proportion (%)
Titanium	241	81.1
Cobalt chrome	40	13.5
Titanium with a hardened layer	8	2.7
Tantalum	8	2.7

Figure 7.16 Humeral stem component material in primary shoulder hemiarthroplasties in the Netherlands in 2014 (n=297).



Fixation	Number (n)	Proportion (%)
Uncemented	272	64.6
Cemented	143	34.0
Hybrid: humerus cemented	6	1.4

Figure 7.17 Type of fixation in primary shoulder hemiarthroplasties in the Netherlands in 2014 (n=421).

components were used and in 32% bone cement was used that was pre-packed in a vacuum mixing system. The bone cement contained antibiotics in most cases (96%). This was most often (89%) gentamicin (Figure 7.19). Furthermore, it had a high viscosity in 91% of the cases and in 8% of the cases viscosity was medium (Figure 7.20). The five most registered types of bone cement are listed in Table 7.5.

Table 7.5 The five most frequently registered types of bone cement used during primary shoulder hemiarthroplasties in the Netherlands in 2014 (n=145).

Name	Proportion (%)
Palacos R+G	48.3
Refobacin Bone Cement R	32.4
Refobacin Plus Bone Cement	4.1
Palacos MV+G	3.4
Simplex ABC EC	3.4

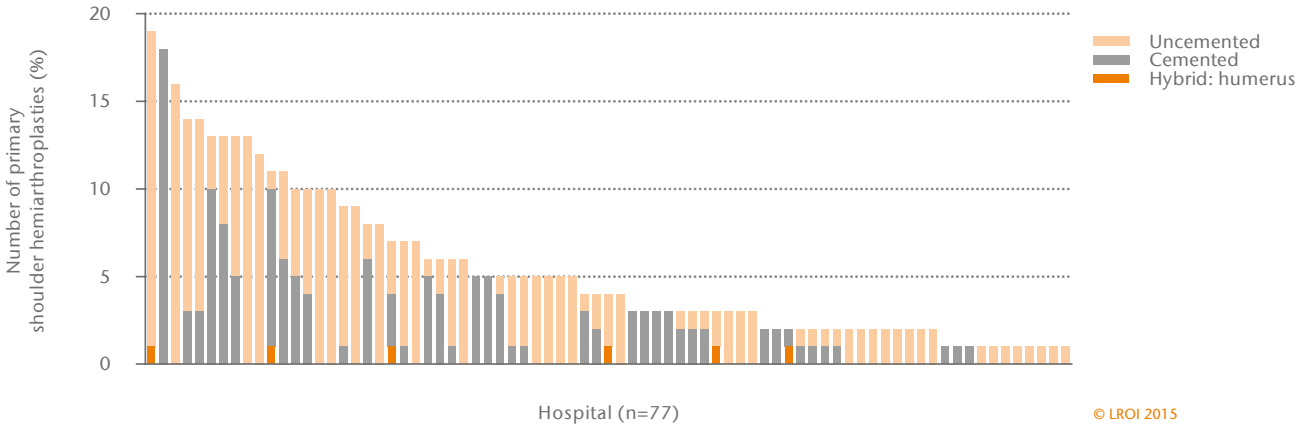
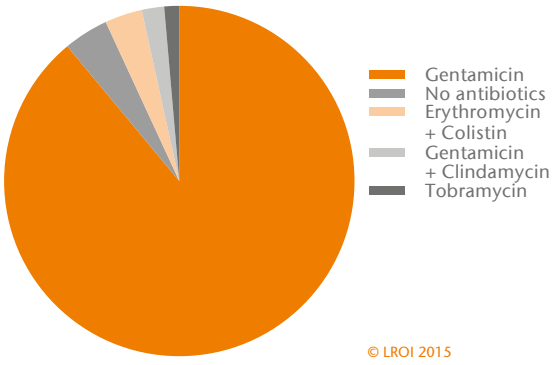
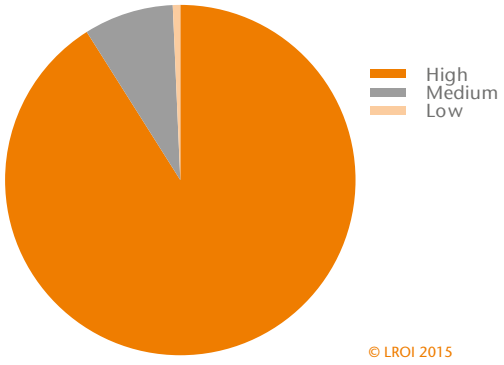


Figure 7.18 Type of fixation in primary shoulder hemiarthroplasty per hospital in the Netherlands in 2014 (n=421).



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	129	89.0
No antibiotics	6	4.1
Erythromycin + Colistin	5	3.4
Gentamicin + Clindamycin	3	2.1
Tobramycin	2	1.4

Figure 7.19 Antibiotics in bone cement in primary shoulder hemiarthroplasties in the Netherlands in 2014 (n=145).



Bone cement viscosity	Number (n)	Proportion (%)
High	132	91.0
Medium	12	8.3
Low	1	0.7

Figure 7.20 Viscosity of bone cement in primary shoulder hemiarthroplasties in the Netherlands in 2014 (n=145).

7.2.2.3 *Total anatomical shoulder arthroplasties*

In total, 63 hospitals performed total shoulder arthroplasties in 2014. These included 53 general hospitals, seven UMCs and six private hospitals. The number of registered total shoulder arthroplasties varied between hospitals from one in eight hospitals to ten or more in 13 hospitals (range: 1-41). The median number of procedures per hospital was 3.

The surgical approach that was used to perform primary total shoulder arthroplasties was deltopectoral in the vast majority of cases (99%). Only six hospitals performed this type of arthroplasty also with an anterosuperior surgical approach (Figure 7.21).

Nearly eighty per cent of the humeral stems that were implanted as part of a primary total shoulder arthroplasty were made of titanium, of which 5% with a hardened layer. Twenty per cent were made of cobalt chrome (Figure 7.22). Humeral heads were nearly always (100%) made of cobalt chrome. Glenoid components consisted in the vast majority of cases (93%) of polyethylene, of which 64% consisted of standard polyethylene (Figure 7.23). Only 2 glenoid liners were implanted in 2014.

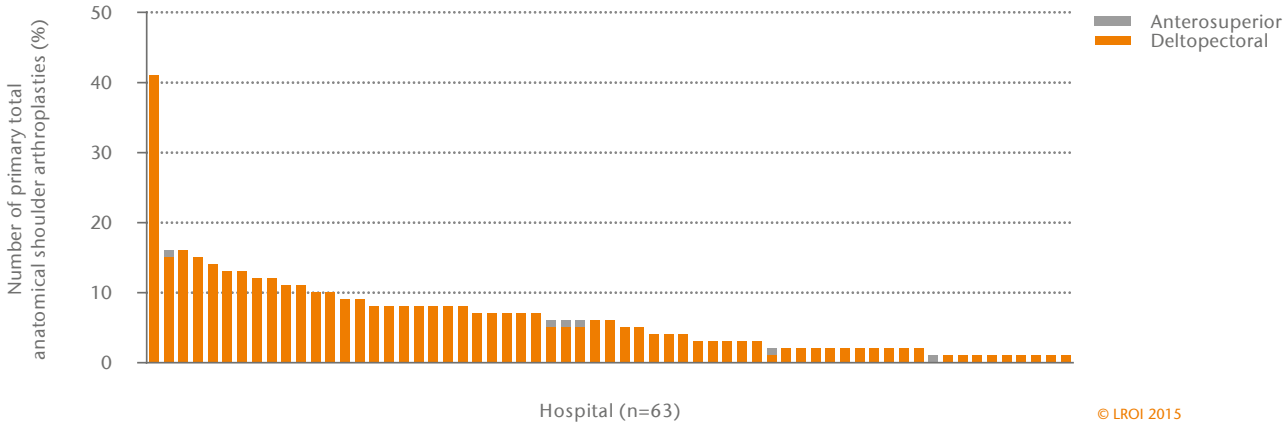
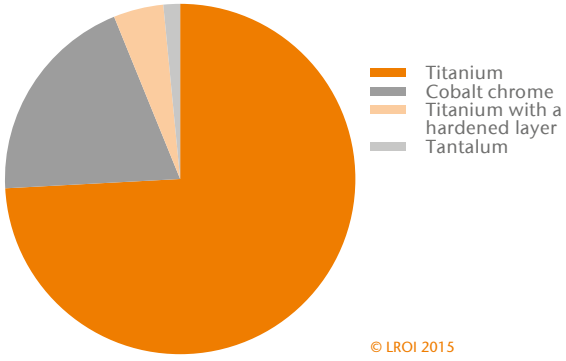
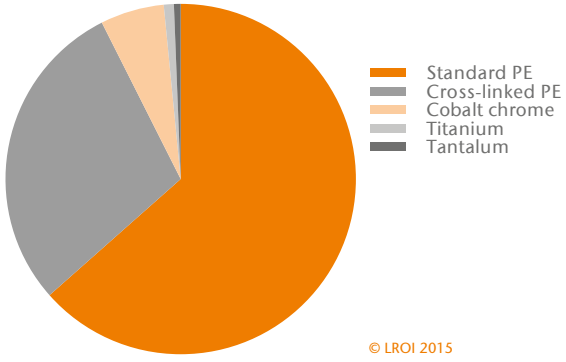


Figure 7.21 Surgical approach for performing a primary total anatomical shoulder arthroplasty per hospital in the Netherlands in 2014 (n=402)



Humeral stem material	Number (n)	Proportion (%)
Titanium	241	74.2
Cobalt chrome	64	19.7
Titanium with a hardened layer	15	4.6
Tantalum	5	1.5

Figure 7.22 Humeral stem component material in primary total anatomical shoulder arthroplasties in the Netherlands in 2014 (n=325).

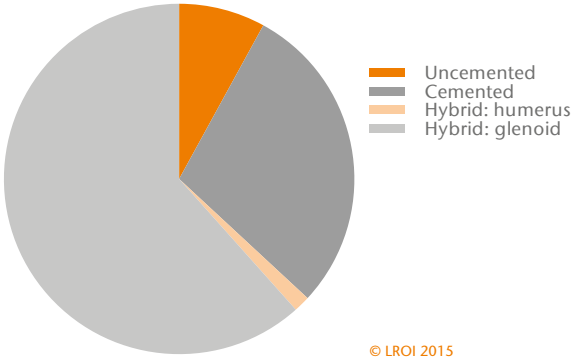


Glenoid component material	Number (n)	Proportion (%)
Standard PE	205	63.5
Cross-linked PE	94	29.1
Cobalt chrome	19	5.9
Titanium	3	0.9
Tantalum	2	0.6

Figure 7.23 Glenoid component material in primary total anatomical shoulder arthroplasties in the Netherlands in 2014 (n=372).
PE: polyethylene.

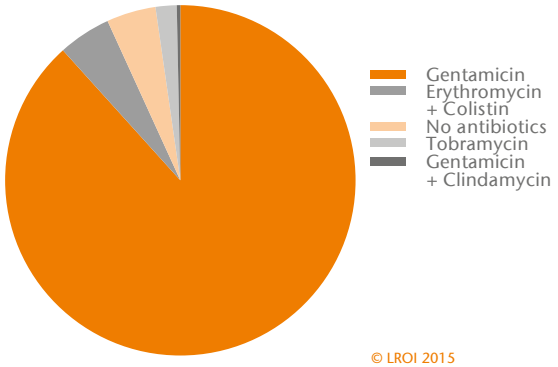
Table 7.6 lists the five most registered humeral stems, humeral heads and glenoid components.

The majority of primary total shoulder arthroplasties (63%) used hybrid fixation, in which mainly glenoid components were cemented (62%). Almost one-third (29%) was fully cemented (Figure 7.24). However, the chosen fixation method varied largely from hospital to hospital (Figure 7.25). Separately packed bone cement components were used in 73% of these procedures and in 27% bone cement was used that was pre-packed in a vacuum mixing system. The bone cement used nearly always (95%) contained antibiotics. This was most often gentamicin (88%) (Figure 7.26). Viscosity of bone cement was generally high (88%) and sometimes medium (10%) in total anatomical shoulder arthroplasties (Figure 7.27). Table 7.7 lists the five most registered types of bone cement that were used in primary total shoulder arthroplasties 2014.



Fixation	Number (n)	Proportion (%)
Uncemented	32	8.0
Cemented	116	28.9
Hybrid: humerus cemented	6	1.5
Hybrid: glenoid cemented	247	61.6

Figure 7.24 Type of fixation in primary total anatomical shoulder arthroplasties in the Netherlands in 2014 (n=401).



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	272	88.3
Erythromycin + Colistin	15	4.9
No antibiotics	14	4.5
Tobramycin	6	2.0
Gentamicin + Clindamycin	1	0.3

Figure 7.26 Antibiotics in bone cement in primary total anatomical shoulder arthroplasties in the Netherlands in 2014 (n=308).

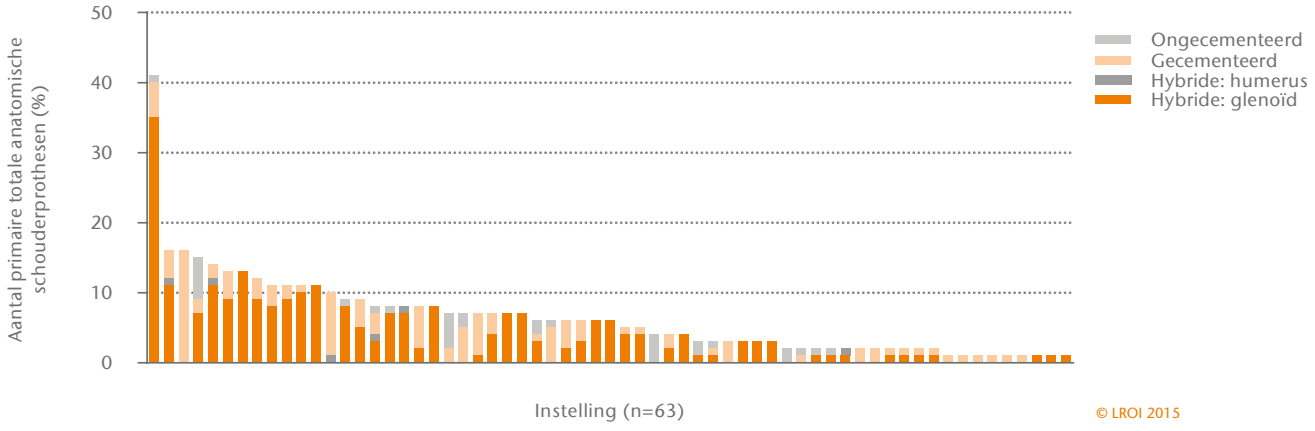


Figure 7.25 Type of fixation in primary total anatomical shoulder arthroplasties per hospital in the Netherlands in 2014 (n=401).

Table 7.6 The five most frequently registered humeral stems, humeral heads and glenoid components in primary total anatomical shoulder arthroplasties performed in the Netherlands in 2014.

Humeral stem (n=339)

Name	Proportion (%)
Global AP	25.7
Aequalis Primair	16.5
Aequalis Press-fit	13
AA Flex (Aequalis Ascend Flex)	8.6
Comprehensive	8.6

Humeral head (n=357)

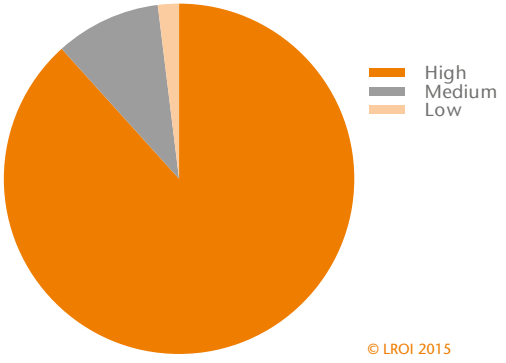
Name	Proportion (%)
Aequalis humerus kop	28.6
Global AP	26.9
Comprehensive	8.4
AA Flex (Aequalis Ascend Flex)	8.1
Simpliciti	6.7

Glenoïdcomponent (n=323)

Name	Proportion (%)
Aequalis Sferisch Glenoid	38.1
Global APG+	29.1
Aequalis Perform Glenoid	9.9
Comprehensive	5.9
Anatomical Shoulder Glenoids	5.9

Table 7.7 The five most frequently registered types of bone cement used during primary total anatomical shoulder arthroplasties in the Netherlands in 2014 (n=308).

Name	Proportion (%)
Palacos R+G	53.2
Refobacin Bone Cement R	16.2
Refobacin Plus Bone Cement	6.5
Cemex	6.2
Simplex ABC EC	4.9



Bone cement viscosity	Number (n)	Proportion (%)
High	272	88.3
Medium	30	9.7
Low	6	1.9

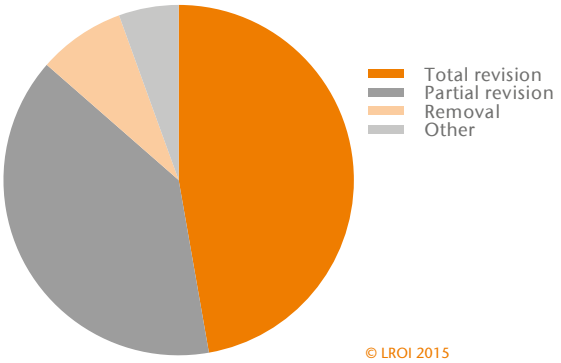
Figure 7.27 Bone cement viscosity in primary total anatomical shoulder arthroplasties in the Netherlands in 2014 (n=308).

7.3 Shoulder revision arthroplasties

Shoulder revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of a shoulder prosthesis. Patients may undergo multiple procedures for one revision. This may be the case when an implant is removed during one surgery due to an infection, and a new prosthesis is implanted during a next surgery. This results in multiple revision arthroplasties, but it still relates to the revision of a single primary prosthesis. Since presently only data on 2014 are registered, we cannot yet link one or more revision procedures to a primary procedure or other revision procedure. Therefore, this chapter does not list patient characteristics.

In 2014, a total of 203 shoulder revision arthroplasties was registered in the LROI. Completeness of the registration of shoulder revision arthroplasties in the LROI is 79% for 2014, based on a comparison to the hospital information system (HIS). 89% of the 203 shoulder revision procedures was performed in general hospitals, 7% in a UMC and 4% in a private hospital. Nearly half (47%) of the registered revision arthroplasties was a total shoulder revision. The revision arthroplasties included 40% partial revisions in 2014 (Figure 7.28). The number of revised components in partial shoulder revision arthroplasties (n=78) varied from 8 glenoid components to 32 glenospheres and 34 humeral liners (Figure 7.29). In 77 revision arthroplasties (38%), a conversion of a shoulder hemiarthroplasty to a total shoulder arthroplasty was performed, and in 8 revision arthroplasties (4%) a conversion was performed from a total arthroplasty to a hemiarthroplasty. Shoulder revision arthroplasties were never amputations in 2014.

The number of shoulder revision arthroplasties varied between hospitals from one revision arthroplasty in 16 hospitals to a minimum of five shoulder revision arthroplasties in ten hospitals, with an outlier of 50 revision arthroplasties in one hospital (median: 3; range: 1-50) (Figure 7.30). The most common reasons for shoulder revision arthroplasties were progressive osteoarthritis (24%), infection (19%) and a cuff rupture (15%) (Table 7.8). Table 7.9 lists the five most registered components in 2014 with respect to shoulder revision arthroplasties. The use of an allograft was registered in 21 (13%) of the shoulder revision arthroplasties.



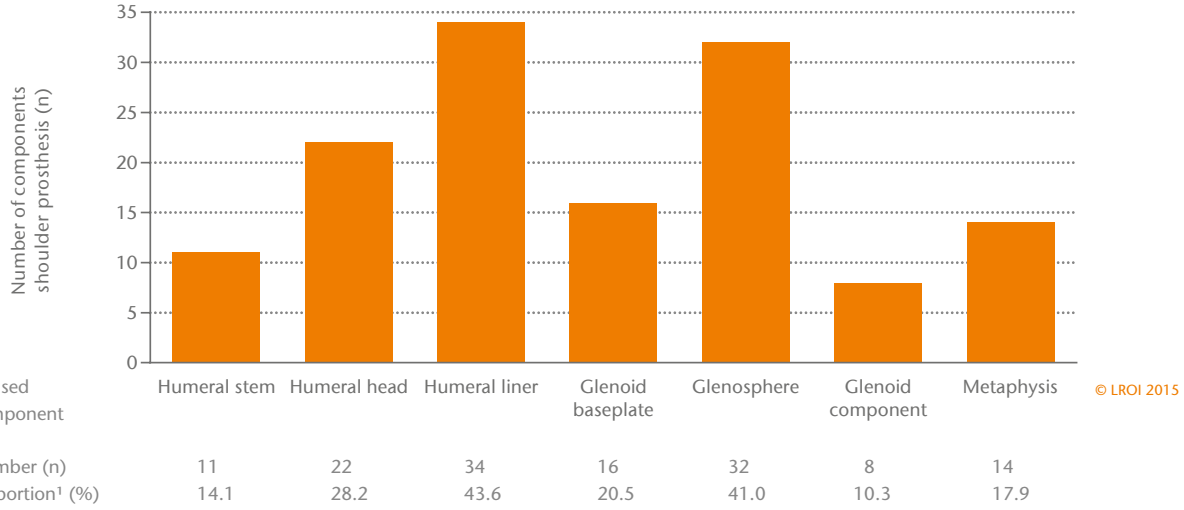
Type of revision	Number (n)	Proportion (%)
Total revision	94	47.2
Partial revision	78	39.2
Removal	16	8.1
Other	11	5.5

Figure 7.28 Type of revision in shoulder revision arthroplasties in the Netherlands in 2014 (n=199).

Table 7.8 Reasons for revision or re-surgery in patients who underwent a shoulder revision performed in the Netherlands in 2014 (n=203).

Reason for revision	Proportion[1] (%)
Progression of osteoarthritis	24.1
Infection	18.7
Cuff rupture	14.8
Cuff arthropathy	12.8
Instability	12.3
Loosening of glenoid component	12.3
Malalignment	11.3
Loosening of humeral component	7.9
Peri-prosthetic fracture	3.0
Other	10.3

[1] A patient may have more than one reason for revision or re-surgery. As such, the total proportion is over 100%.



Revised component	Humeral stem	Humeral head	Humeral liner	Glenoid baseplate	Glenosphere	Glenoid component	Metaphysis
Number (n)	11	22	34	16	32	8	14
Proportion[1] (%)	14.1	28.2	43.6	20.5	41.0	10.3	17.9

Figure 7.29 Revised components in partial shoulder revision arthroplasties in the Netherlands in 2014 (n=78).
[1] More than one component can be replaced during a procedure. As such, the total proportion is over 100%.

Fixation methods for shoulder revision arthroplasties varied considerably. Hybrid fixation was used in 40%, including 15% in which the glenoid was cemented and 25% in which the humerus was cemented. The prosthesis was completely cemented in 22% of shoulder revision arthroplasties (Figure 7.31). In nearly all shoulder revision arthroplasties where bone cement was used, the bone cement contained antibiotics. This was gentamicin in the vast majority of cases (79%) (Figure 7.32). Table 7.10 lists the five most registered types of bone cement used in 2014 with respect to shoulder revision arthroplasties.

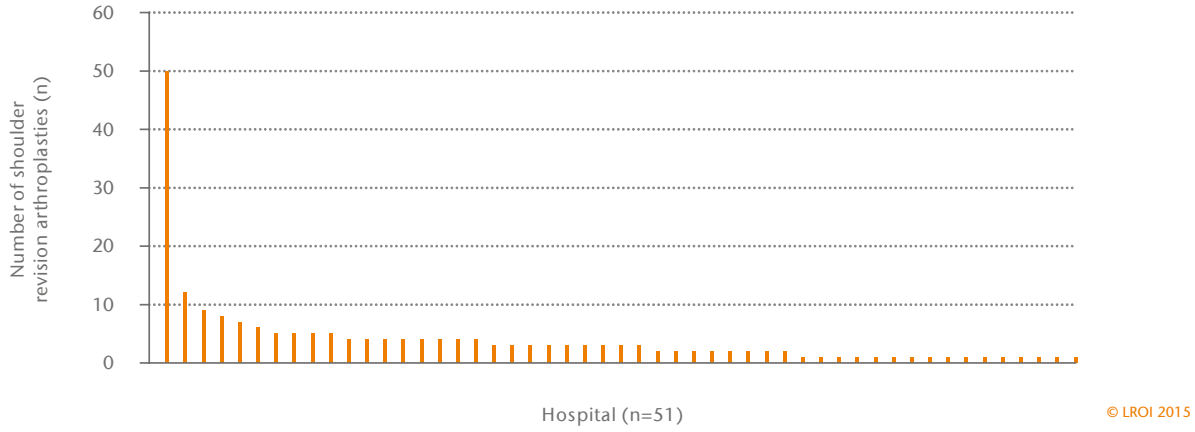
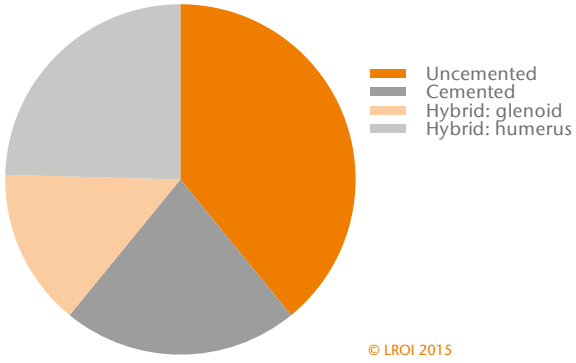
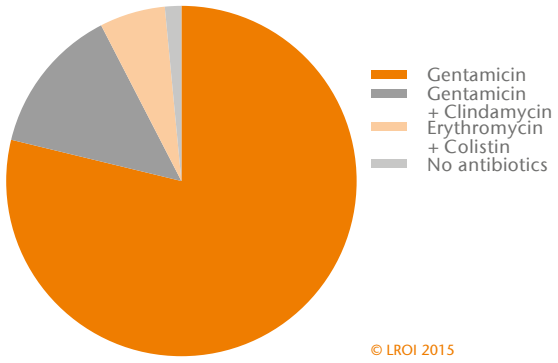


Figure 7.30 Number of shoulder revision arthroplasties per hospital in the Netherlands in 2014 (n=203).



Fixation	Number (n)	Proportion (%)
Uncemented	70	39.1
Cemented	39	21.8
Hybrid: glenoid cemented	26	14.5
Hybrid: humerus cemented	44	24.6

Figure 7.31 Type of fixation in shoulder revision arthroplasties in the Netherlands in 2014 (n=179).



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	52	78.8
Gentamicin + Clindamycin	9	13.6
Erythromycin + Colistin	4	6.1
No antibiotics	1	1.5

Figure 7.32 Antibiotics in bone cement used in shoulder revision arthroplasties in the Netherlands in 2014 (n=66).

Table 7.9 The five most frequently registered humeral stems, humeral heads, humeral liners, glenoid baseplates, glenospheres, glenoid components and metaphyses in shoulder revision arthroplasties implanted in the Netherlands in 2014.

Humeral stem (n=96)		Humeral head (n=53)	
Name	Proportion (%)	Name	Proportion (%)
Delta X-tend	34.4	Aequalis humeruskop	28.3
Aequalis Reversed	18.8	Global AP	26.4
Aequalis Primair	7.3	Sidus Heads	9.4
Comprehensive	6.3	TESS	7.5
Global AP	6.3	Medical Affinis	7.5

Humeral liner (n=94)		Glenoid baseplate (n=71)	
Name	Proportion (%)	Name	Proportion (%)
Delta X-tend	43.6	Delta X-tend	43.7
Aequalis Reversed	25.5	Aequalis Reversed	31.0
Equinoxe	7.4	Equinoxe	8.5
Anatomical Inverse Humeral Poly I	6.4	Comprehensive	5.6
Comprehensive	5.3	Trabecular Metal Baseplate	5.6

Glenosphere (n=94)		Glenoid component (n=25)	
Name	Proportion (%)	Name	Proportion (%)
Delta X-tend	39.4	Aequalis Sferisch Glenoid	36.0
Aequalis Reversed	34.0	Comprehensive	20.0
Equinoxe	7.4	Global APG+	20.0
Comprehensive	5.3	Glenoid	12.0
Affinis Inverse	5.3	Aequalis Perform glenoid	8.0

Metaphysis (n=44)	
Name	Proportion (%)
Aequalis Reversed	45.5
Equinoxe	15.9
Comprehensive	13.6
Anatomical inverse Humeral Cups	11.4
Delta X-tend	9.1

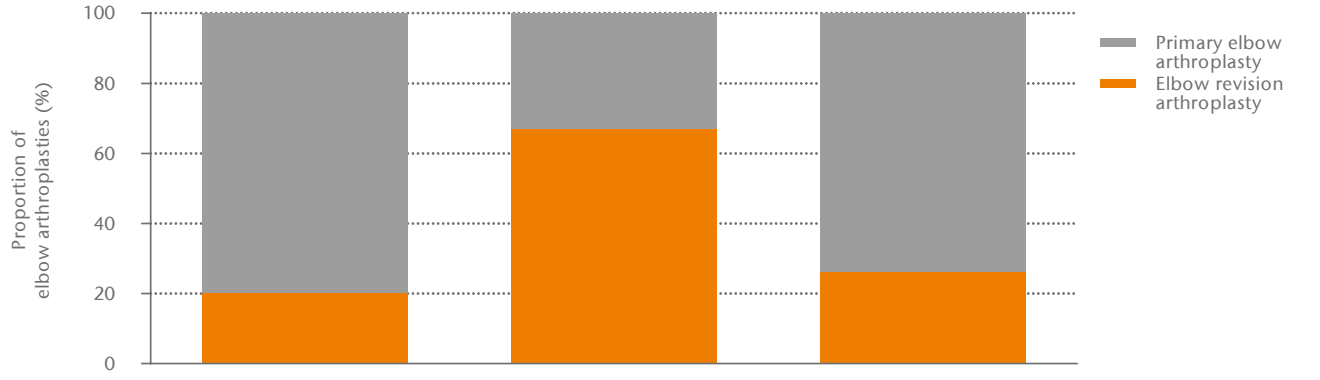
Table 7.10 The five most frequently registered types of bone cement used during shoulder revision arthroplasties in the Netherlands in 2014 (n=66).

Name	Proportion (%)
Palacos R+G	59.1
Refobacin Revision	9.1
Refobacin Bone Cement R	7.6
Simplex ABC EC	6.1
Copal G+C	4.5

8 Elbow arthroplasties

8.1 Trends and associations of primary elbow arthroplasties and elbow revision arthroplasties

In 2014, 145 hospitals registered elbow arthroplasties in the LROI. 107 (74%) were primary elbow arthroplasties and 38 (26%) were elbow revision arthroplasties. Primary elbow arthroplasties were performed in 105 patients. The majority was performed in a general hospital. Two-thirds of elbow arthroplasties that were performed in university medical centres (UMC) were revision arthroplasties (Figure 8.1). Private hospitals did not register elbow arthroplasties. In total, 23 hospitals registered elbow arthroplasties. The total number of elbow arthroplasties varied between hospitals from 1 to 29, with a median of 4 procedures per hospital in 2014 (Figure 8.2).



Type of hospital	General	UMC	Total
Type of procedure			
Primary elbow arthroplasty (%)	79.5	33.3	73.8
Elbow revision arthroplasty (%)	20.5	66.7	26.2
Total (n)	127	18	145

Figure 8.1 Primary elbow arthroplasties and elbow revision arthroplasties (proportion [%] per category) by type of hospital in the Netherlands in 2014.
Please note: Private hospitals did not register elbow arthroplasties for 2014.
General: general hospital; UMC: university medical centre.

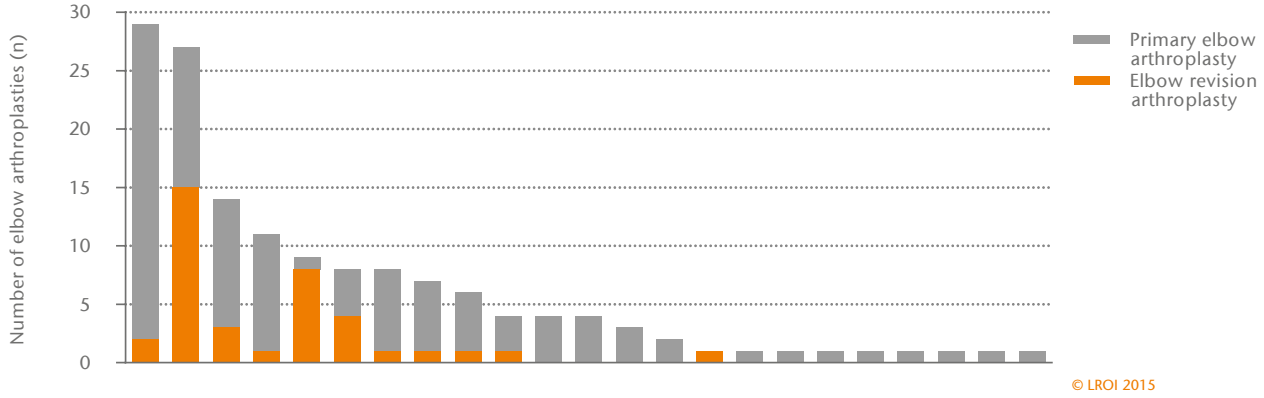


Figure 8.2 Number of primary elbow arthroplasties and elbow revision arthroplasties per hospital in the Netherlands in 2014 (n=145).

8.2 Primary elbow arthroplasties

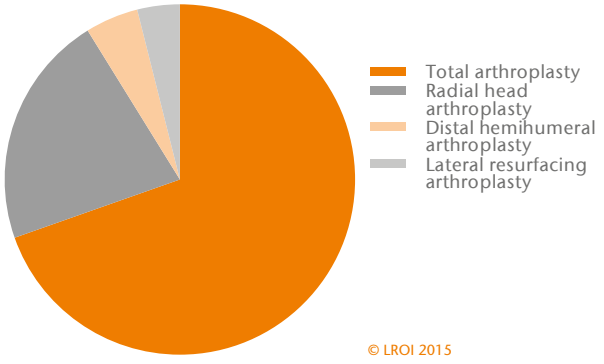
102 primary elbow arthroplasties were registered in 2014. This included 70% total elbow arthroplasties and 22% radial head arthroplasties. Five primary elbow arthroplasties were distal hemihumeral arthroplasties and 4 were lateral resurfacing arthroplasties (Figure 8.3). In 2 primary elbow arthroplasties (2%) the prostheses were implanted bilaterally in 2014.

8.2.1 Demographic data

On average, patients who received primary total elbow arthroplasties (including distal hemihumeral arthroplasties) were 64 years old. Patients who underwent a radial head arthroplasty (including lateral resurfacing arthroplasties) were 51 years old on average. Three quarters were women. The primary diagnosis for having a primary elbow arthroplasty was most often late post-traumatic (31%), followed by rheumatoid arthritis (27%), osteoarthritis (18%) or an acute fracture (18%). Of patients who underwent a total elbow arthroplasty, 11% had ASA score I and 68% had ASA score II. 52% of patients who underwent a radial head arthroplasty had ASA score I and 44% had ASA score II. 21% of all patients who underwent a primary elbow arthroplasty smoked and 70% had overweight. Completeness of registration of primary elbow arthroplasties was 69% (Table 8.1). 43% of patients who underwent primary elbow arthroplasty had undergone previous surgery to the relevant elbow. As such, 31% underwent a lateral arthrotomy before, 21% an osteosynthesis and 18% a posterior arthrotomy. 43% of patients who underwent primary elbow arthroplasty had undergone previous surgery to the relevant elbow (Table 8.2). Of all patients who received a total arthroplasty, 48% had undergone previous surgery, and 36% of patients who received a radial head arthroplasty had undergone previous surgery to the same joint.

8.2.2 Prosthesis characteristics and surgical techniques

Nearly half of the primary elbow arthroplasties in 2014 were performed by means of a lateral approach, of which half was performed laterally without loosening LCL (lateral collateral ligament; 12%) (Figure 8.4). The approach used for performing total elbow arthroplasties (including distal hemihumeral arthroplasties) was in 75% of all cases posterior or triceps-flap, triceps-on, or triceps-split. Radial head arthroplasties (including lateral resurfacing arthroplasties) were nearly always (96%) performed by means of a lateral approach. In seventy per cent of primary elbow arthroplasties cement was used and was performed 22% without the use of cement (Figure 8.5). This also depended strongly on the type of prosthesis, for in 94% of total elbow arthroplasties (including distal hemihumeral arthroplasties) cement was used, when a radial head arthroplasty (including lateral resurfacing arthroplasties) was most often (55%) performed without using cement in 2014. A radial head component was implanted in 12 total elbow arthroplasties. 61% of primary elbow arthroplasties was registered as linked.



Type of elbow arthroplasty	Number (n)	Proportion (%)
Total arthroplasty	71	69.6
Radial head arthroplasty	22	21.6
Distal hemihumeral arthroplasty	5	4.9
Lateral resurfacing arthroplasty	4	3.9

Figure 8.3 Type of primary elbow arthroplasty of patients who underwent a primary elbow arthroplasty in the Netherlands in 2014 (n=102).

Table 8.1 Patient characteristics of all patients with a registered primary elbow arthroplasty by type of primary elbow arthroplasty in the Netherlands in 2014.

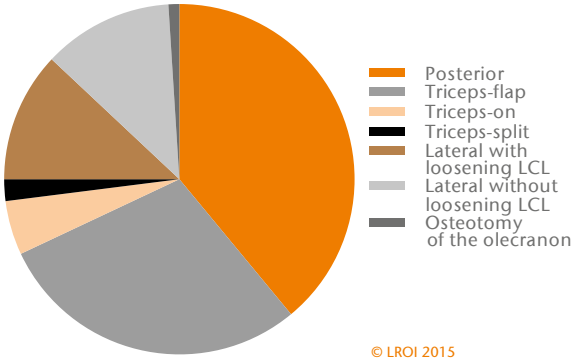
	Total prosthesis[1] (n=75)	Radial head prosthesis[2] (n=25)	Total (n=105)
Completeness (%)			69
Mean age (years) (SD)	6.8 (11.0)	51.4 (11.7)	60.6 (13.0)
Age (years) (%)			
<50	8	44	18
50-59	28	28	27
60-69	39	28	35
70-79	20	0	15
≥80	5	0	5
Gender (%)			
Men	25	28	25
Women	75	72	75
ASA score (%)			
I	11	52	23
II	68	44	60
III-IV	21	4	17
Type of hospital[3] (%)			
General	93	96	94
UMC	7	4	6
Diagnosis (%)			
Late post-traumatic	32	27	31
Rheumatoid arthritis	35	0	27
Osteoarthritis	18	18	18
Acute fracture	9	46	18
Other	6	9	6
Body Mass Index (kg/m²) (%)			
Underweight (≤18.5)	0	4	1
Normal weight (>18.5-25)	28	22	29
Overweight (>25-30)	39	44	39
Obesity (>30-40)	28	26	27
Morbid obesity (>40)	5	4	4
Smoking (%)			
No	76	83	79
Yes	24	17	21

[1] Including distal hemihumeral prostheses.
[2] Including lateral resurfacing prostheses.
[3] In 2014, 19 general hospitals and 3 UMCs implanted primary elbow arthroplasties.
Please note: The type of prostheses is missing in 5 patients who underwent a primary elbow arthroplasty.
General: general hospital; UMC: university medical centre; Private: private hospital; SD: standard deviation.

Table 8.2 Previous surgery to the same joint in patients with primary elbow arthroplasties in the Netherlands in 2014 (n=104).

	Proportion[1] (%)
Previous surgery to the relevant elbow (total)	42.9
Lateral arthrotomy	30.5
Osteosynthesis	21.0
Posterior arthrotomy	18.1
Plate or screw removal	8.6
Medial arthrotomy	5.7
Arthroscopy	5.7
Arthrodesis	1.0
Other	8.6

[1] A patient may have undergone multiple previous surgeries to the same joint. As such, the total proportion is more than 42.9% (proportion of patients with one or more previous surgeries to the same joint).



Surgical approach	Number (n)	Proportion (%)
Posterior	32	39.0
Triceps-flap	29	29.0
Triceps-on	5	5.0
Triceps-split	2	2.0
Lateral with loosening LCL	12	12.0
Lateral without loosening LCL	12	12.0
Osteotomy of the olecranon	1	1.0

Figure 8.4 Surgical approach for performing a primary elbow arthroplasty in the Netherlands in 2014 (n=100).
LCL: Lateral Collateral Ligament.

In most cases (94%) no bonegraft was used. In 4 primary elbow arthoplasties (4%) an autograft was used and in 2 arthroplasties (2%) an allograft was used. The ulnar nerve was either released or moved in 56% of primary elbow arthroplasties.

In over two-thirds of the cases (69%) the humeral components were made of cobalt chrome and 31% were made of titanium. Ulnar components consisted somewhat more often of titanium (41%). Radial head components were always made of cobalt chrome. Radial stem components were made of cobalt chrome in 88% of the cases, 12% were made of titanium. Table 8.3 lists the three most registered total elbow arthroplasties (including distal hemihumeral arthroplasties) and radial head arthroplasties (including lateral resurfacing arthroplasties) in 2014.
Nearly all primary elbow arthroplasties that were performed with cement used bone cement with antibiotics (97%). This was

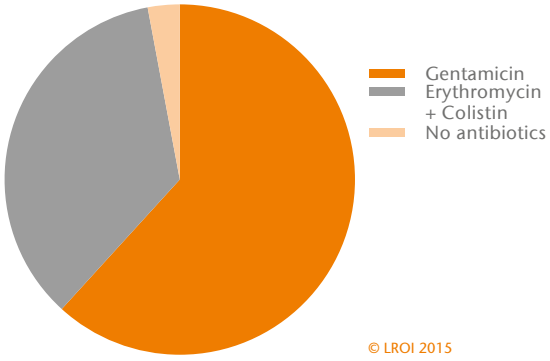
Table 8.3 The three most frequently registered total elbow arthroplasties (including distal hemihumeral arthroplasties) and radial head arthroplasties (including lateral resurfacing arthroplasties) in primary elbow arthroplasties in the Netherlands in 2014.

Total elbow arthroplasties[1] (n=49)		Radial head arthroplasties[2] (n=21)	
Name	Proportion (%)	Name	Proportion (%)
Latitude	32.7	RHS	76.2
Latitude EV	32.7	Explor	14.3
iBP elbow	20.4	Lateral Resurfacing Elbow	9.5

Please note: A total of 71 total elbow arthroplasties and 5 distal hemihumeral elbow arthroplasties were registered.
Only 49 humeral components were registered for these types of elbow arthroplasties.
Please note: A total of 22 radial head arthroplasties and 4 lateral resurfacing elbow arthroplasties were registered. Only 21 radial head components were registered for these types of elbow arthroplasties.
[1] Including distal hemihumeral prostheses.
[2] Including lateral resurfacing prostheses.

Table 8.4 The five most frequently registered types of bone cement used during cemented or hybrid fixated primary elbow arthroplasties in the Netherlands in 2014 (n=68).

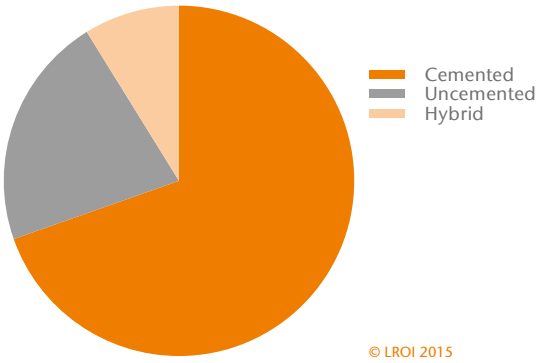
Name	Proportion (%)
Palacos R+G	44.1
Simplex ABC EC	35.3
Refobacin Bone Cement LV	7.4
Refobacin Bone Cement R	7.4
Palacos LV+G	2.9



Bone cement antibiotics	Number (n)	Proportion (%)
Gentamicin	42	61.8
Erythromycin + Colistin	24	35.3
No antibiotics	2	2.9

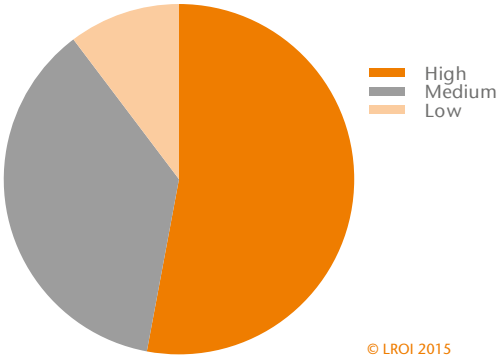
Figure 8.6 Antibiotics in bone cement in cemented or hybrid fixated primary elbow arthroplasties in the Netherlands in 2014 (n=68).

most often (62%) gentamicin (Figure 8.6). Viscosity of cement was high in over half of the cases (53%) and it was low in ten per cent of the cases (Figure 8.7). By far the most used type of bone cement (96%) were separately packed components, so not pre-packed in a vacuum mixing system. Table 8.4 lists the most commonly types of bone cement used in 2014.



Fixation	Number (n)	Proportion (%)
Uncemented	71	69.6
Cemented	22	21.6
Hybrid: humerus cemented	9	8.8

Figure 8.5 Type of fixation in primary elbow arthroplasty in the Netherlands in 2014 (n=102).



Bone cement viscosity	Number (n)	Proportion (%)
High	36	52.9
Medium	25	36.8
Low	7	10.3

Figure 8.7 Bone cement viscosity in cemented or hybrid fixated primary elbow arthroplasties in the Netherlands in 2014 (n=68).

8.3 Elbow revision arthroplasties

Elbow revision arthroplasty is defined as any change (insertion, replacement and / or removal) of one or more components of the elbow prosthesis. Patients may undergo multiple procedures for one revision. This may be the case when an implant is removed during one surgery due to an infection, and a new prosthesis is implanted during a next surgery. This results in multiple revision arthroplasties, but it still relates to the revision of a single primary prosthesis. Since presently only data on 2014 are registered, we cannot yet link one or more revision procedures to a primary procedure or other revision procedure. Therefore, this chapter does not list patient characteristics.

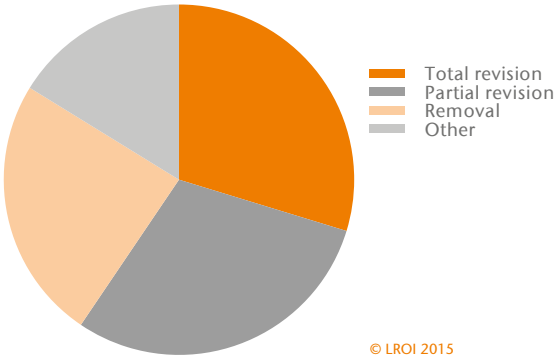
In 2014, 38 elbow revision arthroplasties were registered. Completeness of the registration of elbow revision arthroplasties in the LROI is 75% for 2014, based on a comparison to the hospital information system (HIS). 11 of these arthroplasties were total revisions and 11 elbow revision arthroplasties were partial revisions. In 9 arthroplasties, the prosthesis was removed (Figure 8.8). The most registered humeral component in elbow revision arthroplasties was Latitude EV (n=5). The most registered radial head component was RHS (n=4). Six elbow revision arthroplasties (24%) were performed without cement in elbow revision arthroplasties. The ulnar component was revised in 7 partial revisions, in 2 cases it was the humeral component and in just as many cases it was a revision of the radial head component (Figure 8.9).

None of the elbow revision arthroplasties pertained to arthrodesis or amputation. In 4 cases it pertained to a flail elbow and in 3 cases to a conversion into a total elbow arthroplasty. The most common reason for revision was metallosis, followed by infection (Table 8.5).

Table 8.5 Reasons for revision or re-surgery in patients who underwent an elbow revision arthroplasty in the Netherlands in 2014 (n=38).

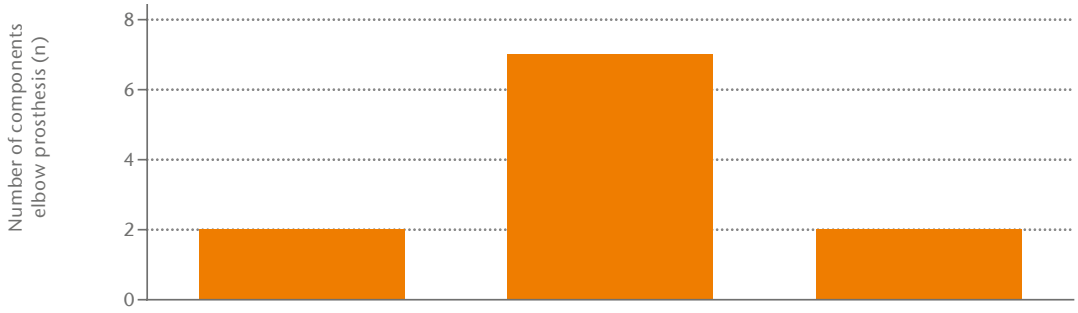
Reason for revision	Proportion[1] (%)
Metallosis	28.6
Infection	25.0
Loosening of ulnar component	14.3
Polyethylene wear	13.9
Loosening of radial head component	11.4
Instability	8.6
Peri-prosthetic fracture	6.7
Loosening of humeral component	5.7
Other	12.5

[1] A patient may have more than one reason for revision or re-surgery. As such, the total proportion is over 100%.



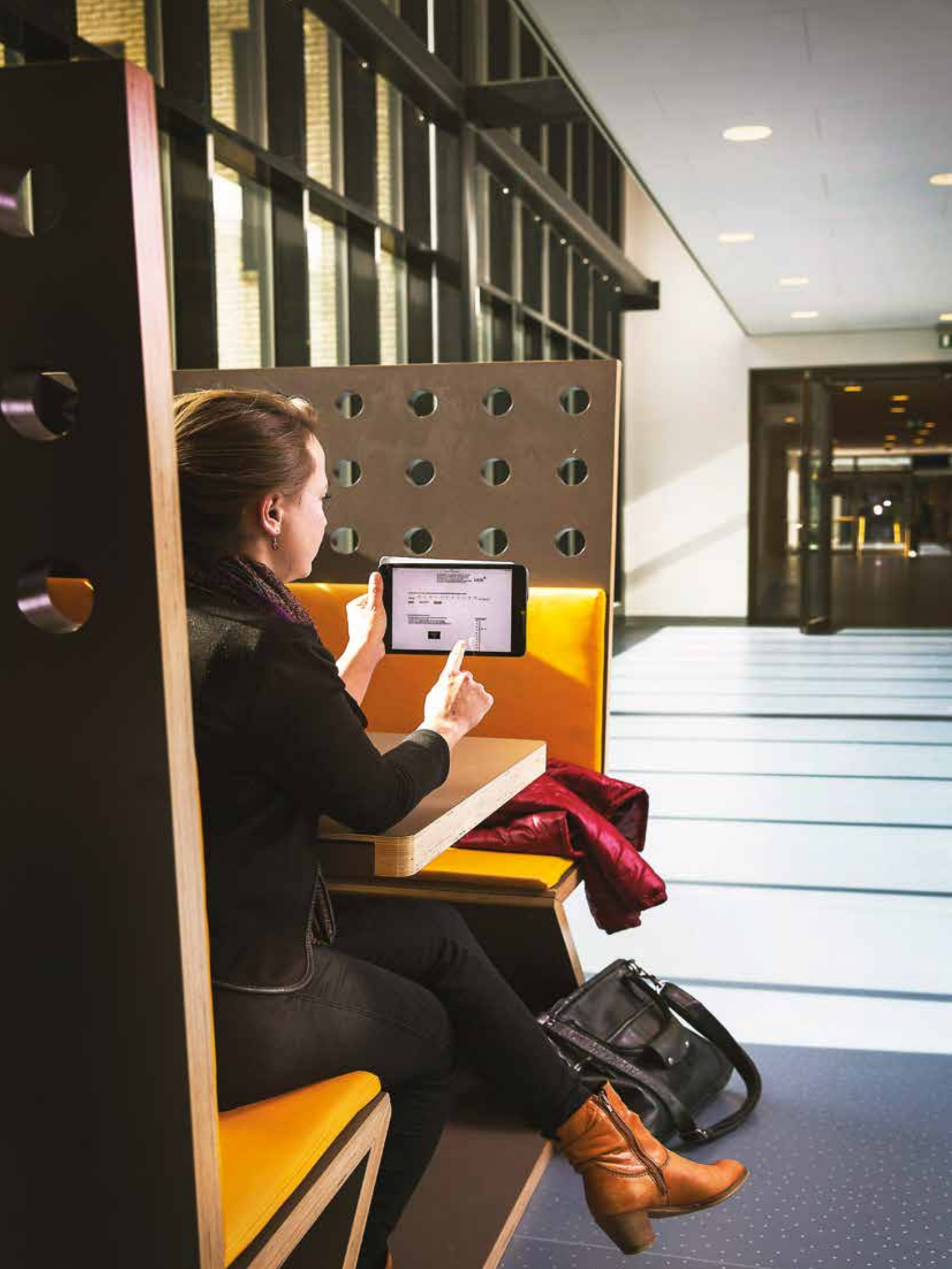
Type of revision	Number (n)	Proportion (%)
Total revision	11	29.7
Partial revision	11	29.7
Removal	9	24.3
Other	6	16.2

Figure 8.8 Type of revision in elbow revision arthroplasties in the Netherlands in 2014 (n=37).



Revised component	Humerus	Ulna	Radial head
Number (n)	2	7	2
Proportion[1] (%)	18.2	63.6	18.2

Figure 8.9 Revised components in partial elbow revision arthroplasties in the Netherlands in 2014 (n=11).
[1] More than one component can be replaced during a procedure.



9 New developments in the LROI

The LROI registration is a registration that is never at a standstill and always in development. With support of LROI's executive board, LROI's scientific advisory board and LROI's head office many valuable developments took place in and around registration. This chapter lists the key developments.

9.1 Transit to new system

In 2015, the LROI started to optimize registration in the LROI. The main purpose was to find a new efficient and practical solution and to integrate the comprehensive LROI in one software system (both input and reporting and dashboard and PROMs). To this end, LROI's executive board investigated what other options were available to host registration in the LROI. In August 2015, the board decided to have this solution hosted by Reports. This software system can meet all LROI's demands and desires and offers a future perspective on further expansion of registration. When this Annual Report was written, the procedure for transit to Reports had commenced. All hospitals will be informed about developments with respect to the transit to a new system. Desires of people that enter data and work with the LROI will be taken into account. These desires will be included in the construction of the new LROI register. It is expected that the final transit to Reports will be achieved by the summer of 2016.

9.2 Patient information, arthroplasty in the picture

Over the past year, all hospitals received the so-called LROI Z card. This foldable map listed information on hip and knee arthroplasties from the 2013 Annual Report. A patient information card will be published alongside the Annual Report this year as well. Information about ankle, shoulder, and elbow arthroplasties will also be included in this year's card. This will allow you to inform your patients to the best of your ability about national data from the LROI.
The LROI also developed a patient letter besides the information card. This patient letter provides information about the arthroplasty that was performed. The hospital can print out the letter with patient and implant specific information after data entry in the LROI, and provide it to their patients. As such, patients will have better insight in the prosthesis that has been implanted into their body.

9.3 Improved LROI legal structure

In order to enhance the structure around the LROI registration and in order to achieve proper agreements about the circumstances in which research may be performed, LROI's legal structure was further improved in 2014 and 2015. Based on new insights and in anticipation of national and international developments in the field of privacy protection, the regulations were further enhanced and the LROI organization has achieved an established scientific framework. In order to have a solid basis for registration, it was also essential to conclude a processing agreement between all Dutch hospitals and the legal entity that administers the LROI database. In addition, a participation agreement was drawn up in which the Dutch hospitals and the LROI have clearly defined limits to the actual use of LROI data.

9.4 First research proposals approved

By enhancing LROI's legal structure it is now possible to use LROI data for research purposes. The first two research proposals have been approved by the LROI executive board on 16 June 2015 after a positive advice was received from the Dutch scientific advisory board. This means that the relevant researchers can now carry out the research proposals and use LROI data in the process.

Both research groups will start working with LROI data in the autumn of 2015. Obviously, the rules that were stipulated in the regulations will be effective and anonymity of patients and all hospitals will be guaranteed at all times.

Those interested in filing LROI research proposals will find more detailed information on LROI's website (www.lroi.nl). Naturally,

it is not necessary to file a research proposal in order to request data of your own hospital.

9.5 Traceability

As was explained in Chapter 2, the LROI sets great store by traceability of joint implants. Since the LROI is a comprehensive collection of all joint arthroplasties that were performed in the Netherlands, LROI's executive board had submitted the register to the Minister of Health, Welfare and Sports (VWS), so that data that have been collected can also be used for the National Implant Register. In case calamities would occur with respect to joint implants, the Health Inspectorate may use the register to determine the impact and what hospitals have implanted the prostheses. This will enable quick location of patients with a specific implant.

9.6 Hip and knee quality indicators

In 2014, quality indicators of hip and knee arthroplasties were offered to Zorginstituut Nederland (ZIN) for the first time by care providers, care insurers and patients. Pre-determined indicator sets offer an advantage, since no extra consultation of individual care insurers is required. This year, the indicator portal in the LROI dashboard could be used for the first time. This indicator portal enabled all hospitals to monitor, approve and submit their quality indicators to the ZIN. An added benefit of the indicator portal is that variables are automatically provided from the LROI. All hospitals that perform hip and knee arthroplasties have submitted the quality indicators by means of the indicator portal. An excellent result was achieved.

9.7 Increased insight in orthopaedic results

As you may have read last year, the LROI has linked patient death dates – if any – to the register. After careful verification of the accuracy of these dates, the survival and revision percentage of arthroplasties can be determined. As such, we are now able to calculate the revision percentage within 1 year. By displaying this percentage graphically by hospital on the LROI dashboard, the insight in the results of a hospital will increase considerably. New reports will continuously be added to LROI's dashboard so that hospitals can compare their own performance to that of other hospitals.

Appendix Participating hospitals in the LROI

Table 1 General hospitals that registered in the LROI in 2014

Admiraal de Ruyter Ziekenhuis H K A S E	Orthopedie Groot Eindhoven H K S
Albert Schweitzer Ziekenhuis H K S	Refaja Ziekenhuis H K S EL
Alrijne Ziekenhuis, location Diaconessenhuis Leiden H K S	Reinier de Graaf Gasthuis H K S
Alrijne Ziekenhuis, location Rijnland Ziekenhuis H K S	Rivas Zorggroep, Beatrixziekenhuis H K S
Amphia Ziekenhuis H K A S	Rode Kruis Ziekenhuis H K S
Antonius Ziekenhuis H K S	Röpcke Zweers Ziekenhuis H K S
Atrium Medisch Centrum H K S E	Scheper Ziekenhuis H K S
BovenIJ Ziekenhuis H K S	Sint Anna Ziekenhuis H K S
Bravis Ziekenhuis, location Bergen op Zoom H K A S E	Sint Antonius Ziekenhuis H K S
Bravis Ziekenhuis, location Roosendaal H K S	Sint Elisabeth Ziekenhuis H K S E
Bronovo Ziekenhuis H K	Sint Franciscus Gasthuis H K S E
Canisius-Wilhelmina Ziekenhuis H K S	Sint Jans Gasthuis H K S E
Deventer Ziekenhuis H K S	Sint Lucas-Andreas Ziekenhuis H K
Diaconessenhuis, Meppel H K S	Sint Maartenskliniek, location Nijmegen H K A S E
Diakonessenhuis, Utrecht H K	Sint Maartenskliniek, location Boxmeer H K S
Elkerliek Ziekenhuis H K A S E	Sint Maartenskliniek, location Woerden H K A S E
Flevoziekenhuis H K	Slingeland Ziekenhuis H K S
Gelre Ziekenhuizen H K S E	Slotervaart Ziekenhuis H K A S
Gemini Ziekenhuis H K S	Spaarne Ziekenhuis H K A S
Groene Hart Ziekenhuis H K S	Spijkenisse Medisch Centrum H K A S
HagaZiekenhuis H K A S E	Streekziekenhuis Koningin Beatrix H K S
Havenziekenhuis H K	Tergooiziekenhuizen H K S E
IJsselland Ziekenhuis H K S E	TweeSteden Ziekenhuis H K S E
Ikazia Ziekenhuis H K S	Van Weel-Bethesda Ziekenhuis H K S
Isala Klinieken H K S	Viecuri Medisch Centrum voor Noord-Limburg H K S
Jeroen Bosch Ziekenhuis H K S	Vlietland Ziekenhuis H K S
Kennemer Gasthuis H K	Waterlandziekenhuis H K S
Langeland Ziekenhuis H K S	Westfries Gasthuis H K A S
Laurentius Ziekenhuis H K A S	Wilhelmina Ziekenhuis H K S
Maasstad Ziekenhuis H K A S E	Zaans Medisch Centrum H K S
Martini Ziekenhuis H K A S E	Ziekenhuis Amstelland H K A
MC Zuiderzee H K S	Ziekenhuis Bernhoven H K S
Meander Medisch Centrum H K S	Ziekenhuis Bethesda H K
Medisch Centrum Alkmaar H K A S E	Ziekenhuis Gelderse Vallei H K S
Medisch Centrum Haaglanden H K A S	Ziekenhuis Nij Smellinghe H K S
Medisch Centrum Leeuwarden H K	Ziekenhuis Rijnstate H K S
Medisch Spectrum Twente H K S	Ziekenhuis Rivierenland H K A S
Ommelander Ziekenhuisgroep H K S	Ziekenhuis Tjongerschans H K S
OCON Orthopedische kliniek H K A S	Ziekenhuis St. Jansdal H K S
Onze Lieve Vrouwe Gasthuis H K A S E	ZorgSaam Zeeuws-Vlaanderen H K S
Orbis Medisch en Zorgconcern H K	

H: hip; K: knee; A: ankle; S: shoulder; E: elbow.

Table 2 University medical centres that registered in the LROI in 2014

Academisch Medisch Centrum H K	Maastricht UMC+ H K A S
Erasmus Medisch Centrum H K S	Radboudumc H K S E
Leids Universitair Medisch Centrum H K A S E	Universitair Medisch Centrum Utrecht H K S
Universitair Medisch Centrum Groningen H K A S E	VU Medisch Centrum H K S

H: hip; K: knee; A: ankle; S: shoulder; E: elbow.

Table 3 Private hospitals that registered in the LROI in 2014

Annatommie H K A S	Medinovakliniek, location Zestienhoven K S
AVE Orthopedische Klinieken H K S	Medisch Centrum Amstelveen H K A
Bergman Clinics H K S	Orthopedie Kliniek K
DC Klinieken Lairesse H K S	Orthopedium H K S
Knee Clinic K	Reinaert Kliniek H K
Medinovakliniek, location Breda H K S	Kliniek ViaSana H K S

H: hip; K: knee; A: ankle; S: shoulder.

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