

# NORDIC ARTHROPLASTY REGISTER ASSOCIATION (NARA) REPORT

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**Participating registries in NARA:**

Danish Hip Arthroplasty Register  
[www.dhr.dk](http://www.dhr.dk)

Danish Knee Arthroplasty Register  
[www.login.procordo.com/php/pages/grp\\_login.php](http://www.login.procordo.com/php/pages/grp_login.php)

Finnish Arthroplasty Register  
[www.thl.fi/far](http://www.thl.fi/far)

Norwegian Arthroplasty Register  
[www.nrlweb.ihelse.net/eng/default.htm](http://www.nrlweb.ihelse.net/eng/default.htm)

Swedish Hip Arthroplasty Register  
[www.shpr.se/en](http://www.shpr.se/en)

Swedish Knee Arthroplasty Register  
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# Introduction

## Nordic Arthroplasty Register Association (NARA)

The Nordic countries, including Denmark, Sweden, Finland, and Norway, have all had a long and successful tradition of arthroplasty registries. Registries are characterized with a high research activity in order to improve the quality of treatment of patients undergoing joint replacement surgery. However, results presented by the Nordic registries suggested differences among the countries related to data collection system, data/variables being collected, data definition, and statistical methods used. Reports from the Nordic registries have further shown differences regarding indication for surgery, characteristics of the joint replacement populations, fixation methods used, and implant survival. Due to these differences, the results from the different Nordic registries have not been fully comparable. Furthermore, although the Nordic registries are population-based, the numbers of patients included in specific populations (e.g., patients that have undergone joint replacement due to rheumatoid arthritis or patients operated due to osteonecrosis) or the number of patients developing specific adverse events after surgery (e.g. revision due to infection or periprosthetic fracture) are relatively small, limiting the statistical precision of risk estimates and possibility to draw valid conclusions.

The Nordic registries have acknowledged these limitations and the need for collaboration across national borders. Thus, the NARA was established in 2007 with the overall aim to improve the quality of our research and our understanding of the clinical course of patients undergoing joint replacement surgery, and thereby enhance our possibility for quality improvement of treatment with joint replacement surgery.

In order to achieve the overall aim of NARA, several specific aims were set. These are summarized below:

- to create one common Nordic minimal dataset, in order to compare demographics and results regarding total joint replacement surgery among countries, and to study results in patient groups which are too small to be studied in each separate country;
- to hold two yearly NARA meetings including two or more representatives from each register;
- to hold an academic seminar at Nordic Orthopaedic Association meeting every other year;
- to promote joint Nordic research where it will be of common interest and higher the quality;
- to cooperate on methods developing in research and quality work in register studies;
- to coordinate a joint Nordic standpoint towards other international register associations.

The NARA steering committee and other representatives from each member country are responsible for overseeing the aims and directing the NARA work.

The NARA project was approved by the Danish Data Protection Agency, J.nr. 2008-41-2024 and 2012-41-0515, and by the Norwegian Social Science Data Services.

## Members of the NARA group

The NARA group consists of people with different academic background, including orthopedic surgeons, epidemiologists, biostatisticians, PhD students, software developers, registry coordinators.

- The Danish Hip Arthroplasty Register
- The Danish Knee Arthroplasty Register

- The Finnish Arthroplasty Register
- The Norwegian Arthroplasty Register
- The Swedish Hip Arthroplasty Register
- The Swedish Knee Arthroplasty Register

In 2015, additional initiatives have been taken in order to establish collaboration between Nordic shoulder arthroplasty registries.

## Purpose of the NARA report

The purpose of this report is to

- provide short description of the NARA common dataset and data management process, as well as statistical analyses used,
- present descriptive data related to demographics and procedure,
- describe validity methods used in NARA,
- present results from the selected projects performed in NARA settings,
- provide the list of published projects based on NARA dataset,
- discuss the current NARA achievements and perspectives on the future.

DOES HEAD SIZE MATTER?



©Swedish Hip Arthroplasty Register

# Material and methods

## Description of NARA common dataset

The NARA dataset include only variables all countries can deliver. It is a dynamic minimal dataset with 25 variables in hip and 20 in knee datasets. Each year a new dataset is made and there is also an ongoing discussion on the variables measurement levels and if other variables should be included or excluded.

The NARA dataset include all primary hip and knee replacement procedures performed in Norway, Denmark, Sweden and Finland since 1995 (for hip procedures) or 1997 (for knee procedures). These years were chosen because registration in Danish registries started in 1995/1997. Primary procedures are linked to revision procedures, if such occurred and are registered in respective national registries. Data are afterwards anonymized and transferred to the common NARA dataset.

Revision procedure is in all countries defined as a surgical procedure including removal, exchange or insertion of any component(s). The variables and their labels are defined in the latest version of “Description of the NARA data hip file v7” and “Description of the NARA data knee file v8”. These descriptions are available after contact to Anne Marie Fenstad via [anne.marie.fenstad@helse-bergen.no](mailto:anne.marie.fenstad@helse-bergen.no).

## Statistical analyses

The NARA group has published statistical guidelines for analysis of arthroplasty data in registers. Assuming that guidelines play an equally important role in improvement of the reliability and the value of registry



research, the NARA study group decided at a meeting in Lund, Sweden, in September 2009, to develop such statistical recommendations.

The guidelines are divided into two parts, one with an introduction and a discussion of the background to the guidelines, and one with a more technical statistical discussion on how specific problems can be handled. The first part contains (a) recommendations for the interpretation of methods used to calculate survival, (b) recommendations on how to deal with bilateral observations, and (c) a discussion of problems and pitfalls associated with analysis of factors that influence survival or comparisons between outcomes extracted from different hospitals (1).

The second part is addressing methodological issues. The sections include recommendations about (a) competing risk problems, (b) detecting and handling departures from the proportional hazards assumption, (c) bilateral observation, and (d) revision rate ranking (2).

The projects performed in NARA settings using NARA dataset have in large extent applied these statistical methods. The group is continuously working on improvement of statistical methods and application of new ones, including propensity score matching method in order to reduce confounding, the multiple imputation method which deals with missing data problem, the Pseudo Value Approach when taking death as a competing risk into account in order to assess the relative risk etc. For further knowledge on statistical methods used in NARA and our experience with the same, please contact members of NARA group or download publications from PubMed.

# Main results

## NARA datasets – Numbers of operations

### NARA-hip dataset

NARA-hip dataset includes currently 620,261 primary hip arthroplasty operations performed in the period from 1995 to 2013 (Table 1). 40% of the hip operations are performed in Sweden, whereas equal proportion of operations is coming from each of the other three countries.

### NARA – knee dataset

NARA-knee dataset includes currently 390,525 primary knee arthroplasty operations performed in the period from 1997 to 2012 (Table 2). 38% of the knee operations are performed in Sweden, whereas only 12.5% of knee operations are performed in Norway.

## NARA datasets – Demographics

### Age

The majority of hip patients were 55–74 years of age at the time of operation, whereas 31.4% were older than 75 years of age (Table 3). The majority of knee patients were 55–74 years of age at the time of operation, whereas 29.5% were older than 75 years of age (Table 3).

### Diagnosis

Approximately 79.5% of hip patients were operated due to primary osteoarthritis followed by hip fracture accounting for 9.4% of all hip patients (Table 4). However, there are some differences between countries. In Norway childhood disease counts for close to 10% of the hip diagnoses,

whereas in the three other countries there are only 1 to 3%. Hip fractures are less common in Finland with 3% of the hip diagnosis, whereas the other three are 10% and above. Femoral head necrosis is more common in Denmark and Sweden.

Approximately 89.5% of knee patients were operated due to primary osteoarthritis out of all knee patients registered in NARA-knee dataset (Table 4).

**Table 1.** Numbers of primary hip arthroplasty operations per country and the proportion of operations performed in men.

Country	Primary operations, 1995–2013	% of total	% of men per country
Denmark	129,693	20.9	42.2
Norway	121,260	19.5	32.0
Sweden	250,134	40.3	40.6
Finland	119,174	19.2	42.6
Total	620,261	100	39.6

**Table 2.** Numbers of primary knee arthroplasty operations per country and the proportion of operations performed in men.

Country	Primary operations, 1997–2012	% of total	% of men per country
Denmark	78,911	20.2	38.4
Norway	48,759	12.5	34.6
Sweden	149,808	38.4	39.4
Finland	113,047	28.9	32.3
Total	390,525	100	36.5

**Table 3.** Age distribution of the hip and knee population in NARA dataset.

	NARA-hip dataset (1995–2013)	NARA-knee dataset (1997–2012)
Age groups	N (% of the total)	N (% of the total)
<45 years	18,167 (2.9)	4,655 (1.2)
45–54 years	49,197 (7.9)	27,297 (7.0)
55–74 years	358,323 (57.8)	243,451 (62.3)
>=75 years	194,574 (31.4)	115,122 (29.5)
Total	620,261 (100%)	390,525 (100%)

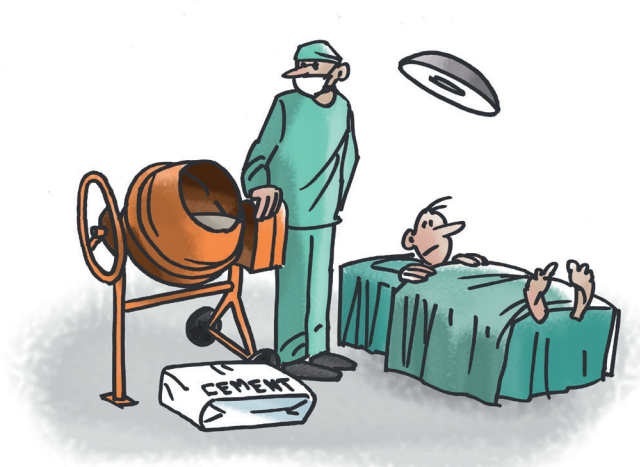
**Table 4.** Distribution of hip and knee diagnosis for primary hips operated in the period 1995–2013 and knees operated in 1997–2012.

	N (% of the total)
Hip diagnosis	
Primary osteoarthritis	493,009 (79.5)
Inflammatory arthritis	19,343 (3.1)
Hip fracture	58,142 (9.4)
Childhood diseases	21,061 (3.4)
Femoral head necrosis	13,741 (2.2)
Others	13,854 (2.2)
Missing	1,111 (0.2)
Total	620,261 (100%)
Knee diagnosis	
Osteoarthritis	349,658 (89.5)
Rheumatoid arthritis	15,432 (4.0)
Others	24,589 (6.3)
Missing	846 (0.2)
Total	390,525 (100%)

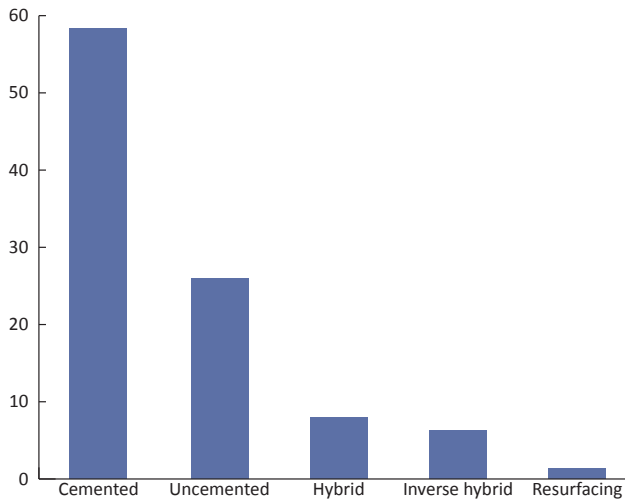
### Type of fixation

In the entire NARA-hip dataset, cemented fixation is the most common used fixation accounting for almost 60% of operations (Figure 1). Again, differences between countries are obvious. In Denmark the hybrid technique is used in more than 20% of the hip operations, whereas in Norway inverse hybrid counts for 15%. The uncemented technique counts for almost 50% of the hip operations in Denmark and Finland, whereas the cemented technique counts for 80% in Sweden and 65% in Norway. The vast majority of knee arthroplasty patients received implant with cemented fixation (Figure 2).

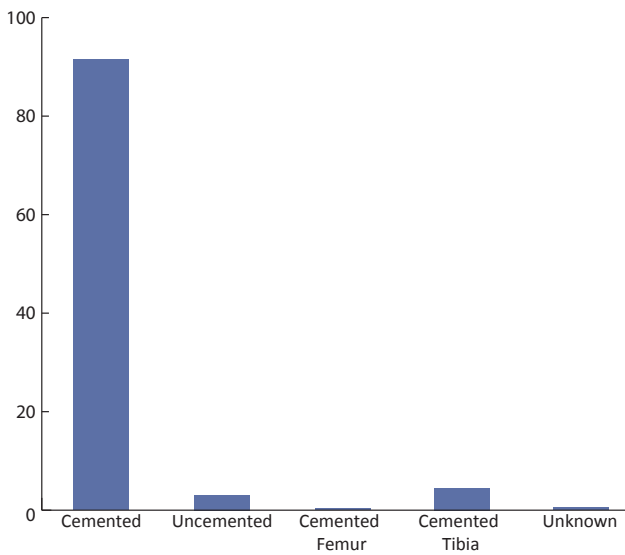
### WHY CEMENTED FIXATION?



©Swedish Hip Arthroplasty Register



**Figure 1.** Distribution (1995–2013) of type of fixation for the hip arthroplasties.



**Figure 2.** Distribution (1997–2012) of type of fixation for the knee arthroplasties

### Prosthetic concepts

A variety of different components has been used (Table 5 and 6). For further information about prosthetic concepts please see the latest annual reports from respective countries which can be found on websites included in the following tables.

**Table 5.** Most frequently used components registered in NARA-hip dataset by country 1995–2013

	5 most frequent acetabular components (N) used in four Nordic countries in the period 1995–2013		5 most frequent femur components (N) used in four Nordic countries in the period 1995–2013	
Denmark	Trilogy	29,549	Bimetric	31,071
	Lubinus	11,543	Exeter	21,775
	Pinnacle	11,328	Corail	13,230
	Durom	7,879	Lubinus SP II	12,463
	Mallory-Head	7,730	CPT	7,100
Norway	Charnley	26,875	Corail	26,647
	Reflection cemented	14,009	Charnley	25,143
	Marathon	10,663	Exeter	19,750
	Exeter	10,019	Spectron EF Primary	10,582
	Elite	6,806	Titan	8,505
Sweden	Lubinus	84,002	Lubinus SP II	102,302
	Charnley	19,706	Exeter Polished	50,945
	Charnley Elite	15,281	Charnley	15,113
	Exeter Duration	12,779	Spectron EF Primary	11,693
	ZCA XLPE	12,576	CLS Spotorno	9,811
Finland	Contemporary	12,848	Exeter	24,245
	Recap	7,734	Biomet collarless	21,669
	Pinnacle	6,576	Lubinus SP II	9,730
	Reflection cemented	6,285	Spectron EF Primary	6,709
	Biomet Vision	6,046	Summit	6,661

**Table 6.** Most frequently used components registered in NARA-knee dataset by country 1997–2012

	5 most frequent femur components (N) used in four Nordic countries in the period 1997–2012		5 most frequent tibia components (N) used in four Nordic countries in the period 1997–2012	
Denmark	PFC	26,921	PFC	21,424
	AGC	13,754	Oxford	11,416
	NexGen	13,610	NexGen	13,014
	Oxford	5,161	AGC	14,051
	Vanguard	4,517	Advance	2,080
Norway	Profix	13,515	Profix	13,509
	LCS Complete	9,588	LCS Complete	9,541
	LCS	4,687	AGC	4,571
	AGC	4,579	Oxford Uni III	4,545
	Oxford Uni III	4,547	LCS	4,366
Sweden	NexGen	37,142	NexGen	37,142
	PFC Sigma	35,863	PFC Sigma	35,863
	AGC	20,178	AGC	20,178
	Duracon	9,669	Duracon	9,669
	Free-Sam MIII	8,159	Free-Sam MIII	8,159
Finland	Triathlon CR	22,208	Triathlon CR	22,208
	Duracon	16,807	Duracon	16,807
	NexGen CR	13,352	NexGen CR	13,352
	PFC Sigma	12,929	PFC Sigma	12,929
	AGC V2	8,335	AGC V2	8,335



## Validity methods used in NARA

The Nordic countries are world leading in the field of International Quality Registers. The results derived from Nordic hip and knee registries are frequently cited in the international literature and considered to be “role models” for the efforts to initiate similar registries in other countries. Key points for national registries to have success in these countries are:

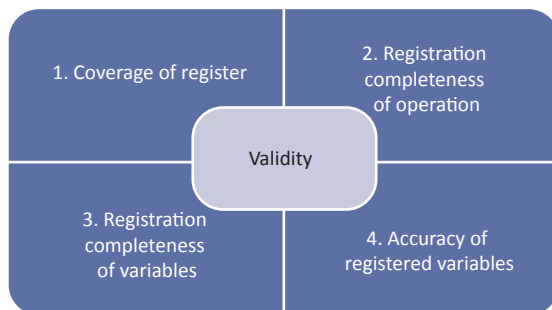
- “Small” country – 4.5 to 10 million inhabitants
- Uniform health care system
- Long traditions of nationwide registry
- High data quality due to regular validation processes
- Uniform unique personal ID-systems
- It is possible to follow up all patients registered in National Arthroplasty Register to their death, emigration or reoperation
- 100% unambiguous linkage of the index operation to all types of complications and outcomes
- Ability to link the database to all other national quality registries and to registries such as National Patient Registries, National Cancer Registries, National Registries for Socioeconomic data, National Prescription database etc.

Validity of registries is one of the most important tasks which each national registry are continually working with. The validity consists of four major aspects (Figure 3), including:

1. Coverage of registries is defined as the proportion of hospitals/ departments contributing to registration in the national register out of the total number of hospitals/departments performing the hip and knee procedures in the country.
2. Registration completeness of operations in a register is defined as the proportion of hip or knee operations registered in the register

out of the total number of hip operations performed in the country. Registration completeness is also called sensitivity.

3. Registration completeness of variables: Although operation may be reported in the register, it is further important that all variables included in the registration form are reported for each operation.
4. Further, it is not only important that all variables are reported in the register for each operation, but also that the values of these variables are accurately reported. Accuracy of registered variables is defined as probability that variable registered in the national register is correctly registered and present what is supposed to present. Accuracy is also called positive predictive value.



**Figure 3.** Four major aspects of validity.

**Denmark:** All orthopedic departments in Denmark are reporting to the Danish Hip and Knee Arthroplasty register (DHR/DKR), including private hospitals. Thus, coverage is 100%.

The registration completeness of hip or knee procedures in the DHR and DKR is compared with the registration completeness in the Danish National Registry of Patients (DNRP), which is considered as the gold standard. The registration completeness is carried out in relation to annual reports, and it is on individual level. Further, these analyses

are improved due to availability of laterality codes in both DHR/DKR and DNRP: Specific NOMESCO procedure codes are used to identify hip and knee procedures in the DNRP. The registration completeness was more than 95% for primary hip procedures and more than 90% for revision hip procedures in the latest annual DHR report 2015. The registration completeness of knee procedures reported in the latest annual DKR report 2015 is 97%.

Following equation is used in Denmark:

$$\frac{\text{Number of arthroplasties in DHR (DKR)} \times 100\%}{\text{Number of arthroplasties in DHR (DKR) and / or DNRP}}$$

In relation to annual reports, both DHR and DKR evaluate the completeness of procedures, variables as well as accuracy of variables. Missing variables are identified and efforts are made to re-collect these data. Several projects have been validating different variables in the Danish joint registries, including the validity of primary diagnosis for hip joint procedure, validity of revisions due to infection and development of algorithm to identify all revisions due to infection using multiple data sources.

**Norway:** All hospitals operating hip and knee arthroplasties report to the Norwegian Arthroplasty Register (NAR), thus the coverage is 100%. The completeness of operations is calculated on an individual level using the following formula:

$$\frac{(\text{Only NAR} + \text{Registered in both registries})}{(\text{Only NPR} + \text{Only NAR} + \text{Registered in both registries})}$$

The completeness compared with the National Patient Register (NPR) was 96.6% for primary hip and 95.3% for primary knee operations in 2008-12 and 88.3% for hip revisions and 88.9 for knee revisions in the same period. These analysis are repeated every second year and presented in the annual report.

Registration completeness of variables is reported back to each department every year. Studies of accuracy of different variables have been performed.

**Sweden:** Annual validation processes for Swedish Hip Arthroplasty Register

1. A decentralized web-based data capture system. Added to this are system developed archetypes, logistics that control the personal ID-number, op site, sex, age, primary and secondary intervention etc. This web site includes an updated database with catalogue numbers of all used implants in Sweden.
2. Every year before the annual report, each department receives a list of primary and secondary interventions. The units are asked to check this list with their local patient administrative system and return the results.
3. Annually we link our database with the NPR (National Patient Registry at the National Board for Health and Welfare) and this as well as all registries at the Board are based on the same and unique personal id number. As a result we obtain “completeness” for each department which we publish in our annual report.
4. We use, in targeted annual validation studies, other national registries at the Board such as Prescribed Drug Registry, Cause of Death Registry etc. At the moment two such studies are conducted – the incidence and registration of infection and periprosthetic cases
5. All medical records regarding reoperations are copied and sent to the register coordinators in Gothenburg. They extract a number of additional variables from each reoperation and control the primary operation, laterality and operation date and control catalogue number on the implant.
6. We started three years ago a monitoring system by site visits at local units. In this system we compare the medical records and local patient administrative systems with our database. So far we have

visited 16 of 79 units but plan to visit all – an expensive but a fairly exact validation process.

7. Internal validation process performed annually by 2–3 different statisticians.

**Sweden:** Validation processes for the Swedish Knee Arthroplasty Register.

Together with the annual report the contact surgeons (one at each hospital) are sent lists containing the IDs of patients and compilations of surgeries reported by their hospital the previous year. These are to be compared with hospital records to make certain that all procedures have been reported.

Since 2007, the Swedish Knee Arthroplasty Register (SKAR) has been annually compared against the NPR, an inpatient register of the health authorities based on ICD and NOMESCO coding. Both registers are based on personal ID's carried by every inhabitant and which facilitates the work.

The true total number of procedures is considered to be the combined number found in both registers and the completeness is estimated being the proportion of the total number in each of the registries.

During the latest comparison (for 2013) the SKAR was found to capture 97.2% of the total number admissions (the NPR 97.3%) but since 2007 the annual capture has been between 96.3% and 97.7%. The results are disclosed in the annual report on hospital level.

Additionally, the SKAR validates results by visiting between 5–10 hospitals annually. Hospital staff is asked to gather information on 25 consecutive knee arthroplasty surgeries from a specific date. During the visit, hospital and SKAR representatives go through the medical records and check if the surgeries have been reported and if the information in the records is the same as was reported to and registered in the SKAR

database. Hitherto 28 hospitals have been visited indicating at least as good completeness as found by the NPR and a very high validity of the information in the register.

**Finland:** Registration completeness is defined as the proportion of hip and knee procedures registered in the national register (FAR) out of the total number of hip and knee procedures performed in the country, identified in the Hospital Discharge Register.

Several validation studies has been performed and published in each country estimating the completeness and accuracy of registration of diagnosis, surgery date, laterality, fixation type (3–6). In addition, validation results can be found in annual reports.

## Examples and results from the selected projects performed in NARA settings

### 1. Focus on fixation methods

Pedersen AB et al. reported that “uncemented implants perform better in relation to long-term risk of aseptic loosening, whereas both uncemented and hybrid rather than cemented implants in patients younger than 55 years had more short-term revisions because problems due to dislocation, periprosthetic fracture and infection has not yet been completely solved.” (7).

Keijo T. Mäkelä et al. found that “the survival of cemented implants for total hip replacement was higher than that of uncemented implants in patients aged 65 years or older. The increased use of uncemented implants in this age group is not supported by these data.” (8).

### 2. Focus on revision due to infection

Dale H et al. found “increased relative risk of revision and increased cumulative 5-year revision rates due to infection after primary THA

during the period 1995–2009. No change in risk factors in the NARA dataset could explain this increase. The authors believe that there has been an actual increase in the incidence of prosthetic joint infections after THA.” (9).

### **3. Focus on periprosthetic fractures**

Thien TM et al. observed that “the risk for revision due to early periprosthetic fracture increased during the 2003 to 2009 period compared with the 1995 to 2002 period both before and after adjustment for demographic factors and fixation (relative risk, 1.44 [95% confidence interval, 1.18 to 1.69];  $p < 0.0005$ ). (10). Uncemented implants had more periprosthetic fracture than cemented, especially in the old age groups. Differences within the implants were reported.”

### **4. Focus on hip diagnosis**

Engesaeter LB et al. observed “no difference in risk of revision between primary THAs performed due to pediatric hip diseases and those performed due to primary OA after adjustment for differences in age, sex, and type of fixation of the prosthesis” (11).

Schrama JC et al. found “a slightly higher overall risk of revision for infection in Rheumatoid Arthritis patients than in Osteoarthritis patients, but the difference was only present after 2001. In THRs with antibiotic-loaded cement, the risk of very early and late infections leading to revision was higher in RA patients than in OA patients” (12).

Bergh C et al. reported that “patients with femoral head necrosis had an overall increased risk of revision. This increased risk persisted over the entire period of observation from 1995 to 2011 and covers more or less all of the 4 most common reasons for revision” (13).

### 5. Focus on structural indicators

Glassou EN et al. examined if hospital procedure volume was associated with the risk of revision after primary THA in the Nordic countries from 1995 to 2011. This study showed a “consistent and strong association between hospital procedure volume and long-term risk of revision after primary THA – primarily based on an association in the large group of cemented THAs. Hospitals’ operating less than 50 procedures per year had an increased risk of revision due to all causes 2, 5, 10 and 15 years after primary cemented THA. There may also be an association between hospital volume and risk of revision in uncemented THAs, however, based on this study the association seems less pronounced (14)”.

Robertsson O et al. published the first study based on NARA-knee dataset, comparing the national knee registries in terms of patient characteristics, diagnosis for knee procedure, operations techniques etc. (15). The study showed considerable differences between the countries and suggested that further classification and standardization work is needed to permit more elaborate studies.

## The list of published studies based on NARA dataset per November 2015

1. The Nordic Arthroplasty Register Association: a unique collaboration between 3 national hip arthroplasty registries with 280,201 THRs. Havelin LI, Fenstad AM, Salomonsson R, Mehnert F, Furnes O, Overgaard S, Pedersen AB, Herberts P, Kärrholm J, Garellick G. *Acta Orthop* 2009; 80(4):393–401.
2. Knee arthroplasty in Denmark, Norway and Sweden. A pilot study from the Nordic Arthroplasty Register Association. Robertsson O, Bizjajeva S, Fenstad AM, Furnes O, Lidgren L, Mehnert F, Odgaard A, Pedersen AB, Havelin LI. *Acta Orthop* 2010; 81(1):82–9.
3. Inferior outcome after hip resurfacing arthroplasty than after



- conventional arthroplasty. Evidence from the Nordic Arthroplasty Register Association (NARA) database, 1995–2007; Johanson PE, Fenstad AM, Furnes O, Garellick G, Havelin LI, Overgaard S, Pedersen AB, Kärrholm J. *Acta Orthop*. 2010;81 (5):535–541 <http://www.ncbi.nlm.nih.gov/pubmed/20919812>
4. Prevention of deep infection in joint replacement surgery. A review. Jämsen E, Furnes O, Engesæter LB, Konttinen YT, Odgaard A, Stefánsdóttir A, Lidgren L. *Acta Orthop*. 2010;81 (6):660–666.
  5. Statistical analysis of arthroplasty data. I. Introduction and background; Ranstam J, Kärrholm J, Pulkkinen P, Mäkelä K, Espehaug B, Pedersen AB, Mehnert F, Furnes O; NARA study group. *Acta Orthop*. 2011 Jun; 82(3):253–7. <http://www.ncbi.nlm.nih.gov/pubmed/21619499>
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## Discussion and perspectives

The primary aim of NARA group is to improve quality of arthroplasty surgery in Nordic countries. This has been successfully done. Through our collaboration with regular meetings and networking the data quality in respective national registries has improved. Thus, more valid basis for quality monitoring and research has been achieved. The misunderstanding about definition of variables has been discussed and common definition was made. For example, before NARA various calculation methods on completeness of registration and revision burden have been used.

Though our internal collaboration, initiatives has been taken in order to improve registration systems in the Danish and Finish register using experience from Sweden and Norway. Finish registration system was restructured and register has passed from paper to electronic registration system. Currently, implant data are gathered electronically using reference code reading from all hospitals in Finland. Similar system is under reconstruction in Denmark with initial funding from NARA. Thus, a substantial work on harmonization of implant reporting and data collection in general is done and been prioritized.

NARA group also collaborates closely with organizations outside the Nordic countries, for example with ISAR (International Society of Arthroplasty Registries), ICOR (International Consortium of Orthopaedic Registries) and NORE (Network Orthopaedic Registries of Europe).

NARA experience could further be used in order to extend work with quality registers in other orthopaedic surgeries than hip and knee. For example, Nordic Knee Register could include all surgical procedures from arthroscopies and cruciate ligament surgery to tibial osteotomies,

and primary and revision arthroplasty. Similarly, Nordic Hip Register could include all surgical procedures from hip arthroscopies to pelvic osteotomies, and primary and revision arthroplasty.

NARA group also contributed to quality improvement through research project answering clinically important and up-to date questions and considerations. Our publications have already significantly affected treating practices. For example, metal-on-metal total hip arthroplasty and resurfacing arthroplasty have been abandoned due to increased revision risk (16). Further, use of uncemented THA in elderly patients has decreased significantly, at least in Finland (Mäkelä et al. 2014). Projects have further contributed to education of young researchers and awareness of evidence-based decision making.

The group has received a large grant from the NordForsk for the period 2014–2016.

## Conclusions

In conclusion, NARA collaboration has been successful because countries were able to agree on a common dataset and variable definition, and merge data. Collaboration was also successful because the group was able to initiate a number of research projects and provide answers to clinically relevant questions. A number of specific goals, set up in 2007 are achieved, and new one has emerged in meanwhile.

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## The NARA Shoulder committee

Even for the most common diagnoses (proximal humeral fractures and osteoarthritis), data in the national shoulder registries are often insufficient to compare revision rates. In order to set benchmark revision rates and to detect arthroplasty designs with a higher than anticipated revision rate, international collaboration is needed.

Participants from Denmark, Finland, Norway and Sweden were invited to the NARA meeting in March 2014. Differences in organization, definitions, included variables, and outcome measures between the national shoulder arthroplasty registries were discussed and a common minimal data set was defined. 19,857 primary arthroplasties were reported to the registries in Denmark, Norway and Sweden from 2004-2013. The Finnish register is currently under a renewal process and was unable to deliver data. There were 6,856 (35%) patients with osteoarthritis and 6,757 (34%) with a proximal humeral fracture. Total shoulder arthroplasty (34%), stemmed hemiarthroplasty (23%) and resurfacing hemiarthroplasty (28%) were used in the treatment of osteoarthritis whereas mainly stemmed hemiarthroplasty (90%) was used in the treatment of proximal humeral fractures.

A manuscript describing the process of merging data is currently under review and 2 manuscripts setting benchmark revision rates for proximal humeral fractures and osteoarthritis are in progress. Furthermore, by adapting compatible variables and by establishing a common patient-reported outcome measure, we aim to increase the usefulness of the collaboration in near future.



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