BMJ Open

Knee arthroscopy in Norway: changes in rates from 2012 to 2016

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-021199
Article Type:	Research
Date Submitted by the Author:	16-Dec-2017
Complete List of Authors:	Holtedahl, Robin; Fram Rehabilitation Centre Brox, Jens; Oslo University Hospital, Department of Physical Medicine and Rehabilitation Aune, Arne Kristian; Aleris Hospital, Orthopaedic Department Nguyen, Daniel; South-Eastern Norway Regional Health Authority Risberg, May Arna; Norwegian School of Sport Sciences, Department of Sports Medicine Tjomsland, Ole; South-Eastern Norway Regional Health Authority, Division of Quality and Specialist Areas
Keywords:	arthroscopy, Knee < ORTHOPAEDIC & TRAUMA SURGERY, meniscus, osteoarthritis, degenerative, rates

Knee arthroscopy in Norway: changes in rates from 2012 to 2016

Robin Holtedahl, Fram Rehabilitation Centre, Rykkinnvei 100, 1349 Rykkinn, Norway, robi-hol@online.no, +4790248973

Jens Ivar Brox, Department of Physical Medicine and Rehabilitation, Oslo University Hospital, 0407 Oslo, Norway
Arne Kristian Aune, Aleris Hospital, Orthopaedic Department, 3016 Drammen, Norway
Daniel Nguyen, South-Eastern Norway Regional Health Authority, 2317 Hamar, Norway
May Arna Risberg, Norwegian School of Sport Sciences, Department of Sports Medicine, 0806 Oslo, Norway
Ole Tjomsland, South-Eastern Norway Regional Health Authority, 2317 Hamar, Norway

Word count: 2581

ABSTRACT

Objective To examine rates of publicly financed knee arthroscopic surgery in Norway between 2012 and 2016.

Design Analysis of anonymised data from the National Patient Registry.

Interventions Beginning in 2012, South-Eastern Norway Regional Health Authority implemented administrative measures to bring down rates of knee arthroscopy. Similar measures were not introduced in the other three Regional Health Authorities.

Main outcome measures We compared annual arthroscopy rates in South-Eastern Norway Regional Health Authority with corresponding rates in the rest of the country. Variations by county, public hospital *vs* publicly reimbursed private hospital, gender and age were also assessed.

Results The overall annual rate of arthroscopic procedures peaked in 2013, then declined 41% by 2016, from 357 to 211 per 100 000 inhabitants, respectively. Public hospitals in South-Eastern Norway Regional Health Authority reported the largest decrease, with a median reduction of 154/100 000 (95% confidence interval 121 to 181) compared to 13/100 000 (-43 to 111) in public hospitals in the other three Regional Health Authorities (p=0.014). In publicly reimbursed private hospitals rates increased by 12% (p<0.0001 for difference). The proportion of patients ≥ 50 years (excluding meniscal repairs) was 54% in 2012 and fell to 46% in 2016. Average rates per county varied by a factor of 3:1.

Conclusion We report a marked reduction of knee arthroscopic procedures from 2012 to 2016 in publicly funded hospitals. The largest decrease was reported in South-Eastern Norway Regional Health Authority, and this coincides in time with implemented administrative measures. The results suggest that the trend of increasing rates of knee arthroscopies can be reversed through purposeful professional and administrative interventions.

Strengths and limitations of this study

- This is the first study investigating trends in national rates of knee arthroscopy in Norway.
- Because reporting to the National Patient Registry is a requirement for public reimbursement we consider the data reliable.
- The data allow analyses of trends in arthroscopy rates according to type of procedure, county of residence, Regional Health Authority, hospital type, age and gender.
- Diagnoses were not registered and the study period was limited to five years.
- Rates of knee arthroscopy in private hospitals are not available.

INTRODUCTION

Therapeutic knee arthroscopy has become the most commonly performed outpatient orthopaedic procedure in most countries with available data, including Norway. Joint debridement and lavage for osteoarthritis and meniscal resection or repair for meniscal lesions are the most commonly performed procedures. The increasing rates have been especially pronounced in middle-aged and elderly patients.[1] However, evidence of radiologically verified degenerative changes, including meniscal tears, are common in this age group, even in those without knee pain or history of knee injury.[2 3] Large regional variations of knee arthroscopy have also been described.[4] Several randomised controlled trials published during the last decades have been unable to demonstrate superiority of arthroscopic procedures over a sham procedure[5] or supervised physiotherapy.[6-11] These results have led to a critical reappraisal of these procedures, including recent systematic reviews and guidelines advising against arthroscopy as a first line of treatment for degenerative knee disorders.[12–14]

Of the four Regional Health Authorities in Norway, South-Eastern Norway Regional Health Authority is the largest, and responsible for secondary health services for more than half the Norwegian population. In 2012 South-Eastern Norway Regional Health Authority initiated a process aiming to reduce the volume of publicly financed arthroscopic procedures, as well as reducing unwarranted regional variations. In joint meetings with the Chief Medical Officers in the region and the Division of Orthopaedic Surgery, Oslo University Hospital, results of recent studies of arthroscopic procedures for degenerative meniscal tears and osteoarthritis were discussed, and also distributed to the Chief Medical Officers at private hospitals with reimbursement contracts in the region. In 2015, South-Eastern Norway Regional Health Authority adjusted the terms for the contracts with the public and private providers, requiring that the proportion of treated patients above the age of 50 years did not exceed 20%, and that physical therapy should be tried for at least three months prior to surgery. Similar measures were not introduced in the other Regional Health Authorities.

The aims of this study are to estimate overall time trends in knee arthroscopy rates in Norway from 2012 to 2016, and to elucidate possible associations between observed changes and administrative or professional incentives.

METHODS

Subjects and procedures

We extracted anonymised data from Norwegian Patient Registry on arthroscopic knee procedures in public hospitals and private hospitals with reimbursement contracts between 2012 and 2016. Private hospitals operating on contract with the regional trust are hereafter denoted “private hospitals”. Procedures not reimbursed by the public health system were not included. The procedures were debridement for osteoarthritis (code NGF31), meniscal repair (NGD21) and meniscal resection (NGD11) as defined by Nomesco Classification of Surgical Procedures (NCSP). Only the primary procedure was registered. The rates of knee arthroscopies were based on the number of individual procedures, not patients. We did not obtain diagnoses of the patients, and the proportion of traumatic *vs* atraumatic cases is not known. Patients younger than 10 years were excluded. We analysed age-adjusted rates per county based on population statistics from Statistics Norway (https://www.ssb.no/en/); the number of procedures done in public hospitals vs private hospitals; time trends in total rates; regional variations; and rates per age group and gender. Correlations between arthroscopy rates in public and private hospitals per county were analysed.

Ethics and statistics

This study included only anonymous data extracted from the Norwegian Patient Registry. Approval of access to the registry was obtained from the National Data Inspectorate. Differences in arthroscopy rates across gender and hospital provider type were analysed using χ^2. D’Agostino-Pearson test was used to test for normal distribution. Unpaired non-parametric data were analysed using the Mann-Whitney U test. Associations between rates in public *vs* private hospitals per county were assessed

using Pearson correlation coefficient. Analyses were performed using Medcalc v.17.9.7 (www.medcalc.org).

RESULTS

From 2012 to 2016 there were 66 901 arthroscopic procedures for meniscal lesions and osteoarthritis. 22 664 (34%) of the procedures were performed in private hospitals. The total arthroscopic rates were 15 203 in 2012, increasing to 16 148 in 2013 and decreasing to 9 543 procedures in 2016, a reduction of 41% from 2013 to 2016. The rates per 100 000 inhabitants were 357 in 2013 and 211 in 2016. In public hospitals there were 10 709 arthroscopies in 2012 and 6 250 in 2016, a 42% reduction; in private hospitals the corresponding numbers were 2 943 and 3 293, an increase of 12% ($p<0.0001$ for difference public *vs* private hospitals). In 2016, the average rate in all hospitals in the ten counties in South-Eastern Norway Regional Health Authority was 174 per 100 000 *vs* 202 per 100 000 in the remaining nine counties. The median reduction of arthroscopy rates in the study period in public hospitals in South-Eastern Norway Regional Health Authority was 154 (95% confidence interval 121 to 181) per 100 000 compared to 13 (-43 to 111) in the other three Regional Health Authorities ($p=0.014$). This corresponds to a 45% reduction in public hospitals in South-Eastern Norway Regional Health Authority, compared to 8% in the remaining Regional Health Authorities combined (figure 1).

Meniscal procedures comprised about 85% of all knee arthroscopies throughout the study period. The overall rate of meniscal resections fell by 36% in the study period, from 256 to 156 per 100 000. The reduction was 48% in public hospitals, whereas there was a seven percent increase in private hospitals ($p<0.0001$ for difference public *vs* private). The rate of meniscal repairs increased by 116%, from 11 to 23 per 100 000, 87% of which were performed in public hospitals. Cartilage debridement rates decreased overall from 44 to 29 per 100 000, with a 45% decline in public hospitals but a 16% increase in private hospitals ($p<0.0001$).

Average overall rates of meniscal resection and debridement in the study period were highest in the 50-59 age group, whereas 82% of meniscal repairs were performed in patients younger than 40 years. Meniscal resections were reduced by 24% in patients less than 50 years old and by 46% in patients 50 years or older in the study period (p<0.0001 for difference between age groups) (figure 2). The corresponding numbers for debridement were 26% and 36% (p=0.04).

The proportion of arthroscopic procedures in patients 50 years or older (excluding meniscal repairs) fell from 54% to 44% in South-Eastern Norway Regional Health Authority, from 53% to 48% in the other Regional Health Authorities and from 58% to 48% in private hospitals (p=0.9 for differences) (figure 3).

The average annual number of arthroscopic procedures performed on males was 2 593 and on females 1 729 (p<0.0001 for difference). The male preponderance was more pronounced in the younger age groups (65% males <50 years *vs* 54% males ≥50 years). Males comprised 61% of meniscal resections, 63% of repairs and 54% of debridements.

Age-adjusted average rate of arthroscopies per county of residence in the study period ranged from 175 to 505 per 100 000 (figure 4). Despite the rate reduction nationally in the study period, the rate ratio between county with highest and lowest rate was practically unchanged. There were also large variations in the contribution of private hospitals to overall arthroscopic rates per county, ranging from 6% to 68% (figure 4). There was a moderate positive correlation between the rate of arthroscopies performed in public and private hospitals per county (r=0.47).

DISCUSSION

Using data from the Norwegian National Registry, this study found that knee arthroscopy rates in Norway peaked in 2013 but by the end of 2016 had declined by 41%. To our knowledge, reductions of this magnitude have not been reported from other countries. While public hospitals reported a 45% reduction, private hospitals reported a 12% increase in the study period. Public hospitals in South-Eastern Norway Regional Health Authority reported more than a fivefold decrease in rates

compared to public hospitals in the other Regional Health Authorities. Of the four Regional Health Authorities, South-Eastern Norway Regional Health Authority took the most active steps towards bringing down rates of knee arthroscopy, initially in the form of strong recommendations to public and private hospitals from 2012, and in 2015 introducing more restrictive administrative preconditions for renewed contracts. There were large unwarranted variations between counties in the volumes of arthroscopy, with approximately a 3:1 ratio between highest and lowest age-adjusted rates, and even larger variations in the proportion of procedures done in private hospitals.

Because reporting of data to the Norwegian Patient Registry is a precondition for reimbursement, the figures presented most likely represent a reliable estimate of the actual number of arthroscopic procedures in this five-year period. However, coding practices may vary between hospitals, and we cannot exclude recording errors. We did not differentiate between traumatic and non-traumatic disorders, and we have no information about clinical diagnosis or concomitant procedures (for instance if debridement was performed in conjunction with meniscal resection). Due to restrictions from the National Data Inspectorate we were not able to obtain data prior to 2012, which precludes the possibility of viewing the rates in a longer time perspective.

Another limitation is the lack of publicly available information about the volume of knee arthroscopies performed by surgical units without public reimbursement contracts, even though compulsory reporting from these clinics to the Norwegian Patient Registry has recently been called for. Voluntary health insurance has played an increasing role in Norwegian health care, with approximately a twelve-fold increase in the number of insured persons during the last decade. By 2015, almost 500 000 persons were covered, with 95% of the expenses carried by employer. In addition, it is known that some procedures are financed through out-of-pocket payments. The Regional Health Authorities have no financial or administrative role in privately financed surgical services. It is at least theoretically conceivable that the reduction of publicly financed arthroscopic

procedures might be offset by an increase in the private sector, which from a public health perspective would be highly undesirable.

Other authors have reported significant increases in knee arthroscopy rates since the 1990's,[1 15 16] though this is not invariably the case[16 17]. There is limited evidence of more recent trends. Comparisons between studies are challenging due to varying coding procedure practices and differences in health insurance. Denmark and Sweden have publicly accessible databases, which include privately financed procedures (the corresponding database in Finland is only accessible in Finnish). In the period from 2011 to 2015 Swedish rates of knee arthroscopy were virtually unchanged, at about 200 procedures per 100 000 (socialstyrelsen.se). The Danish rate was 340 per 100 000 in 2011, falling to 240 in 2015, with meniscal resections reduced by 20% and debridement by 36% (sundhedsstyrelsen.dk). The reductions in Denmark have taken place without any known administrative regulations. A Swiss study of patients over the age of 40 described a nine percent reduction in arthroscopy rates, from 388 to 352 per 100 000 between 2012 and 2015, without any known administrative or political regulations.[18]

The overall reductions in knee arthroscopy rates in Norway are approximately twice as large as those reported from Denmark. Equally noteworthy are the much larger rate reductions in public hospitals in the South-Eastern Norway Regional Health Authority compared to the other Regional Health Authorities. The latter finding could conceivably be conceptualized as the outcome of a quasi-controlled public health study, i.e. the combined result of strong recommendations from the South-Eastern Norway Regional Health Authority to hospitals in their catchment area, starting in 2012, and more restrictive contract terms from 2015. It is tempting to attribute the large rate reductions in public hospitals in this Regional Health Authority to such measures, though it is prudent to emphasise that secular associations do not equate with causality.

The reduction in arthroscopy rates in Norway could conceivably be due to fewer patients with knee problems consulting their GPs, fewer patients being referred to surgical departments, more referrals

being rejected by the surgical clinics, or a combination. The relative contribution of these factors is not known. Despite the overall reduction, knee arthroscopies are still performed more often than justified based on recent high-quality research and evidence-based clinical practice guidelines. This is especially relevant for the middle-aged and older age groups, where degenerative disorders comprise the majority. The requirement in the most recent bids from South-Eastern Norway Regional Health Authority of at most 20% of operated patients being 50 years or older was based on evidence showing that practically all patients in this age group have complaints that are not expected to benefit from arthroscopic procedures. Though the total rates of knee arthroscopy were reduced from 2012 to 2016, the proportion of older to younger patients was only reduced by seven percentage points in the same period. If the 80/20 rule had been implemented as required, about 2 300 fewer arthroscopies would have been performed in 2016 (excluding meniscal sutures). With almost half of the treated patients being 50 years or older in 2016, we are still a long way from achieving these goals.

The large differences in arthroscopy rates per county are unlikely to be explained by medical factors, and are more probably the result of varying attitudes and traditions among both the referring GPs and orthopaedic surgeons and different access to evidence-based conservative management.[19] The positive per-county correlation between rates in public and private hospitals implies that the private sector contributes to the variability of rates across counties. This would suggest that a supply-sensitive model is more appropriate than a demand-sensitive model, i.e. instead of compensating for deficiencies in the public sector, the private hospitals drive up overall rates even in counties with adequate capacities in public hospitals.[19] Increasing arthroscopy rates in private hospitals have also been reported from Denmark and Australia.[4 20] Financial incentives are likely to influence surgical rates, especially in the private sector.[21]

The approach to the treatment of degenerative knee disorders could be described as preference sensitive, in that there has not traditionally been a clear consensus on how this group should be

managed. Unrealistic expectations about postoperative function, recovery time etc. could have contributed to the generally increasing popularity of knee arthroscopy during the last two decades.[22] Improving patients' knowledge of treatment options, including non-operative strategies, can significantly reduce demand for knee surgery.[23] Inspired by recent randomised trials showing that supervised physiotherapy is at least as effective as arthroscopic procedures in alleviating degenerative knee disorders, national models for implementation of evidence-based guidelines for treatment of degenerative meniscus tears, early and moderate knee and hip osteoarthritis were established in Denmark (GLAD: www.glaid.dk) and Sweden (BOA: https://boa.registercentrum.se).[24] Similar national models were established in Norway in 2015 through a treatment program named AktivA (www.aktivmedartrose.no).

CONCLUSIONS

Rates of publicly funded arthroscopic knee procedures in Norway decreased overall by 41% from 2012 to 2016. Only public hospitals reported reductions, while rates in publicly reimbursed private hospitals increased by 12% in the same period. Compared to the other Regional Health Authorities, there was a five-fold reduction of procedures in public hospitals in the South-Eastern Norway Regional Health Authority. This coincides in time with strong recommendations to the surgical departments from 2012 and more restrictive contract terms from 2015, primarily stipulating an upper limit on reimbursements for surgery on patients 50 years or older. Internal dissemination and implementation of knowledge from recent controlled trials may also have contributed to the decline. Based on results from recent randomised trials on degenerative knee disease, in our view too many middle-aged and elderly patients are still being subjected to arthroscopic knee procedures. There is also an unexplainable regional variation in arthroscopy rates. However, the results of our study indicate that poorly documented and potentially harmful surgical practices can be reduced through both professional guidance and administrative regulations.

Contributors RH, OT, JIB, MAR AND AKA conceptualised the study. DN searched and provided data from the National Patient Registry. AKA provided expertise on arthroscopic procedures and coding. RH analysed the data and did the statistical analysis. RH prepared the initial manuscript draft, which was subsequently edited by all authors. All authors read and approved the final manuscript and agreed to submission. RH is the guarantor.

Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.
Ethical approval: Not required. Data sharing: No additional data available.

Funding: None.

Transparency: The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted. All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. Thorlund JB, Hare KB, Lohmander LS. Large increase in arthroscopic meniscus surgery in the middle-aged and older population in Denmark from 2000 to 2011. *Acta Orthop* 2014;85(3):287–92. doi:10.3109/17453674.2014.919558

2. Tornbjerg SM, Nissen N, Englund M, Jørgensen U, Schjerning J, Lohmander LS, et al. Structural pathology is not related to patient-reported pain and function in patients undergoing meniscal surgery. *Br J Sports Med* 2016;bjsports-2016-096456. doi:10.1136/bjsports-2016-

096456

3. Guermazi A, Niu J, Hayashi D, Roemer FW, Englund M, Neogi T, et al. Prevalence of abnormalities in knees detected by MRI in adults without knee osteoarthritis: population based observational study (Framingham Osteoarthritis Study). *BMJ* 2012;345:e5339. doi: 10.1136/bmj.e5339 (Published 29 August 2012)

4. Hare KB, Vinther JH, Lohmander LS, Thorlund JB. Large regional differences in incidence of arthroscopic meniscal procedures in the public and private sector in Denmark. *BMJ Open* 2015;5(2):e006659. doi:10.1186/1471-2474-14-71

5. Sihvonen R, Paavola M, Malmivaara A, Itälä A, Joukainen A, Nurmi H, et al. Arthroscopic Partial Meniscectomy versus Sham Surgery for a Degenerative Meniscal Tear. *N Engl J Med* 2013;369(26):2515–24. doi:10.7326/M15-0899

6. Herrlin S, Hållander M, Wange P, Weidenhielm L, Werner S. Arthroscopic or conservative treatment of degenerative medial meniscal tears: a prospective randomised trial. *Knee Surg Sports Traumatol Arthrosc* 2007;15(4):393–401. doi:10.1007/s00167-006-0243-2

7. Moseley JB, O'Malley K, Petersen NJ, Menke TJ, Brody B a, Kuykendall DH, et al. A controlled trial of arthroscopic surgery for osteoarthritis of the knee. *N Engl J Med* 2002;347(2):81–8. doi:10.1056/NEJMoa013259

8. Katz JN, Brophy RH, Chaisson CE, de Chaves L, Cole BJ, Dahm DL, *et al.* Surgery versus Physical Therapy for a Meniscal Tear and Osteoarthritis. *N Engl J Med* 2013;**368**:1675–84. doi:10.1056/NEJMoa1301408

9. Kise NJ, Risberg MA, Stensrud S, Ranstam J, Engebretsen L, Roos EM. Exercise therapy versus arthroscopic partial meniscectomy for degenerative meniscal tear in middle aged patients: randomised controlled trial with two year follow-up. *BMJ* 2016;354354:3740–3740. doi: 10.1136/bmj.i3740

10. Yim J-H, Seon J-K, Song E-K, Choi J-I, Kim M-C, Lee K-B, et al. A comparative study of meniscectomy and nonoperative treatment for degenerative horizontal tears of the medial meniscus. *Am J Sports Med* 2013;41:1565–70. doi:10.1177/0363546513488518

11. Kirkley A, Birmingham TB, Litchfield RB, Giffin R, Willits KR, Wong CJ. A Randomized Trial of Arthroscopic Surgery for Osteoarthritis of the Knee. *N Engl J Med* 2008;11:1097–1107. doi:10.1056/NEJMoa0708333

12. Thorlund J, Juhl C, Roos EM, Lohmander LS. Arthroscopic surgery for degenerative knee: systematic review and meta-analysis of benefits and harms. *Br J Sports Med* 2015;49:1229-35. doi: 10.1136/bjsports-2015-h2747rep

13. Khan M, Evaniew N, Bedi A, Ayeni OR, Bhandari M. Arthroscopic surgery for degenerative tears of the meniscus: a systematic review and meta-analysis. *CMAJ* 2014;186(14):1057–64. doi: 10.1503/cmaj.140433/-/DC1

14. Beaufils P, Becker R, Kopf S, Englund M, Verdonk R, Ollivier M, et al. Surgical management of degenerative meniscus lesions: the 2016 ESSKA meniscus consensus. *Knee Surgery, Sport Traumatol Arthrosc* 2017;25(2):335–46. doi:10.1007/s00167-016-4407-4

15. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. *Am J Sports Med* 2013;41(10):2333–9. doi:10.1177/0363546513495641

16. Hamilton D, Howie C. Why do rates of knee arthroscopy differ between England and Scotland? *thebmj* 2015;:350–1. doi:10.1136/bmj.h4720

17. Harris IA, Madan NS, Naylor JM, Chong S, Mittal R, Jalaludin BB. Trends in knee arthroscopy and subsequent arthroplasty in an Australian population : a retrospective cohort study. *BMC Musculoskeletal Disorders* 2013;14:1–6. doi:10.1186/1471-2474-14-143

18. Muheim LLS, Senn O, Früh M, Reich O, Rosemann T, Neuner-Jehle SM. Inappropriate use of

arthroscopic meniscal surgery in degenerative knee disease. *Acta Orthop* 2017;3674:1–6. doi:10.1080/17453674.2017.1344915

19. Birkmeyer JD, Reames BN, McCulloch P, Carr AJ, Campbell WB, Wennberg JE. Understanding of regional variation in the use of surgery. *Lancet* 2013;382:1121–9. doi:10.1007/s00167-016-4407-4

20. Bohensky MA, Sundararajan V, Andrianopoulos N, de Steiger RN, Bucknill A, Kondogiannis CM, et al. Trends in elective knee arthroscopies in a population-based cohort, 2000-2009. *Med J Aust* 2012;197:399–403. doi:10.5694/mja11.11645

21. Mitchell JM. Effect of physician ownership of specialty hospitals and ambulatory surgery centers on frequency of use of outpatient orthopedic surgery. *Arch Surg* 2010;145:732–8. doi: 10.1001/archsurg.2010.149

22. Pihl K, Roos EM, Nissen N, Jørgensen U, Schjerning J, Thorlund JB. Over-optimistic patient expectations of recovery and leisure activities after arthroscopic meniscus surgery. *Acta Orthop* 2016;87:1–7. doi:10.1080/17453674.2016.1228411

23. Arterburn D, Wellman R, Westbrook E, Rutter C, Ross T, McCulloch D, et al. Introducing decision aids at group health was linked to sharply lower hip and knee surgery rates and costs. *Health Aff* 2012;31:2094–104. doi: 10.1377/hlthaff.2011.0686

24. Skou ST, Roos EM. Good Life with osteoArthritis in Denmark (GLA:D™): evidence-based education and supervised neuromuscular exercise delivered by certified physiotherapists nationwide. *BMC Musculoskelet Disord* 2017;181):72. doi: 10.1186/s12891-017-1439-y

Captions

Figure 1. Knee arthroscopies per county in South-Eastern Norway Regional Health Authority in 2012 and 2016 vs counties in other Regional Health Authorities. Median, 25-75 percentiles and maximum/ minimum.

Figure 2. Number of procedures per year for ages <50 and >=50. NGD11=Meniscal resection. NGD21=Meniscal repair. NGF31=Debridement/ lavage.

Figure 3. Number of meniscal resections and debridement/ lavage for ages <50 and >=50 in public hospitals in South-Eastern Norway Regional Health Authority, public hospitals in other Regional Health Authorities and private hospitals with reimbursement contracts.

Figure 4. Age-adjusted annual rates of knee arthroscopy per 100 000. Average 2012 to 2016 per county of residence, public hospitals and private hospitals with reimbursement contracts. Asterisk: counties in South-Eastern Norway Regional Health Authority.

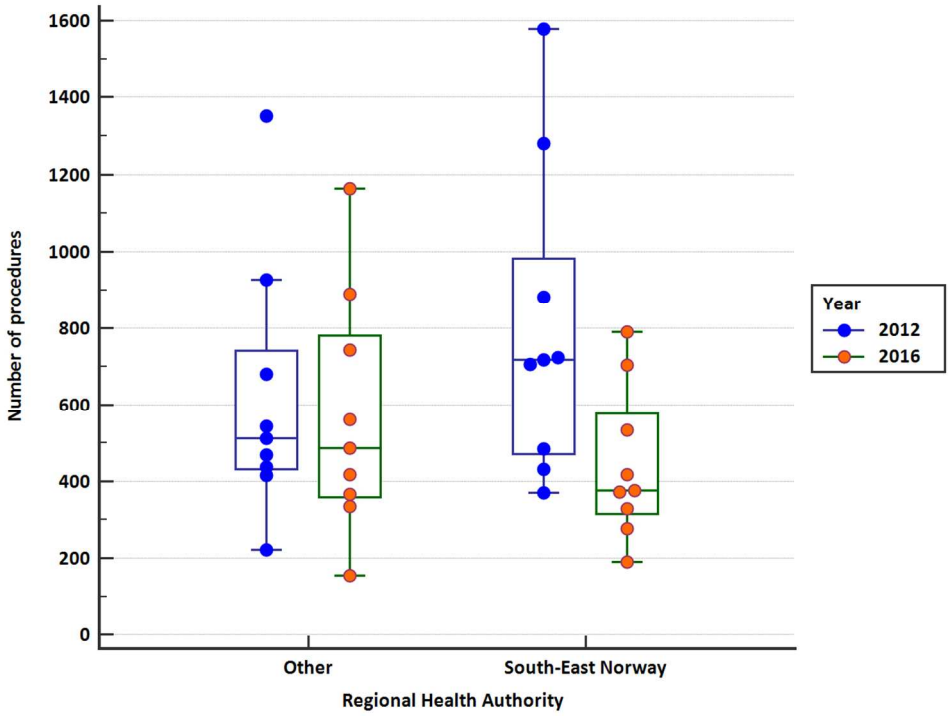


Figure 1. Knee arthroscopies per county in South-Eastern Norway Regional Health Authority in 2012 and 2016 vs counties in other Regional Health Authorities. Median, 25-75 percentiles and maximum/ minimum.

112x84mm (300 x 300 DPI)

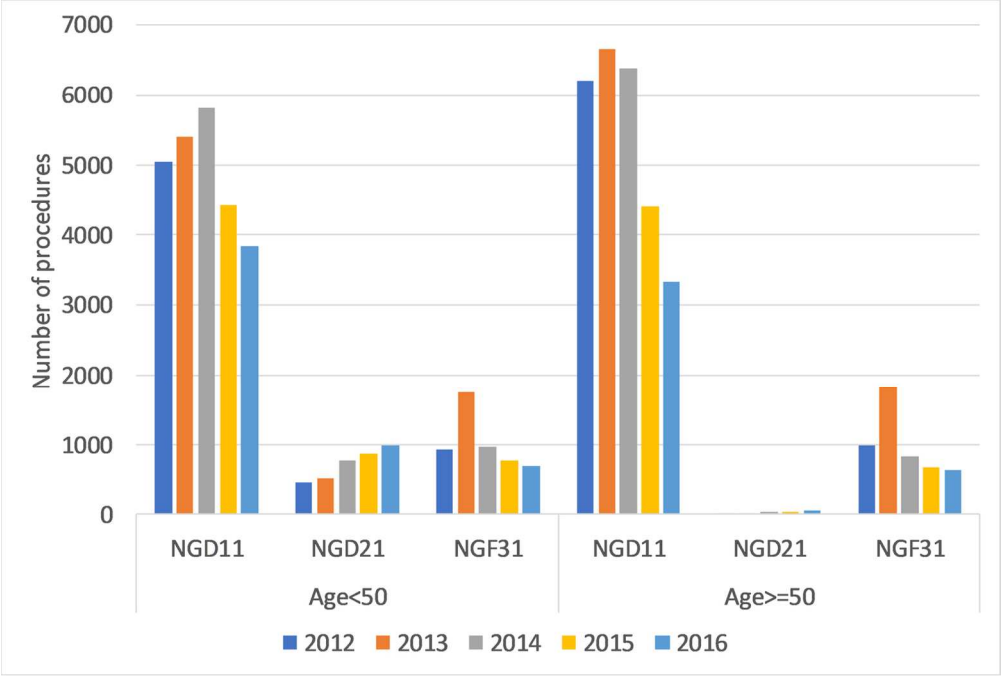


Figure 2. Number of procedures per year for ages <50 and >=50. NGD11=Meniscal resection. NGD21=Meniscal repair. NGF31=Debridement/ lavage.

130x88mm (300 x 300 DPI)

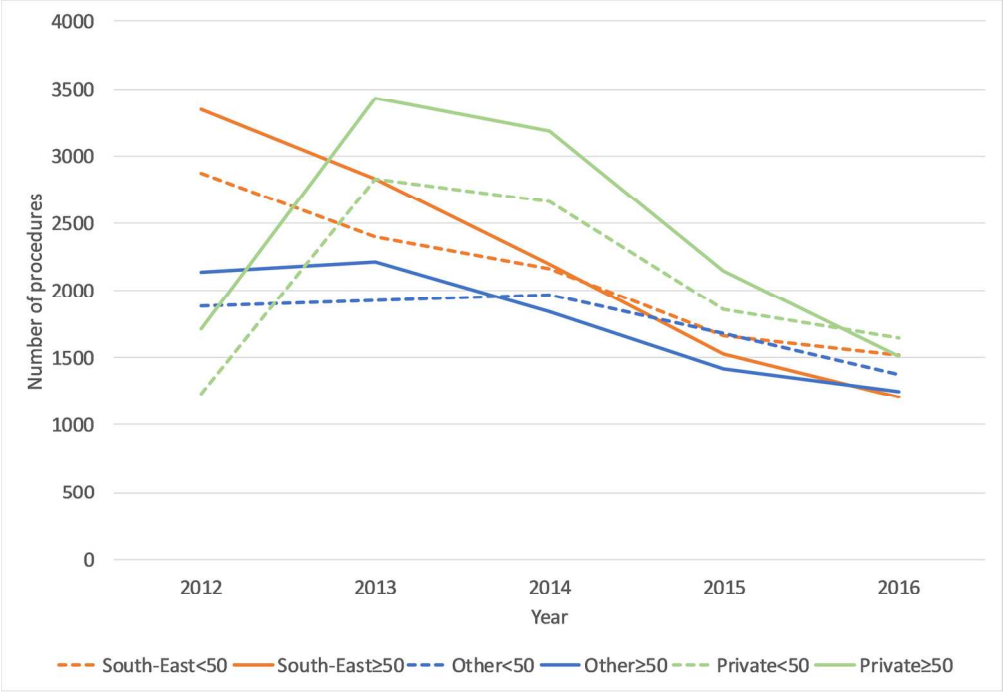


Figure 3. Number of meniscal resections and debridement/ lavage for ages <50 and >=50 in public hospitals in South-Eastern Norway Regional Health Authority, public hospitals in other Regional Health Authorities and private hospitals with reimbursement contracts.

160x111mm (300 x 300 DPI)

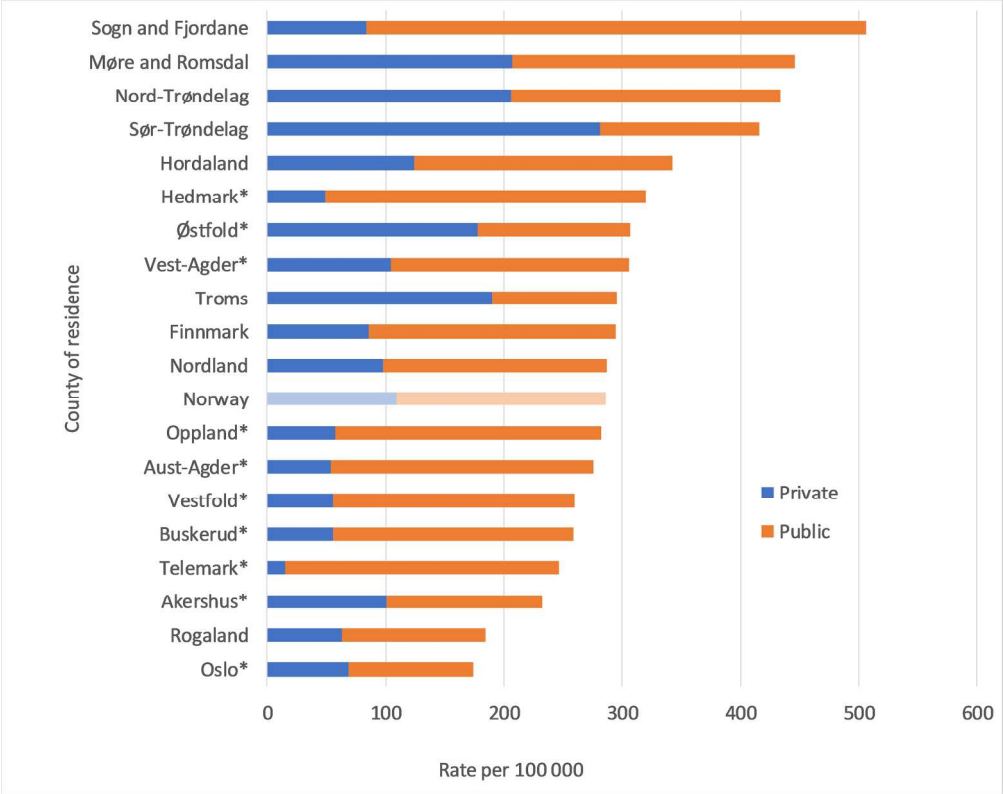


Figure 4. Age-adjusted annual rates of knee arthroscopy per 100 000. Average 2012 to 2016 per county of residence, public hospitals and private hospitals with reimbursement contracts. Asterisk: counties in South-Eastern Norway Regional Health Authority.

189x150mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Changes in the rate of publicly financed knee arthroscopies: an analysis of data from the Norwegian Patient Registry from 2012 to 2016

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-021199.R1
Article Type:	Research
Date Submitted by the Author:	10-Apr-2018
Complete List of Authors:	Holtedahl, Robin; Innlandet Hospital Trust-Division Ottestad; Husebybakken 28 B Brox, Jens; Oslo University Hospital, Department of Physical Medicine and Rehabilitation; University of Oslo, Medical Faculty Aune, Arne Kristian; Aleris Hospital, Orthopaedic Department Nguyen, Daniel; South-Eastern Norway Regional Health Authority Risberg, May Arna; Norwegian School of Sport Sciences, Department of Sports Medicine Tjomsland, Ole; South-Eastern Norway Regional Health Authority, Division of Quality and Specialist Areas
Primary Subject Heading:	Surgery
Secondary Subject Heading:	Evidence based practice, Health economics, Sports and exercise medicine
Keywords:	arthroscopy, Knee < ORTHOPAEDIC & TRAUMA SURGERY, meniscus, osteoarthritis, degenerative, rates

Changes in the rate of publicly financed knee arthroscopies: an analysis of data from the Norwegian Patient Registry from 2012 to 2016

Robin Holtedahl, Department of Habilitation and Rehabilitation, Innlandet Hospital Trust-Division Ottestad, Norway

Jens Ivar Brox, Department of Physical Medicine and Rehabilitation, Oslo University Hospital, 0407 and Medical Faculty, University of Oslo, Oslo, Norway
Arne Kristian Aune, Aleris Hospital, Orthopaedic Department, 3016 Drammen, Norway
Daniel Nguyen, South-Eastern Norway Regional Health Authority, 2317 Hamar, Norway
May Arna Risberg, Norwegian School of Sport Sciences, Department of Sports Medicine, 0806 Oslo, Norway
Ole Tjomsland, South-Eastern Norway Regional Health Authority, 2317 Hamar, Norway

Correspondence to

Robin Holtedahl; robi-hol@online.no, +4790248973

Word count: 2457

ABSTRACT

Objective To examine rates of publicly financed knee arthroscopic surgery in Norway between 2012 and 2016.

Design Analysis of anonymised data from the National Patient Registry.

Interventions Beginning in 2012, South-Eastern Norway Regional Health Authority implemented administrative measures to bring down rates of knee arthroscopy. Similar measures were not introduced in the other three Regional Health Authorities.

Main outcome measures We analysed annual national rates of publicly financed knee arthroscopies in 2012 and 2016. We compared rates in South-Eastern Norway Regional Health Authority with corresponding rates in the rest of the country. Variations by county, public hospital *vs* publicly reimbursed private hospital, gender and age were also assessed.

Results The overall annual rate of arthroscopic procedures declined by 33% from 2012 to 2016, from 310 to 207 per 100 000 inhabitants, respectively. Hospitals in South-Eastern Norway Regional Health Authority reported a 48% reduction, compared to mean 13% in the other three Regional Health Authorities. In public hospitals rates decreased nationally by 42%, while rates in publicly reimbursed private hospitals increased by 12%. Rates in publicly reimbursed private hospitals decreased by 30% in South-Eastern Norway Regional Health Authority but increased by 63% in the other Regional Health Authorities. The proportion of patients ≥ 50 years (excluding meniscal repairs) in Norway was 54% in 2012 and fell to 46% in 2016. Average rates per county varied by a factor of 3:1.

Conclusion We report a marked overall reduction of knee arthroscopic procedures from 2012 to 2016 in publicly funded hospitals. The largest decrease was reported in South-Eastern Norway Regional Health Authority, and this coincides in time with implemented

administrative measures. The results suggest that the trend of increasing rates of knee arthroscopies can be reversed through purposeful professional and administrative interventions.

Strengths and limitations of this study

- We consider the data reliable because reporting to the National Patient Registry is a requirement for public reimbursement.
- Diagnoses were not registered and the study period was limited to five years.
- Rates of knee arthroscopy in private hospitals without reimbursement by public health care are not available.

INTRODUCTION

Therapeutic knee arthroscopy has become the most commonly performed outpatient orthopaedic procedure in most countries with available data, including Norway. Joint debridement and lavage for osteoarthritis and meniscal resection or repair for meniscal lesions are the most commonly performed procedures. The increasing rates have been especially pronounced in middle-aged and elderly patients.[1] However, evidence of radiologically verified degenerative changes, including meniscal tears, are common in this age group, even in those without knee pain or history of knee injury.[2 3] Large regional variations of knee arthroscopy have also been described.[4] Several randomised controlled trials published during the last decades have been unable to demonstrate superiority of arthroscopic procedures over a sham procedure[5] or supervised physiotherapy.[6-11] These results have led to a critical reappraisal of these procedures, including recent systematic reviews and guidelines advising against arthroscopy as a first line of treatment for degenerative knee disorders.[12–14]

Of the four Regional Health Authorities in Norway, South-Eastern Norway Regional Health Authority is the largest, and responsible for secondary health services for more than half the Norwegian population. In 2012 South-Eastern Norway Regional Health Authority initiated a process aiming to reduce the volume of publicly financed arthroscopic procedures, as well as reducing unwarranted regional variations. In joint meetings with the Chief Medical Officers in the region and the Division of Orthopaedic Surgery, Oslo University Hospital, results of recent studies of arthroscopic procedures for degenerative meniscal tears and osteoarthritis were discussed, and also distributed to the Chief Medical Officers at private hospitals with reimbursement contracts in the region. In 2015, South-Eastern Norway Regional Health Authority adjusted the terms for the contracts with the public and private providers, requiring that the proportion of treated patients above the age of 50 years did not exceed 20%, and that physical therapy should be tried for at least three months prior to surgery. Similar measures were not introduced in the other Regional Health Authorities.

The aims of this study are to estimate overall time trends in knee arthroscopy rates in Norway from 2012 to 2016, and to elucidate possible associations between observed changes and administrative or professional incentives.

METHODS

Subjects and procedures

We extracted anonymised data from Norwegian Patient Registry on arthroscopic knee procedures in public hospitals and private hospitals with reimbursement contracts between 2012 and 2016. Private hospitals operating on contract with the regional trust are hereafter denoted "private hospitals". Procedures not reimbursed by the public health system were not included. The procedures were debridement for osteoarthritis (code NGF31), meniscal repair (NGD21) and meniscal resection (NGD11) as defined by Nomesco Classification of Surgical Procedures (NCSP). Only the primary procedure was registered. The rates of knee arthroscopies were based on the number of individual procedures, not patients. We did not obtain diagnoses of the patients, and the proportion of traumatic *vs* atraumatic cases is not known. Patients younger than 10 years were excluded. We analysed age-adjusted rates per county based on population statistics from Statistics Norway (https://www.ssb.no/en/); the number of procedures done in public hospitals vs private hospitals; time trends in total rates; regional variations; and rates per age group and sex. Correlations between arthroscopy rates in public and private hospitals per county were analysed.

Ethics and statistics

This study included only anonymous data extracted from the Norwegian Patient Registry. Approval of access to the registry was obtained from the National Data Inspectorate. Differences in arthroscopy rates across gender and hospital provider type were analysed using Chi-squared test. D'Agostino-Pearson test was used to test for normal distribution. Unpaired non-parametric data were analysed using the Mann-Whitney U test. Associations between rates in public *vs* private hospitals per county

were assessed using Pearson correlation coefficient. Analyses were performed using Medcalc v.17.9.7 (www.medcalc.org).

Patient and Public Involvement

Patients or public were not involved in this study.

RESULTS

From 2012 to 2016, 66 901 arthroscopic procedures were performed in public and private hospitals for meniscal lesions and osteoarthritis. 13 652 procedures were performed in 2012, increasing to 16 157 in 2013 and decreasing to 9 543 in 2016. The rate of procedures per 100 000 was 310 in 2012 and 207 in 2016, a reduction of 33%. In the ten counties in South-Eastern Norway Regional Health Authority the overall rate in this period decreased from 325 to 171 per 100 000 (48%). In the remaining nine counties the overall rate decreased from 290 to 253 per 100 000 (13%). The corresponding median rate reductions per county were 46% (confidence interval from 41.2% to 49.6%) and 5% (confidence interval -20.6% to 30.4%), respectively. Figure 1 shows the number of procedures per county in South-Eastern Norway Regional Health Authority compared to the other Regional Health Authorities in 2012 and 2016. Supplementary figure 1 shows the number of procedures per Regional Health Authority in 2012 and 2016.

22 664 (34%) of all knee arthroscopies in the study period were performed in private hospitals, in which there nationally were 2 943 procedures in 2012 and 3 293 in 2016, an increase of 12%. In public hospitals the corresponding numbers were 10 709 and 6 250, a 42% reduction ($p<0.0001$ for difference public vs private hospitals). In private hospitals in South-Eastern Norway Regional Health Authority there was a 30% reduction in mean rate per 100 000 in the study period, from 62 to 43, while there was an increase of 63% in private hospitals in the remaining Regional Health Authorities, from 67 to 109 ($p=0.0008$ for difference between the Regional Health Authorities). In public hospitals in South-Eastern Norway Regional Health Authority there was a decrease of 49%, from mean rate

248 to 128 per 100 000, while there was a decrease of 31% in the remaining Regional Health Authorities, from 212 to 146 (p=0.07 for difference) (table 1).

Table 1. Number, rate and rate change of all knee arthroscopies in 2012 and 2016 per Regional Health Authority (RHA), public and private hospitals.

	Number of procedures		Rate per 100 000		Rate change 2012-2016 (%)
	2012	**2016**	**2012**	**2016**	
All regions / hospitals	13 652	9 543	310	207	-33
South-East RHA	8 024	4 421	326	171	-48

Other RHAs*	5 628	5 122	290	253	-13
All public hospitals	10 709	6 250	243	136	-42
All private hospitals	2 943	3 293	67	71	12
Public hospitals South-East RHA	6 430	3 306	248	128	-49
Public hospitals other RHAs	4 279	2 944	212	146	-31
Private hospitals South-East RHA	1 594	1 115	62	43	-30
Private hospitals other RHAs	1 349	2 178	67	109	63

* West, Mid-Norway and North Regional Health Authorities

Meniscal procedures comprised about 85% of all knee arthroscopies throughout the study period. The overall rate of meniscal resections fell from 256 to 156 per 100 000, a 36% reduction. In public hospitals there was a 48% reduction, whereas there was a seven percent increase in private hospitals (p-value<0.0001 for difference public *vs* private). The overall rate of meniscal repairs increased from 11 to 23 per 100 000, 87% of which were performed in public hospitals. Cartilage debridement rates decreased overall from 44 to 29 per 100 000, with a 45% reduction in public hospitals but a 16% increase in private hospitals (p-value<0.0001 for difference) (table 2).

Table 2. Number and proportion of meniscal resections, meniscal repairs and debridement by sex, age group, Regional Health Authority (RHA), public and private hospitals in 2012 and 2016.

		Meniscal resection		Meniscal repair		Debridement	
		2012	**2016**	**2012**	**2016**	**2012**	**2016**
Sex, number (%)*	**Males**	7 181 (60)	4 482 (62)	358 (66)	648 (62)	1 950 (54)	677 (51)
	Females	4 859 (40)	2 691 (38)	184 (34)	401 (38)	1 633 (46)	652 (49)
Age group, number (%)	**10-19**	301 (3)	343 (5)	155 (32)	289 (28)	70 (4)	71 (5)
	20-29	722 (6)	719 (10)	180 (37)	334 (32)	156 (8)	134 (10)
	30-39	1 286 (11)	939 (13)	86 (18)	224 (21)	261 (14)	164 (12)
	40-49	2 734 (24)	1 842 (26)	47 (10)	149 (14)	451 (23)	326 (25)
	50-59	3 117 (28)	1 849 (26)	12 (2)	45 (4)	530 (28)	342 (26)

	60-69	2 313 (21)	1 072 (15)	4 (1)	6 (1)	350 (18)	210 (16)
	70-79	674 (6)	372 (5)	-	-	96 (5)	78 (6)
	80+	106 (1)	37 (1)	-	-	13 (1)	4 (0.3)
Patients ≥50 by hospital type and region (%)	**Public, South East RHA**	59	46	-	4	52	56
	Public, other RHAs	54	46	4	6	53	34
	Private (all RHAs)	54	48	4	3	50	47
Hospital type and region, number (%)	**Public, South East RHA**	5531 (50)	2426 (34)	281 (58)	615 (59)	653 (23)	298 (39)
	Public, other RHAs	3157 (28)	2114 (29)	205 (42)	295 (28)	822 (34)	508 (23)
	Private, South East RHA	1515 (13)	978 (14)	-	76 (7)	79 (4)	60 (4)
	Private, other RHAs	976 (9)	1653 (23)	-	63 (6)	373 (19)	463 (34)
	Sum annual procedures	**11 253 (100)**	**7 173 (100)**	**486 (100)**	**1 049 (100)**	**1 927 (100)**	**1 329 (100)**

*values for "2012" refer to 2013

The proportion of patients 50 years or older having meniscal resection and debridement in the study period fell from 54% to 44% in public hospitals in South-Eastern Norway Regional Health Authority, from 53% to 48% in public hospitals in the other Regional Health Authorities and from 58% to 48% in private hospitals in all regions (p=0.9 for differences) (figure 2, table 2). For meniscal repairs, the proportion of patients 40 years or older increased nationally from 13% to 19% in the study period (table 2). Rates of meniscal resections nationally were reduced by 24% in patients younger than 50 years and by 46% in patients 50 years or older in the study period (p<0.0001 for difference between age groups) (figure 3). The corresponding reductions for debridement were 26% and 36% (p =0.04) (table 2).

The percentage of males having knee arthroscopy in the study period was on average 60%. The male preponderance was more pronounced in the younger age groups (65% males <50 years *vs* 54% males ≥50 years). For males arthroscopy rates decreased by 44% and for females by 39% in the study

period (p=0.0009 for sex difference). In 2016, males comprised 62% of meniscal resections and repairs whereas debridements were performed at approximately similar rates for males and females (table 2).

The age-adjusted average rates of arthroscopies per county of residence in 2016 ranged from 119 to 391 per 100 000. There were also large variations in the contribution of private hospitals to overall arthroscopic rates per county, ranging from 7% to 69% (figure 4). There was a moderate positive correlation (r=0.47) between the rate of arthroscopies performed in public and private hospitals per county.

DISCUSSION

Using data from the Norwegian National Registry, this study found that knee arthroscopy rates nationally decreased by 33% from 2012 to 2016. The reductions varied by region, with hospitals in South-Eastern Norway Regional Health Authority reporting a 48% reduction compared to 13% in the other regions. Public hospitals reported a 42% reduction from 2012 to 2016, whereas private hospitals reported a 12% increase.

Reporting of data to the Norwegian Patient Registry is a precondition for reimbursement, and the figures presented are likely to represent a reliable estimate of the actual number of arthroscopic procedures in this five-year period. Coding practices may vary between hospitals, and we cannot exclude recording errors. We did not differentiate between traumatic and non-traumatic disorders, and we have no information about clinical diagnosis or concomitant procedures (for instance if debridement was performed in conjunction with meniscal resection). Due to restrictions from the National Data Inspectorate we were not able to obtain data prior to 2012, which precludes the possibility of viewing the rates in a longer time perspective.

Another limitation is the lack of publicly available information about the volume of knee arthroscopies performed by surgical units without public reimbursement contracts, even though compulsory reporting from these clinics to the Norwegian Patient Registry has recently been called

for. Voluntary health insurance has played an increasing role in Norwegian health care, with approximately a twelve-fold increase in the number of insured persons during the last decade. By 2015, almost 500 000 persons (1/10 of the population) were covered, with 95% of the expenses carried by employer. In addition, some procedures are financed through out-of-pocket payments. The Regional Health Authorities have no financial or administrative role in privately financed surgical services.

Other authors have reported increases in knee arthroscopy rates, especially meniscal resections, since the 1990's[1 15-17] though this is not invariably the case.[16 18 19] There is limited evidence of more recent trends. Comparisons between studies are challenging due to varying coding procedure practices and differences in health insurance. A Swiss study of patients age >40 years reported a nine percent reduction in knee arthroscopy rates, from 388 to 352 per 100 000 between 2012 and 2015, with no described administrative or political regulations.[20] Finland, Denmark and Sweden have publicly accessible databases, which all use the Nomesco classification and include privately financed procedures (sampo.thl.fi; sundhedsstyrelsen.dk; socialstyrelsen.se respectively). From 2012 to 2016 arthroscopy rates per 100 000 in Sweden decreased from 206 to 157 (24%), in Denmark from 290 to 183 (37%) and in Finland from 339 to 187 (52%). These reductions have reportedly taken place without any administrative regulations. From 2017 arthroscopic procedures for degenerative knee conditions are no longer included in publicly funded healthcare services in Finland.

In spite of the decreases in arthroscopy rates in Norway since 2013, rates in 2016 were still higher than in Denmark, Sweden and Finland. One noteworthy finding in the present study is the divergence of rates in South-Eastern Regional Health Authority *vs* rates in other regions, as well as in public *vs* private hospitals nationally. It is tempting to attribute the described reductions in both public and private hospitals in South-Eastern Norway Regional Health Authority to the recommendations and more restrictive contract terms in the period 2012 to 2015, though it is prudent to emphasise that secular associations do not equate with causality.

Despite the described overall reductions, knee arthroscopies are still performed more often than justified based on recent high-quality research and evidence-based clinical practice guidelines.[14] This is especially relevant for the middle-aged and older age groups, where degeneration plays a major role. The requirement in the most recent bids from South-Eastern Norway Regional Health Authority is that at most 20% of operated patients should be >50 years. This is based on evidence showing that practically all patients in this age group have complaints that are not expected to benefit from arthroscopic procedures.[12 13] The proportion of older to younger patients was only reduced by seven percentage points in the same period, which supports the need for stronger regulation of reimbursement. If the 80/20 rule had been implemented as required, about 2 300 fewer arthroscopies would have been performed in 2016 (excluding meniscal sutures).

The large differences in arthroscopy rates per county are unlikely to be explained by medical factors. Factors at the administrative level (i.e. differing influences and involvement by the Regional Health Authorities), varying attitudes and traditions among the referring GPs and orthopaedic surgeons and different access to evidence-based conservative management may play a role.[21] The positive per-county correlation between rates in public and private hospitals suggests that the private sector contributes to the variability of rates across counties. A supply-sensitive model may be more appropriate to explain this than a demand-sensitive model. [21] Instead of compensating for deficiencies in the public sector, the private hospitals seem to drive up overall rates even in counties with adequate capacities in public hospitals. Increasing arthroscopy rates in private hospitals have also been reported from Denmark and Australia.[4 22] Financial incentives are likely to influence surgical rates, especially in the private sector.[20 23]

The approach to the treatment of degenerative knee disorders could be described as preference sensitive, in that there has not traditionally been a clear consensus on how this group should be managed. Beliefs about the need for surgery in order to recover from a meniscal “injury” as well as over-optimistic expectations of postoperative function and recovery have most likely contributed to

the popularity of knee arthroscopy during the last two decades.[24] Improving patients' and health care providers´ knowledge about evidence-based medicine is likely to reduce demand for knee surgery.[25] Inspired by recent randomised trials showing that arthroscopic procedures are not more effective than supervised physiotherapy in alleviating pain and improving function in patients with degenerative meniscal disorders, national models for implementation of evidence-based guidelines for treatment of degenerative meniscus tears, early and moderate knee and hip osteoarthritis were established in Denmark (GLAD: www.glaid.dk) and Sweden (BOA: https://boa.registercentrum.se).[26] Similar national models were established in Norway in 2015 through a treatment program named AktivA (www.aktivmedartrose.no).

CONCLUSIONS

Rates of publicly funded arthroscopic knee procedures in Norway decreased overall by 33% from 2012 to 2016. Only public hospitals reported reductions, while rates in publicly reimbursed private hospitals increased by 12% in the same period. Compared to the other Regional Health Authorities, the reduction of procedures was larger in hospitals in the South-Eastern Norway Regional Health Authority. This coincides in time with strong recommendations to the surgical departments from 2012 and more restrictive contract terms from 2015. We also observed an unexplainable regional variation in arthroscopy rates. Results from the present study suggest that poorly documented and potentially harmful surgical practices can be reduced through both professional guidance and administrative regulations.

Contributors RH, OT, JIB, MAR AND AKA conceptualised the study. DN searched and provided data from the National Patient Registry. AKA provided expertise on arthroscopic procedures and coding. RH analysed the data and did the statistical analysis. RH prepared the initial manuscript draft, which was subsequently edited by all authors. All authors read and approved the final manuscript and agreed to submission. RH is the guarantor.

Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.
Ethical approval: Not required. Data sharing: No additional data available.

Funding: None.

Transparency: The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted. All authors had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. Thorlund JB, Hare KB, Lohmander LS. Large increase in arthroscopic meniscus surgery in the middle-aged and older population in Denmark from 2000 to 2011. *Acta Orthop* 2014;85(3):287–92. doi:10.3109/17453674.2014.919558
2. Tornbjerg SM, Nissen N, Englund M, Jørgensen U, Schjerning J, Lohmander LS, et al. Structural pathology is not related to patient-reported pain and function in patients undergoing meniscal surgery. *Br J Sports Med* 2016;bjsports-2016-096456. doi:10.1136/bjsports-2016-096456
3. Guermazi A, Niu J, Hayashi D, Roemer FW, Englund M, Neogi T, et al. Prevalence of abnormalities in knees detected by MRI in adults without knee osteoarthritis: population based observational study (Framingham Osteoarthritis Study). *BMJ* 2012;345:e5339. doi: 10.1136/bmj.e5339 (Published 29 August 2012)
4. Hare KB, Vinther JH, Lohmander LS, Thorlund JB. Large regional differences in incidence of arthroscopic meniscal procedures in the public and private sector in Denmark. *BMJ Open* 2015;5(2):e006659. doi:10.1186/1471-2474-14-71
5. Sihvonen R, Paavola M, Malmivaara A, Itälä A, Joukainen A, Nurmi H, et al. Arthroscopic Partial Meniscectomy versus Sham Surgery for a Degenerative Meniscal Tear. *N Engl J Med*

2013;369(26):2515–24. doi:10.7326/M15-0899

6. Herrlin S, Hållander M, Wange P, Weidenhielm L, Werner S. Arthroscopic or conservative treatment of degenerative medial meniscal tears: a prospective randomised trial. *Knee Surg Sports Traumatol Arthrosc* 2007;15(4):393–401. doi:10.1007/s00167-006-0243-2
7. Moseley JB, O'Malley K, Petersen NJ, Menke TJ, Brody B a, Kuykendall DH, et al. A controlled trial of arthroscopic surgery for osteoarthritis of the knee. *N Engl J Med* 2002;347(2):81–8. doi:10.1056/NEJMoa013259
8. Katz JN, Brophy RH, Chaisson CE, de Chaves L, Cole BJ, Dahm DL et al. Surgery versus Physical Therapy for a Meniscal Tear and Osteoarthritis. *N Engl J Med* 2013;368:1675–84. doi:10.1056/NEJMoa1301408
9. Kise NJ, Risberg MA, Stensrud S, Ranstam J, Engebretsen L, Roos EM. Exercise therapy versus arthroscopic partial meniscectomy for degenerative meniscal tear in middle aged patients: randomised controlled trial with two year follow-up. *BMJ* 2016;354354:3740–3740. doi: 10.1136/bmj.i3740
10. Yim J-H, Seon J-K, Song E-K, Choi J-I, Kim M-C, Lee K-B, et al. A comparative study of meniscectomy and nonoperative treatment for degenerative horizontal tears of the medial meniscus. *Am J Sports Med* 2013;41:1565–70. doi:10.1177/0363546513488518
11. Kirkley A, Birmingham TB, Litchfield RB, Giffin R, Willits KR, Wong CJ. A Randomized Trial of Arthroscopic Surgery for Osteoarthritis of the Knee. *N Engl J Med* 2008;11:1097–1107. doi:10.1056/NEJMoa0708333
12. Thorlund J, Juhl C, Roos EM, Lohmander LS. Arthroscopic surgery for degenerative knee: systematic review and meta-analysis of benefits and harms. *Br J Sports Med* 2015;49:1229-35. doi: 10.1136/bjsports-2015-h2747rep
13. Khan M, Evaniew N, Bedi A, Ayeni OR, Bhandari M. Arthroscopic surgery for degenerative tears of the meniscus: a systematic review and meta-analysis. *CMAJ* 2014;186(14):1057–64. doi: 10.1503/cmaj.140433/-/DC1
14. Beaufils P, Becker R, Kopf S, Englund M, Verdonk R, Ollivier M, et al. Surgical management of degenerative meniscus lesions: the 2016 ESSKA meniscus consensus. *Knee Surgery, Sport Traumatol Arthrosc* 2017;25(2):335–46. doi:10.1007/s00167-016-4407-4
15. Abrams GD, Frank RM, Gupta AK, Harris JD, McCormick FM, Cole BJ. Trends in meniscus repair and meniscectomy in the United States, 2005-2011. *Am J Sports Med* 2013;41(10):2333–9. doi:10.1177/0363546513495641
16. Hamilton D, Howie C. Why do rates of knee arthroscopy differ between England and Scotland? *thebmj* 2015;:350–1. doi:10.1136/bmj.h4720
17. Lazic S, Boughton O, Hing C et al. Arthroscopic washout of the knee: A procedure in decline.

Knee 2014;21:631–4. doi:10.1016/j.knee.2014.02.014

18. Harris IA, Madan NS, Naylor JM, Chong S, Mittal R, Jalaludin BB. Trends in knee arthroscopy and subsequent arthroplasty in an Australian population : a retrospective cohort study. *BMC Musculoskeletal Disorders* 2013;14:1–6. doi:10.1186/1471-2474-14-143
19. Mattila VM, Sihvonen R, Paloneva J et al. Changes in rates of arthroscopy due to degenerative knee disease and traumatic meniscal tears in Finland and Sweden. *Acta Orthop* 2016;87:5–11. doi:10.3109/17453674.2015.1066209
20. Muheim LLS, Senn O, Früh M, Reich O, Rosemann T, Neuner-Jehle SM. Inappropriate use of arthroscopic meniscal surgery in degenerative knee disease. *Acta Orthop* 2017;3674:1–6. doi:10.1080/17453674.2017.1344915
21. Birkmeyer JD, Reames BN, McCulloch P, Carr AJ, Campbell WB, Wennberg JE. Understanding of regional variation in the use of surgery. *Lancet* 2013;382:1121–9. doi:10.1007/s00167-016-4407-4
22. Bohensky MA, Sundararajan V, Andrianopoulos N, de Steiger RN, Bucknill A, Kondogiannis CM, et al. Trends in elective knee arthroscopies in a population-based cohort, 2000-2009. *Med J Aust* 2012;197:399–403. doi:10.5694/mja11.11645
23. Mitchell JM. Effect of physician ownership of specialty hospitals and ambulatory surgery centers on frequency of use of outpatient orthopedic surgery. *Arch Surg* 2010;145:732–8. doi: 10.1001/archsurg.2010.149
24. Pihl K, Roos EM, Nissen N, Jørgensen U, Schjerning J, Thorlund JB. Over-optimistic patient expectations of recovery and leisure activities after arthroscopic meniscus surgery. *Acta Orthop* 2016;87:1–7. doi:10.1080/17453674.2016.1228411
25. Arterburn D, Wellman R, Westbrook E, Rutter C, Ross T, McCulloch D, et al. Introducing decision aids at group health was linked to sharply lower hip and knee surgery rates and costs. *Health Aff* 2012;31:2094–104. doi: 10.1377/hlthaff.2011.0686
26. Skou ST, Roos EM. Good Life with osteoArthritis in Denmark (GLA:D™): evidence-based education and supervised neuromuscular exercise delivered by certified physiotherapists nationwide. *BMC Musculoskelet Disord* 2017;181:72. doi: 10.1186/s12891-017-1439-y

Figure legends

Figure 1. Number of knee arthroscopies per county in South-Eastern Norway Regional Health Authority in 2012 and 2016 *vs* other Regional Health Authorities. Each dot represents a county. Horisontal bars represent medians.

Figure 2. Number of meniscal resections and debridement for ages <50 and >=50 in public hospitals in South-Eastern Norway Regional Health Authority, public hospitals in other Regional Health Authorities and all private hospitals with reimbursement contracts.

Figure 3. Number of meniscal resections, meniscal repairs and debridement per year for ages <50 and ≥50. All Regional Health Authorities, public and private hospitals.

Figure 4. Age-adjusted annual rates of knee arthroscopy per 100 000 in 2016 per county of residence, public and private hospitals. Asterisk: counties in South-Eastern Norway Regional Health Authority.
Supplementary figure 1. Number of knee arthroscopies per Regional Health Authority in 2012 and 2016.

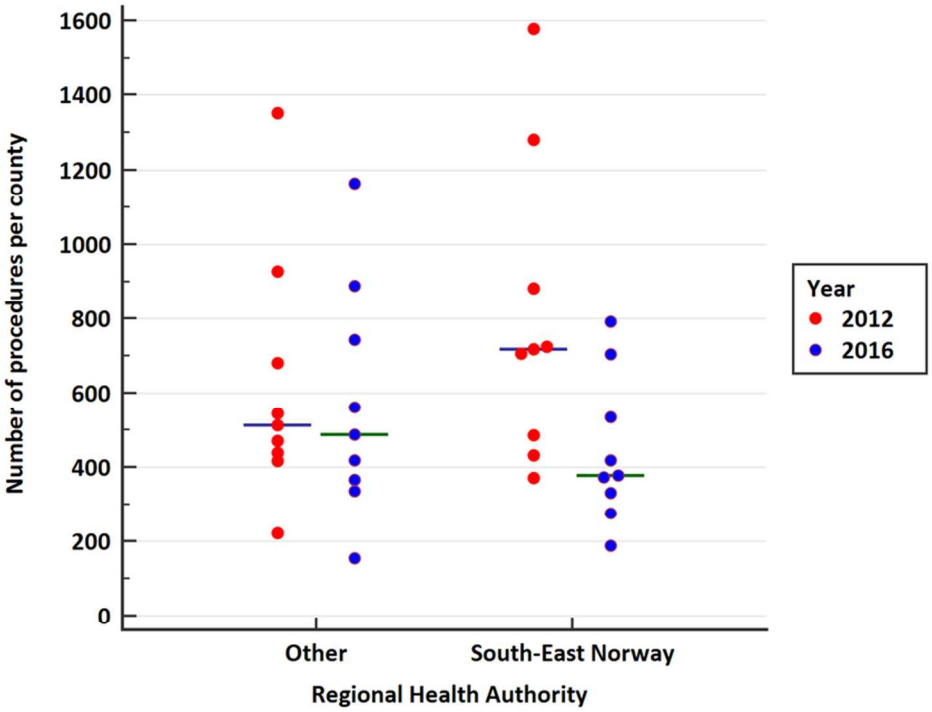


Figure 1. Number of knee arthroscopies per county in South-Eastern Norway Regional Health Authority in 2012 and 2016 vs other Regional Health Authorities. Each dot represents a county. Horisontal bars represent medians.

76x57mm (300 x 300 DPI)

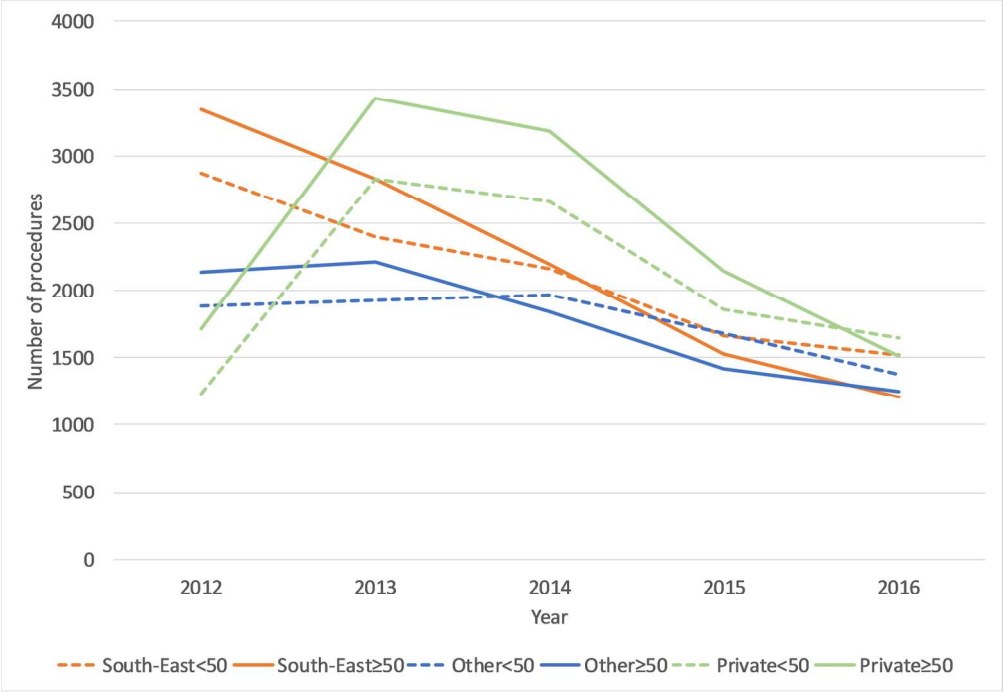


Figure 2. Number of meniscal resections and debridement for ages <50 and ≥50 in public hospitals in South-Eastern Norway Regional Health Authority, public hospitals in other Regional Health Authorities and all private hospitals.

160x111mm (300 x 300 DPI)

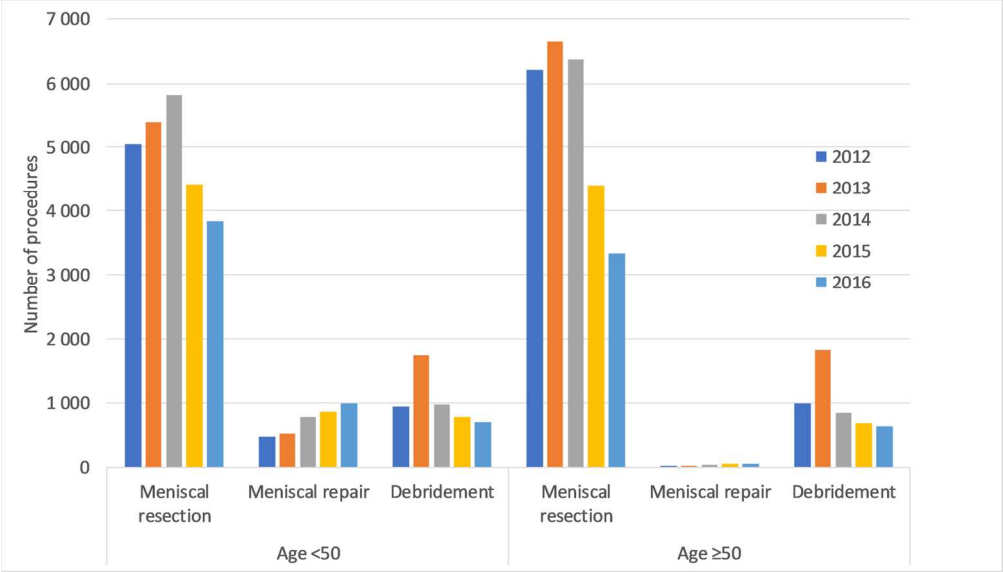


Figure 3. Number of meniscal resections, meniscal repairs and debridement per year for ages <50 and ≥50. All Regional Health Authorities, public and private hospitals.

145x83mm (300 x 300 DPI)

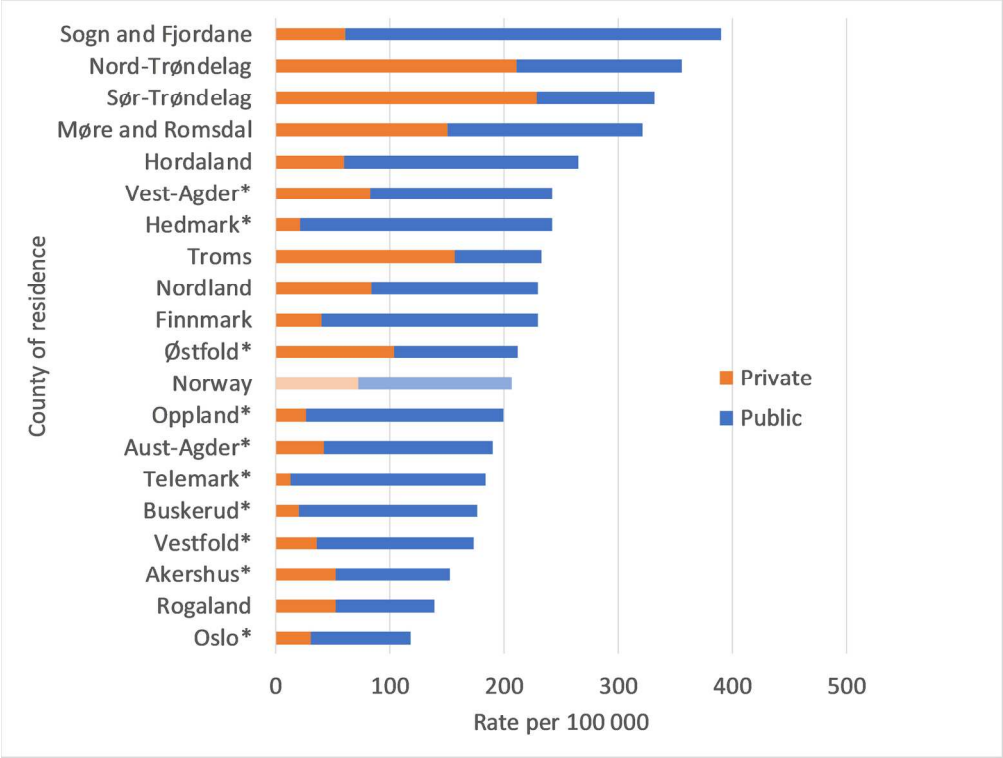
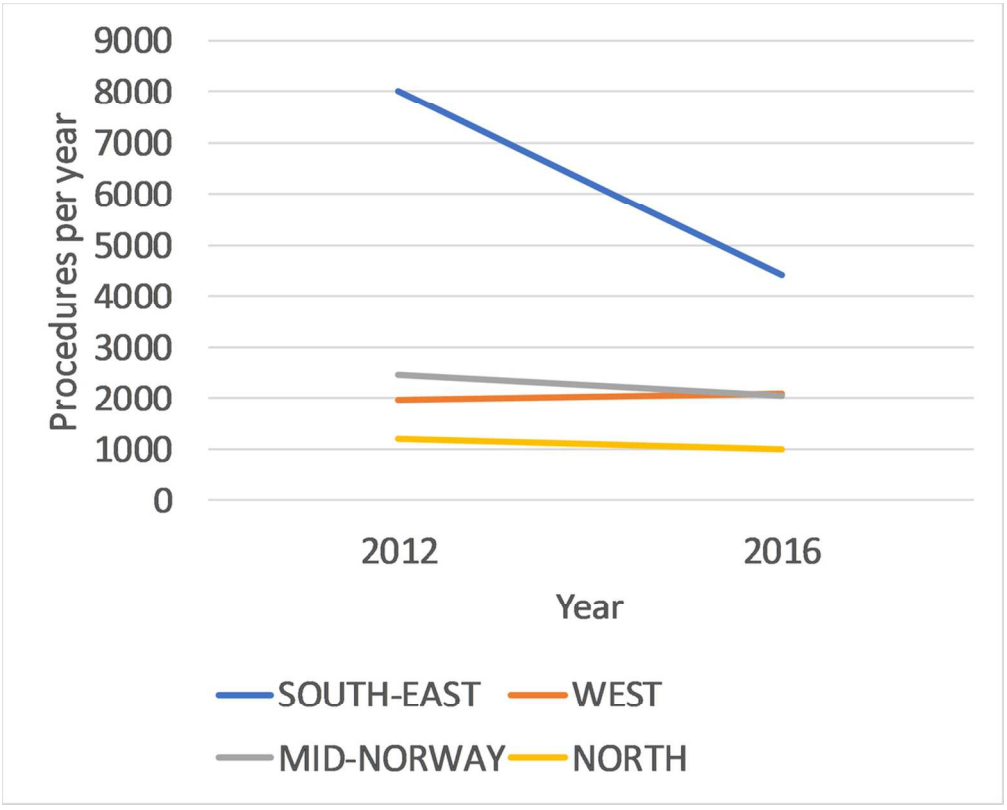


Figure 4. Age-adjusted annual rates of knee arthroscopy per 100 000 in 2016 per county of residence, public and private hospitals. Asterisk: counties in South-Eastern Norway Regional Health Authority.

168x127mm (300 x 300 DPI)



Supplement figure 1. Number of knee arthroscopies per Regional Health Authority in 2012 and 2016.

101x81mm (300 x 300 DPI)

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5,6
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6,7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	6,7
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6,7
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6,7, table 1 and 2
Discussion			
Key results	18	Summarise key results with reference to study objectives	8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9,10
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Not applicable

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.