

# Geographical Variation In Common Orthopedic Procedures In Norway: A Cross-Sectional Population Based Study

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## Research Article

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# Abstract

## Background

Standardised surgery rates for common orthopedic procedures vary across geographical areas in Norway. The aim in this study is to explore whether area-level factors related to demand and supply in publicly funded healthcare are associated with geographical variation in surgery rates for six common orthopedic procedures.

## Methods

Cross-sectional population based study of the 19 hospital referral areas in Norway. Adult admissions for arthroscopy for degenerative knee disease, arthroplasty for osteoarthritis of the knee and hip, surgical treatment for hip fracture, and decompression with or without fusion for lumbar disc herniation and lumbar spinal stenosis over 5 years (2012-2016) were included. Extremal quotients, coefficients of variation and systematic components of variance were used to estimate variation in age and sex standardised surgery rates. Linear regression analyses were conducted to explore the association between standardised surgery rates and proportion of population in urban areas, unemployment, proportion of persons living in low-income households, proportion of persons with a high level of education, and mortality.

## Results

Arthroscopy for degenerative knee disease showed the highest level of variation and the number of arthroscopies decreased during the period. There was considerable variation in procedures for lumbar disc herniation and lumbar spinal stenosis, moderate to low variation for arthroplasty for osteoarthritis of the knee and hip, and least variation in surgical treatment for hip fracture. Association between surgery rates and socioeconomic and supply factors were weak for arthroscopy for degenerative knee disease and decompression for lumbar disc herniation and spinal stenosis. Standardised surgery rates for arthroplasty for osteoarthritis of the knee and hip, and surgical treatment for hip fracture were not associated with the supply and demand factors included in this study.

## Conclusions

Variation in surgery rates were particularly high for arthroscopy for degenerative knee disease, and these rates decreased considerably during the five-year period. Factors reflecting socioeconomic circumstances, health and supply have a weak association to orthopedic surgery rates at an area-level. Whether this reflects the equity of universal health care services, or if area-level factors are not detailed enough to detect an existing association is being explored in two ongoing Norwegian studies.

## Background

The number of orthopedic surgical procedures per population, i.e. the surgery rate, vary for all common orthopedic procedures in Norway (1, 2, 3, 4), as well as in most other countries (5, 6, 7, 8, 9). For some procedures, like hip fracture repair where the efficacy of the treatment and positive outcomes are not disputed, the variation is small and likely to describe differences in incidence. However, surgery rates for several other orthopedic conditions show marked geographic variation.

Norway is a country with a universal health system that strives to provide equitable access to healthcare for all inhabitants (10). The prevalence of diseases in the relatively homogeneous population is assumed to vary minimally with area of residence. What causes variation in surgery rates under these conditions? Socioeconomic factors are known to impact health and the demand for healthcare (11). Supply of health services can have an influence on utilization as well (11). We examine these factors in the setting of orthopedic healthcare in Norway.

Geographic variation has been a field of interest in international research for a long time (12). It can be caused by differences in morbidity or preferences in the patient population, but it can also be unwarranted as a result of differences in medical practice and supply of procedures (13). The risk of unwarranted variation is overuse, underuse or wrong utilization of the health services. (14). Since geographic variation can be system dependent, it is necessary to examine factors associated with such variation in Norwegian healthcare.

The aim in this study is to explore whether area-level factors related to demand and supply in publicly funded healthcare are associated with geographical variation in surgery rates for six common orthopedic procedures.

## Methods

### Study design

The STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines were used to guide the conduct and reporting of this cross-sectional population based study (15).

### Setting

The public health care system in Norway has an equal distribution of monetary resources, and uniform training and licensing for healthcare staff. Most patients are treated at the public hospital serving their residential address. Orthopedic surgery is provided free of cost to patients in the public health care system. In private hospitals, the patients or their insurance providers cover expenses of surgery. Many patients have private health insurance paid for by their employers. Some of the private hospitals have government funding through contracts with the public regional health authorities. A recent study showed that the effectiveness of spine surgery is equivalent in private and public hospitals (16).

Conservative treatment for orthopedic conditions is available in the public health care system, but referral pathways vary and display great inconsistency. Data on the structure of and access to conservative

treatment was not available in this study.

## Data source, Participants, and Variables

The Norwegian Patient Registry (NPR) covers all publicly funded specialist healthcare services in Norway, including treatment in private institutions and specialists contracted to regional health authorities (17).

Standardised surgery rates were calculated for the Orthopaedic Healthcare Atlas for Norway (1) from a dataset of hospital admissions supplied by the NPR. All admissions in the time period of 2012–2016, based on defined orthopedic diagnoses and procedures were included.

We included all cases who underwent six specific surgical procedures; arthroscopy for degenerative knee disease, arthroplasty for osteoarthritis of the knee, arthroplasty for osteoarthritis of the hip, surgical treatment for hip fracture, decompression with or without fusion for lumbar disc herniation and decompression with or without fusion for lumbar spinal stenosis. An additional table file shows the inclusion criteria in terms of the International Classification of Diseases (ICD-10) and NOMESKO Classification of Surgical Procedures (NCSP) codes (see Additional file 1). Cases 18 years and older were included for all the above mentioned procedures, with the exception of arthroscopy for degenerative knee disease, for which cases aged 50 years and older were included. This age group was chosen to maximize inclusion of those with complaints related to osteoarthritis, who are not expected to benefit from arthroscopic procedures (4). Patients where municipality of residence was not available or registered as 'abroad' were excluded (less than 1 % of admissions).

We gathered the data for factors possibly associated with geographic variation from online national registers, Statistics Norway (SSB) and three national medical quality registers (the Norwegian arthroplasty registry, the Norwegian hip fracture registry and the Norwegian registry for spine surgery). The Norwegian Medical Association provided data on the numbers of surgeons according to area of residence.

### *Definition of hospital referral areas and standardised surgery rates.*

The 19 geographical areas roughly correspond to hospital referral areas (HRAs) of health trusts in Norway. Treatment was recorded according to patients' area of residence (postal code), and not based on which hospital or health trust delivered the treatment.

For each of the six procedures, surgery rates per 100,000 adult population ( $\geq 18$  years) were calculated, per year per hospital referral area. Rates were directly standardised for age and gender using the relevant age group of the population of Norway on 1 January 2016 as the standard population. Necessary population data was extracted from SSB tables 07459 and 10826.

## Quantifying variation

The extent of variation in standardised surgery rates for each procedure across areas was estimated using the extremal quotient (EQ; maximum rate divided by minimum rate), the coefficient of variation (CV;

standard deviation of rates divided by mean of rates), and the systematic component of variance (SCV) (18, 19, 20, 21, 22, 23).

## **Analysis of factors associated with variation**

To quantify supply related factors we analysed the impact of the numbers of hospitals and surgeons. We retrieved online data on public and private hospitals from three national medical quality registers. The number of hospitals per 100,000 population was calculated for each hospital referral area and procedure. Private hospitals included both hospitals with partial public funding and hospitals with no public funding. Main analyses were performed using data for the total number of hospitals per area, including both public and private hospitals. In addition, we performed sensitivity analyses to detect the possible effect of the number of public and private hospitals separately. Data on the number of surgeons per 100,000 population was calculated for each hospital referral area from data supplied by the Norwegian Medical Association. Data on orthopedic surgeons listed according to residential address in 2016 were used for knee and hip procedures. For spine procedures, the number of surgeons was the sum of orthopedic surgeons and neurosurgeons listed according to residential address in 2016. We also performed sensitivity analyses to detect possible effects of the numbers of orthopedic surgeons and neurosurgeons separately.

To quantify demand related factors, we retrieved online available data on nine socioeconomic variables from SSB on municipality and sub city level and calculated proportions and rates per hospital referral area. Based on a correlation analysis and an assessment of relevance, we chose to include the following factors to quantify demand; the proportion of population in urban areas (SSB table 05212), the unemployment rate (SSB table 10594), the proportion of persons living in low-income households (SSB table 06947), the proportion of persons with a high level of education (SSB tables 09429 and 09434), and the mortality rate (SSB table 12983).

A linear multivariate regression analysis was performed for each procedure. Model performance was evaluated using adjusted R-squared. A p-value < 0.05 was considered statistically significant.

We used R version 4.03, a free software program for statistical computing, for all statistical analysis.

## **Results**

Table 1  
Numbers of procedures, surgical rates and variation statistics

Procedure	Total number of procedures (2012–2016)	Rate	Min	Max	EQ	CV	SCV
Arthroscopy for degenerative knee disease*	33 621	383	147	670	4.5	30	10.3
Arthroplasty for osteoarthritis of the knee	28 539	146	120	224	1.9	16	2.6
Arthroplasty for osteoarthritis of the hip	37 298	191	158	228	1.4	9	0.8
Surgical treatment for hip fracture	44 460	222	197	242	1.2	5	0.2
Decompression for lumbar disc herniation	15 991	80	49	124	2.6	20	3.8
Decompression for lumbar spinal stenosis	16 064	82	56	115	2.1	23	4.9
Rate; number of procedures per 100 000 adult population, EQ; extremal quotient, CV; coefficient of variation, SCV; systematic component of variation. * Patients 50 years and older							

Geographical variation in standardised surgery rates is shown in Table 1 and Figure 1. The number of knee arthroscopies decreased during the period from 8,857 arthroscopies in 2013 to 4,172 in 2016. The numbers were stable for the other procedures.

Arthroscopy for degenerative knee disease was the procedure with the highest level of variation (SCV 10.3, 4.5-fold) and the highest standardised rate among the eligible population. There was also considerable variation of the rates for decompression for lumbar spinal stenosis (SCV 4.9, 2.1-fold) and lumbar disc herniation (SCV 3.8, 2.6-fold). For arthroplasty for osteoarthritis of the knee variation was moderate (SCV 2.6, 1.9-fold), while the variation was relatively low for arthroplasty for osteoarthritis of the hip (SCV 0.8, 1.4-fold). Surgical treatment for hip fracture showed least variation in surgery rates (SCV 0.2, 1.2-fold).

Table 2  
National mean and lowest and highest values per HRA for factors associated with variation.

	<b>National mean</b>	<b>Min HRA mean</b>	<b>Max HRA mean</b>
% unemployed	1.8	1.2	2.2
% with high level of education	28.8	21.9	51.5
% in low income household	10.4	8.0	14.9
% mortality	0.8	0.6	1.1
% in urban areas	76.7	57.1	99.7
	National rate	Min HRA rate	Max HRA rate
Surgeons per 100 000 population			
Knee and hip procedures	9.5	4.0	18.4
Lumbar spine procedures	10.7	4.0	23.5
Hospitals per 100 000 population			
Arthroscopy for degenerative knee disease	3.8	1.2	7.1
Arthroplasty for osteoarthritis of the knee	1.7	0.3	3.4
Arthroplasty for osteoarthritis of the hip	1.8	0.3	3.4
Surgical treatment for hip fracture	1.4	0.3	3.4
Lumbar spine procedures	1.0	0.0	1.9
HRA; hospital referral area			

#### Factors associated with variation

National mean, and lowest and highest values per hospital referral area for factors associated with variation are shown in Table 2. The association between surgery rates and socioeconomic and supply factors were weak for arthroscopy for degenerative knee disease and decompression for lumbar disc herniation and spinal stenosis. Higher rates of arthroscopy for degenerative knee disease were associated with more orthopaedic surgeons (adjusted coefficient 24.8, 95% CI 2.7 to 47.0), and a smaller proportion of the population living in urban areas (adjusted coefficient - 13.3, 95% CI -25.4 to -1.2). For decompression for lumbar spinal stenosis, higher rates were associated with more hospitals (adjusted coefficient 22.4, 95% CI 4.6 to 40.2), and a larger proportion of the population living in urban areas (adjusted coefficient 2.1, 95% CI 0.4 to 3.8). For decompression for lumbar disc herniation, higher rates were associated with lower mortality (adjusted coefficient - 192.6, 95% CI -384.2 to -1.1). For lumbar

spine procedures, a sensitivity analysis including the number of neurosurgeons and orthopedic surgeons as separate variables did not strengthen the association.

Surgery rates for knee and hip arthroplasty, and surgical treatment for hip fracture were not associated with the supply and demand factors included in this study.

A sensitivity analysis of public and private hospitals included as separate variables did not render notable associations for any of the procedures included in the study.

An additional table file includes full univariable and multivariable models of the linear regression analysis with standardised surgery rates as outcome (see Additional file 2).

## Discussion

### Key results

The main finding in this study was that variation in standardised surgery rates ranged from almost none to tenfold across the six orthopedic procedures in publicly funded Norwegian hospitals between 2012 and 2016. The variation was very high (SCV > 10) for arthroscopy for degenerative knee disease for patients 50 years and older, moderate (SCV 3–5) for the decompression procedures for lumbar disc herniation and lumbar spinal stenosis, and low (SCV < 3) for arthroplasty for osteoarthritis of the knee or hip, and surgical treatment for hip fracture.

The rates for arthroscopy for degenerative knee disease decreased markedly in all hospital referral areas. This indicates that practice is being adapted to recommendations in new guidelines (24). Persisting variation in arthroscopy rates might suggest, however, that different areas are adapting asynchronously. A similar pattern of decrease has been reported in other European countries, as well as in the US (5, 25, 26).

We observed that higher rates of arthroscopy for degenerative knee disease had a weak association to more orthopedic surgeons and a larger proportion of the population living in rural areas. The reason for this is unknown and may relate to local practice differences, availability of services or specific lifestyle demands.

Studies from Ireland, Korea and the UK (5, 7, 27) report an increase in knee arthroplasty with deprivation. Rates for knee and hip arthroplasty have also been associated with numbers of surgeons, hospital capacity (7, 27, 28), and socioeconomic factors (28, 29). Our findings align with those reported by de Pina et al. (9) and Mäkelä et al. (30), who found no association with supply or socioeconomic factors. The relatively low variation in arthroplasty for osteoarthritis of the hip is similar to that seen in Finland, where variation decreased from threefold in 1998 to 1.9-fold in 2005 (30).

As surgical treatment of a hip fracture is considered both effective and necessary, we did not expect to find any association with supply or demand related factors. The small amount of variation in hip fracture

surgery is in line with other reports (5, 31, 32) and variation is generally considered to reflect the relatively small differences in incidence.

Variation in spine surgery procedures, similar to that found in the current study, has been observed both internationally and in Norway (3, 5, 33), and is related to more uncertainty about the effectiveness of the procedures (34). Bederman et al. (33) found that higher rates were associated with lower income, but found no association with supply of physicians. The number of hospitals was negatively associated with spine surgery rates in Ireland (5). We found no notable association between spine surgery rates and the area-level supply or demand related factors analysed in our study.

## **Strengths and weaknesses**

The main strength of this study is the availability of nationwide data on orthopedic procedures performed at publicly funded hospitals, which gives a comprehensive picture of variation in public healthcare.

While the majority of orthopedic surgery, and all hip fracture surgery, in Norway is performed in publicly funded hospitals, the proportion of private providers range from 12 to 30 percent (arthroscopy for degenerative knee disease 19 of 64, decompression for lumbar disc herniation and lumbar spinal stenosis 10 of 43, arthroplasty for osteoarthritis of the knee 9 of 60, and arthroplasty for osteoarthritis of the hip 7 of 60 hospitals). Most private hospitals perform both publicly funded and privately funded treatment, but report only publicly funded activity to the NPR. Accordingly, absence of data on privately funded activity is a limitation in our analysis, as the data does not reflect all activity. For some of the studied procedures, private activity has been reported to increase variation (4, 16). Further, the number of hospitals is a crude measure as it does not account for differences in hospital capacity.

Conservative treatment is an important option for many orthopedic conditions. While this is generally acknowledged, the lack of uniformity in conservative care in the Norwegian public health care system might be a driver of variation in surgery rates. It is a limitation that we could not account for this, due to the availability of data.

The number of surgeons includes practicing surgeons nationwide, but remains a rough estimate as surgeons' area of residence might not always coincide with the area in which they work, especially in the larger capitol area. Furthermore, we have not included the varying number of surgeons in training, who independently perform some of the included procedures in many hospitals. The proportion of surgeons in training varies between geographical areas, but we did not have access to these data. Finally, some surgeons are not permanently employed, but contracted through staffing agencies. Data quantifying this are not available, either.

It is a limitation of the study design that data on demand-related factors were available on area, and not individual, level. This precludes us from exploring variation in surgery rates in light of demand in the patient groups involved. Hence, the analysis of associations between surgery rates and demand-related factors only gives rough estimates of this relationship. Nevertheless, geographic variation research

conducted at a national level, using area-level units of analysis while crude, is important in signalling potential inequality and treatment underuse or overuse (35, 36).

## Interpretation

The associations found in our study between area-level demand and supply-related factors and surgery rates were weak. We might assume that the included orthopedic surgery rates are not notably associated with regional numbers of hospitals or surgeons, or with income, education, unemployment, health level (estimated by mortality as a proxy) or with urbanization. This could be a result of longstanding efforts in Scandinavia to facilitate equity by universal health care and tax paid education.

On the other hand, one could argue that area-level factors reflecting demand are not detailed enough to detect the associations that may exist between socioeconomic factors and surgery rates. To further explore this, qualitative analyses and more detailed multilevel analyses including individual-level data of factors known to influence surgery rates are needed. This is being explored in two ongoing Norwegian studies on geographic variation in hip and knee arthroplasty and lumbar spine surgery, using mixed methods design consisting of multilevel analyses on registry data and qualitative data collection from focus groups (general practitioners) and individual interviews (patients and surgeons).

While sociodemographics and healthcare supply do not seem to explain variation in common orthopedic procedures based on our findings, we acknowledge that there are more factors known to impact utilization of health care. These include differences in preferences among surgeons, the effect of shared decision-making, as well as capacity and structural aspects of the health care system (6, 8, 11, 37, 38, 39).

## Conclusions

In Norway between 2012 and 2016, variation in surgery rates were particularly high for arthroscopy for degenerative knee disease such as meniscal tears and osteoarthritis, and these rates decreased considerably during the five-year period. Factors reflecting socioeconomic circumstances, health and supply have a weak association to orthopedic surgery rates at an area-level. Whether this reflects the equity of universal health care services, or if area-level factors are not detailed enough to detect an existing association is being explored in two ongoing Norwegian studies.

## Abbreviations

STROBE STrengthening the Reporting of OBservational studies in Epidemiology

NPR The Norwegian Patient Registry

ICD-10 International Classification of Diseases

NCSP NOMESKO Classification of Surgical Procedures

SSB Statistics Norway

HRA hospital referral area

EQ extremal quotient

CV coefficient of variation

SCV systematic component of variance

## Declarations

### *Ethics approval and consent to participate*

All protocols were carried out in accordance with relevant guidelines and regulations. The basis for the processing of data has been the General Data Protection Regulation. Approval by an ethics committee and consent to participate was not required for this register study.

### *Consent for publication*

Not Applicable

### *Availability of data and materials*

Data may be obtained from a third party and are not publicly available. Census data and data on socioeconomic factors is publicly available from Statistics Norway at <https://www.ssb.no/>.

### *Competing interests*

None declared.

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### *Authors' contributions*

MH, VH, HKB and TI conceptualized the study. HKB and KIO analysed the data and MH, VH, HKB, MEW and TI interpreted the results. MH and VH wrote the original draft and MEW, JEG, ONF and TI contributed to the editing and reviewing of the paper. All authors have read and approved the manuscript.

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## Disclaimer

Data from the Norwegian Patient Register has been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended nor should be inferred.

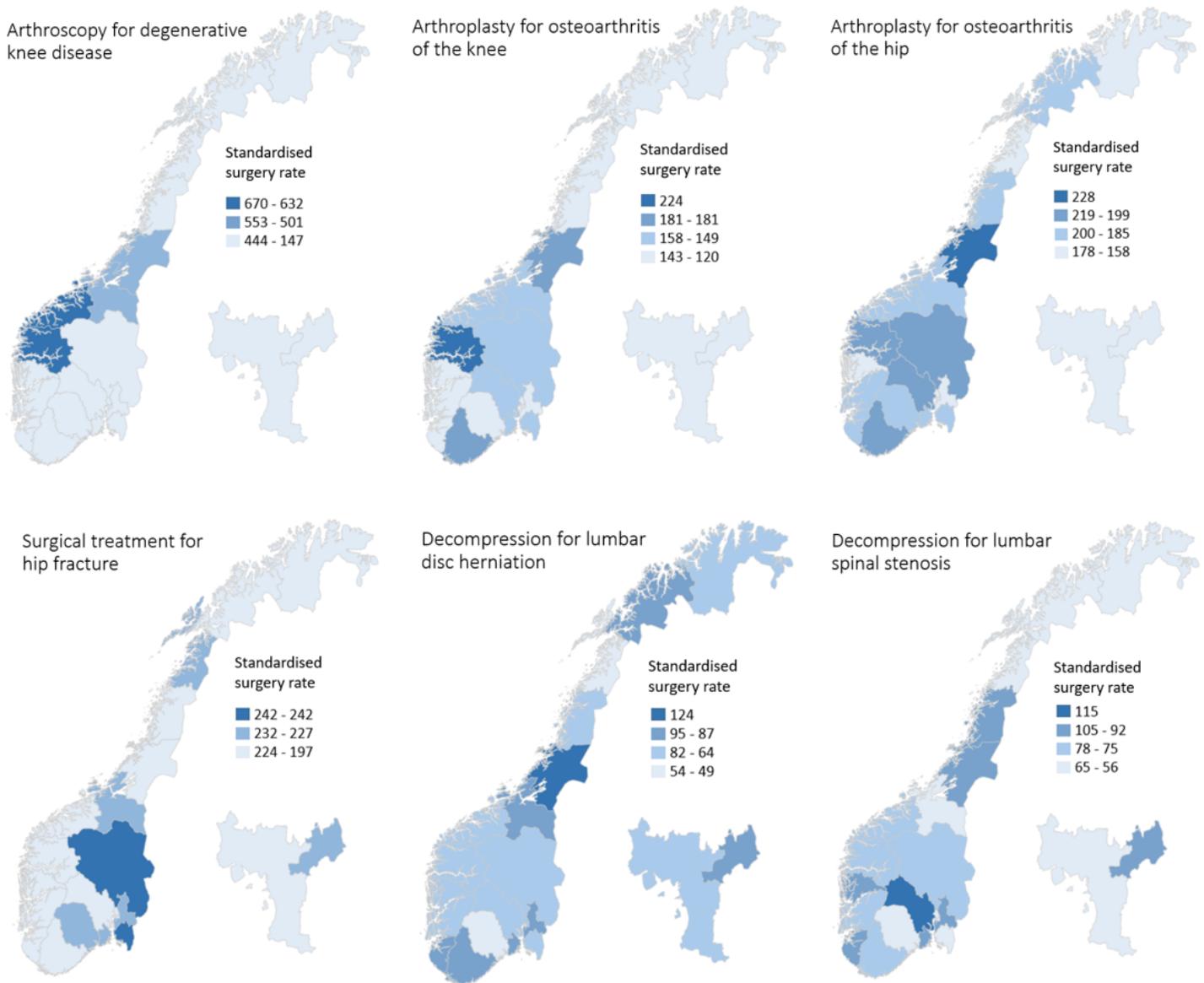
## References

1. Bale M, Aksnes JV, Holsen M, Osvoll KI, Bedane HK. Orthopaedic Healthcare Atlas for Norway. Use of orthopaedic health services 2012–2016. Helse Førde health trust report 1/2018.
2. Uleberg B, Mathisen S, Shu J, Balteskard L, Steindal AH, Byhring HS, Leivseth L, Førde OH. Day surgery in Norway 2013–2017. A selection of procedures. SKDE report 3/2018.
3. Ingebrigtsen T, Balteskard L, Guldhaugen KA, Kloster R, Uleberg B, Grotle M, Solberg TK. Treatment rates for lumbar spine surgery in Norway and Northern Norway Regional Health Authority 2014–18. Tidsskrift for Den norske legeförening. 2020.
4. Holtedahl R, Brox JI, Aune AK, Nguyen D, Risberg MA, Tjomsland O. Changes in the rate of publicly financed knee arthroscopies: an analysis of data from the Norwegian patient registry from 2012 to 2016. *BMJ open*. 2018;8:6.
5. Walsh ME, Boland F, O’Byrne JM, Fahey T. Geographical variation in musculoskeletal surgical care in public hospitals in Ireland: a repeated cross-sectional study. *BMJ open*. 2019;9(5), e028037.
6. Hamilton DF, Howie CR. Knee arthroscopy: influence of systems for delivering healthcare on procedure rates. *BMJ*. 2015;351:h4720.
7. Kim AM, Kang S, Park JH, Yoon TH, Kim Y. Geographic variation and factors associated with rates of knee arthroplasty in Korea—a population based ecological study. *BMC musculoskeletal disorders*. 2019;20(1):400.
8. Pabinger C, Lothaller H, Geissler A. Utilization rates of knee-arthroplasty in OECD countries. *Osteoarthritis and Cartilage*. 2015;23(10):1664–1673.
9. de Pina MDF, Ribeiro AI, Santos C. Epidemiology and variability of orthopaedic procedures worldwide. In *European Instructional Lectures* (pp. 9–19). Springer, Berlin, Heidelberg. 2011.
10. Helse- og omsorgsdepartementet. Verdier i pasientens helsetjeneste – melding om prioritering. Meld. St. 34 (2015–2016). 2016.
11. Appleby J, Raleigh V, Frosini F, Bevan G, Gao H, Lyscom T. Variations in health care: the good, the bad and the inexplicable. *King's Fund*. 2011.
12. Wennberg J, Gittelsohn A. Small variations in health care delivery. *Science*. 1973;182(4117):1102–8.
13. SKDE. Indikatorer for måling av uberettiget variasjon. Utredning fra SKDE for de regionale helseforetakene. Bonen B, Editor. 2016.
14. Elshaug AG, Rosenthal MB, Lavis JN, Brownlee S, Schmidt H, Nagpal S, Littlejohns P, Srivastava D, Tunis S, Saini V. Levers for addressing medical underuse and overuse: achieving high-value health

- care. *Lancet*. 2017;390(10090):191–202.
15. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. *Int J Surg* 2014;12:1495–9.
  16. Madsbu MA, Salvesen Ø, Carlsen SM, Westin S, Onarheim K, Nygaard ØP, et al. Surgery for herniated lumbar disc in private vs public hospitals: A pragmatic comparative effectiveness study. *Acta neurochirurgica*. 2020;162(3),703–711.
  17. Bakken IJ, Ariansen AM, Knudsen GP, Johansen KI, Vollset SE. The Norwegian Patient Registry and the Norwegian Registry for Primary Health Care: Research potential of two nationwide health-care registries. *Scandinavian journal of public health*. 2020;48(1):49–55.
  18. Ibáñez B, Libroero J, Bernal-Delgado E, Peiró S, López-Valcarcel BG, Martínez N, Aizpuru F. Is there much variation in variation? Revisiting statistics of small area variation in health services research. *BMC health services research*. 2009;9(1):60.
  19. Diehr P, Cain K, Connell F, Volinn E. What is too much variation? The null hypothesis in small-area analysis. *Health Services Research*. 1990;24(6):741–71.
  20. Fay M, Feuer E. Confidence intervals for directly standardized rates: a method based on the gamma distribution. *Statistics in Medicine*. 1997;16:791–801.
  21. Ng HKT, Filardo G, Zheng G. Confidence interval estimating procedures for standardized incidence rates. *Computational Statistics and Data Analysis*. 2008;52:3501–3516.
  22. Nelson M. *dsrTest: Tests and Confidence Intervals on Directly Standardized Rates for Several Methods*. R package version 0.2.1. 2017.
  23. McPherson K, Wennberg JE, Hovind OB, Clird P. Small-area variations in the use of common surgical procedures: an international comparison of New England, England, and Norway. *N Engl J Med*. 1982;307(21):1310–4.
  24. Siemieniuk RA, Harris IA, Agoritsas T, Poolman RW, Brignardello-Petersen R, Van de Velde S, Buchbinder R, Englund M, Lytvyn L, Quinlan C, et al. Arthroscopic surgery for degenerative knee arthritis and meniscal tears: a clinical practice guideline. *BMJ*. 2017;357:j1982.
  25. Howard DH. Trends in the Use of Knee Arthroscopy in Adults. *JAMA Intern Med*. 2018;178:1557.
  26. Mattila VM, Sihvonen R, Paloneva J, Felländer-Tsai L. Changes in rates of arthroscopy due to degenerative knee disease and traumatic meniscal tears in Finland and Sweden. *Acta orthopaedica*. 2016;87(1):5–11.
  27. Judge A, Welton NJ, Sandhu J, Ben-Shlomo Y. Geographical variation in the provision of elective primary hip and knee replacement: the role of socio-demographic, hospital and distance variables. *Journal of Public Health*. 2009;31(3):413–422.
  28. Schäfer T, Pritzkeleit R, Jeszenszky C, Malzahn J, Maier W, Günther KP, Niethard F. Trends and geographical variation of primary hip and knee joint replacement in Germany. *Osteoarthritis and Cartilage*. 2013;21(2):279–288.

29. Youm J, Chan V, Belkora J, Bozic KJ. Impact of socioeconomic factors on informed decision making and treatment choice in patients with hip and knee OA. *The Journal of arthroplasty*. 2015;30(2):171–175.
30. Mäkelä KT, Peltola M, Häkkinen U, Remes V. Geographical variation in incidence of primary total hip arthroplasty: a population-based analysis of 34,642 replacements. *Archives of orthopaedic and trauma surgery*. 2010;130(5):633–639.
31. Widmer M, Matter P, Staub L, Schoeni-Affolter F, Busato A. Regional variation in orthopedic surgery in Switzerland. *Health & place*. 2009;15(3):791–798.
32. Birkmeyer JD, Sharp SM, Finlayson SR, Fisher ES, Wennberg JE. Variation profiles of common surgical procedures. *Surgery*. 1998;124(5):917–923.
33. Bederman SS, Coyte PC, Kreder HJ, Mahomed NN, McIsaac WJ, Wright JG. Who's in the driver's seat? The influence of patient and physician enthusiasm on regional variation in degenerative lumbar spinal surgery: a population-based study. *Spine*. 2011;36(6):481–489.
34. Lurie JD, Bell JE, Weinstein J. What rate of utilization is appropriate in musculoskeletal care? *Clin Orthop Relat Res*. 2009;467:2506–11.
35. Corallo AN, Croxford R, Goodman DC, Bryan EL, Srivastava D, Stukel TA. A systematic review of medical practice variation in OECD countries. *Health Policy*. 2014;114(1):5–14.
36. Westert GP, Groenewoud S, Wennberg JE, Gerard C, DaSilva P, Atsma F, Goodman DC. Medical practice variation: public reporting a first necessary step to spark change. *International Journal for Quality in Health Care*. 2018;30(9):731–735.
37. Riksrevisjonens undersøkelse av årsaker til variasjon i forbruk av helsetjenester. Del av Dokument 3:2 (2019–2020). <https://www.riksrevisjonen.no/globalassets/rapporter/no-2019-2020/variasjonforbrukhelsetjenester.pdf>. Accessed 1 Jul 2021.
38. Saini V, Garcia-Armesto S, Klemperer D, Paris V, Elshaug AG, Brownlee S, et al. Drivers of poor medical care. *The Lancet*. 2017;390(10090):178–190.
39. Finkelstein A, Gentzkow M, Williams NH. Sources of Geographic Variation in Health Care: Evidence from Patient Migration Online Appendix. 2014.

## Figures



**Figure 1**

Geographical variation in standardised surgery rates. Enlarged map of capital area in lower right hand corner of each map.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Additionalfile1.pdf](#)
- [Additionalfile2.pdf](#)