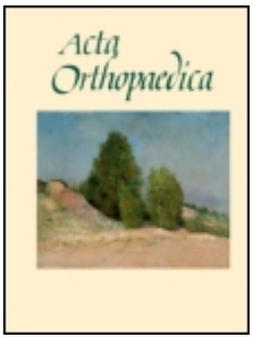

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Regional variation in incidence of primary total hip arthroplasties and revisions in Denmark, 1996–2002

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Background **We examined incidence rates (IR) of total hip arthroplasty (THA) in Denmark according to county and type of hospital, and investigated possible factors associated with any variations.**

Methods **Through the Danish Hip Arthroplasty Registry, we identified all cases of primary THAs (n = 37,144) and revisions (n = 6,446) between 1996 and 2002. Unadjusted and age- and gender-standardized, hospital type- and county-specific IRs were calculated. Using multiple regression analysis, we examined possible factors associated with the variations.**

Results **Over the study period, age- and sex-standardized IRs of primary THAs for university and other hospitals increased by 10% and 40%, respectively. IRs of revisions increased for other hospitals by 33%, but decreased for university hospitals by 30%. Unadjusted IRs varied among counties (n = 15), which remained despite age- and gender-standardization. The IR ratio was 1.4 (95% CI: 1.3–1.6) when comparing the counties with the highest and lowest IRs. No association was found between IRs of THA and the number of orthopedic surgeons per 100,000 inhabitants, proportion of patients with primary arthrosis, preoperative Harris Hip Score, hospital costs, the counties' Gross Domestic Product, or population density.**

Interpretation **Substantial regional differences in the IRs of THA procedures were found. We found no associations between IRs and a range of patient- and healthcare system-related factors.**

We have recently reported an increase in the incidence rates (IR) of primary THAs in Denmark from 100.5 (95% CI: 97.6–103.5) in 1996 to 131.1 (95% CI: 128.3–134.9) in 2002, and of revisions from 19.2 (95% CI: 17.9–20.5) to 20.7 (95% CI: 19.4–22.1) per 100,000 inhabitants in the same period (Pedersen et al. 2005). The increase in IRs of THA procedures was found among both women and men, in all age groups, and to be independent of the diagnosis for primary THA, except for rheumatoid arthritis where we found a decrease.

Studies from other populations have indicated that IRs of THA procedures vary among different types of hospitals (e.g., university, central, and local) (Malchau et al. 2002), among countries, and among regions within the same country (Alibhai et al. 2001, Wells et al. 2002, Merx et al. 2003). Although regional variations in IRs of THA and other types of surgery have been described before, there is a lack of information on the possible factors associated with these variations (Peterson et al. 1992).

Healthcare in Denmark has undergone a marked change over the last few years, beginning with free hospital choice for all patients since 1993 and followed by a reduction in the number of somatic hospitals from 90 to 60, and a decrease in the average length of stay in hospitals from 6.7 to 5.1 days between 1990 and 2002 (Ministry of the Interior and Health 2003). The objective of this study was therefore to estimate the IRs of THA procedures in Denmark according to different types of hospi-

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tals and counties in the period 1996–2002, during which changes to the healthcare system took place, and to identify variations. Furthermore, we aimed to examine the role of patient-related and healthcare system-related factors in relation to any regional variation in the IRs of THA procedures.

Methods

The Danish healthcare system

In the Danish healthcare system, the responsibility for financing, planning, running, and management of hospitals lies with 14 counties and one municipality. About 28% of the population is covered by private health insurance in addition to general public insurance (Ministry of the Interior and Health 2003). The Danish health service provides free medical care, including emergency and other admissions to hospitals and outpatient clinics after referral from the general practitioner. More than 95% of the patients are registered with one general practitioner of their choice. After referral from the general practitioner, patients have free hospital choice in the entire country, which also includes some of the private hospitals.

Data sources

The Danish Hip Arthroplasty Registry (DHR) is a nationwide population-based clinical database which was implemented by the Danish Orthopaedic Society in 1995 (Lucht 2000), and has previously been described in detail (Pedersen et al. 2004). Through continuous feedback to the orthopedic community, the aims of the Registry are to examine trends in occurrence of THA procedures, to reduce the revision burden, and to improve outcome of THA surgery in Denmark.

From the DHR, we identified all cases of primary THA and revision performed in Denmark between January 1, 1996 and December 31, 2002. After the exclusion of patients with erroneously registered third primary THAs (n = 8), the analysis included 37,144 patients who underwent primary THA and 6,446 patients who underwent revision during the study period.

The Central Personal Registry (CPR) was used to obtain data on the county of residence at the time of surgery for all patients included in the analyses. Through the use of the civil registry number which is unique to every Danish citizen and encodes sex and date of birth, the CPR records all changes in vital status of all Danish citizens including changes in address, date of emigration, and the date of death since 1968. The civil registry number allows linkage of information from various registers.

We obtained data on the population size according to age and sex at the middle of each calendar year from StatBank Denmark (http://statistikbanken.dk), together with county-specific data on population density and gross domestic product (GDP). Data on the number of orthopedic surgeons per county at the middle of each calendar year were obtained from the Danish Medical Association. We obtained data on the "European Standard Population" (divided into 18 age groups) within SEER*Stat from http://www-dep.iarc.fr/dataava/ewstdpop.htm.

County-specific data on hospital costs per capita were obtained from the Association of County Councils (Http://arf-socinfo.csc-scandihealth.com/ArfWebInfo/Statistik/FormShowGroup.aspx?Group=-24).

Statistics

IRs of THA procedures according to hospital type. According to hospital type (university and other hospitals), annual IRs of primary THAs or revisions were calculated by dividing the number of patients undergoing primary THA or revision according to calendar year, by the corresponding number of persons at risk in Denmark per year. Other hospitals include local, central and private hospitals, and as such it is not a homogeneous group. Age was divided into 5 groups (i.e., 10–49, 50–59, 60–69, 70–79, and 80+ years). We estimated annual age-standardized IRs of primary THA or revision using the age distribution (18 age groups) of the European Standard Population as a reference. Furthermore, annual age-standardized IRs of primary THA and revision for private hospitals only were calculated. Annual IRs were expressed per 100,000 person years, with 95% CI. Poisson regression was used to estimate incidence rate ratios (IRR) using the year 1996 as the reference.

County-specific IRs of THA procedures. First, we estimated the unadjusted IRs of primary THA or revision. The county of residence is not always

Table 1. Characteristics of the total hip arthroplasty (THA) patients registered in the Danish Hip Arthroplasty Registry, 1996–2002

Characteristic	1996	1997	1998	1999	2000	2001	2002
Primary THA, n (%)	4,633 (84.0)	4,897 (84.4)	5,044 (85.0)	5,280 (85.3)	5,431 (85.7)	5,557 (85.2)	6,302 (86.4)
Revision, n (%)	883 (16.0)	905 (15.6)	889 (15.0)	911 (14.7)	904 (14.3)	966 (14.8)	988 (13.6)
Hospital type, n (%)							
Primary THA							
University hospitals	813 (17.5)	760 (15.5)	765 (15.2)	854 (16.2)	860 (15.8)	791 (14.2)	935 (14.8)
Other hospitals	3,820 (82.5)	4,137 (84.4)	4,277 (84.8)	4,426 (83.8)	4,571 (84.2)	4,766 (85.8)	5,367 (85.2)
Revision							
University hospitals	331 (37.5)	343 (37.9)	327 (36.8)	305 (33.5)	305 (33.7)	277 (28.7)	264 (26.7)
Other hospitals	552 (62.5)	562 (62.1)	562 (63.2)	606 (66.5)	599 (66.3)	689 (71.3)	724 (73.3)
Total number of inhabitants at risk in Denmark	4,608,491	4,618,164	4,626,797	4,638,703	4,653,478	4,669,518	4,689,729

identical to the county where the surgery has been carried out; however, the dwelling county is responsible for the expenses of the surgery. The regional IRs, based on patients' county of residence, were calculated per 100,000 person years.

Secondly, we standardized the IRs by age and sex according to the distribution in the Copenhagen Hospital Cooperation (H:S), which was the county with the lowest unadjusted IRs. Poisson regression analysis was then used to calculate unadjusted and age- and sex-adjusted IRR, again with H:S as the reference.

Thirdly, we examined whether regional variations were associated with different patient- and healthcare system-related factors. Coefficients of variation were used to describe the size of the variation of the factors examined and IRs among the counties. Univariate linear regression analysis was performed with age- and sex-standardized IRs of primary THAs as the dependent variable. IRs were included in the univariate regression analysis in rank ordering, i.e. from the lowest to the highest estimate of IR. As patient-related data, we included the county-specific proportion of patients with primary arthrosis, the Harris Hip Score (HHS) before surgery, and population density (number of inhabitants per square meter). The healthcare system-related data included the county-specific GDP, hospital costs per capita, and the number of orthopedic surgeons per 100,000 inhabitants.

Fourthly, we performed a multiple linear regression analysis including all the examined factors in the model. The regression coefficients were then calculated with 95% CIs, which was used to describe statistical significance of association. By application of the residuals confer fitted diagram, the statistical model was found to be suitable. In order to describe the amount of variation in the IRs that could be explained by the multiple model applied, R-squared (R2) was calculated.

All analyses were done using Stata statistical software, release 8.0 (Stata Corporation, Collage Station, TX).

Results

The characteristics of the THA patients registered in the DHR during the period 1996–2002 are presented in Table 1.

IRs of primary THA and revision according to type of hospital

IRs of primary THAs at university and other hospitals increased during the study period, i.e., IRRs were 1.1 (95% CI: 0.9–1.3) and 1.4 (95% CI: 1.3–1.4) in 2002 and 1996, respectively; however not significant for university hospitals. Furthermore, IRs of revisions at other hospitals increased in the same period also; IRR was 1.3 (95% CI: 1.1–1.5). In contrast, annual IRs of revisions at university hospitals decreased from 6.2 (95% CI: 2.7–14.6) to 4.5 (95% CI: 1.7–12.3) per 100,000 person years in the same period, giving an IRR of 0.7 (95% CI: 0.4–1.0) (Table 2). IRs of primary THA at private hospitals were unchanged in the study period, giving an IRR of 1.0 (95% CI: 1.0–1.1) when comparing 2002 with 1996, whereas IRs of revision

Table 2. Hospital-specific incidence rates (IR) of primary total hip arthroplasty (THA) and revision per 100,000 person years, standardized according to the European Standard Population, 1996–2002

Hospital type	1996	1997	1998	1999	2000	2001	2002
University hospitals							
Primary THA	15.0	13.9	13.8	15.7	15.4	14.1	16.5
Revision	6.2	6.3	6.0	5.6	5.5	4.9	4.5
Other hospitals							
Primary THA	71.6	76.5	78.9	81.7	83.6	86.2	96.9
Revision	10.1	10.2	10.3	11.0	10.8	12.2	12.8

Table 3. Incidence rate ratio (IRR) of primary total hip arthroplasty (THA) and revision for each Danish county compared with Copenhagen Hospital Cooperation (H:S) (Poisson regression)

		Primary THA			Revision	
Counties	Person years	THA (n)	Crude IRR (95% CI [a])	Adjusted IRR [b] (95% CI [a])	Revision (n)	Crude IRR (95% CI [a])	Adjusted IRR (95% CI [a])
H:S	3,644,182	3,163	1.0 (ref.)	1.0 (ref.)	796	1.0 (ref.)	1.0 (ref.)
Copenhagen county	3,725,886	4,072	1.3 (1.2–1.3)	1.1 (1.1–1.2)	667	0.8 (0.7–0.9)	0.8 (0.7–0.8)
Frederiksborg	2,199,387	2,526	1.3 (1.3–1.4)	1.3 (1.2–1.3)	547	1.1 (1.0–1.3)	1.2 (1.1–1.3)
Roskilde	1,394,380	1,475	1.2 (1.1–1.3)	1.3 (1.2–1.4)	237	0.8 (0.8–0.9)	0.8 (0.7–1.0)
West Zealand	1,801,941	2,294	1.5 (1.4–1.5)	1.3 (1.2–1.4)	390	1.0 (0.9–1.1)	0.9 (0.8–1.0)
Great Stream	1,597,433	2,346	1.7 (1.6–1.8)	1.4 (1.3–1.4)	389	1.1 (1.0–1.3)	0.9 (0.8–1.1)
Bornholm	276,087	431	1.8 (1.6–2.0)	1.4 (1.3–1.6)	83	1.4 (1.1–1.7)	1.1 (0.9–1.4)
Funen	2,891,186	3,766	1.5 (1.4–1.6)	1.3 (1.3–1.4)	497	0.8 (0.7–0.9)	0.7 (0.6–0.8)
South Jutland	1,545,866	2,174	1.6 (1.5–1.7)	1.4 (1.3–1.5)	272	0.8 (0.7–0.9)	0.7 (0.6–0.8)
Ribe	1,354,561	1,652	1.4 (1.3–1.5)	1.3 (1.3–1.4)	425	1.4 (1.3–1.6)	1.4 (1.2–1.6)
Vejle	2,106,678	2,342	1.3 (1.2–1.4)	1.2 (1.0–1.3)	417	0.9 (0.8–1.0)	0.9 (0.8–1.0)
Rinkjøbing	1,651,990	1,887	1.3 (1.2–1.4)	1.3 (1.2–1.3)	376	1.0 (0.9–1.2)	1.0 (0.9–1.2)
Aarhus	3,865,611	3,594	1.1 (1.0–1.1)	1.1 (1.0–1.1)	584	0.9 (0.8–1.0)	0.8 (0.7–0.8)
Viborg	1,419,522	1,690	1.4 (1.3–1.5)	1.2 (1.1–1.3)	218	0.7 (0.6–0.8)	0.6 (0.5–0.7)
North Jutland	3,020,018	3,557	1.4 (1.3–1.4)	1.2 (1.1–1.3)	485	0.7 (0.6–0.8)	0.8 (0.6–0.8)

[a] 95% confidence interval
[b] Adjusted for age and sex.

at private hospitals increased in the same period, giving an IRR of 2.0 (95% CI: 1.5–2.3) when comparing 2002 with 1996.

Regional variation in IRs of primary THA and revision

Unadjusted IRs of primary THAs showed substantial variation among the counties, as IRs varied from 86.8 (95% CI: 83.3–89.9) in H:S to 156.1 (95% CI: 142.0–171.6) in Bornholm County per 100,000 person years (Table 3). The coefficient of variation was 16%. Unadjusted IRRs varied between 1.1 (95% CI: 1.0–1.1) and 1.8 (95% CI: 1.6–2.0), when using H:S as the reference.

After age- and sex-standardization, the regional variation in IRs of primary THAs was reduced, as the coefficient of variation dropped to 9.2%. Standardized IRs varied from 86.8 (95% CI: 83.3–89.9) in H:S to 123.3 (95% CI: 121.6–125.9) in Bornholm County, per 100,000 person years. Adjusted IRRs of primary THAs varied between 1.1 (95% CI: 1.0–1.1) and 1.4 (95% CI: 1.3–1.6) in different counties compared with H:S (Table 3).

Unadjusted IRs of revisions also showed regional variations, as IRs varied from 15.1 (95% CI: 13.9–16.4) in Aarhus county to 31.4 (95% CI: 28.5–34.5) in Ribe county per 100,000 person years. The coefficient of variation was 24%. Variation remained after age- and sex-standardization, as the coefficient of variation still was 24% (Table 3). Unadjusted IRRs of revisions varied between 0.7 (95% CI: 0.6–0.8) and 1.4 (95% CI: 1.1–1.7), whereas

Table 4. Characteristics of the possible factors associated with regional variation (factors are expressed on average between 1995 and 2002 per county)

Factor	Mean (range)	Coefficient of variation (%)	Unadjusted regression coefficient (95 % CI) [b]	Adjusted regression coefficient(95 % CI) [c]
The number of orthopedic surgeons per 100,000 inhabitants	8.2 (4.9–12)	20	-4.13 (-7.52; -0.75)	-3.09 (-8.82; 2.64)
Harris Hip Score	42 (23–45)	10	-0.837 (-2.04; 0.366)	-0.041 (-1.51; 1.42)
Proportion of patients with primary arthrosis	78 (68–84)	5	1.55 (-0.015; 3.12)	0.927 (-1.16; 3.009)
Population density [a]	640 (56-6944)	275	-0.004 (-0.007; -0.001)	0.003 (-0.006; 0.012)
Gross domestic product per capita	210 (160–364)	25	-0.16 (-0.252; -0.076)	-0.157 (-0.390; 0.076)
Hospitals costs per capita	6,860 (6,463–7,272)	4	0.024 (-0.0005 ;0.048)	0.005 (-0.021; 0.031)

[a] Number of inhabitants per square meter.
[b] Based on univariate linear regression, with age- and gender-standardized incidence rates of primary total hip arthroplasty as the dependent variable.
[c] Based on multiple linear regression.

the adjusted IRRs varied between 0.6 (95% CI: 0.5–0.7) and 1.4 (95% CI: 1.2–1.6) (Table 3).

Factors associated with regional variation

The factors possibly associated with age- and sex-standardized IRs of primary THA varied among the counties (Table 4). Three factors appeared to be associated with regional variation in IRs of primary THA in the univariate regression analyses, i.e. the number of orthopedic surgeons per 100,000 inhabitants, population density, and the GDP per capita (Table 4). However, these associations disappeared when mutually adjusting for all 6 factors (Table 4). The multiple model explained 71% of the regional variation in the IRs of primary THA.

In addition, no association was found between regional variations in IRs of revisions and number of orthopedic surgeons per 100,000 inhabitants, proportion of patients with primary arthrosis, HHS, population density, hospital costs per capita, and GDP per capita. However, this multiple model explained only 17% of the regional variation in IRs of revisions.

Discussion

The main strength of our study was the access to a nationwide clinical database with documented high overall data validity (Pedersen et al. 2004), allowing a population-based design. Furthermore, detailed data on the size of the Danish population were available and age standardization was performed according to the European Standard Population, which allows comparisons of incidences over time and with other populations. We aimed to identify factors that could be associated with regional variation, which has not been examined in detail before.

The limitations of our study included uncertainties about some of the possible factors associated with variation in IRs of primary THAs or revisions. Thus, because of voluntary registration of HHS, the registration degree of HHS before primary THA surgery was only 72%. Also, we had no information on a number of other factors which may possibly be associated with variation in IRs, e.g. general practitioners' and patients' preferences for the surgery, waiting time, local guidelines about clinical decision-making, or the number of nurses, anesthesiologists and other health staff who actively participate in performing surgery. Furthermore, we cannot exclude the possibility of collinearity between at least some of the covariates examined in the linear regression analyses. However, it should be noted that our multiple model did not appear unstable, i.e. the model coefficients were not associated with large variances and only minor changes were found when comparing the unadjusted and adjusted regression coefficients. Furthermore, the coefficients of variation for the specific covariates showed huge variation (between 4% and 275%). These findings argue against the presence of major collinearity in the dataset. Most of the factors

included in the linear regression analyses (Table 4) were not available on an individual level (except for Harris Hip Score). It was therefore only possible to conduct the linear regression analyses at the county (group) level and the factors examined could not be adjusted for in the Poisson regression analyses (Table 3). Finally, completeness of registration for revision in the DHR is 81%, which could also influence estimates of IRs.

IRs of primary THA and revision according to type of hospital

The recent changes in the Danish healthcare system—with reorganization of the surgical activities—imply that THA procedures have been centralized to some extent at units outside university hospitals. This explains the lower and decreasing activity at university hospitals found in our study. Two recent reports from Sweden and Canada (Malchau et al. 2002, Bourne et al. 2004) have described similar findings. This tendency may be troublesome, as most of the young surgeons spend major parts of their orthopedic training in university hospitals. In addition, clinical research, which is primarily done at university hospitals, often requires a high volume of patients. It should be noted, however, that factors other than the administrative reorganization of the surgical activity may be responsible for the lower activity at the university hospitals. Thus, the patients treated at a university hospital are likely to differ from the average patient treated at other types of hospitals. For example, the proportion of patients operated on due to secondary arthrosis (such as rheumatoid arthritis and sequelae of hip diseases in childhood) was 43% in university hospitals, as compared to 20% in other hospitals. These patients may require more extensive surgery than patients with primary arthrosis. Similarly, patients with higher co-morbidity, who may also require more extensive treatment, are also often referred to university hospitals. In addition, some university hospitals perform specific types of hip surgery on young patients other than THA (e.g. Ganz osteotomy), occupying both time and space for THA procedures (Søballe 2003).

Regional variation in IRs of primary THA and revision

The substantial regional variation in crude IRs of primary THAs and revisions found in this study generally agreed with the results of other studies (Peterson et al. 1992, Söderman et al. 2000, Alibhai et al. 2001, Mahomed et al. 2003, Bourne et al. 2004). Regional variations have also been found for numerous other surgical procedures including lower extremity revascularization, spinal surgery, radical and transurethral prostatectomy, coronary artery bypass grafting, mastectomy, knee arthroplasty, angioplasty, and cataract surgery (Birkmeyer et al. 1998, Majeed et al. 2002, Wells et al. 2002, Skinner et al. 2003).

It might be expected that regional variation in crude IRs is due to differences in the age and sex distribution of the population in various counties, as the IRs of THA procedures are closely related to increasing age and female sex. However, the regional variations in our study remained despite age- and sex-standardization.

A relatively large number of orthopedic surgeons would imply a large surgical capacity and therefore possibly a higher surgical activity. However, Peterson et al. (1992) found a low correlation between the number of orthopedic surgeons per 100 beneficiaries and the rate of THAs in the USA in 1988. We found no clear association in the multivariate model between the number of orthopedic surgeons per 100,000 inhabitants and IRs of THA procedures, after adjusting for other factors. However, it should be noted that we used the overall number of orthopedic surgeons per county per 100,000 inhabitants for each year, although not all orthopedic surgeons perform hip arthroplasty, i.e., some perform surgery on other joints or may be involved in clinical research. This may have lessened our ability to find an association between the number of orthopedic surgeons and the IR of THA procedures.

Primary arthrosis is the most frequent diagnosis in patients with indication for a THA procedure, and it is considered to be easier to perform THA in these patients than in patients with secondary arthrosis. Thus, we expected to see an increase in IRs of primary THA with increasing number of patients operated on due to primary arthrosis. However, proportions of patients with primary arthrosis did not appear to explain the regional variations, after we had adjusted for other factors.

HHS before surgery was used as an indicator of hip function and there was variation in HHS among

the counties. We hypothesize that counties with higher IRs of primary THAs used a lower threshold before offering THA, i.e. surgery was performed at an earlier stage in these counties. The HHS did not appear to be associated with the IRs of primary THAs or revisions, either as an independent factor or in combination with all other examined factors.

The counties have wide-ranging power to organize the healthcare system for their citizens, according to regional wishes and facilities available, without the intervention of the government. As counties with higher GDP are able to invest more in healthcare, one could hypothesize that surgeons in counties with a high GDP may experience financial restrictions to a lesser degree when organizing and dimensioning the THA service. This could possibly affect how patients are put in order of priority, and the incidence of both primary THA and revisions. We hypothesized that higher GDP may be associated with higher IRs of primary THA. Our data showed that regional variations in IRs of primary THA procedures were not associated with GDP. We have no simple explanation for this lack of association, just as we also have no clear explanation for the lack of association between hospital costs per county per capita and IRs of primary THA. However, our findings may reflect that although counties with higher GDP have more financial resources available, hip replacement surgery may not have first priority when these resources are allocated.

Peterson et al. (1992) found that IRs were highest in the states in the USA with the lowest population densities, based only on data from one year. The present study could not confirm these findings.

Other healthcare system-related factors may have some effect on regional variation in IRs of THA procedures, such as waiting time, which varied substantially between counties. Longer waiting time may be associated with general practitioners' greater willingness to refer patients to surgery. However, it has been shown previously that referral rate from general practitioners increases with better specialist coverage and becomes reduced with the distance from the specialist (Christensen et al. 1989). Similarly, waiting time may be associated with differences in local guidelines and recommendations for clinical decision-making. Furthermore, although hip arthroplasty is performed by the orthopedic surgeon, other health professionals including nurses, anesthesiologists etc. actively participate in the treatment and care of the patients. Regional variations in the availability of such healthcare professionals may have a major influence on the surgical activity. Although the number of nurses increased by 14% from 1990 to 1999 (Ministry of the Interior and Health 2003), the lack of nurses is almost a daily problem in many local hospitals (Leick 2001).

Other possible causes of regional variation include differences in patients' preferences. In the United States, Katz et al. (1994) reported that women have poorer functional status before surgery than men, implying that they are operated on at a more progressive stage of their disease. Such differences may possibly also exist for other patient characteristics, including characteristics that demonstrate regional variation, such as socioeconomic status; however, this has not yet been examined.

In conclusion, we found substantial variation in IRs of primary THAs and revisions among different types of hospitals and different counties in Denmark during the period 1996–2002. Variation could not be explained by different regional age- and sex-distribution of the populations, nor by the factors we examined (i.e. the number of orthopedic surgeons, the proportion of patients with primary arthrosis, HHS before surgery, population density, hospital costs, gross domestic product).

It is plausible that regional variation in IRs of THA procedures occurs because of physician disparities in clinical and surgery decision-making. The Danish healthcare system has undergone major changes in the last few decades, and efforts have been made to ensure free and equal access to hospitals for all patients. However, greater effort must be made to establish a wider consensus among patients, surgeons, and politicians on the criteria for primary THA and revision in order to reduce regional variation in the incidence of THA procedures and to optimize the clinical outcomes in Denmark.

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Alibhai A, Saunders D, Johnston D W C, Bay D. Total hip and knee replacement surgeries in Alberta utilization and association outcomes. Health Care Manag Forum 2001; 14 (2): 25-32.

Birkmeyer J D, Sharp S M, Finlayson S R, Fisher E S, Wennberg J E. Variation profiles of common surgical procedures. Surgery 1998; 124 (5): 917-23.

Bourne R B, Maloney W J, Wright J G. An AOA critical issue the outcome of the outcomes movement. J Bone Joint Surg (Am) 2004; 86 (3): 633-40.

Christensen B, Sorensen H T, Mabeck C E. Differences in referral rates from general-practice. Fam Pract 1989; 6 (1): 19-22.

Katz J N, Wright E A, Guadagnoli E, Liang M H, Karlson E W, Cleary P D. Differences between men and women undergoing major orthopedic-surgery for degenerative arthritis. Arthritis Rheum 1994; 37 (5): 687-94.

Leick C. Ringe indsats mod mangel på sygeplejersker. Sygeplejersken 2001; 47: 5-7.

Lucht U. The Danish Hip Arthroplasty Register. Acta Orthop Scand 2000; 71 (5): 433-9.

Mahomed N N, Barrett J A, Katz J N, Phillips C B, Losina E, Lew R A, Guadagnoli E, Harris W H, Poss R, Baron J A. Rates and outcomes of primary and revision total hip replacement in the United States medicare population. J Bone Joint Surg (Am) 2003; 85 (1): 27-32.

Majeed A, Eliahoo J, Bardsley M, Morgan D, Bindman A B. Variation in coronary artery bypass grafting, angioplasty, cataract surgery, and hip replacement rates among primary care groups in London: association with population and practice characteristics. J Public Health Med 2002; 24 (1): 21-6.

Malchau H, Herberts P, Eisler T, Garellick G, Soderman P. The Swedish Total Hip Replacement Register. J Bone Joint Surg (Am) (Suppl 2) 2002; 84: 2-20.

Merx H, Dreinhofer K, Schrader P, Sturmer T, Puhl W, Gunther P, Brenner H. International variation in hip replacement rates. Ann Rheum Dis 2003; 62 (3): 222-6.

Ministry of the Interior and Health. Health care in Denmark. 2003.

Pedersen A B, Johnsen S P, Overgaard S, Søballe K, Sørensen H T, Lucht U. Registration in The Danish Hip Arthroplasty Registry. Completeness of total hip arthroplasties and positive predictive value of registered diagnosis and postoperative complications. Acta Orthop Scand 2004; 75 (4): 434-41.

Pedersen A B, Johnsen S P, Overgaard S, Søballe K, Sørensen H T, Lucht U. Total hip arthroplasty in Denmark. Incidence of primary operations and revisions during 1996-2002 and estimated future demands. Acta Orthop Scand 2005; 76: 182-9.

Peterson M G, Hollenberg J P, Szatrowski T P, Johanson N A, Mancuso C A, Charlson M E. Geographic variations in the rates of elective total hip and knee arthroplasties among Medicare beneficiaries in the United States. J Bone Joint Surg (Am) 1992; 74 (10): 1530-9.

Skinner J, Weinstein J N, Sporer S M, Wennberg J E. Racial, ethnic, and geographic disparities in rates of knee arthroplasty among Medicare patients. N Engl J Med 2003; 349 (14): 1350-9.

Søballe K. Pelvic osteotomy for acetabular dysplasia. Acta Orthop Scand 2003; 74 (2): 117-8.

Söderman P, Malchau H, Herberts P, Johnell O. Are the findings in the Swedish National Total Hip Arthroplasty Register valid? A comparison between the Swedish National Total Hip Arthroplasty Register, the National Discharge Register, and the National Death Register. J Arthroplasty 2000; 15 (7): 884-9.

The Association of County Council. Available from: URL: http://arf-socinfo.csc-scandihealth.com/ArfWebInfo/Statistik/FormShowGroup.aspx?Group=-24. Accessed November 10, 2003.

The European (18 age groups) Standard Population within SEER*Stat. Available from: URL: http://www-dep.iarc.fr/dataava/ewstdpop.htm. Accessed September 10, 2003.

The StatBank Denmark. Available from: URL: http://statistikbanken.dk. Accessed July 24, 2003.

Wells V M, Hearn T C, McCaul K A, Anderton S M, Wigg A E, Graves S E. Changing incidence of primary total hip arthroplasty and total knee arthroplasty for primary osteoarthritis. J Arthroplasty 2002; 17 (3): 267-73.