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A Retrospective Evaluation of Joint Endoprosthesis Infections and Depending Costs

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Abstract

Background: Joint endoprosthesis are standard treatment in orthopedic surgery, but the risk of infection represents a major drawback for elderly patients with comorbidities. Therefore, we investigated joint endoprosthesis infections in Germany (2005-2012) focusing on elderly patients. We extrapolated infection related costs to estimate the burden for the health care system.

Methods: Nationwide data on joint endoprosthesis implantations and infections were acquired from OPS and ICD-10-GM codes obtained by the federal statistical office. The incidence of infection related to age (One-way ANOVA) were analyzed and contingency testing (Chi^2-test) for consecutive years (infected vs. non-infected implants) performed, focusing on the elderly (≥65 years). To calculate treatment costs, obtained data from a tertiary care university hospital in 2012 were extrapolated to nationwide cases.

Results: Age groups differed in overall implantations (n=2,993,192; $p<0.001$), infections (n=118,004 $p<0.001$) but not in infections/implantations. In consecutive years non-infected implants increased compared to infected implants ($p<0.01$). Overall implantations and infection numbers increased in the elderly ($p<0.05$). Total infections increased by 1.2% throughout the observational period. Averaged treatment costs at the hospital amounted 14,340.07€/case in 2012, resulting in an extrapolated burden of 251,711,249.00€ for the German health care system.

Importance: Endoprosthetic joint infections (PJI) have enormous implications for the German health care system producing approximately 250 million € costs/year. Bearing in mind that (i) elderly patients are subjected to a higher risk to develop an implant infection, (ii) incidences of infection increase and (iii) demographical data are subjected to change towards the elderly, preventive measures should be implemented to counteract the expectancy of a predominant role of infected implants in elderly patients.

Keywords: Endoprosthesis; Infection; Costs; Economic Damage

Introduction

The implantation of a joint endoprosthesis is a standard procedure in trauma and orthopedic surgery performed thousand fold every day. Besides a bundle of positive effects and a lasting increase of quality of life in most cases, infections represent an important charge – individually as well as socioeconomically. Although endoprosthetic joint infections (PJI) are a rather rare complication with a reported incidence between 1% and 2.4% [1-3], the potential impact on the health care system is huge [3,4]. Furthermore, some studies identified risk factors more prevalent in elderly patients and thus, suggesting that especially older patients could be jeopardized [5]. Therefore, the aim of our present study was to analyze the number of endoprosthetic joint implantations and the incidence of associated infections in Germany with special focus on elderly patients. To estimate associated treatment costs in Germany locally obtained data of a high-volume trauma center were extrapolated.

Patients and Methods

Nationwide data acquisition

National data on endoprosthetic joint implantations were acquired by an online search for the specific procedure classification code (OPS = Operationen und Procedure Schluessel), which are annually released by the German Institute for Medical Documentation and Information (DIMDI). Simultaneously, data concerning the diagnosis of infected joint endoprosthesis were collected by searching the German modification (GM) of the latest version of International Statistical Classification of Diseases and Related Health Problems (ICD-10-GM). After selection and matching of corresponding OPS and ICD-10-GM codes, the German federal statistical office (DESTATIS) was contacted to provide data on total numbers and age-distribution assigned to the requested codes. The observational period evaluated in this study reached from 2005 to 2012.

Local data acquisition

After approval of the local ethic committee (approval number 2585-2015) data from all patients who were diagnosed and treated with an an infection of an endoprothesis at a tertiary care university hospital in 2012 were retrospectively collected. Patients were identified due to their specific patient and case number. Then all discharge letters, operational protocols and microbiology examinations were screened to identify the infected implant as well as the causative germ. All those cases in which no germ could be identified were excluded. After identification of cases, the billing department of the hospital was contacted and asked to provide information on the total sum of diagnosis related group (DRG) codes in Euro, for each included case. Only the initial hospital costs (primary hospital stay) were accounted. If a patient had to be resubmitted into the hospital within 2012 for further treatment of the previous infection, all treatment costs were taken into account, but the infection was counted only once.

In addition, patient specific comorbidities and the underlying microorganism causing the infection were recorded to better describe the study population.

Statistical analysis

Statistical analysis was performed using graph pad Prism 4.0 Software (San Diego California, USA). One-Way ANOVA followed by Bonferroni's comparison of groups was used to analyze infections, implantations and their relation in regard to an age group , Chi2-test with Yates correction was performed for comparison of infected and non-infected implants in consecutive years and 2005 vs. 2012. To perform this analysis it was assumed, that the year of infection and the year of implantation were identical.

In addition an extrapolation of "joint endoprothesis" related costs was performed based on data acquired at a tertiary care university hospital in 2012. The mean of those costs was then multiplied by the total number of this specific ICD-10-GM Code in Germany.

Furthermore, patient characteristics were recorded and a Pearson correlation between comorbidities was performed. As we only looked at patients with coded endoprosthesis infection, no regression analysis between comorbidities and implant infection was possible.

Results

Identification of procedure classification codes (OPS) for endoprostheses

Following procedure classification codes for endoprosthesis implantations could be identified (Table 1).

OPS 5-82	Endoprosthetic joint and bone replacement
5-820	Implantation of an endoprosthesis of the hip
5-822	Implantation of an endoprosthesis of the knee
5-824	Implantation of an endoprosthesis on the upper extremity
5-826	Implantation of an endoprosthesis on the lower extremity

Table 1: OPS Codes for implantation of endoprostheses

Revisions, exchanges or removal of an endoprosthesis of the hip, knee, the upper or lower extremity (i.e. OPS Code 5-821,5-823, 5-825 and 5-827) have not been taken into account, as these codes do not define if a prosthesis could be kept in place or had to be removed. While implantations of an endoprosthesis of the hip (OPS Code 5-820), knee (OPS Code 5-821) and lower extremity (OPS Code 5-826) showed constant implantation numbers throughout the observational period, implantations of an endoprosthesis at the upper extremity (OPS Code 5-824) increased (Table 2).

Year / Code	2005 n (%)	2006	2007	2008	2009	2010	2011	2102	Total/ Code
5-820	194,453 (58.1)	199,040 (57.3)	204,018 (55.9)	209,487 (54.9)	213,174 (54.6)	213,697 (54.6)	213,935 (54.4)	212,304 (54.6)	1,660,108 1,195,845
5-822	128,932 (38.5)	135,393 (39.0)	146,562 (40.1)	154,722 (40.6)	159,137 (40.7)	158,100 (40.4)	158,207 (40.2)	154,792 (39.8)	68,177
5-824	9,572 (2.9)	11,256 (3.2)	12,615 (3.4)	14,979 (3.9)	16,340 (4.2)	17,921 (4.6)	19,383 (4.9)	19,755 (5.1)	15,418
5-826	1,732 (0.5)	1,866 (0.5)	2,062 (0.6)	2,092 (0.5)	2,129 (0.5)	1,933 (0.5)	1,844 (0.5)	1,760 (0.5)	2,993,192
Total/ Year	334,689 (100)	347,555 (100)	365,257 (100)	381,280 (99.9)	374,440 (100)	391,651 (100.1)	393,369 (100)	388,611 (100)	2,993,192

Table 2: Anatomical distribution of implantations according to OPS Codes and year of implantation

ICD-10-GM Code for infections of endoprosthesis

For endoprosthesis infections only one code could be identified in the ICD-10-GM system. This code is T84.5 (infection and inflammatory reaction of a joint endoprosthesis). Another code T84.7 defines infections and inflammatory reactions of orthopedic endoprosthesis, implants or transplants and was therefore not taken into account, as it does not clearly define an endoprosthesis.

Age distribution of total endoprosthesis implantations in Germany between 2005 and 2012

Between 2005 and 2012 a total number of 2,993,192 joint endoprosthesis have been implanted in Germany. Using One-Way ANOVA overall "age" was a relevant parameter for implantation (p<0.001). (Figure 1) depicts implantations performed between 2005 and 2012 regarding absolute numbers of implantations per year. The maximum number of implantations could be identified in ages between 70 to <80 years.

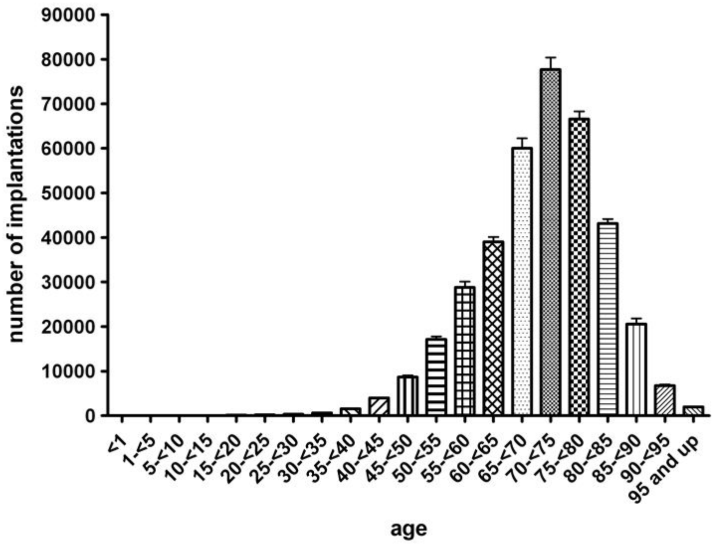


Figure 1: Bar graph showing the distribution of endoprosthesis implantations within age groups from 2005 until 2012. One Way ANOVA revealed age as a predictor of implantation (p<0.0001). Values are depicted as mean and standard error of mean. Age 70 to <80 (p>0.05). Significant differences (p<0.001) could be seen between (65-<70 and. 70-<75); (65-<70 and 75-<80); (65-<70 and 85-<90); (70-<75 and 80-<85); (75-80 and 80-85)

In addition, statistical relevant differences could also be observed in comparison of younger and elderly patients. As we are focusing on implant infections in the elderly, those results are not shown.

Age distribution of total endoprosthesis infections according to ICD-10-GM T84.5 in Germany from 2005 to 2012

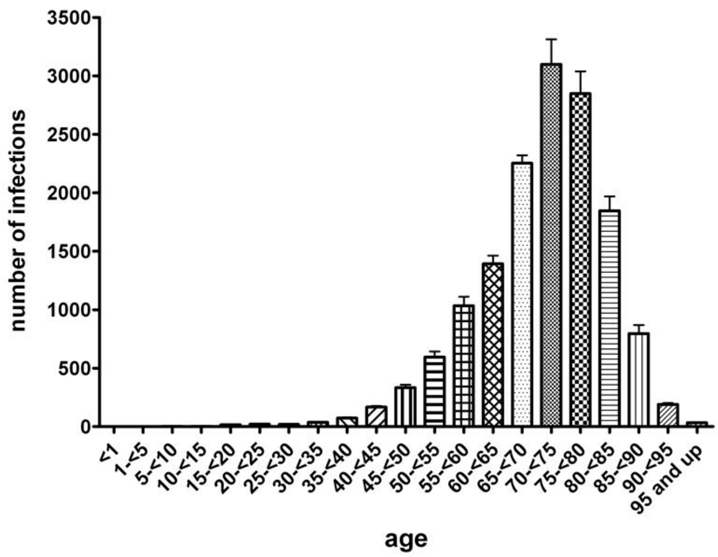


Figure 2: Bar graph showing the distribution of endoprosthesis infections from 2005 until 2012 in relation to age. One-Way ANOVA showed age as a predictor for infection (p<0.001), Values are depicted as mean and standard error of mean. Significant differences (p<0.05) could be detected between (55-<60 and 60-<65 years); (60-<65 and 65-<70 years); (70-<75 and 75-<80 years); (75-<80 and 80-85 years); (45-<50 and 50-<55 to all ages up to <85 years (p< 0.001))

Between 2005 and 2012 a total of 118,004 infections of joint endoprosthesis could be identified in Germany. A maximum of infections could be seen in ages of 75-<80 years. Using One-Way ANOVA age was also a predictor (p<0.001) for infection (Figure 2).

Relation of endoprosthesis implantations to endoprosthesis infections

In total 3.9% of all joint endoprosthesis implanted between 2005 and 2012 showed an infection. As a maximum of implantations and infections could be detected in patients aged 75-<80 years, the number of infections in relation to implantation numbers were analyzed (Figure 3). Here, only very young ages (5-<10 years) showed increased infection/implantation rates in comparison to 10-<15 years and in comparison to all ages from 20 years up (p<0.001).

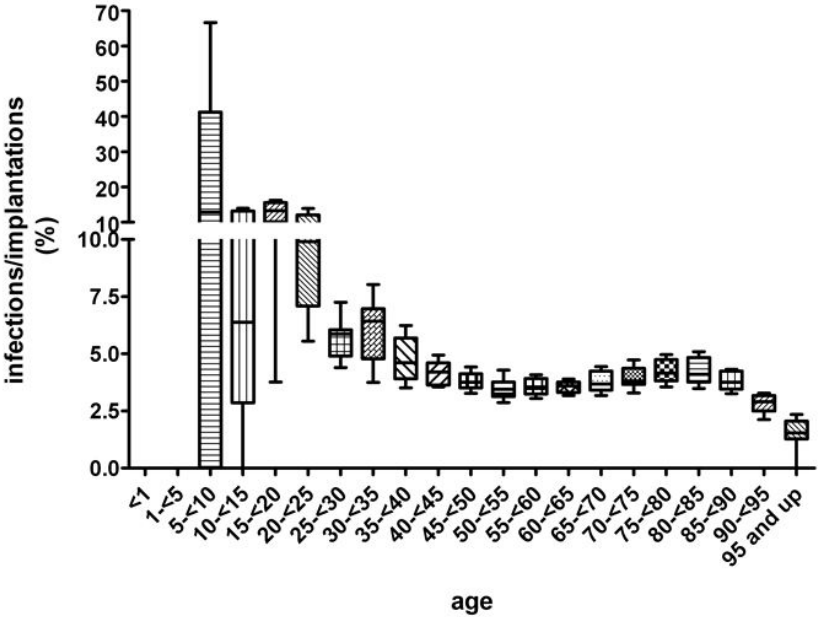
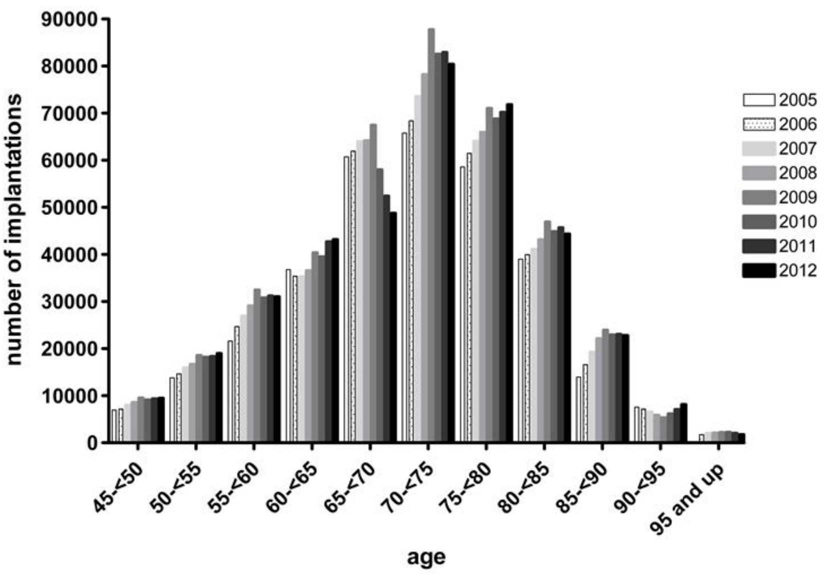


Figure 3: Boxplot showing percentage of infections in relation to number of implantations from 2005-2012, line within the box represents median, box represents 25th -75th percentile, whiskers represent full range of values, only ages 5-10 showed significant differences to other age groups (p<0.001) in One-Way ANOVA followed by Bonferroni comparison of all groups

Characteristics of infections and implantations from 2005 to 2012

As the above performed analysis does not take into account whether or not there is an increase / decrease of implantations, infections or their relation between 2005 and 2012, we first analyzed each year separately (Table 2), regardless of age distribution and then subdivided years into age groups (Figure 4).



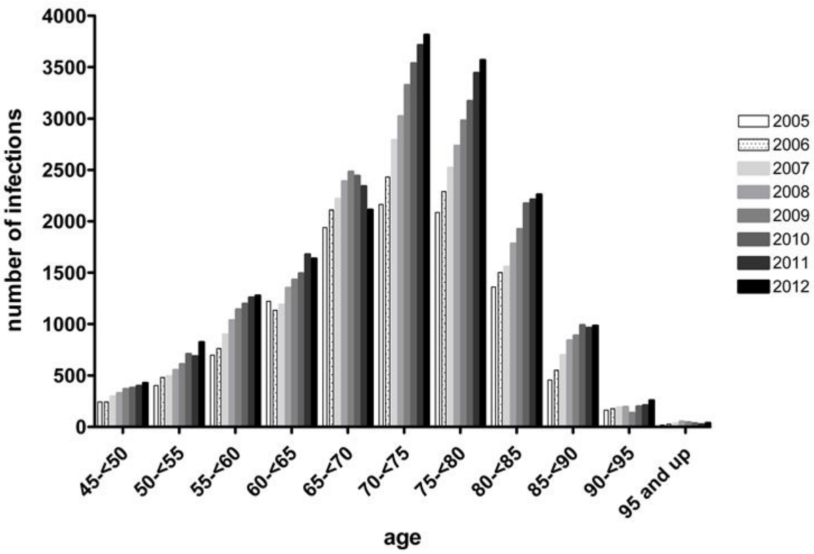


Figure 4: A. Bar graph of age distribution and number of implantations for each year between 2005 and 2012starting at 45 years of age. Of note implantations increased steadily in ages 70 and older. B shows the distribution of infections within the same timeframe. Also number of infections increased steadily in elderly patients from 70 years

Here, an overall increase of 1.2% between 2005 and 2012 was detectable. To further analyze this finding, the number of infected vs. non-infected (*total implantation number – number of infections*) individuals within each year was calculated. Consecutive years as well as 2005 vs. 2012 were compared by Chi^2-test (Table4).

Relation of infected to non-infected individuals showed an increase of infected patients in all consecutive years except in the comparison of 2008 and 2009, were no difference could be detected (Table 4, Figure 5). In addition comparison of 2005 and 2012 showed an increase in patients with implant infection ($p< 0.001$) confirming the relevance of the overall increase in infection rate seen in (Table 3).

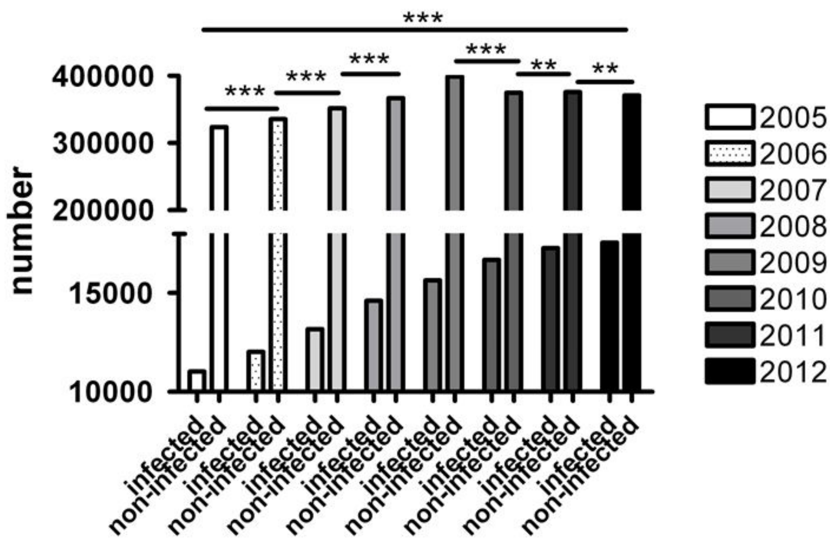


Figure 5: Bar graph showing the number of infected implants in relation to non-infected implants for all age groups between 2005 and 2012. Chi^2-test with Yates correction and two tailed p-value revealed significance for comparison of all consecutive years except 2008-2009 Asterix marks significant values: * p<0.05, ** p<0.01, ***p<0.001

Year	Percentage of infections	Year	Percentage of infections
2005	3,30%	**2009**	4,00%
2006	3,50%	**2010**	4,30%
2007	3,60%	**2011**	4,40%
2008	3,80%	**2012**	4,50 %

Table 3: Endoprosthesis infection rates from 2005 to 2012

To further analyze if this overall increase in implant infections is age dependent, we performed a subgroup analysis (Chi^2 test for consecutive years) in elderly patients ≥65 years of age comparing consecutive years. Within this population patients between 65-<70 and 70-<75 years showed more infections ($p< 0.05$) in four periods, followed by patients aged 75-<80 years and 80-<85 years with 2 periods with increased infection rate ($p<0.01$). In younger ages (i.e. 55-<60 years and 60-<65 years) only one period of time with an increase of infections ($p<0.05$) was detectable (Table 5). Comparing infected and non-infected implants in 2005 with 2012 showed an increase of infections for all patients ≥65 years of age analyzed ($p<0.01$).

Years	Xi Values for Chi2-test with Yates correction	P Values for chi2-test with Yates correction
2005-2006	1117,18	<0.001*
2006-2007	758,81	<0.001*
2007-2008	26,46	<0.001*
2008-2009	1,75	0.1859
2009-2010	124,67	<0.001*
2010-2011	8,40	0.0038*
2011-2012	6,72	0.0095*
2005 vs. 2012	707,02	< 0.001*

Table 4: Results of the Chi^2-test with Yates correction for infected and non-infected endoprostheses; * marks significant values

Age Years	55-<60	60-<65	65-<70	70-<75	75-<80	80-<85	85-<90	90-<95	>95
2005 vs 2006									
xi	0.78	0.68	4.09	6.98	2.3	4.03	0.07	1.98	1.83
p	0.377	0.410	0.043*	0.008*	0.129	0.045*	0.791	0.159	0.176
2006 vs 2007									
xi	2.48	1.37	0.26	5.41	3.6	0.03	2.21	1.73	0.03
p	0.115	0.242	0.610	0.020*	0.658	0.862	0.145	0.188	0.862
2007 vs 2008									
xi	2.08	5.48	6.06	0.44	3.74	6.67	0.92	1.59	3.66
p	0.149	0.019*	0.014*	0.507	0.053	0.010*	0.337	0.207	0.056
2008 vs 2009									
xi	0.08	1.04	0.14	0.55	0.19	0.06	0.19	***5.48***	0.73
p	0.777	0.308	0.708	0.458	0.663	0.806	0.663	***0.019****	0.393
2009 vs 2010									
xi	6.31	2.99	23.12	26.68	14.04	29.75	11	4.26	0.97
p	0.012*	0.084	0.001*	<0.001*	0.0002*	<0.0001*	0.001*	0.029*	0.325
2010 vs 2011									
xi	0.86	1.14	4.55	3.74	6.69	0	0.55	0.89	1.15
p	0.354	0.286	0.033*	0.053	0.010*	1	0.458	0.345	0.283
2011 vs 2012									
xi	0.24	0.99	1.01	7.08	0.29	3.05	0.54	0.55	6.74
p	0.624	0.320	0.315	0.008*	0.590	0.081	0.462	0.458	0.009*
2005 vs 2012									
xi	27.75	13.01	98.22	193.05	153.71	128.43	25.27	15.06	6.78
p	<0.001*	0.0003*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.009*

Table 5: Result of Chi^2-test for infected and non-infected endoprostheses comparing consecutive years and 2005 with 2012 in relation to age; * marks significant values the *bold italic* underlining shows years in which a significant decrease of infections could be observed

Relation of increase in implantations of the upper extremity to increase in overall infections

We could show that the number of implantations of prosthesis in the upper extremity during the observational period was rising from 2.9% in 2005 to 5.1% in 2012 (Table 2). At the same time overall prosthetic infections rose from 3.3% to 4.5% (Table 3). The overall delta for implantation increase in the upper extremity was 2.2%, while the increase of infections was 1.2%.

Patient characteristics and identified microorganisms

In 2012 a total number of 76 patients was coded T 84.5 in our tertiary care hospital. Of those patients, we could identify one or several causative species for the underlying infection in 58 patients (76.3%). Three patients died in hospital (5.2%) due to septic shock. In all three cases a causative germ could be identified.

Staphylococcus aureus (identified in 15 samples, (5 samples MRSA or ORSA)) was the most common bacterium found, followed by staphylococcus epidermidis (n=12), pseudomonas aeruginosa (n=4), enterococcus faecalis (n=4) and propionibacterium acnes (n=4). In total, we could identify specimens 61 times, with a total of 23 different species.

Infected endoprostheses could be found after following surgical procedures:

Total hip replacement surgery	n=24
Total knee replacement surgery	n=23
Replacement surgery of the femur	n=4
Implantation of an elbow prosthesis	n=1
Implantation of a dual head prosthesis	n=3
Implantation of an arthrodesis plate (knee)	n=1
Implantation of a shoulder prosthesis	n=1
Total replacement surgery of the ankle	n=1

Comorbidities of patients treated for endoprosthesis infection in 2012 can be found in supplemental table 1. Briefly, 44.8% of all patients were male, with a mean age of 69 years. 15.5% of all patients suffered from coronary artery disease, 60.3% had hypertension, 12.1% were diabetic, 8.6% smoked and 24.1% had a history of cancer. Pearson correlation revealed a positive correlation for hypertension and hyperlipidemia (p=0.049; correlation coefficient 0.265), and a negative correlation for hepatitis and hypertension (p=0.040; correlation coefficient -0.275), while at the same time hepatitis was negative correlated to age (p=0.002; coefficient -0.397), but positively correlated to sepsis (p=0.010; coefficient 0.341). These results indicate, that elderly patients suffered from hypertension, while younger patients had hepatitis, which was associated to sepsis. At the same time patients suffering from sepsis had a positive correlation to mortality (p>0.001, correlation coefficient 0.76). Hypothyreosis was more common in female patients (p=0.02; correlation coefficient -0.310 to male sex). Diabetes could be found to be associated to adipositas (p=0.021; correlation coefficient 0.309). Unsurprisingly, a history of malignant disease correlated to chemotherapy, radiation and a history of breast cancer (data not shown).

Extrapolated costs for endoprosthesis infections in 2012

As the ICD-10-GM code does not give any information on specific joint endoprosthesis related complications, it is difficult/ impossible to directly calculate associated treatment costs. The “flat rate” for coding T84.5 in 2012 (example of one standard case) was 2,975.80€. Unfortunately this amount does not resemble realistic costs, because each patient “produces” individual costs due to his/ her individual comorbidities. More and above, the length of stay on the ICU and of mechanical ventilation differ from patient to patient, as do the resulting overall days in hospital. Also procedures may be different. All those individual components are separately coded. In the end the sum of all coded diagnoses and procedures results in costs/case, in the exemplary case 10,379.59€. Of note, this exemplary case did not include need for mechanical ventilation or hemodialysis therapy, which is often necessary for patients with multiple comorbidities.

To at least acquire an approximation of total yearly costs due to infections of joint endoprosthesis, we performed a retrospective analysis of patients who were admitted to our institution (high-volume trauma center) in 2012 and acquired total costs/case as described above. A total of 58 patients were treated at our institution in 2012 due to a joint endoprosthesis infection. Total costs/case ranged from 622.85€ to 64,646.49€ with an average of 14,340.07€. Extrapolating those costs/case to a total of 17,553 joint endoprosthesis infections in Germany in 2012 resulted in an average total of 251,711,249.00€. (min. 10,928,146.70€ to max. 1,134,739,839.00€)

Discussion

In his study we analyzed the infection of joint endoprosthesis in relation to total implantations in Germany between 2005 and 2012. Overall we could detect a 1.2% increase of infections and a mean incidence of 3.9% infections within this time frame, respectively. This is in line with the reports of most other groups who reported on 1-2% [1], 2.0-2.5% [2], and 2.0-2.4% [3] per year or total ranges between 0.5% - 9% [6-9]. We think that the high infection rates seen in our study throughout the German population in part resulted from the fact that with the current coding system it is impossible to discriminate early, delayed or late infections, as these different stages of infection are not displayed in the ICD-GM T84.5 code. Furthermore, and due to the unavailability of time-specific data, we artificially had to assume that the year of implantation and the year of infection had been equal. Consequently, all resulting data artificially describe early infections and thus, may overestimate real-world incidences of infection. However, due to the fact that more exact and reliable data are lacking, our findings represent the closest estimation possible. Nevertheless, Blomfeld et al. showed in a very large study cohort of more than 3,800 consecutive patients, that most of the infections occurred early (76%) after surgery. Taking this into account, realistic numbers for Germany will possibly be round about 2.9% [1].

In our present study we only could obtain (i) information on total numbers of implantation and (ii) total numbers of infections in relation to age for joint endoprosthesis from the German statistical office by asking for information on ICD-10-GM Code and OPS Codes. In combination with the fact that the ICD-10-GM Code T84.5 only summarizes infections of joint endoprosthesis, regardless of type, implantation procedure and location it was challenging to gain direct insight into underlying mechanisms for infection. Therefore, a subdivision into prosthesis type, implantation procedure, location and year of implantation would be desirable and could help to further investigate putative causes of infections. So far, only a division into anatomical location was possible (Table 2). With a revised coding system, a correlation to comorbidities and other patient-/ implant- characteristics would be possible. This could help to find putative risks for the implant infection per se and help to adapt treatment strategies. In this regard a relatively small Australian study cohort (n=139 patients) could identify fever, pus, hypotension, rheumatoid arthritis and revision surgery to be independent predictors of increased costs due to prosthetic joint infection in a multivariate analysis [10]. Another group, Kapadia et al. assessed risk factors, preventive measures and treatment options for periprosthetic joint infections based on a pubmed search from 1960 to 2014 [5]. The search could identify uncontrolled diabetes [11], malnutrition [12], morbid obesity [13], smoking [14, 15], immunocompromising diseases [4], alcohol consumption [16] and nasal carriage of S. aureus [17] as risk factors for prosthetic graft or deep surgical site infection [5]. However, these risk factors have been identified through single center cohorts and therefore represent only selected opinions so that an establishment of a federal registry would make results more reliable and comparable.

Although no compulsory nationwide German register for joint prosthesis implantations exists, in 2012 the voluntary EPRD ("Endoprothesenregister Deutschland GmbH") has been initiated [18] after initial attempts had failed [19,20]. Up to June 2015 more than 100,000 operations have been registered (www.eprd.de). However, looking at those numbers identified in this study, in 2012 alone, the total number of endoprosthesis implantations was 388,611. Thus, reporting on about 100,000 operations registered within a 4-year period and bearing in mind almost steady numbers of implantations since 2009, the total number of implantations within this time span can be estimated to a total of 1.5 million cases. The register therefore comprises less than 10% of all implantations performed (in Germany). This low percentage highlights the importance of a broader inclusion of patients and the urgent need to convince patients and surgeons to participate. An interesting approach in this regard was already initiated in 2004 by the English Royal College of Surgeons. They started an open discussion in the media and thus, prompted patients to actively ask surgeons to participate in registries. Thus, if a hospital wanted to keep implantation numbers high they better decided to take part [21]. As a result the UK subsequently made the register compulsory (since 2011) for all independent and NHS hospitals. Before that time point the register was only compulsory for independent hospitals and a participation was "expected" for NHS hospitals [22]. Difficulties in patient acquisition are therefore not a new problem and are seen in the beginning of many newly established registers. And indeed a comparison of all European registers showed that only very few were already compulsory in the beginning [20]. In addition, a full functioning and representative register should comprise a minimum of approximately 90% of all nationwide implantations to reliably display real data [20]. Unfortunately, those inclusion rates are not commonly achieved so that only countries with mandatory participation such as Finland, England/Wales, Denmark and Slovakia reach 100% rates [20,23]. The German register still suffers from most of the before mentioned problems, which strongly necessitate a better patient information, governmental funding and preferably a mandatory participation.

We could demonstrate that within the observational period evaluated in this study, joint endoprosthesis implantations in elderly patients have increased (Figure 4A). At the same time infections in the elderly rose (Figure 4B) and showed a significant increase in several age groups (Table 5). Taking into account demographical data of the German federal statistical office as well as the World Health Organization (WHO) which expect an increase of the elderly population (>65 years) by about 33% between 2011 and 2030 [24, 25], an increase in implantation numbers especially in elderly patients is very likely. As our data demonstrates, that the risk to develop an endoprosthesis infection is higher in the elderly and age is an independent predictor for infection, we believe that with the expected demographical changes, it can also be expected in the future, that infections in the elderly will play an even more predominant role. Given the expected demographical increase in elderly patients of 33%, it is necessary that the health care system immediately reacts to those expectancies within Germany and worldwide. A first step would be to revise the coding system making it possible to identify the underlying procedure for implantation. Another possible reaction could be the implementation of a compulsory register which would allow a risk stratification of patients and would truly help to counteract prosthesis infection.

As already mentioned above, we technically had to assume that the year of implantation and the year of infection corresponded to each other, because time-specific data are lacking within the ICD-10-GM coding system. Thus, we could only relate to early infections rather than retarded (between 12 and 24 month) or late infections (after 24 month). However, interestingly we could demonstrate stagnation in implantation numbers although we saw an increase of infections (Figure 5). Looking at numbers starting at 2009 (i.e. 2009, 2010, 2011, 2012) we still observed an increase of infections so that it is likely, but remains only speculative as further analysis is impossible, that retarded and late infections are also increasing within this 4 year observational period evaluated here. Although we cannot provide statistics on that part an international comparison underlines this assumption because similar results were observed in another study that showed stagnation of implantations while infections increased [5].Interestingly, we could show an increase of infections of 1.2% during the observational period. At the same time we could identify an increase of endoprosthesis implantations in the upper extremity (delta 2.2%) while implantations at all other anatomical locations remained at a steady state. Therefore, one might speculate that the increase in overall infections seen might be related to the increase of implantations in the upper extremity. But again, we can unfortunately not provide any further insight into this interesting field, as the German data acquisition does not provide this information. Given the fact that 1-8% of all shoulder implants are prone to infection [27], and shoulder implants resemble the majority of implantations in the upper extremity, but still only resemble up to 5% of all implantations performed in Germany in 2012, the increase in infections seen within the observational period can at least in part, be explained by the increase of upper extremity implantations (i.e. 8% (assumed worst infection rate) of 5% (upper extremity implantations in 2012) equals 0.4% of infections).

We have estimated costs through extrapolation for joint endoprosthesis infections. These extrapolations were based on a single center analysis in our tertiary care high volume hospital with focus on implant infections. A multicenter approach might have led to different cost estimations according to differences in patient collective and associated comorbidities. Nevertheless, we found average treatment costs of approximate 14,340€. (16,100 US$) per case of an infected joint endoprosthesis. Based on these single center data we extrapolated these expenditures to Germany resulting in more than 251 million € (more than 281 million US$) which had to be spent in 2012 only for the treatment of infected joint endoprosthesis. In 2012 Kurtz et al. investigated the economic burden for prosthetic joint infections and necessary revisions in the US from 2001 to 2009 [3, 4]. The authors could show an increase from US$ 320 million to US$ 566 million per year including revisions and estimated costs of more than US$ 1.62 billion in 2020 [3]. They also based their estimation on the ICD-coding system, making results gained in our study comparable to the US dataset. Like Kurtz et al. our cost extrapolation does also not include costs in relation to subsequent care, physical therapy, rehabilitation, home care or pharmaceutical care after hospital discharge, so that the estimation of more than 251 million € will certainly be understated. Furthermore our estimation is in accordance to a French data set, where an estimation of 259 million € per year could be identified [28]. Cost analyses from Australia revealed a median of 34,800 Australian $ /case (22,310 €/case) when hospital costs, in the home costs and antibiotic therapy costs were included [10].

Conclusions

Joint endoprosthesis associated infections represent a serious individual, social and economic burden for our national health care system. A problem, which will aggravate over the next years and therefore urgently, needs measures to counteract this development. So far the coding system in Germany is insufficient to monitor the infection of an endoprosthesis after implantation. Therefore, it should be revised. Registers can be considered as a tool to depict real world scenarios, outside of mono- or multicenter studies, but so far the German register lacks broad inclusion of patients. It should be taken into consideration to implement a compulsory register in Germany as seen in Scandinavian countries. This could help to dissect causes of infections, stratify patients into risk groups, and develop treatment as well as logistic options and in summary of all help to prevent endoprosthesis infections in the long end.

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References

1. Blomfeldt R, Kasina P, Ottosson C, Enocson A, Lapidus LJ (2015) Prosthetic joint infection following hip fracture and degenerative hip disorder: a cohort study of three thousand, eight hundred and seven consecutive hip arthroplasties with a minimum follow-up of five years. International orthopaedics 39: 2091-6.

2. Militz M, Buhren V (2010) Replacement of infected knee and hip endoprosthesis. Chirurg 81: 310-20.

3. Kurtz SM, Lau E, Watson H, Schmier JK, Parvizi J (2012) Economic burden of periprosthetic joint infection in the United States. J Arthroplasty 27: 61-5.

4. Berbari EF, Osmon DR, Lahr B, Eckel-Passow JE, Tsaras G, et al. (2012) The Mayo prosthetic joint infection risk score: implication for surgical site infection reporting and risk stratification. Infect Control Hosp Epidemiol 33: 774-81.

5. Kapadia BH, Berg RA, Daley JA, Fritz J, Bhave A, et al. (2015) Periprosthetic joint infection. Lancet. 387: 386-94.

6. Dale H, Skramm I, Lower HL, Eriksen HM, Espehaug B, et al. (2011) Infection after primary hip arthroplasty: a comparison of 3 Norwegian health registers. Acta Orthop 82: 646-54.

7. Harrison T, Robinson P, Cook A, Parker MJ (2012) Factors affecting the incidence of deep wound infection after hip fracture surgery. J Bone Joint Surg Br 94: 237-40.

8. Ong KL, Kurtz SM, Lau E, Bozic KJ, Berry DJ, et al. (2009) Prosthetic joint infection risk after total hip arthroplasty in the Medicare population. J Arthroplasty 24: 105-9.

9. Westberg M, Snorrason F, Frihagen F (2013) Preoperative waiting time increased the risk of periprosthetic infection in patients with femoral neck fracture. Acta Orthop 84: 124-9.

10. Peel TN, Cheng AC, Lorenzo YP, Kong DC, Buising KL, et al. (2013) Factors influencing the cost of prosthetic joint infection treatment. J Hosp Infect 85: 213-9.

11. Marchant MH Jr, Viens NA, Cook C, Vail TP, Bolognesi MP (2009) The impact of glycemic control and diabetes mellitus on perioperative outcomes after total joint arthroplasty. J Bone Joint Surg Am 91: 1621-9.

12. Jaberi FM, Parvizi J, Haytmanek CT, Joshi A, Purtill J (2008) Procrastination of wound drainage and malnutrition affect the outcome of joint arthroplasty. Clin Orthop Relat Res 466: 1368-71.

13. Andrew JG, Palan J, Kurup HV, Gibson P, Murray DW, et al. (2009) Obesity in total hip replacement. J Bone Joint Surg Br 91: 424-9.

14. Sadr Azodi O, Bellocco R, Eriksson K, Adami J (2006) The impact of tobacco use and body mass index on the length of stay in hospital and the risk of post-operative complications among patients undergoing total hip replacement. J Bone Joint Surg Br 88: 1316-20.

15. Peersman G, Laskin R, Davis J, Peterson M (2001) Infection in total knee replacement: a retrospective review of 6489 total knee replacements. Clin Orthop Relat Res: 15-23.

16. Bradley KA, Rubinsky AD, Sun H, Bryson CL, Bishop MJ, et al. (2011) Alcohol screening and risk of postoperative complications in male VA patients undergoing major non-cardiac surgery. J Gen Intern Med 26: 162-9.

17. Bode LG, Kluytmans JA, Wertheim HF, Bogaers D, Vandenbroucke-Grauls CM, et al. (2010) Preventing surgical-site infections in nasal carriers of Staphylococcus aureus. N Engl J Med 362: 9-17.

18. Hassenpflug J, Liebs TR (2014) Registries as a tool for optimizing safety of endoprostheses. Experiences from other countries and the setup of the German arthroplasty register.Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 57: 1376-83.

19. Pitto RP, Lang I, Kienapfel H, Willert HG (2002) The German Arthroplasty Register. Acta Orthopaedica Scandinavica 73: 30-3.

20. Kolling C, Simmen BR, Labek G, Goldhahn J (2007) Key factors for a successful National Arthroplasty Register. J Bone Joint Surg Br 89: 1567-73.

21. The Royal College of Surgeons (2004) 1st Annual report National Joint Registry for England and Wales. Hempstead HP2 4NW, England: National Joint Registry for England.

22. The National Joint Registry for England (2013) 10th Annual report 2013. Hernel Hempstead, Hertfordshire, UK: National Joint Registry.

23. Serra-Sutton V, Allepuz A, Espallargues M, Labek G, Pons JM (2009) Arthroplasty registers: a review of international experiences. Int J Technol Assess Health Care 25: 63-72.

24. DESTATIS (2011) Demographischer Wandel in Deutschland. In: Deutschland sAdBudL, editor: statistische Aemter des Bundes und der Laender: 8-9.

25. Dye C, Burma T, Evans D, Harries A, Lienhardt C, et al. (2013) The world health report 2013: research for universal health coverage. Geneva, Switzerland: WHO.

26. De Angelis G, Mutters NT, Minkley L, Holderried F, Tacconelli E (2015) Prosthetic joint infections in the elderly. Infection 43: 629-37.

27. Pinder EM, Ong JC, Bale RS, Trail IA (2016) Ten questions on prosthetic shoulder infection. Shoulder Elbow 8: 151-7.

28. Grammatico-Guillon L, Baron S, Gaborit C, Rosset P, Rusch E, et al. (2013) Letter in response to the article on bone and joint infection in the United States: French data. The Journal of arthroplasty 28: 1055.