ORIGINAL ARTICLE

Lower Limb Amputation in Germany

An Analysis of Data From the German Federal Statistical Office Between 2005 and 2014

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SUMMARY

Background: Declining amputation rates have been reported in multiple countries in recent years. It is not yet known whether amputation rates have declined in Germany as well.

Methods: On the basis of DRG (diagnosis-related group) data, we received a list from the German Federal Statistical Office of all major and minor amputations documented in German hospitals from 2005 to 2014. Changes over this period were studied with linear regression.

Results: The absolute number of amputations per year in Germany rose slightly from 55 689 in 2005 to 57 637 (+3.5%) in 2014. After the exclusion of cases in which the main diagnosis was trauma, intoxication, musculoskeletal disease, diseases of the skin and subcutaneous tissue, or neoplasia, the corresponding numbers were 48 043 in 2005 and 48 561 in 2014 (+1.1%). The age-adjusted rate of major amputations per 100 000 persons per year fell from 23.3 to 16.1 (−30.9%), while the rate of minor amputations rose from 35.0 to 43.9 (+25.4%). The percentage of major amputations that took place in patients with diabetes mellitus as the main diagnosis or a side diagnosis declined from 70.2% to 63.7%. For all of these changes, $p < 0.0001$.

Conclusion: From 2005 to 2014, the major amputation rate fell by 30.9% while the minor amputation rate rose by 25.4%. The goal of lowering amputation rates still further will be best served not only by applying the recognized preventive measures in patients with foot lesions, but also by further research into the causes of the recent changes in amputation numbers. Prospective registries will be needed.

► Cite this as:

Kröger K, Berg C, Santosa F, Malyar N, Reinecke H: Lower limb amputation in Germany—an analysis of data from the German Federal Statistical Office between 2005 and 2014. *Dtsch Arztebl Int* 2017; 114: 130–6.
DOI: 10.3238/arztebl.2017.0130

In the Saint Vincent Declaration of 1989, representatives of governments, health authorities, and patients' organizations from all European countries demanded, under the auspices of the World Health Organization (WHO), that the rate of amputations in diabetics be halved within 5 years (1). In the following years, however, it emerged that the goals could by no means be achieved as rapidly as originally assumed (2).

Nevertheless, the past 10 years have seen the publication of encouraging figures demonstrating decreases in the rate of major amputations in many European countries as well as the USA and Australia (3–13) (Table 1). In this country too, studies have reported a downward trend in major amputations (18–20). We therefore set out to ascertain whether amputation rates are also steadily decreasing in Germany.

Patient selection and methods

The national diagnosis-related groups (DRG) statistics from the German Federal Statistical Office include data from all hospitals in Germany that use the DRG system. More than 99% of inpatient treatments are covered. All hospitals are legally obliged to transmit comprehensive information on hospital treatments, including patient demographic data, diagnoses, comorbidities, complications, and procedures, to the *Institut für das Entgeltsystem im Krankenhaus* (InEK; Institute for Hospital Fees). InEK uses the data for an annual adjustment of the DRG system and passes them on to the Federal Statistical Office. All diagnoses from the years 2005 to 2014 were coded according to the German version of the *International Classification of Diseases and Related Health Problems, 10th Edition* (GM ICD-10).

Detailed lists of all major and minor amputations (coded 5-864 and 5-865, respectively, in the German procedure classification OPS) were provided by the Federal Statistical Office following submission of an analysis plan. In addition, age-adjusted amputation rates per 100 000 inhabitants were calculated. The term major amputation is used to mean any amputation above the ankle region, up to and including hemipelvectomy. All amputations distal to the ankle are designated minor. This includes the Syme procedure, in which the calcaneum, talus, and mortise are removed.

In the attempt to ensure that only amputations indicated by peripheral arterial occlusive disease (PAOD) and/or diabetes mellitus (diabetic foot syndrome, DFS)

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TABLE 1

Recently published studies on trends in amputation over a number of years

Study, country	Population	Study period	Major amputations: change during study period	Minor amputations: change during study period
USA				
Rowe et al., 2009 (4)	National sample, hospitalized patients (age ≥ 18 years)	1996–2005	Decrease from 30.8% to 21.8% of all acute admissions with PAOD	n.d.
Goodney et al., 2009 (3)	Medicare population (age ≥ 67 years, disabled, on dialysis)	1996–2006	Decrease from 263 to 188 per 100 000 insurees	n.d.
UK				
Vamos et al., 2010 (6)	National hospital data (age ≥ 16 years)	2004–2008	Decrease from 118 to 102 per 100 000 persons with DM	Decrease from 157 to 149 per 100 000 persons with DM
Ireland				
Buckley et al., 2012 (14)	Survey of hospitalized patients (age ≥ 16 years)	2005–2009	Increase from 47.9 to 48.0 per 100 000 persons with DM	Increase from 96.2 to 127 per 100 000 persons with DM
Spain				
Lopez-de-Andres et al., 2015 (11)	National hospital discharge data	2001–2008	Increase from 7.12 to 7.47 per 100 000 persons with DM type 2	Increase from 9.23 to 10.97 per 100 000 persons with DM type 2
Italy				
Lombardo et al., 2014 (15)	National hospital discharge data	2001–2010	Decrease from 114.5 to 79.3 per 100 000 persons with DM	Decrease from 168.8 to 161.1 per 100 000 persons with DM
Finland				
Winell et al., 2013 (16)	National hospital discharge data and dates of death	1997–2007	Decrease from 13.6 to 9.3 per 100 000 person-years in persons with DM	Increase from 11.0 to 13.5 per 100 000 person-years in persons with DM

Author, country, population investigated, observation period, and details of major and minor amputations (based on [17]). DM, diabetes mellitus; n.d., no data; PAOD, peripheral arterial occlusive disease

were included, we excluded amputations in patients with the principal diagnosis of tumor (C00–D48), cutaneous or subcutaneous disease (L00–L99), musculoskeletal disease (M00–M99), or injury/poisoning (S00–T98). Hereinafter, these diagnoses are referred to as CLMS, from their ICD codes.

To encompass diabetes mellitus (DM) as risk factor for amputation, following exclusion of CLMS diagnoses all amputations with the diagnosis DM (E10–E14), whether main or secondary, were included in analysis.

Linear regression analysis was used for statistical evaluation of trends over the 10-year study period.

Results

The absolute number of amputations in Germany rose slightly from 55 689 in 2005 to 57 637 (+3.5%) in 2014. After exclusion of patients with CLMS main diagnoses, the figures were 48 043 and 48 561 (+1.1%).

The number of non-CLMS major amputations went down from 19 189 in 2005 to 13 048 in 2014 (Table 2).

The age-adjusted rate of amputations per 100 000 inhabitants dropped from 23.3 in 2005 to 16.1 in 2014, a decrease of 30.9%. The number of minor amputations rose from 28 854 in 2005 to 35 513 in 2014. The age-adjusted rate of amputations per 100 000 inhabitants went up from 35.0 to 43.9, an increase of 25.4%. As shown in Figure 1, the number of major amputations in patients with CLMS main diagnoses did not decrease over the 10-year observation period.

The decrease in major amputations was seen both in men and in women. In contrast, the increase in minor amputations was much greater in men (eTable). Looking at the age-group figures and just comparing 2005 with 2014, the curves for age-adjusted major amputation rate begin to diverge in the sixth decade of life for men and in the seventh decade for women. For minor amputations men show a distinct increase from the middle of the seventh decade of life onward, in contrast to women (eFigure).

The proportion of major amputations in which the diagnosis DM had been coded dropped from 70.2% in

TABLE 2

Total number of amputations, number of amputations after exclusion of cases with the ICD main diagnoses C00–D48, L00–L99, M00–M99, and S00–T98 (CLMS), and age-standardized rates of amputations per 100 000 inhabitants after exclusion of CLMS: major and minor amputations

Year	Major amputations (ICD 5-864)			Minor amputations (ICD 5-865)		
	Total	After exclusion of CLMS	Per 100 000	Total	After exclusion of CLMS	Per 100 000
2005	22 619	19 189	23.3	33 070	28 854	35.0
2006	22 003	18 590	22.6	33 702	29 715	36.1
2007	21 246	17 928	21.8	34 021	30 081	36.6
2008	20 744	17 272	21.0	35 465	31 315	38.1
2009	20 009	16 323	19.9	36 604	32 143	39.3
2010	18 758	15 193	18.6	37 717	33 148	40.5
2011	18 071	14 509	18.1	38 580	33 719	42.0
2012	17 295	13 795	17.2	38 809	33 847	42.1
2013	17 151	13 535	16.8	40 575	35 099	43.5
2014	16 645	13 048	16.1	40 992	35 513	43.9
Difference between 2005 and 2014	–5974	–6141	–7.2	+7922	+6659	+8.9
Relative change 2005 to 2014	–26.4%	–32.0%	–30.9%	+24.0%	+23.1%	+25.4%
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

ICD, International Classification of Diseases and Related Health Problems

2005 to 63.7% in 2014. The equivalent figures for minor amputations were 93.9% and 85.6%. Separation of main and secondary diagnoses shows that this fall is due to a decrease in coding of DM as principal diagnosis. The proportion of major amputations with the main diagnosis DM went down from 29.7% to 22.8% ($p < 0.0001$), and the proportion of minor amputations with the main diagnosis DM fell from 55.8% to 50% ($p < 0.0001$) (Figure 2). In contrast, the proportions of both major and minor amputations with DM as secondary diagnosis fluctuated slightly over the observation period but essentially remained unchanged.

Discussion

The data presented here show that there was a marked decrease in the number of major amputations carried out each year in Germany between 2005 and 2014. The annual number of minor amputations increased over the same 10-year period.

Owing to the style of documentation in the German DRG system we cannot distinguish amputations performed primarily because of a diabetes-related problem from those attributable primarily to PAOD, particularly since the two diseases frequently occur together and precise classification is often impossible. Almost half (49.7%) of patients with

PAOD have DM (21), and over one quarter (26.3%) of patients aged 65 years or more have PAOD (22). We thus focused not on these underlying diseases, but on the amputations performed. The annual total of amputations in patients with CLMS main diagnoses was fairly stable over the observation period. A decrease could be shown only for patients with non-CLMS diagnoses. In this group, 63.7% of the cases of major amputation and 85.6% of the cases of minor amputation were in patients with the coded diagnosis DM. This disease is therefore of great etiological importance.

According to the German Health Interview and Examination Survey for Adults (DEGS) 2012, the prevalence of known DM has reached 7.2%, an increase of 2% over the previous German National Health Interview and Examination Survey in 1998 (23). DM is usually incurable and has a lasting influence on DFS. In contrast to DM, coding of the diagnosis PAOD gives no information as to whether arterial perfusion was still restricted at the time of amputation or whether PAOD was an old diagnosis coded along with the current diagnosis. We view only DM as a lasting risk factor. However, the coded diagnosis DM says nothing about whether or not an advanced Wagner–Armstrong stage of DFS was

Age-standardized rates of all major and minor amputations per 100 000 inhabitants and all major and minor amputations after exclusion of cases with the ICD main diagnoses C00–D48, L00–L99, M00–M99, and S00–T98 (CLMS)

actually the reason for the clinical decision to amputate. Our data merely show that despite a general increase in the number of people with DM (23), the proportion of amputations in which DM was coded decreased slightly over the observation period. This trend is attributable particularly to falls in the number of cases with amputation and in the proportion of all amputations with DM as main diagnosis. If the proportion of amputations with a secondary diagnosis of DM had increased to the same extent, a change in coding behavior could have been suspected. Since that is not the case, however, it can be assumed that among the risk factors for amputation DM has slightly decreased and other factors such as confinement to bed and decubitus ulcers have increased in importance (24, 25). Thus, in the period 2008 to 2011 around every fifth patient with a major amputation had a secondary diagnosis of dementia (26). In bedridden demented patients with advanced tissue destruction, primary major amputation makes more sense than revascularization (27, 28).

Overall, the decrease in major amputations in Germany is in line with developments in other countries (Table 1). Direct comparisons, however, are hampered by the heterogeneity of the study populations. According to an analysis of Medicare data in the USA, the rate of amputations went down by 45% between 1996 and 2011, but the population was restricted to persons over 67 years of age, persons with disabilities, and patients who required dialysis. A fall in the number of major amputations was mainly responsible for the decrease (3). In Australia, analysis of data from the Western Australian Data Linkage System for the period 2000 to 2010 revealed decreases in the rate of major amputations of

6.2% per year in diabetics and 6.9% per year in persons without DM (10). The rates of minor amputations fell by 0.6% and 1.4% per annum, respectively. In England, Vamos et al. analyzed the National Health Service data of all patients over 16 years of age with nontraumatic amputation in the period 2004 to 2008 (6). During this time the incidence of diabetes-related amputations went down by 9.1% from 27.5 to 25.0 per 10 000 diabetics ($p > 0.2$). In Spain, national hospital discharge data for the years 2001 to 2012 were evaluated (11). The authors found a decrease of 9.84% in minor amputations between 2001 and 2008, with the rate remaining constant thereafter. Major amputations in type 2 diabetics increased by 4.29% between 2001 and 2004, but then decreased by 1.85% from 2004 to 2012.

Although major amputation represents a greater detriment to physical integrity, minor amputations should also be prevented. The data on minor amputations in German hospitals are an underestimate of the true situation. An unknown but probably high number of patients with foot lesions are nowadays treated out of hospital, and the treatment includes amputation of gangrenous or mummified toes. In view of the rising prevalence of DM, the rate of minor amputations may reflect the burden placed on the healthcare system by the increasing number of DM patients, while the rate of major amputations affords insight into the efficacy of treatment strategies. The lack of a decrease—or indeed the presence of an increase—in minor amputations could indicate that in Germany, in comparison with other countries, primary prevention of foot lesions is insufficiently effective or that the available

Proportion of all major and minor amputations with diabetes mellitus (E10–E14) coded as main or secondary diagnosis, after exclusion of cases with the ICD main diagnoses C00–D48, L00–L99, M00–M99, and S00–T98 (CLMS)

FIGURE 2

treatment options are either not offered early enough or fail to take effect. On the other hand, the increase in minor amputations is found above all in elderly men, raising the question of whether sex-specific changes in behavior of the elderly might be responsible. In the EURODIABLE Study, which investigated foot lesions in a cohort of 1088 patients at 14 European centers, a multivariable model identified male sex as an independent predictor of lack of healing (29).

It is not clear what precise changes in the health-care system underlie the decrease in major amputations. Increased awareness of DFS among office-based physicians or general improvement of care structures may be responsible. An analysis carried out by our group showed a possible link between major amputations and, in particular, percutaneous transluminal angioplasty (PTA) of the crural arteries and the number of referrals for podological treatment (30). This seems logical, because PTA of the crural arteries is indicated only in patients with foot wounds and prescription of podological treatment is restricted to patients with DM and DFS. However, the findings do not show whether PTA and podology in themselves prevent amputation in individual patients or whether they are just markers of basic improvements in care structures with earlier escalation of treatment. This needs to be investigated further in care evaluation studies.

There appears to be room for further reduction in the rate of amputations. For instance, analysis of a German health insurance fund's data for the period 2009 to 2011, which permitted case-related evaluation, showed that in 37% of inpatients with chronic

critical ischemia treated with amputation, neither angiography nor attempted revascularization was documented in the 24 months before surgery (31, 32). There is thus an urgent need for clarification of how, and on what basis, the decision to amputate is arrived at in each individual patient.

Limitations

Although routinely recorded data contained in electronic medical records are often used for secondary purposes, no systematic analysis of coding quality in Germany has yet been carried out (33, 34). Controlled studies are needed to determine whether coding as a precondition for further use of the data in medicine and in healthcare policy corresponds to reality. It can be assumed, however, that—in contrast to subjective parameters and comorbidities—hard clinical endpoints such as amputation and death are affected very little or not at all by coding errors and are an accurate reflection of medical practice.

Also deserving of mention is the fact that the data are procedure related, not patient related. Therefore, it is unknown how many patients underwent amputation of more than one limb or first had a minor amputation and later a major amputation of the same limb. The decrease in amputations may therefore be even greater in terms of the number of persons affected.

Summary

Despite the aging of society and the increasing number of persons with DM, the data show a pronounced drop of 30.9% in the annual number of major amputations in Germany between 2005 and 2014. However, the rate of minor amputations rose over the same period. The

precise reasons for these developments are unclear. Together with targeted implementation of the existing strategies for prevention of foot lesions, prospective registries are necessary to clarify the effect of changes in behavior among the elderly and of medical treatment methods.

KEY MESSAGES

- The total annual number of major amputations carried out in German hospitals fell by 26.4% between 2005 and 2014 (from 22 619 to 16 645). After exclusion of cases with the main diagnoses trauma or intoxication, musculoskeletal disease, diseases of the skin or subcutaneous tissue, and neoplasia, the decrease was 32% (from 19 189 to 13 048).
- In the same period, the total annual number of minor amputations performed in hospital rose by 24%, from 33 070 to 40 992. After exclusion of the above-mentioned main diagnoses, the increase was 23.1% (from 28 854 to 35 513).
- The marked rise in the overall number of minor amputations is due principally to an increased amputation rate in men above 70 years of age.
- Focusing on amputations without the above-mentioned main diagnoses, the proportion of cases with a coded diagnosis of diabetes mellitus fell from 70.2% in 2005 to 63.7% in 2014 for major amputations and from 93.9% to 85.6% for minor amputations.

Acknowledgment

We are grateful to the staff of Section VIII A 1 of the Federal Statistical Office for extracting and providing data from the DRG statistics.

Conflict of interest statement

Prof. Kröger has received reimbursement of conference attendance fees and travel costs as well as payments for lectures from UCB Pharma, Sanofi, and Bayer.

Prof. Reinecke has received payments for consultancy from Bristol-Myers, Pfizer, and Pluristem. Study support (third-party funding) was provided to him by Pluristem, Bard, Bayer, and Biotronik.

The remaining authors declare that no conflict of interest exists.

Manuscript submitted on 25 May 2016, revised version accepted on 26 October 2016

Translated from the original German by David Roseveare

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Supplementary material

eTable, eFigure:
www.aerzteblatt-international.de/17m0130

CLINICAL SNAPSHOT

Subungual Telangiectatic Granuloma

Subungual telangiectatic granuloma with a ruff-like border around its base.

A 28-year-old woman presented with a rapidly growing mass on the right hallux that had occasionally bled. The tumor was excised and histological examination revealed a lobulated, well-vascularized mass with CD31-positive endothelium, loose connective tissue, and no cutaneous adnexal structures. This is a case of (pyogenic) telangiectatic granuloma, a benign capillary tumor that often arises after trauma. It can also arise after tumor chemotherapy or rheumatological antibody therapy. These tumors tend to bleed and can become secondarily infected.

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Conflict of interest statement

The author declares that no conflict of interest exists.

Cite this as: Wollina U: Subungual telangiectatic granuloma. *Dtsch Arztebl Int* 2017; 114: DOI: 10.3238/arztebl.2017.0136

Supplementary material to:

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Dtsch Arztebl Int 2017; 114: 130–6. DOI: 10.3238/arztebl.2017.0130

eTABLE

Age-standardized rates of major and minor amputations per 100 000 inhabitants after exclusion of cases with the ICD main diagnoses C00-D48, L00-L99, M00-M99, and S00-T98 (CMLS): men and women

Year	Major amputations (ICD 5-864)		Minor amputations (ICD 5-865)	
	Men	Women	Men	Women
2005	27.0	19.7	47.4	23.1
2006	26.6	18.7	49.5	23.2
2007	25.6	18.2	50.6	23.1
2008	25.1	17.1	53.7	23.2
2009	24.2	15.9	55.6	23.5
2010	22.9	14.4	57.8	23.9
2011	22.6	13.7	61.0	23.9
2012	21.6	12.9	60.9	24.1
2013	20.9	12.8	63.4	24.5
2014	20.8	11.6	64.4	24.1
Difference between 2005 and 2014	-6.2	-8.1	+17.0	+1.0
Relative change 2005 to 2014	-23.0%	-41.1%	+35.9%	+4.3%
p-value	<0.0001	<0.0001	<0.0001	<0.0001

ICD, International Classification of Diseases and Related Health Problems