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International Variations in Amputation Practice: A VASCUNET Report

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WHAT THIS PAPER ADDS

This paper provides a novel and unique comparison of amputation practices among patients with peripheral arterial disease (PAD) in 12 European and Australasian countries participating in the VASCUNET collaboration. The authors discovered important differences, which may indicate disparities in access to vascular surgical intervention across the countries studied. This paper further aims to harmonise medical treatment to achieve the best possible overall outcomes for PAD patients.

Objectives: To study international differences in incidence and practice patterns as well as time trends in lower limb amputations related to peripheral arterial disease and/or diabetes mellitus.
Methods: Data on lower limb amputations during 2010—2014 were collected from population based administrative data from countries in Europe and Australasia participating in the VASCUNET collaboration. Amputation rates, time trends, in hospital or 30 day mortality and reimbursement systems were analysed.
Results: Data from 12 countries covering 259 million inhabitants in 2014 were included. Individuals aged $\geq$ 65 years ranged from 12.9% (Slovakia) to 20.7% (Germany) and diabetes prevalence among amputees from 25.7% (Finland) to 74.3% (Slovakia). The mean incidence of major amputation varied between 7.2/100,000 (New Zealand) and 41.4/100,000 (Hungary), with an overall declining time trend with the exception of Slovakia, while minor amputations increased over time. The older age group ($\geq$65 years) was up to 4.9 times more likely to be amputated compared with those younger than 65 years. Reported mortality rates were lowest in Finland (6.3%) and highest in Hungary (20.3%). Countries with a fee for service reimbursement system had a lower incidence of major amputation compared with countries with a population based reimbursement system (14.3/100,000 versus 18.4/100,000, respectively, $p < .001$).
Conclusions: This international audit showed large geographical differences in major amputation rates, by a factor of almost six, and an overall declining time trend during the 4 year observation of this study. Diabetes prevalence, age distribution, and mortality rates were also found to vary between countries. Despite limitations attributable to registry data, these findings are important, and warrant further research on how to improve limb salvage in different demographic settings.

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INTRODUCTION

Peripheral arterial disease (PAD) and diabetes are the major causes of lower limb amputation throughout the world.[1] A recent systematic review reported that more than 202 million inhabitants are affected by PAD worldwide with a substantial increase in prevalence over time, emphasizing

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Table 1. Official demographics (data source: EUROSTAT), amputation rates, proportion of diabetics among amputees, and in hospital mortality as reported by the representatives of this study.

Country	Total no. of inhabitants in 2014	Population 65 years or older in 2014 (%)	Major amputations per 100,000 2010—2014	Minor amputations per 100,000 2010—2014	Diabetics among amputees mean (%)	Major amputees: In hospital mortality mean (%)	Re-imbursement system
Germany	80,767,463	16,799,632 (20.80)	2010: 20.0 2011: 19.0 2012: 18.5 2013: 18.4 2014: 17.6	2010: 35.9 2011: 36.7 2012: 37.5 2013: 39.2 2014: 39.2	66.82	18.54	FFS
United Kingdom	54,316,618	9,537,708 (17.56)	2010: 9.5 2011: 9.1 2012: 8.6 2013: 8.7 2014: 8.2	2010: 13.4 2011: 13.8 2012: 13.9 2013: 15.2 2014: 15.1	53.74	7.68	PB
Spain	46,452,771	8,511,020 (18.32)	2010: 7.6 2011: 7.7 2012: 7.6 2013: 7.7 2014: 7.6	2010: 7.4 2011: 7.6 2012: 8.1 2013: 8.7 2014: 8.4	65.64	NDA	FFS
Australia	23,460,694	3,456,188 (14.73)	2010: 9.1 2011: 8.7 2012: 8.0 2013: 8.4 2014: 7.5	2010: 26.7 2011: 28.2 2012: 29.0 2013: 29.0 2014: 30.0	73.50	NDA	FFS
Hungary	9,877,365	1,748,021 (17.70)	2010: 42.3 2011: 41.5 2012: 41.4 2013: 42.3 2014: 39.6	2010: 34.1 2011: 33.7 2012: 33.7 2013: 33.0 2014: 33.6	55.16	20.88	PB
Sweden	9,747,355	1,912,884 (19.62)	2010: 12.7 2011: 11.9 2012: 12.9 2013: 11.7 2014: NDA	2010: 2.9 2011: 2.8 2012: 3.0 2013: 2.8 2014: NDA	41.28	14.52	PB
Austria	8,543,932	1,571,996 (18.40)	2010: 23.6 2011: 23.1 2012: 23.4 2013: 22.1 2014: 21.0	2010: 22.7 2011: 24.0 2012: 23.0 2013: 15.4 2014: 15.5	NDA	14.29	FFS
Denmark	5,639,719	1,040,682 (18.45)	2010: 18.5 2011: 17.3 2012: 19.0 2013: 18.7 2014: 17.5	2010: 8.9 2011: 9.0 2012: 8.5 2013: 9.8 2014: 10.1	43.44	NDA	PB
Finland	5,471,753	1,091,388 (19.95)	2010: 18.9 2011: 18.1 2012: 17.4 2013: 17.8 2014: 17.7	2010: 17.0 2011: 19.2 2012: 19.6 2013: 20.7 2014: 20.3	25.73	6.12	PB
Slovakia	5,415,949	661,800 (13.54)	2010: 27.4 2011: 28.3 2012: 30.6 2013: 29.0 2014: 30.2	2010: 45.4 2011: 38.9 2012: 48.5 2013: 48.9 2014: 51.6	74.32	NDA	PB
Norway	5,165,802	834,302 (16.15)	2010: 11.8 2011: 12.0 2012: 11.6 2013: 10.2 2014: 10.4	2010: 5.2 2011: 5.6 2012: 5.1 2013: 4.5 2014: 4.6	47.41	6.27	PB

Table 1-*continued*

Country	Total no. of inhabitants in 2014	Population 65 years or older in 2014 (%)	Major amputations per 100,000 2010—2014	Minor amputations per 100,000 2010—2014	Diabetics among amputees mean (%)	Major amputees: In hospital mortality mean (%)	Re-imbursement system
New Zealand	4,554,600	662,400 (14.54)	2010: 7.6 2011: 7.6 2012: 7.3 2013: 7.4 2014: 6.1	2010: 10.1 2011: 8.7 2012: 10.0 2013: 10.8 2014: 7.0	54.53	NDA	PB

Table sorted by population number. FFS = fee for service; PB = population based; NDA = no data available.

the global burden of this disease.[2] In parallel, the latest International Diabetes Federation (IDF) Diabetes Atlas revealed a 7.3% (5.5—10.9%) increase in the age adjusted prevalence of diabetes among persons aged 20—79 years, causing 627,000 premature deaths in 2015.[3,4] Morbidity and mortality data related to lower limb amputations show exceptionally poor results, a finding that may partly be explained by gaps in basic patient care and treatment following an amputation.[5] Moreover, the economic burden of caring for amputees within the healthcare system is substantial.[6]

The significant impact of these procedures on well being and health expenditure[7] underline the importance of assessing the trends and practice patterns in lower limb amputations related to PAD and diabetes. Several countries have already reported national major and/or minor amputation rates using administrative data.[8—14] Although most studies revealed decreasing incidences of major amputations,[8,13] the numbers of minor amputations increased simultaneously.[10,12,13] There are a lack of data covering amputation practice and outcomes internationally, as well as wide variation in published results.[15] Data collection, merging, and analysis of amputation procedures and results following an amputation on a broad international level are complicated because of incompleteness of data sets, differences in the administrative healthcare systems, and a relative lack of standardisation of procedural and diagnosis codes internationally. Additionally, many different medical specialties are involved in the treatment of amputees. Furthermore, every patient can be amputated on two sides and at different levels, which influence the data analysis and comparison of outcomes. In an effort to enforce the discussion and to emphasise the need for further research regarding these problems, this study aimed to compare international practice patterns and time trends in lower limb major amputation related to PAD or diabetes using population based administrative data from 12 countries in Europe and Australasia.

METHODS

The VASCUNET collaboration

VASCUNET is a collaboration of vascular registries from Europe and Australasia, administered and partly funded by the European Society for Vascular Surgery (ESVS). It was founded in 1997, and several contributions have been published since.[16,17] VASCUNET aims to increase knowledge and understanding of vascular disease, and to promote excellence in vascular surgery, by means of international vascular audit.

A data extraction and study protocol were developed, based on expert consensus (Table S1). For this study, national statistics were used to determine in hospital major and minor amputations using the International Classification of Diseases (ICD-10) coding I70 (Atherosclerosis), I74 (Arterial embolism or thrombosis), or I73.9 (Embolism and thrombosis of unspecified artery), and Procedure Codes (ICD-9-CM) coding for major (84.10, 84.14, 84.15, 84.17, 84.18, 84.19) or minor (84.11, 84.12, 84.13) amputations of the lower limb. The four Scandinavian registries have specifically designed operative procedure codes, according to the Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures. Austria is using an individually adapted ICD-10 coding system. The study included procedures conducted between January 1, 2010 and December 31, 2014. The numbers of major (above ankle level) and minor amputations (below ankle level) for vascular disease were requested, the number of all diabetics among the target population, and the percentage of diabetics among amputees. Post-operative mortality was defined as in hospital mortality among all countries, except for Sweden and Denmark in which it was death within 30 days of the amputation that was reported (Table S2). Population data were accessed through the Statistical Office of the European Union (EUROSTAT). Data on life expectancy, gross domestic product (GDP) per capita, proportion of active and never-smokers, and estimated expenditures for health care were accessed through the Organisation for Economic Co-operation and Development (OECD). Data were requested by the VASCUNET representatives (Australia, Denmark, Finland, Germany, Hungary, New Zealand, Norway, United Kingdom, and Sweden) or directly from the national authorities in Austria, Spain, and Slovakia. Swedish data were extracted and submitted from an ongoing observational cohort study collecting data from different official data sources.[18] CAB collected and coordinated the data set.

Countries were also grouped and analysed by whether they primarily use fee for service (FFS), where physician's payment is proportional to the number of procedures performed, or population based (PB) reimbursement, where physician's payment is independent of the number of procedures performed.

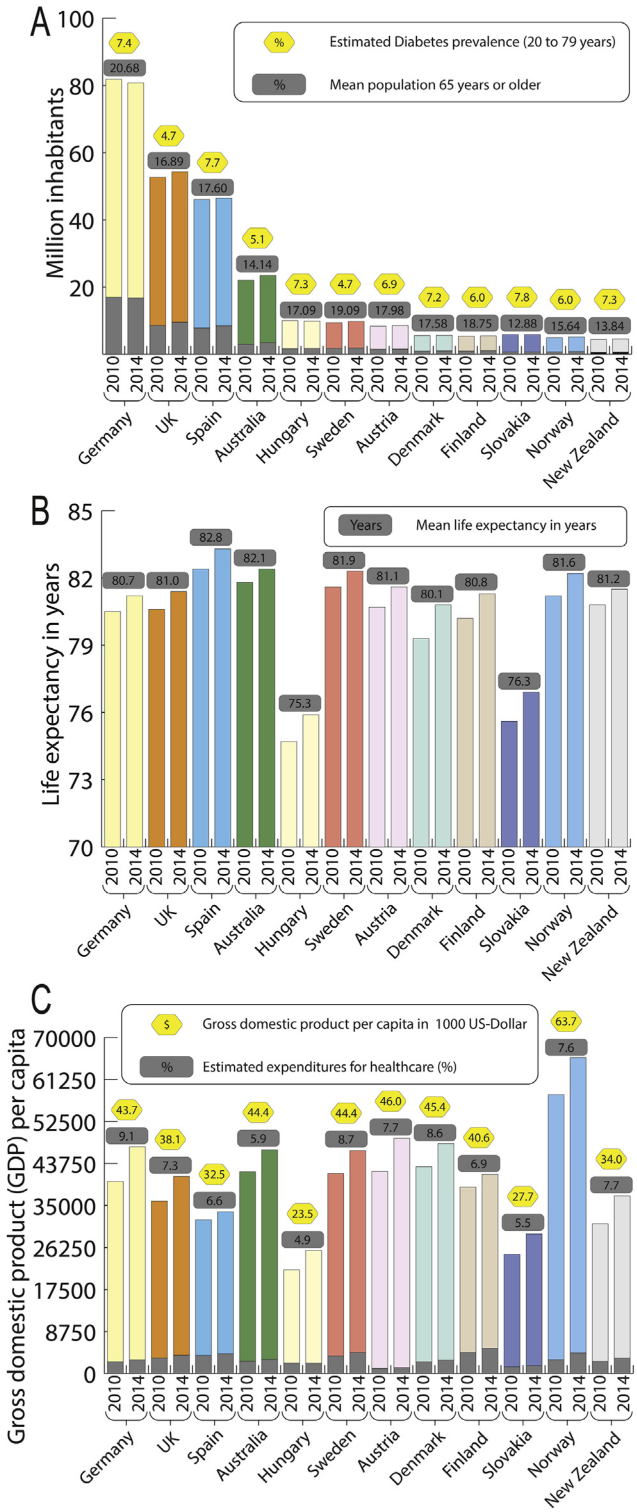

Figure 1. (A) Total population, diabetes prevalence, and population aged 65 years or older (mean values in grey boxes). Figure sorted by population number. Source of data: EUROSTAT, National Federal Statistics, and International Diabetes Federation Atlas (2015). (B) Life expectancy in years. Source: Organisation for Economic Co-operation and Development (OECD). (C) Gross domestic product (GDP) per capita and estimated expenditures for health care in %. Source: Organisation for Economic Co-operation and Development (OECD) aggregated national accounts and health expenditure and financing.

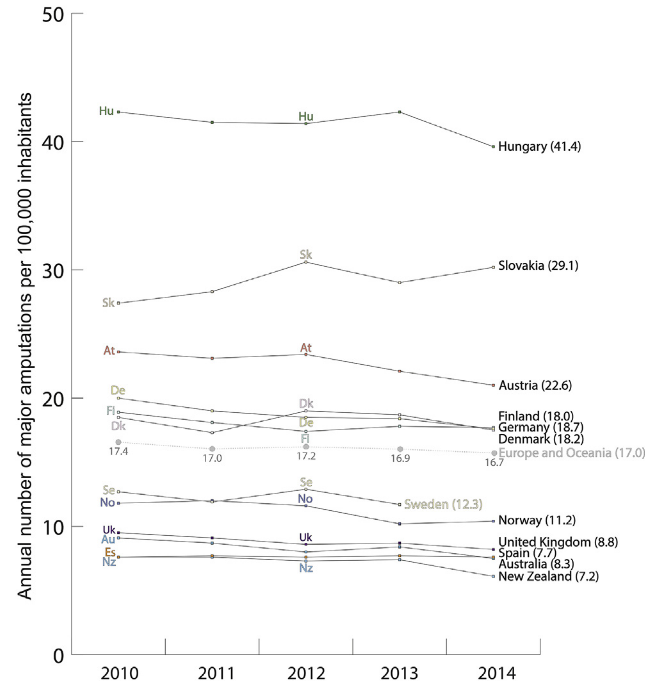

Figure 2. Annual number of major amputations per 100,000 inhabitants. Mean values (2010—2014) for each country in brackets. The dashed line in grey shows mean annual incidence among all countries (Europe and Australasia). (At, Austria; Au, Australia; Dk, Denmark; Fi, Finland; De, Germany; Hu, Hungary; Nz, New Zealand; No, Norway; Sk, Slovakia; Es, Spain; Sw, Sweden; Uk, United Kingdom).

Statistical analysis

The data were primarily analysed using descriptive statistics, mean and standard deviations for continuous variables, and relative frequencies for categorical variables. Quantitative data were further visually displayed in figures and tables. Rates and univariable differences were compared using Fisher's exact test.

Ethical considerations

Several review boards determined that retrospectively using aggregated data from national statistics is not human subject research, as de-identified data sets were used. Thus, patient informed consent was not obtained for this study. Ethical approval was, however, obtained for the Swedish data set (the Regional Ethical Review Board at the University of Gothenburg, Sweden, approved the study under the reference number 649—14 and T784—16).

RESULTS

Twelve countries, of which eight had PB reimbursement, submitted data to this study covering a total of 259 million inhabitants in 2014 (Table 1). The proportion of elderly (defined as $\geq$ 65 years) varied between 12.9% in Slovakia and 20.7% in Germany (Fig. 1A). The estimated life expectancy varied between 75.3 years in Hungary and 82.8 years in Spain (Fig. 1B). The national gross domestic product (GDP) per capita varied between 23,500 US Dollars in Hungary and 63,700 US Dollars in Norway, while the estimated

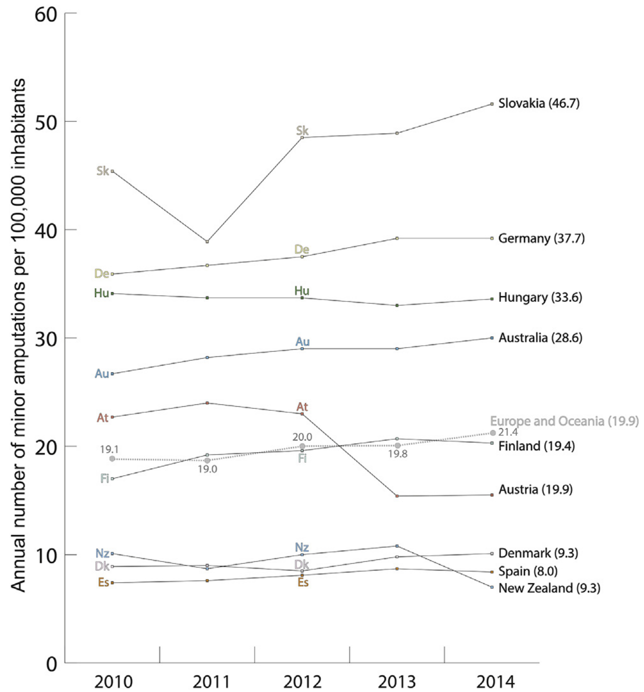

Figure 3. Annual number of minor amputations per 100,000 inhabitants. Mean values (2010–2014) for each country in brackets. The dashed line in grey shows mean annual incidence among all countries (Europe and Australasia). (At, Austria; Au, Australia; Dk, Denmark; Fi, Finland; De, Germany; Hu, Hungary; Nz, New Zealand; Sk, Slovakia; Es, Spain). No valid (unknown external validity) data available for Sweden, Norway, and United Kingdom.

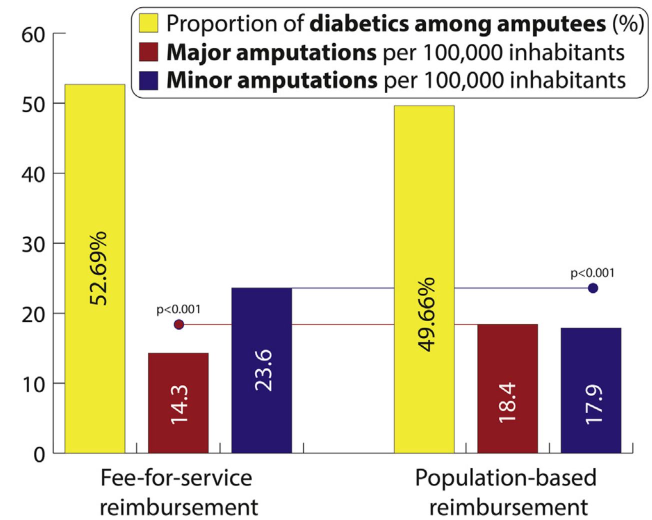

Figure 4. Comparison of diabetics among amputees, major amputations per 100,000 inhabitants, and minor amputations per 100,000 inhabitants.

expenditures for health care varied between 4.9% in Hungary and 9.1% in Germany (Fig. 1C). Diabetes prevalence among amputees was available for 11 countries and varied between 25.7% (Finland) and 74.3% (Slovakia) (Table 1). The mean incidence of major amputations ranged between 7.2/100,000 in New Zealand and 41.4/100,000 in Hungary (Fig. 2). The mean incidence of minor amputations ranged between 8.0/100,000 in Spain and 46.7/100,000 in Slovakia (Fig. 3). While annual incidences of major amputations decreased from 2010 to 2014, except for Slovakia, minor amputations increased during the same time period (Figs. 2 and 3). In hospital mortality following major and minor amputations varied significantly between the participating countries. The lowest in hospital mortality following major amputation was reported from Finland (6.12%), while the highest was reported from Hungary (20.88%) (Table 1).

While the proportion of diabetes among amputees was slightly higher in countries with FFS reimbursement system (52.7%) compared with countries with a PB reimbursement system (49.7%), the incidence of major amputations (14.3/100,000 vs. 18.4/100,000) was lower in countries with FFS ($p < .001$). In contrast, the incidence of minor amputations (23.6/100,000 vs. 17.9/100,000) was higher in countries with FFS ($p < .001$) (Fig. 4). The incidence of major amputations was 3.5 (Hungary) to 4.9 (Sweden) times higher among the elderly compared with all age groups (Fig. 5).

While the proportion of active smokers among inhabitants $\geq$ 15 years varied from 11.9% in Sweden to 25.8% in Hungary, the proportion of never smokers varied from 70.0% in Austria to 83.3% in Sweden (Fig. 6).

DISCUSSION

In this large international survey on amputation rates for PAD, significant differences were identified between countries regarding amputation practices and outcomes. Firstly, the number of amputations performed per 100,000 population varied considerably between countries, being highest in Hungary and lowest in New Zealand with an overall declining trend for major amputations, except for Slovakia. Secondly, risk factors such as diabetes prevalence and age, differed between participating countries. A high prevalence of diabetes was reported in the total population of Slovakia, Spain, Germany, and New Zealand, according to data extracted from the International Diabetes Federation. The proportion of elderly was lowest in Slovakia and New Zealand. The highest proportion of active smokers was reported in the population of Hungary, Austria, Spain, and Slovakia. Thirdly, major amputations were less common in FFS countries compared with countries with PB reimbursement systems. In addition, major amputations were more frequent in countries with lowest GDP per capita and healthcare expenditures (Hungary, Slovakia).

Variation in amputation rates may be explained by multiple background factors such as differences in disease burden and comorbidities, where diabetes in particular has a great impact.[19] Other predictive factors for amputation are low socio-economic status[20] and economic factors. In addition, differences in vascular maintenance and the number of vascular surgeons per 100,000 inhabitants may play a role. This information, however, could not be collected in this analysis. A higher amputation rate was found among PB reimbursed countries compared with those with a FFS system. As these complex associations cannot be analysed in a simplistic way, the overall GDP per

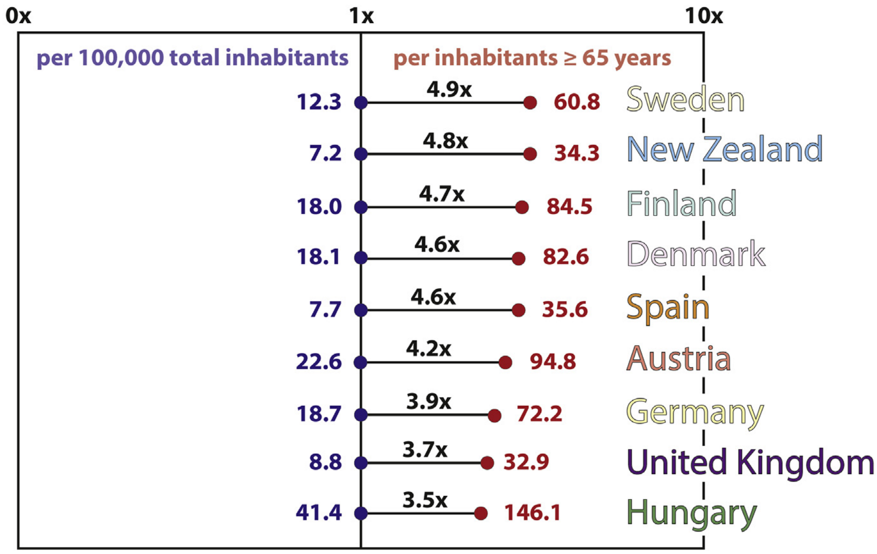

Figure 5. Ratio of major amputations among old inhabitants (≥65 years) in relation to major amputations in total population. (Data range for Denmark: 2011−2014, Data range for Sweden: 2010−2013, No data available: Slovakia, Norway, Australia).

capita and estimated healthcare expenditures may serve as a suitable composite covariable. Again, highest major amputation rates were found in countries with lowest GDP and healthcare expenditures (Hungary, Slovakia). Healthcare systems vary within countries. In the US it has been shown that low income and non-insured patients are more likely to have an amputation compared with affluent patients more frequently benefitting from lower extremity revascularisations.[21] Rowe et al. document major amputations and revascularisation procedures at 28% and 54% among private insurance patients and 47% and 26% among the Medicare population, respectively, thus highlighting the inverse relationship.[8] This is in line with previous VASCUNET reports that revealed differences in operative management depending on the health economic system: a patient with an asymptomatic carotid artery stenosis or a small aortic aneurysm was more likely to be treated in countries with FFS compared with PB reimbursement systems.[22,23] Other confounding factors may be lifestyle factors such as smoking habits. In a recently published review article, smoking together with male sex were identified as two predisposing risk factors for amputation among diabetic patients.[24] According to the Organisation for Economic Co-operation and Development (OECD), the proportion of active smokers was greater in countries with the highest major amputation rates (Hungary, Slovakia, Austria). Information on national preventive medicine (e.g. smoking cessation programs) was not available, and thus not taken into account. Moreover, the proportion of never smokers in the population was highest in countries with lowest major amputation rates (Sweden, UK, Norway) (Fig. 6).

Furthermore, there are several important differences in treatment practices. The availability of professional wound care, best medical treatment, technical equipment, availability of vascular specialists with expertise to provide endovascular or open revascularisations, and the general healthcare infrastructure to transfer patients between facilities varies significantly among participating countries and

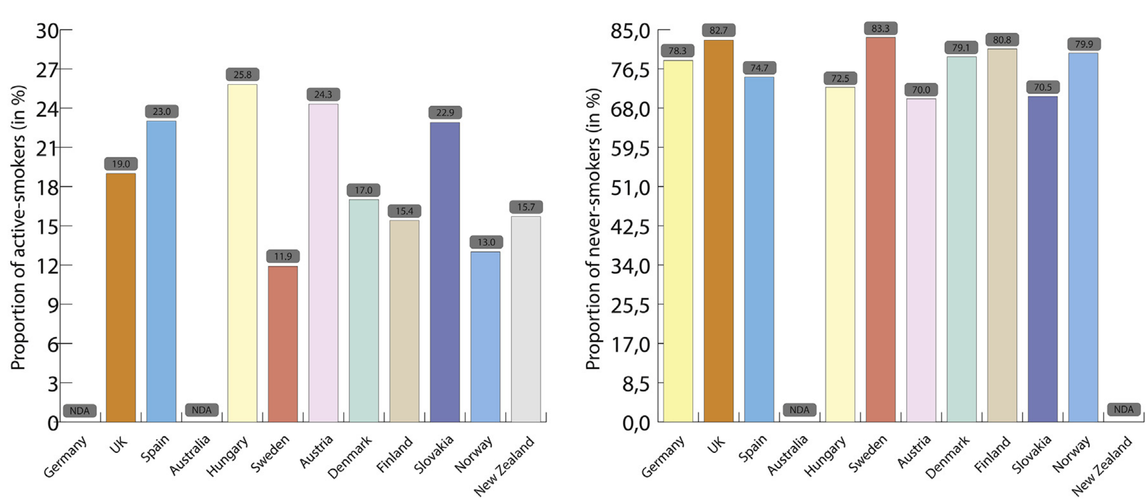

Figure 6. Proportion of active smokers in % (left) and never smokers in % (right). Source: Organisation for Economic Co-operation and Development (OECD).

is likely to influence limb salvage rates. A previous VASCUNET report concerning lower limb bypass surgery confirmed significant differences: in Finland, 25 per 100,000 patients were offered bypass surgery, compared with the UK where 2,3 per 100,000 patients were operated on.[16] The amputation practice variation is partly a reflection of the aggressiveness of limb salvage, as well the countries' amputation prevention programs, mainly diabetic foot management. Unfortunately, data on primary amputation versus amputation after limb salvage attempt are not available in this data set. In earlier published data from Hungary, primary amputations without a revascularisation procedure were performed in 71.5% of all PAD patients undergoing amputation. Few revascularisation attempts may explain the high amputation rates in Hungary.[25]

Remarkably, Slovakia is the only country with increasing major amputation rates, taking the second place after Hungary, and followed by Austria. All other countries showed a declining trend during the 4 year observation of this study. Taking all possible explanations into consideration, Slovakia showed the highest prevalence of diabetes (7.8%), the second lowest life expectancy (76.3 years), the second lowest gross domestic product per capita (27,700 US Dollars), the second lowest healthcare expenditures (5.5%), and showed the second lowest proportion of never smokers (70.5%), compared with the other countries. The most distinguishing differences between countries with higher and lower major amputation rates were apparently economic factors, where only Hungary had lower GDP and healthcare expenditures as well as the highest amputation rates.

Despite data not being age adjusted in this study, amputation rates decreased over time. Considering the global epidemiological transition towards an older age distribution, the declining trend in major amputation rates would probably have been even more pronounced if adjusted for age. While major amputation rates decreased over time, despite the short time period studied, minor amputation incidences increased during the same study period. It should be noted, however, that many minor amputations are performed in outpatient clinics that tend to have a less complete registration of surgical procedures than inpatient care, making data for minor amputations less robust.

Reported post-operative mortality among patients undergoing major amputations varied almost fourfold between the extremes (6% in Finland compared with 21% in Hungary), both defined as status at the time of discharge. Core variables such as proportion of patients at age $\geq$ 65 years, proportion of diabetics, or reimbursement system could not explain the observed differences. The wide range may however, be partly explained by observation time. For example, the higher Swedish mortality rates compared with Finland and Norway may be influenced by the studied time frame, as mortality was defined as death during the first 30 post-operative days in Sweden (where the linkage to the population registry makes it possible to study death with almost 100% accuracy) and as death during hospital stay in Finland and Norway. Information on other influencing factors on in hospital mortality, such as availability of step down facilities allowing for early discharge from hospital, was not available, and thus not taken into account.

Reported diabetes prevalence among amputees varied between 25.7% in Finland and 74.3% in Slovakia. The variation can only be explained to some extent by differences in diabetes prevalence according to the International Diabetes Federation Atlas (6.0% vs. 7.8%, respectively). Apart from disparities in diagnosis and patient selection, data registration and coding practice may have an impact.

As expected, increased age was associated with an increase in major amputation rates: patients aged 65 years and above showed up to an almost five times increased rate (Fig. 5).

Limitations

This study has several limitations. Despite using a clear and detailed study protocol and search algorithm to permit comparable data extraction from governmental databases, there are still significant differences in coding practices, collection of administrative data, and availability of data. Therefore, the external and internal validities of these results remain questionable, leading to a risk of bias and possibly misleading messages.[26] Especially when working with data from multiple registries, the risk of type I error becomes significant.[27] As a result of data privacy regulations, no patient related follow up was available for this study. Therefore, each procedure (e.g. primary toe amputation, secondary major amputation) was collected and analysed as an individual event. Second, information regarding comorbidities or outcome following hospital discharge was not addressed. Robust data on lifestyle factors such as smoking habits and physical activity, were difficult to obtain. It is assumed that the practices of coding and registration have remained rather stable over time in each country, making the time trends more robust than the head to head comparisons between countries. This is of particular importance for the comparison of mortality. Significant differences in time of follow up (30 days vs. the in hospital period) and discharge practice between countries may decrease the validity of the comparison of this outcome. Furthermore, it is unlikely that coding practices would alter in a harmonious way all over Europe and Australasia, which makes the main finding of this study, that major amputation rates are decreasing over time, even more plausible.

CONCLUSION

This international audit from 12 countries on amputation related to PAD showed a declining trend of major amputations over time. These findings, along with the demographic development, are important and require reflection, further research, and action to make healthcare providers and governments aware of the need to strengthen both prevention and treatment of limb threatening ischaemia among PAD patients in an effort to decrease major lower limb amputations.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ejvs.2018.04.017.

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COUP D'OEIL

Autologous Arteriovenous Loop Fistula in the Forearm With Transposition of a Matured Forearm Cephalic Vein

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A 61 year old dialysis patient presented with thrombosed brachiocephalic arteriovenous fistula in the left arm after multiple revisions. On clinical examination it was noted that the patent brachiocephalic anastomosis (arrowhead) was still draining into a considerable length of dilated cephalic vein in the forearm (presenting bruit). Under local anaesthesia a sufficient length of the cephalic vein was dissected free and mobilised (Panel A) to loop back (Panel B, dotted line) for an end to end anastomosis to the basilic vein in the cubital fossa (Panel B, arrow). The presented technique avoids any artificial conduit and spares the brachial site for future interventions.

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