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Original article

Quantifying the incidence of lower limb amputation in people with and without diabetes in Wales between 2008–2018

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ABSTRACT

Background: There is variance in the incidence of lower extremity amputation across and within countries including within the UK. National data shows up to a fourfold variance in the amputation rate throughout the regions of England and differences in amputation incidence have been reported in Scotland and Ireland. Lower extremity amputation rate has yet to be documented within Wales. The aim of this cohort study was to examine trends in diabetes and non-diabetes related lower extremity amputation incidence within the Welsh population and to examine the influence of diabetes on the relative risk of amputation.
Materials and Methods: All first-time amputations between 2008-2018 were extracted from SAIL, a repository of all routine medical data of residents of Wales. People with diabetes were identified using an algorithm utilising data from several clinical and non-clinical sources. Crude and direct age and sex adjusted incidences were estimated over time.
Results: Over the period 3505 major amputations and 4335 minor amputations occurred. The diabetes population greater than 17 years of age increased by 29.4% from 143,595 in 2008 to 206,818 in 2018. There was a statistically significant rate reduction in major amputation in both populations. In the diabetes population the number of major amputations reduced from 6.9 [5.5–8.5]/10 000 person years (PY) in 2008 to 4.9 [5.4–6.2]/10 000 PY in 2018. However, for major amputation, the risk of incident amputation in people with diabetes was 7.3 fold higher [7.1–7.5] than those without diabetes. The relative risk of minor amputation for those with diabetes was higher at 11.9 [11.8 –1.01]. There was no reduction in this risk over the period.
Conclusion: This study found that rates of major amputation decreased over the study period but the risk of amputation for persons with diabetes remained substantial. As the population with diabetes increases so do crude rates of amputation, providing a substantial financial and societal cost to the Welsh Population.

Introduction

The most recent National Institute for Health and Care Excellence (NICE) guidelines 'Diabetic Foot Problems: Prevention and Management' have highlighted that levels of morbidity and mortality related to diabetes-related foot disease throughout the UK are at an unacceptably high level. Foot related complications create a significant burden on people with diabetes (PWD), the National health service (NHS) and the United Kingdom (UK) economy and there is a marked variation in their incidence across regions [1]. Foot problems, ranging from ulceration to amputation, account for the highest proportion of hospital admissions for any long-term micro or macrovascular complication of diabetes [2]. With the rising prevalence of diabetes and age distribution shifts, crude rates of amputation are expected to

Abbreviations: AR, amputation rate; ARd, amputation rate diabetes; ARn, amputation rate non diabetes; ARt, amputation rate total; ADBE, annual district birth extract; ADDE, annual district death extract; ALF, anonymised linking field; BMA, British Medical Association; DHCW, Digital Health and Care Wales; DSR, direct standardised rates; GDPR, General Data Protection Regulations; ICD10, International Classification of Diseases 10; IGRP, independent Information Governance Review Panel; NHS, National health service; NRES, National Research Ethics Service; ONS, Office of National Statistics; OPDW, Outpatient Database for Wales; OPCS4, Office of Population Census and Surveys interventions and procedures version 4; PHE, Public Health England; PWD, people with diabetes; PEDW, Patient Episode Database for Wales; PY, person years; QOF, quality and outcomes framework; SAIL, Secure Anonymised Information Linkage Databank; UK, United Kingdom; WDSD, Welsh Demographic Service Database; WLGP, Welsh Longitudinal General Practice database; WOB, week of birth

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increase further. The cost of amputation to the NHS will soon become overwhelming, due high procedural costs, expensive supplementary care, and the loss to the working adult population.

It is estimated that every 20 s an amputation secondary to diabetes-related foot disease occurs somewhere in the world [3]. However, there is variance in the incidence of amputation across and within countries, including within the UK. National data shows up to a four-fold variance in the amputation rate throughout the regions of England [4] and differences in amputation incidence have been reported in Scotland and Ireland. As variance in amputation rates are seen between and within countries the first step in addressing these issues is to accurately identify the amputation rates within a population. At present there are no published data on diabetes-related amputations in Wales, and literature reporting the incidence of amputation in any population within Wales are lacking [5,6]. Establishing time trends from the available data from within the UK is difficult due to methodological differences in definitions of age groups, populations and amputation, variance in the use of standardisation, as well as differing methods in the presentation of results. There is marked variability in the incidence rates between health trusts within England [7,8] and regions of Scotland [9]. It is not possible to assume that rates in England will be comparable to rates within Wales.

At present there is no study that has examined the incidence rate of lower extremity amputation within the Welsh population. Although a number of strategies to improve amputation rates in the diabetes population have been introduced regionally [10] and nationally [11], changes in amputation rates over time have not been explored. Our aim was to examine trends in diabetes and non-diabetes related lower extremity amputation incidence and to determine the influence of diabetes on the relative risk of amputation in the Welsh population.

Methods

Ethics approval

Approval for the use of anonymised data in this study, provisioned within the Secure Anonymised Information Linkage (SAIL) Databank was granted by an independent Information Governance Review Panel (IGRP) under project 0716. The IGRP has a membership comprised of senior representatives from the British Medical Association (BMA), the National Research Ethics Service (NRES), Public Health Wales and Digital Health and Care Wales (DHCW). Usage of additional data was granted by the data owner. The SAIL Databank follows the General Data Protection Regulations (GDPR) and is UK Data Protection Act compliant.

Data

Data were extracted from SAIL, a repository of routine medical data primarily focused on the residents of, or people receiving services in Wales from primary, secondary and outpatient settings. Patients are represented within the database by an anonymised linking field (ALF), based on their NHS number, name, sex, date of birth and postcode. This allows researchers to track a person's interaction with any service, intervention or dataset and accurately link these within the databank [12]. It allows for construction of population level patient cohorts. People in the SAIL databank without an ALF were excluded from the study.

This study primarily used clinical data from the Welsh Longitudinal General Practice database (WLGP) the Patient Episode Database for Wales (PEDW) and the Outpatient Database for Wales (OPDW). Nonclinical data were extracted from the Office of National Statistics (ONS) annual district birth extract (ADBE) and annual district death extract (ADDE) as well as the Welsh Demographic Service Database (WDSD). Any events, admissions or services received prior to December 2018 were included. Persons without a documented week of birth (WOB) were not included.

Amputation

All amputations in persons aged over 17 years between 2008 and 2018 were identified, regardless of cause, in line with other national publications and Public Health England (PHE) analysis [7,8,13]. PEDW was used to identify amputations using relevant classification of Office of Population, Census and Surveys interventions and procedures version 4 (OPCS4) codes. PEDW summarises all standard hospital admissions and day-case activity undertaken in NHS Wales, plus data on Welsh residents treated in English NHS Trusts [14]. It includes demographic data, diagnosis (primary, related and associated using International Classification of Diseases 10 (ICD10) codes) and procedures (coded using OPCS4 codes). Amputations were defined as major if above the ankle (OPCS4 codes: X09:X095, X098, X099) and minor if through or below the ankle (X10:X11.9) [15]. Procedures on amputation stumps (X12), which included re-amputations at a higher level were not included in the incidence rates but were used within the observation period to identify a history of amputation. Amputations were identified as incident if no record of amputation was found within the 5 years prior to the amputation of interest [16]. Amputation type was determined within the lookback period and a person was included in the incident major amputation analysis if they had previously undergone a minor amputation but not if the opposite was true due to the aetiology of the amputation types. Laterality, the side on which the procedure was performed, was not assigned as there were no data available on the accuracy or frequency of laterality codes used within PEDW.

Diabetes

People with diabetes were identified using an established algorithm [17,18] utilising linked data from several clinical and non-clinical sources within SAIL (WLGP, PEDW). People were classified as having diabetes if a diabetes code was present across any of the databases. To assess for the accuracy of the algorithm in T1DM, it was validated using data from a local diabetes register for children with diabetes in Wales. Those in the study population were included in the WDSD at entry into the study and either remained in Wales for the study period or were censored as they died or moved out of Wales. People were considered to have diabetes from first registration of diabetes; patients with gestational diabetes were excluded unless the person went on to develop T2DM.

Analysis

All analysis was undertaken using R (R version 3.6.1, 2019) and figures were produced using the package ggplot2 [19].

The incident amputation number, crude rate and age-sex standardised rates of minor and major amputations with 95% confidence intervals ([]) were calculated for the entire population (amputation rate total, ARt), population with diabetes (amputation rate diabetes, ARd) and population without diabetes (amputation rate non diabetes, ARn). The annual amputation rate (AR) per 10 000 person years (PY) was estimated with number of incident or total amputations per individual as the numerator. The denominator was derived from ONS Wales mid-year population estimates [20]. The denominator for the diabetes population was the cumulative person years at risk for all people identified as having diabetes in the respective year. The age-specific non-diabetes population was then obtained by removing the age-specific diabetes population from the ONS entire population estimate. Annual direct age-sex-standardised rates for the whole population were calculated using the age categories 17–24, 25–44, 45–64, 65–74, 75–84 and 85+ years. The ONS Wales mid-year population estimate for 2013 was used as the population for standardisation.

The incident major and minor amputation rate was computed counting only first major or minor amputations occurring per person within the period if a previous amputation had not occurred within the lookback period. If an incident major and incident minor amputation occurred in the same person with diabetes within 1 year, the patient was counted in both incident minor and incident major analysis only if the minor amputation preceded the major amputation. An amputation was determined to be attributable to diabetes if the person was identified as having diabetes prior to or within 3 months of amputation, as per previous publication [9].

Amputation rate ratios were calculated for diabetes and non-diabetes populations using the direct standardised rates (DSR). Confidence intervals for the DSRs were calculated using Dobson & Byar's method [21]. Standard errors for directly standardised rates were calculated in the package using Chiang's method [22]. The relative risk of an individual with diabetes undergoing amputation compared with that of an individual without diabetes was calculated with confidence intervals calculated using the delta method [21].

To assess for changes in the rate of amputation over the period, Poisson regression was used to look at the effect of year on amputation and all models were assessed for over dispersion. The indicator values in each year were compared to the baseline incidence in 2008. Each indicator had a value of one for the year 2008 and changes were measured in relation to the baseline year.

Results

Complete study population and crude amputation number

Between the period of 2008–2018, 4335 incident minor amputations (2535 diabetes, 1800 non diabetes) and 3505 incident major amputations (1736 diabetes, 1769 non diabetes) occurred. A description of all incident amputation over the period is shown in Table 1. The crude diabetes prevalence over the 10-year period increased by 2.1% from 5.9% in 2008 to 8.0% of the whole population in 2018. The diabetes population greater than 17 years of age increased by 29.4% from 143,595 in 2008 to 206,818 in 2018. Over half (n = 3579) of the people undergoing amputation over the entire period had a diagnosis of diabetes. A higher proportion of men undergoing amputation had a diagnosis of diabetes (61.9%) compared to women (45.1%). This was consistent over the period.

62.7% of incident amputations occurred in those aged over 65 years (61.3% diabetes, 64.2% non-diabetes). There was a higher incidence of amputation in males with diabetes compared to females (3.00 95% CI [2.91–3.08]) which was higher than the incidence ratio seen in the non-diabetes population (1.52 [1.46–1.58]). There was an excess of minor amputations in those with diabetes compared to those without with a higher major to minor amputation incidence rate ratio (1.87 [1.81–1.93] vs 1.04 [0.99–1.08] respectively).

In both diabetes and non-diabetes the crude incidence rate of major amputations decreased from 10.7 to 6.7 and 0.8 to 0.7 respectively, and minor amputations increased slightly from 13.8 to 14.2 with diabetes population but remained similar in those without diabetes at 0.7 between 2008 and 2018.

Incidence rate of major and minor lower limb amputation in the population with and without diabetes and the influence of diabetes on risk of amputation

The age and sex standardised AR as well as the relative risk of amputation in the population with diabetes compared to those without diabetes for each calendar year are shown in Fig. 1. The results of the fully adjusted Poisson models are shown in Table 2.

In the total population the rate of incident major amputation (1.3 [1.2–1.3]/10 000 PY) was lower than that of incident minor amputation (1.6 [1.5–1.6]/10 000 PY). For major and minor amputation, the rate was higher for men. Over the 11-year period, when controlling for population changes in age and gender, there was no significant change in the rate of incident minor amputation in the whole population. There was a statistically significant rate reduction for incident major amputation reducing from 1.5 [1.3–1.6]/10 000 PY in 2008 to 1.1 [1.0–1.1]/10 000 PY in 2018. When stratified by gender the rate change was only significant for men.

PWD underwent a greater number of incident amputations, however, as in the total population, the rate of incident major amputation (5.8 [5.4–6.2]/10 000 PY) was lower than that of incident minor amputation (9.5 [7.8–11.5]/10 000 PY). Again, as in the whole population, the rate of amputation was higher for men. Over the period there was no statistically significant change in the standardised rate of any incident minor amputations per year in the diabetes population, despite the increase in the crude rate and total number of people undergoing amputation. Poisson regression analysis identified a significant decrease in the incidence of major incident amputation after adjustment for age and sex (Table 2). There was a rate reduction in the number of incident major amputations in the diabetes population from 6.9 [5.5–8.5]/10 000 PY in 2008 to 4.9 [5.4–6.2]/ 10 000 PY in 2018 corresponding to a 30% relative risk reduction between the two years (Fig. 1b). When stratified by gender the rate of change was greater in women but significant for both genders. The rate of minor amputation in the diabetes population remained stable over the period.

For major amputation the risk of incident amputation in people with diabetes was 7.3-fold higher [7.1–7.5] than in those without. When stratified by gender the relative risk of major amputation associated with diabetes was higher for women (10.0 [9.6–9.5]) than men (7.5 [7.3–7.7]). For minor amputations the risk of incident amputation with diabetes was 11.9-fold higher [11.8 –1.01] than without diabetes. When stratified by gender the relative risk of minor amputation in the diabetes population was higher for men (14.8 [14.6 –15.0]).

The non-diabetes population underwent fewer incident amputations and the rate of incident major (0.8 [0.7- 0.8]/10 000 PY) and minor (0.8 [0.7–0.8]/10 000 PY) amputation was the same. Again, the rate of amputations for the whole period was higher for men. There was an increase in the crude number of people undergoing incident amputation over the 11 years but there was no significant change in the age-sex standardised amputation rate for incident amputation. Poisson regression analysis showed no significant decrease in incidence of amputation per year after adjustment for age and sex. Despite no reduction in the total incident major amputation rate, in the gender stratified analysis there was a significant reduction in the rate of major amputations in men without diabetes from 0.9 [0.8 –1.1]/ 10 000 PY in 2008 to 0.7 [0.6–0.8]/ 10 000 population years in 2018. A 22.2% relative risk reduction.

The incidence of incident major and minor amputation was significantly higher within the male population. The age standardised rate of any amputation type was 2–3-fold higher amongst men compared to women, in both those with and without diabetes. This was consistent over the period and the overall rate of change did not differ significantly between genders in minor amputation.

Discussion

This national study was the first performed to quantify the incidence of amputation in both the diabetes and non-diabetes populations in Wales. In all populations the crude number of major amputations fell across the period and the minor amputation rates increased although not as prominently in the population without diabetes. Despite the population with diabetes representing only 7% of

Table 1
Number and crude incidence of all incident amputations between 2008 and 2018 in the population with and without diabetes per year.

Population		Year										
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Diabetes	Major number (%)	154 (45.6)	153 (49.4)	152 (49.2)	168 (51.2)	176 (50.6)	146 (48.3)	169 (54.0)	154 (47.4)	170 (50.1)	157 (51.8)	137 (47.2)
	Minor number (%)	198 (55.0)	205 (55.1)	201 (55.5)	196 (58.5)	192 (52.6)	237 (58.5)	236 (59.3)	277 (62.4)	283 (61.1)	221 (59.2)	289 (63.1)
	Person Years (%)	143,595 (5.9)	151,174 (6.2)	159,327 (6.5)	166,820 (6.8)	173,975 (7.0)	180,024 (7.2)	186,599 (7.5)	191,726 (7.6)	197,084 (7.8)	200,167 (7.9)	203,302 (8.0)
	Major Crude incidence*	10.7	10.1	9.5	10.1	10.1	8.1	9.1	8.6	8.6	7.8	6.7
	Minor Crude incidence*	13.8	13.6	12.6	11.7	11	13.2	12.6	14.4	14.4	11	14.2
Non Diabetes	Major number (%)	184 (54.4)	157 (50.6)	157 (50.8)	160 (48.8)	172 (49.4)	156 (51.7)	144 (46.0)	171 (52.6)	169 (49.9)	146 (48.2)	153 (52.8)
	Minor number (%)	162 (45.0)	167 (44.9)	161 (44.5)	139 (41.5)	173 (47.4)	168 (41.5)	162 (40.7)	167 (37.6)	180 (38.9)	152 (40.8)	169 (36.9)
	Person Years (%)	2,283,246 (94.1)	2,291,694 (93.8)	2,296,628 (93.5)	2,303,743 (93.2)	2,306,569 (93.0)	2,309,233 (92.8)	2,314,088 (92.5)	2,316,170 (92.4)	2,324,189 (92.2)	2,331,696 (92.1)	2,339,817 (92.0)
	Major Crude incidence*	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.7	0.6	0.7
	Minor Crude incidence*	0.7	0.7	0.7	0.6	0.8	0.7	0.7	0.7	0.8	0.7	0.7

(%): percentage of total population;.
* : per 10,000 person years of the population at risk.

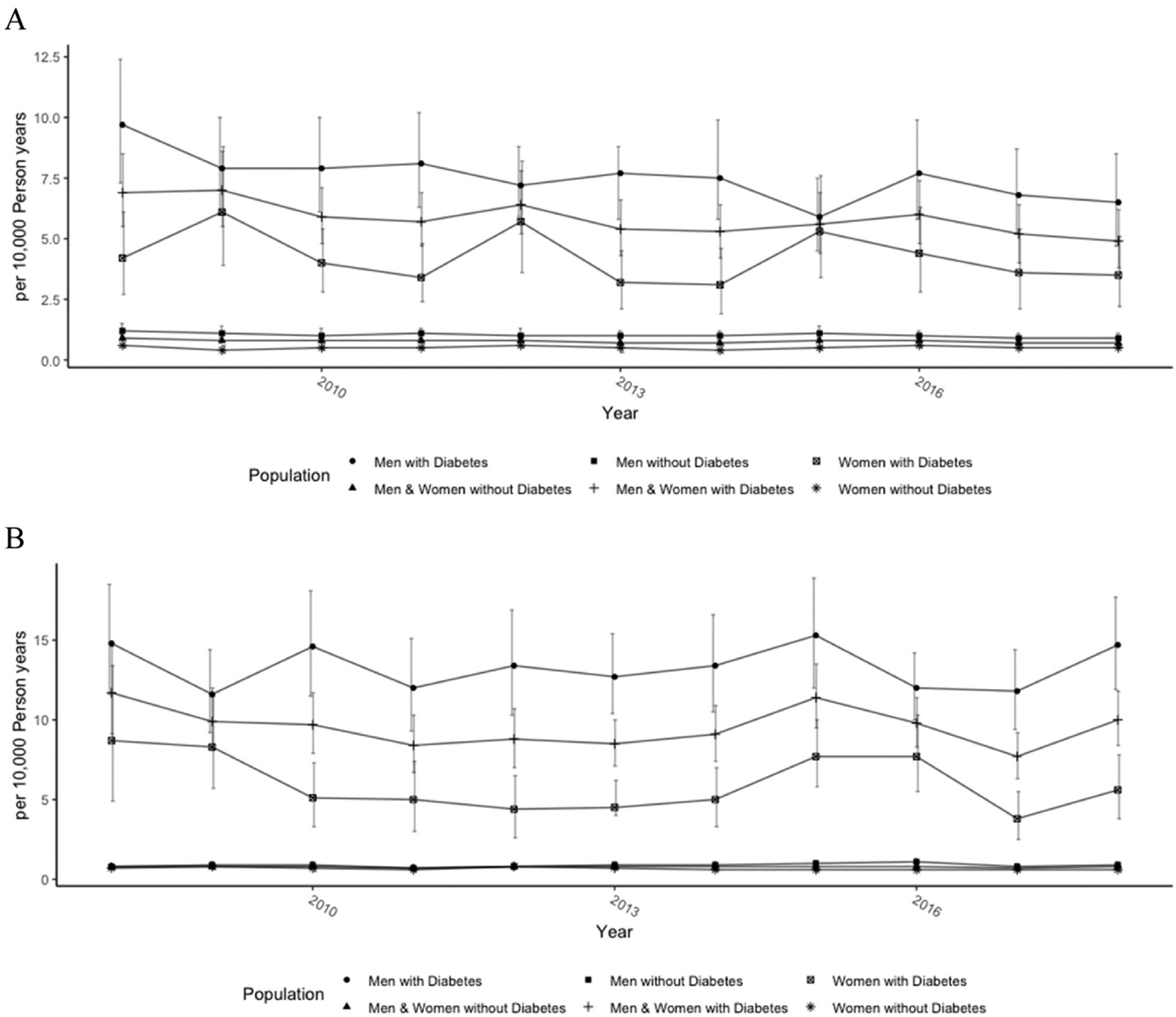

Fig. 1. Time trend of age-sex standardised incident amputation rate of (A) major amputation (B) minor amputation with 95% CI.

the total population, over 50% of the incident amputations performed over the period were on PWD.

As expected, directly standardised amputation rates in the population with diabetes were considerably higher compared to those in the population without diabetes. This was apparent across all amputation types with particularly high standardised rates for minor amputations in men when compared to the non-diabetes population. Despite the introduction of several strategies to reduce amputation rate, the relative risk of any amputation associated with diabetes did not change significantly over the study period. However, when adjusted for age and sex, the incidence of incident major amputations in the male diabetes and non-diabetes population and in the female diabetes population decreased over the period. There was no significant change in incident minor amputation rates for any population when looking at Wales as whole. As expected, amputation risk increased significantly with age, however, age had a much greater effect on risk of amputation in the non-diabetes population. The risk for amputation of any type was higher in men than women.

Comparing the outcomes of this analysis to other published studies examining amputation rates is made difficult by variance in study design. A recent systematic review [23] highlighted the methodological differences in studies examining the epidemiology of lower limb amputations in England. There was variance in amputation definition, numerator type and denominator definition and use of standardisation of rates. If only crude rates are used it is not possible to make comparisons due to differences in population structure. There was variance in the populations used to standardise, resulting in marked variance in major lower extremity amputation prevalence from 3.0 to 76.1/100 000 PY in the whole English population and 0.7 to 332.4/100 000 PY in the diabetes population. This study analysed incident amputation rate primarily, as amputations are not independent events with initial amputation a significant predictor of future amputation [24].

Major lower limb amputations are viewed as an adverse outcome of diabetes and are associated with poor survival rates and reduced quality of life. They are often used as a measure of the quality of foot care services, as an outcome indicator for the comprehensive chain of service from prevention of foot problems to cardiovascular risk management and vascular surgical care. For the whole of Wales, for the rolling period of 2016–2018 in the population with diabetes we found a total major amputation rate of 6.7 [6.0–7.5]/10 000 PY. This was lower than the findings from the PHE analysis of major amputations in England which reported a rate of 8.2/10 000 PY for the period of 2015/16 to 2017/18 [8], with no reported change in the rate of incident major amputation over the period of 2013/2014 to 2017/2018 in the population with diabetes. The reduction in age and sex

Table 2
Incident rate ratios (IRR) of incident lower- extremity amputation per year adjusted for age, sex and presence of diabetes.

Independent Variable	Total	Total		Total		Men		Women	
		Men	Women	Diabetes	No Diabetes	Diabetes	No Diabetes	Diabetes	No Diabetes
	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]	IRR [95% CI]
Major amputation									
Year[a]	0.97 [0.95–0.99]*	0.97 [0.95–0.99]*	0.97 [0.95–1.00]	0.96 [0.95–0.97]*	0.98 [0.97–1.00]	0.96 [0.95–0.98]*	0.98 [0.96–0.99]*	0.95 [0.93–0.98]*	0.99 [0.97–1.01]
Diabetes(Y vs N)	6.51 [5.73–7.41]*	6.55 [5.59–7.68]*	6.43 [5.19–7.96]*	–	–	–	–	–	–
Gender (M vs W)	2.19 [1.94–2.46]*	–	–	2.01 [1.83–2.22]*	2.35 [2.15–2.58]*	–	–	–	–
Age (years)[b]									
45–64	4.3 [3.54–5.24]*	4.55 [3.61–5.75]*	3.72 [2.59–5.36]*	3.32 [2.45–4.48]*	3.23 [2.76–3.77]*	3.98 [2.96–5.35]*	3.41 [2.84–4.09]*	2.44 [1.41–4.21]*	2.83 [2.10–3.81]*
65–74	7.55 [6.39–9.93]*	7.45 [6.13–9.06]*	7.81 [5.68–10.74]*	3.66 [2.70–4.95]*	8.41 [7.16–9.88]*	4.36 [3.23–5.89]*	8.13 [6.75–9.78]*	2.75 [1.61–4.69]*	9.00 [6.48–12.48]*
74–85	11.13 [9.12–13.59]*	11.04 [8.62–14.14]*	11.3 [8.02–15.91]*	4.22 [3.10–5.74]*	17.11 [14.55–20.1]*	5.12 [3.77–6.94]*	17.02 [14.01–20.68]*	3.02 [1.74–5.24]*	17.31 [12.71–23.56]*
85+	13.33 [10.28–17.27]*	12.93 [9.34–17.92]*	13.71 [8.89–21.17]*	3.68 [2.60–5.21]*	25.96 [21.4–31.46]*	4.87 [3.32–7.12]*	24.28 [19.33–30.48]*	2.32 [1.33–4.06]*	27.93 [19.76–39.48]*
Minor amputation									
Year[a]	1.00 [0.98–1.02]	1.01 [0.98–1.03]	0.98 [0.96–1.01]	1.00 [0.99–1.02]	1.00 [0.98–1.01]	1.01 [0.99–1.02]	1.01 [0.98–1.03]	0.99 [0.96–1.02]	0.98 [0.96–1.00]
Diabetes(Y vs N)	10.15 [8.63–1.19]*	13.3 [10.89–16.24]*	6.28 [4.96–7.94]*	–	–	–	–	–	–
Gender (M vs W)	1.91 [1.67–2.19]*			2.40 [2.14–2.69]*	1.49 [1.35–1.65]*	–	–	–	–
Age (years)[b]									
45–64	4.08 [3.16–5.28]*	3.67 [2.70–4.99]*	4.54 [3.12–6.62]*	1.99 [1.60–2.47]*	3.39 [2.82–4.07]*	2.03 [1.56–2.63]*	3.02 [2.37–3.85]*	1.91 [1.30–2.79]*	4.18 [3.40–5.16]*
65–74	5.91 [4.67–7.49]*	4.77 [3.57–6.36]*	8.23 [5.85–11.58]*	1.80 [1.46–2.22]*	9.49 [7.90–11.40]*	1.88 [1.45–2.44]*	7.78 [6.30–9.61]*	1.58 [1.11–2.26]	12.97 [1.01–1.67]*
74–85	8.03 [6.16–10.48]*	6.08 [4.35–8.51]*	12.6 [8.80–18.05]*	2.06 [1.66–2.57]*	18.04 [15.1–21.49]*	2.08 [1.59–2.72]*	14.84 [11.92–18.48]*	2.02 [1.41–2.89]*	24.24 [19.54–30.07]*
85+	8.98 [6.55–12.3]*	7.32 [4.78–11.21]*	12.49 [8.27–18.87]*	1.81 [1.43–2.30]*	25.34 [20.4–31.46]*	1.95 [1.47–2.59]*	25.76 [18.94–35.03]*	1.56 [1.05–2.31]	28.32 [21.92–36.58]*

[a] IRR per 1 year increment.
[b] Reference category 17–44 years.
* statistically significant $p<0.05$. IRR- Incidence Rate Ratio.

standardised major amputation rate in the male and female population with diabetes in Wales could be seen as a positive indicator of improvement in services within Wales. It is suggestive that national campaigns such as the introduction of markers in quality and outcomes framework (QOF), annual audits and campaigns such as 'Putting Feet First' are having an effect in Wales. This, however, was not reflected in the findings in the non-diabetes population and when stratified by gender, specifically the female population.

Women make up a greater proportion of the elderly population of Wales but even after age standardisation, the rate of risk reduction was not equal. Women have been found to have a higher rate of asymptomatic PVD [25]. This can result in delayed diagnosis and missed opportunities for revascularisation, with women more likely to present with critical limb ischaemia. This study did not explore differences in revascularisation rates over the period. This may explain the variance between genders and could be a contributing factor to the reduction in major amputation rates [7].

In our study, relative risk of major amputation associated with diabetes was higher than that reported in the PHE analysis at 8.0 [7.9−8.1] over the period. In the literature the relative risk of amputation associated with diabetes for England has been reported as ranging between 7.4 and 41.3 [23]. The variation may be explained by differences in study design and definitions used, making comparison difficult. Despite this, rates of amputation are still considerably higher within the diabetes population and with the consensus that most major amputations in PWD are preventable, the slow decline in incident amputation rate in this population is disappointing.

A strength of this study was the use of the SAIL databank to identify people with diabetes as it was possible to use primary, secondary and prescription data in the classification. In many studies from England an ICD-10 code at time of amputation were used to identify diagnosis of diabetes, or one data source or whole population QOF data was used, which meant age and sex specific rates of diabetes had to be stratified. This could lead to an underestimation of the denominator and an inflated crude and standardised amputation rate in the diabetes population. The use of an accurate algorithm for diagnosis of diabetes with an adequate lookback period could explain the lower major and minor amputation rates. Further investigation is required to explore disparities in rates of change between the genders and if there is variance in the regions of Wales as reported in the other countries of the UK.

There are limitations to this study. An increased incidence of diabetes may explain some of the reduction in amputation incidence rate, as major amputation is an end-stage process and an increase in the number of newly diagnosed, relatively healthy people within the denominator may mean the rates do not reflect a true reduction in amputation rate. The use of the whole Welsh population for standardisation partially protects against bias caused by a rapidly increasing population with diabetes [26]. Individuals with a missing WOB were not used in the study as it was not possible to verify records within SAIL; although the number was small it may be possible that some amputations were not included. There was also variance in the coverage of each dataset. The databanks within SAIL that were utilised in the study included 100% of the population of Wales from 1999 apart from the WLGP database which has 80% coverage. The WLGP data was used for the identification of patients with diabetes in combination with PEDW data. This may have made the classification of diabetes less accurate in a cohort of patients in the study, however, the numbers of persons with diabetes were within 5% of the published population data from Diabetes UK.

No adjustment was made for history of cardiovascular or cerebrovascular disease or rates of prior peripheral vascular disease or endovascular intervention, well known risk factors for lower extremity amputation. However, there has been no significant change in the rate of CVD over the period suggesting this would not influence the time trend for lower extremity amputation [27].

In summary, the present study is the largest study of lower limb amputation rates and corresponding time trends within the population with and without diabetes and is the first nationwide study of amputation rates in the Welsh population over any time. The amputation rate within the population with diabetes remained higher over the whole study period however, promisingly, we did identify some reduction in the rate of major amputation for this population. As national programmes directed at reducing amputation rates continue, the need for ongoing monitoring of amputation rates is integral.

Data availability statement

The data used in this study are available in the SAIL Databank at Swansea University, Swansea, UK, but as restrictions apply, they are not publicly available. All proposals to use SAIL data are subject to review by an independent Information Governance Review Panel (IGRP). Before any data can be accessed, approval must be given by the IGRP. The IGRP gives careful consideration to each project to ensure proper and appropriate use of SAIL data. When access has been granted, it is gained through a privacy protecting safe haven and remote access system referred to as the SAIL Gateway. SAIL has established an application process to be followed by anyone who would like to access data via SAIL at https://www.saildatabank.com/application-process.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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This study makes use of anonymised data held in the SAIL databank, which is part of the national e-health records research infrastructure for Wales. We would like to acknowledge all the data providers who make anonymised data available for research.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.deman.2023.100144.

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