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The cost of diabetic foot ulcers and amputations to the National Health Service in England

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Abstract

Aim To estimate the healthcare costs of diabetic foot disease in England.

Methods Patient-level data sets at a national and local level, and evidence from clinical studies, were used to estimate the annual cost of health care for foot ulceration and amputation in people with diabetes in England in 2014–2015.

Results The cost of health care for ulceration and amputation in diabetes in 2014–2015 is estimated at between £837 million and £962 million; 0.8% to 0.9% of the National Health Service (NHS) budget for England. More than 90% of expenditure was related to ulceration, and 60% was for care in community, outpatient and primary settings. For inpatients, multiple regression analysis suggested that ulceration was associated with a length of stay 8.04 days longer (95% confidence interval 7.65 to 8.42) than that for diabetes admissions without ulceration.

Conclusions Diabetic foot care accounts for a substantial proportion of healthcare expenditure in England, more than the combined cost of breast, prostate and lung cancers. Much of this expenditure arises through prolonged and severe ulceration. If the NHS were to reduce the prevalence of diabetic foot ulcers in England by one-third, the gross annual saving would be more than £250 million. Diabetic foot ulceration is a large and growing problem globally, and it is likely that there is potential to improve outcomes and reduce expenditure in many countries.

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Introduction

Ulceration and amputation are relatively common complications of diabetes, and exact a high human and financial cost. They attract less public concern, research effort, and political and clinical attention than other conditions with similar impacts on quality of life and survival. It is estimated that at least 2% of people with diabetes in England experience at least one new diabetic foot ulcer each year [1]; around 58 000 people in 2014–2015. Many ulcers persist for months; some never heal, and some lead to amputation. In England, there are at least 7000 lower limb amputations in people with diabetes annually [2]. Five-year mortality after first major amputation has been estimated at 68% to 79% [3,4], comparable with that for people with diabetes starting renal replacement therapy (68%) [5] or after a first stroke (44%) [6]. Five-year mortality after diabetic foot ulcer has been estimated at 40% [7] and the hazard ratio for death after ulceration at 2.48, after adjustment for other risks. [8].

Early access to specialist care can reduce ulcer duration, and improve healing and lower amputation rates [9–11]. In England, national guidelines specify that all areas should have a foot protection service and a multidisciplinary foot service, and that all those with active foot problems should receive early expert assessment [12]. Some areas of England have systematically improved services and reported significantly improved outcomes [13] but the incidence of major amputation varies sevenfold across the country, after adjustment for age and ethnicity [14]. The National Diabetes Foot Care Audit (NDFA) of England and Wales indicates substantial geographic variation in service provision, and that delays in assessment are associated with increased ulcer severity and longer ulcer duration. The proportion of ulcers healed at 24 weeks after expert assessment varies by 40% across providers [15].

There is increasing awareness of the importance of robust cost data to inform decisions on the allocation of healthcare

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What's new?

- At least 2% of people with diabetes experience new foot ulcers annually, and one in 400 undergoes amputation.
- The cost of diabetic foot disease in England is almost 1% of the health service budget.
- More than 90% of these costs are for ulcer care.
- It is hoped that knowledge of human and financial costs will increase research effort, clinical attention and compliance with national guidance, to improve ulcer healing rates and reduce amputations.

budgets. However, national data to support population-level expenditure estimates are rarely available. The existence of a national health service in England, and of consistent national data sets covering large areas of care, supports estimation of aggregate costs for some aspects of care. However, much diabetic foot care is provided in community settings such as podiatry and district nursing, where patient-level and diagnosis-specific data are generally not available. The absence of routine data in this area, and the resulting ignorance of resource use and costs, arguably contributes to the relative neglect of this serious and common complication of diabetes. In this article, we seek to address this problem, using national patient-level data sets to estimate inpatient activity and costs, and supplementing these with local and study data for activity in other settings.

We previously published estimates of the cost of diabetic foot care in England in 2010–2011 [16]. Since then, diabetes prevalence has increased, foot care services have changed in many parts of the country and the NDFA has greatly increased our understanding of ulcer care delivery and outcomes. We have also gained access to improved data for aspects of care not included in national data sets. In this article, we provide new estimates of the direct clinical cost of diabetic foot ulcers from the perspective of the National Health Service (NHS) in England.

Methods

A prevalence-based, attributable cost of illness study was undertaken to estimate the cost to the NHS in England of diabetic foot disease in 2014–2015. Annual activity levels and costs were estimated for inpatient care for ulceration and amputation, community, outpatient and primary care for ulceration, and prosthetic, physiotherapy and wheelchair provision after amputation.

Hospital Episode Statistics (HES) for England were used to identify relevant inpatient activity, and the cost of this activity was estimated using national NHS tariffs and Reference Costs. In other areas, activity was estimated using data from individual hospitals. Clinic attendance, imaging and wheelchair costs were taken from NHS Reference Costs [17], costs for professional time for dressing changes from Personal Social Services Research Unit (PSSRU) unit costs of health and social care [18], and medication costs from the British National Formulary [19]. All costs are expressed in 2014–2015 UK pounds. Inflation adjustments were made using the PSSRU Hospital and Community Health Services Pay and Prices Index [18]. Cost sources are summarized in Table 1.

Inpatient care

HES data for 2014–2015, supplied by NHS Digital, were searched to identify all admissions in England with a diabetes diagnosis code (International Classification of Diseases-10 codes E10–14) and diagnosis or procedure codes related to foot disease or amputation. Trauma-related amputations were excluded.

Most inpatient admissions in the NHS in England are reimbursed using national tariffs assigned to Healthcare Resource Groups (HRGs). An HRG is a grouping of clinically similar treatments that are also considered similar in cost. Clinical advisers identified the HRGs likely to identify admissions specific to ulceration (if the admission included a foot ulcer-specific diagnosis or procedure code). For admissions grouped to these HRGs, and for all amputation admissions, the cost of the admission was estimated using national tariffs [20]. Further details are given in Tables S1–S4.

People with diabetes who are admitted to hospital for treatment unrelated to the foot often also have foot ulcers, and these admissions will generally be grouped to HRGs unrelated to foot care. For these admissions, costs were estimated only for excess length of stay, relative to diabetes admissions without foot disease. Extended estimating equation (EEE) multiple regression was used to estimate the association between foot disease and length of stay in these admissions, adjusting for age, gender, admission method (elective or emergency) and specialty type (surgical or non-surgical) [21]. Analysis was performed in Stata 14.1. The unit cost of an inpatient day for a person with diabetic foot disease was estimated at £376, based on the weighted mean cost of an inpatient day in HRGs KB03A-B (Diabetes with Lower Limb Complications) in NHS Reference Costs [22].

Community, outpatient and primary care for ulceration

Local data were used to estimate the weekly costs of care in community, outpatient and primary settings, and the outputs were combined with estimates of diabetic foot ulcer prevalence to estimate annual costs.

Studies suggest that resource use is related to ulcer severity [15,23,24]. Costs were therefore estimated for two subgroups, A and B. Group A was defined as people who have ulcers with no infection or relatively mild infection, and who

Table 1 Resource use and unit cost sources

		Resource use	Unit costs
Inpatient care	Foot ulcer- or amputation-specific admissions	Hospital Episode Statistics 2014–2015	National tariffs [20]
	Excess bed days in other admissions	Regression analysis	NHS Reference Costs [17]
Community, outpatient and primary care	Clinic attendances	Group A, Jeffcoate *et al.* [25]; Group B. LNWUH	NHS Reference Costs [17]
	Professional time for dressing changes		PSSRU [18]
	Prescribing		BNF [19]
	Offloading		LNWUH
Post-amputation care	Physiotherapy	RNOH	NHS Reference Costs [17]
	Prosthetic provision and care	RNOH	RNOH
	Wheelchairs	Based on assumption that 50% of patients undergoing major or minor amputation receive wheelchairs	NHS Reference Costs [17]
	NHS transport	Based on assumption that NHS transport provided for 50% of physiotherapy attendances	NHS Reference Costs 2010–2011 (as transport costs were not provided in 2014–2015), inflation adjusted [22].

BNF, British National Formulary; LNWUH, London North West University Healthcare NHS Trust, NHS, National Health Service; PSSRU, Personal Social Services Research Unit; RNOH, Royal National Orthopaedic Hospital NHS Trust.

do not have peripheral arterial disease or osteomyelitis. This was taken to be equivalent to a SINBAD (site, ischaemia, neuropathy, bacterial infection, area and depth) score of ≤ 2 [24]. Group B have ulceration with a SINBAD score of ≥ 3.

The mean weekly cost of ulcer care for people in Group A was estimated using data gathered from nine UK foot clinics participating in a prospective randomized controlled trial of dressing preparations [25]. People with ulcers extending to the tendon, periosteum or bone, or with osteomyelitis at recruitment, were excluded. Patient diaries and clinic records provided details of professional time, prescribing, off-loading and dressings. For this study, we calculated costs for professional time for dressing changes, prescribing and off-loading, using the original resource use data, and 2014–2015 costs. For clinic attendances the original cost estimates, taken from NHS Reference Costs, were updated for inflation.

Weekly costs for people in Group B were estimated from data supplied by London North West University Healthcare NHS Trust, which also provided data on resource use for all people presenting with diabetes and ulcers with a SINBAD score ≥ 3 between 1 April 2014 and 31 March 2015. People with Charcot foot were excluded. Individuals were followed to the end of treatment or for 12 months, whichever came first. Patient records were examined retrospectively to provide data on clinic attendances, prescribing, imaging, orthotics, casts, domiciliary rehabilitation, NHS transport and treatment duration. Mean weekly costs for these elements of care were estimated for each person. Marginal weekly district nurse resource use for dressing changes was estimated for a subgroup. The trust reviewed foot clinic expenditure on dressings and other consumables over a 3-month period, estimated mean weekly expenditure, and used the proportion of clinic attendances that were for diabetes and ulcers with SINBAD score ≥ 3 (83%) to apportion costs to this group (Table 2).

There is uncertainty regarding diabetic foot ulcer prevalence in England; there is no national diabetic foot ulcer register. National audits in Scotland in 2010 and 2015 have indicated that between 2% and 2.5% of the diabetes population has active foot ulceration at any given time ([26] and GP Leese, personal communication). We have used these estimates here as a proxy for prevalence in England.

Table 2 Group B estimated unit costs

Resource use	Estimated unit cost
Non-consultant-led clinic attendance (including nurse or podiatrist visits)	First attendance £154; Follow-up attendance £116
Consultant-led clinic attendance	First attendance £253; Follow-up attendance £178
MRI	£138
Nuclear bone scan	£206
Angiogram	£374
Prescribing	Drug- and quantity-specific
District nurse visits	£25 for 20 min
Domiciliary rehabilitation	£29 for 30 min
NHS Transport	£13
Orthotics	Device-specific
Dressings and other consumables per patient per week	£3

MRI, magnetic resonance imaging.

The number of people with diabetic foot ulcers in any given week was estimated by applying these point prevalence estimates to the number of patients on the national general practice diabetes register for England in 2014–2015 [27].

The NDFA reported that, of 22 000 ulcer episodes in England and Wales in 2014–2017, 46% had a SINBAD score ≥ 3 at first expert assessment [15]. In our base case analysis, we assume that 46% of those with active prevalent diabetic foot ulcers have a SINBAD score ≥ 3.

Post-amputation care

Costs were estimated for prosthetics, physiotherapy and wheelchair provision after amputation. Based on data from the United National Institute for Prosthetics and Orthotics Development [28] and the National Diabetes Audit [29], we estimated that 29% of people with diabetes who undergo major amputation are referred to prosthetic services. Further details are given in (Table S5).

The Royal National Orthopaedic Hospital NHS Trust in London provided unit costs for prosthesis provision and associated care, and details of the mean number of physiotherapy sessions after major and minor amputation. It was assumed that NHS transport is provided for 50% of physiotherapy sessions and that wheelchairs are provided for 50% of people who undergo amputation.

Sensitivity analyses

One-way deterministic sensitivity analyses were undertaken to estimate the impact of uncertainty on cost estimates. The proportion of prevalent ulcers that are severe may be higher than our estimate, which is taken from NDFA. The NDFA records ulcer severity at first expert assessment. It is known that mean time to healing is longer for severe ulcers, and the risk of non-healing increases with ulcer severity. In sensitivity analysis we model the cost impact if 50% and 60%, respectively, of prevalent ulcers are severe.

There is also substantial variation in individual-level costs for severe ulcer care. We model the impact on total costs if mean per person costs for Group B were at the upper and lower bounds, respectively, of the 95% confidence intervals (CI). We also model the impact on total costs if Group A costs were 20% above and below our base case estimate. For inpatient care, we model the impact on costs of counting only excess bed day costs (based on our regression results) for all ulcer admissions. We also model the impact of ulcer prevalence of 3% in the diabetes population.

Results

Inpatient care

HES recorded 96 492 admissions with diabetes and foot ulcer or amputation codes in 2014–2015; 6.3% of all admissions with a diabetes diagnosis code. Of these, 7407 included codes for amputation or procedures on amputation stumps, and 89 085 included ulceration codes without amputation. The tariff price of admissions involving non-traumatic amputation or procedures on amputation stumps in diabetes was £43.80 million. Of admissions with diabetes and foot disease without amputation, 38 290 were grouped to HRGs related to foot care. The tariff price of these admissions was £125.48 million.

Of the 50 795 admissions with diabetes and ulceration grouped to HRGs unrelated to foot care, 2652 were elective day cases, which were excluded from the analysis. The mean (95% CI) length of stay for admissions with ulcers grouped to non-ulcer-specific HRGs was 16.58 (16.54–16.62) days, compared with 7.46 (7.45–7.46) days in diabetes admissions without ulceration. The results of the EEE regression analysis suggest that ulceration was associated with a length of stay that was 8.04 days longer (95% CI 7.65 to 8.42) relative to that for people with diabetes and no ulceration (Table 3). The cost of excess bed days for people with foot disease in admissions grouped to non-foot-care HRGs is estimated at £145.45 million. The total cost of inpatient care is estimated at £314.73 million (Table 4).

Community, outpatient and primary care for ulceration

For Group A, data were provided for 317 individuals for up to 24 weeks of care. Adjusting for healing and withdrawals, mean treatment duration during the study period was estimated at 14.26 weeks. Mean costs per week of treatment were estimated at £68.45 for dressings, professional time and medications, and £10.69 for off-loading.

Table 3 Extended estimating equation regression results summary

Variable	Estimated incremental effect on length of stay (days)	Lower confidence interval (95%)	Upper confidence interval (95%)	*P*-value
Foot ulcer	8.04	7.65	8.42	< 0.001
Emergency admission	1.59	1.45	1.73	< 0.001
Year of age	0.11	0.10	0.12	< 0.001
Male	0.44	0.38	0.50	< 0.001
Surgical admission	0.85	0.76	0.95	< 0.001

For Group B, data from London North West University Healthcare NHS Trust indicate that, between 1 April 2014 and 31 March 2015, 66 people presented with diabetes and ulcers with a SINBAD score ≥ 3. One person was excluded because care was shared with another trust, and no data were available for care at the other trust. For the 65 remaining people, mean treatment duration was 34.38 weeks (95% CI 29.63 to 39.14). The mean cost per patient-week of treatment for clinic attendances, podiatry, prescribing, imaging, hospital outreach, NHS transport and orthotics was £234.73 (95% CI 195.23–274.22). The estimated mean number of ulcer-related district nurse visits per week of treatment was 1.48 (95% CI 0.71 to 2.24) and the estimated mean weekly cost was £28.52 (95% CI 13.72–43.32). The apportioned cost of dressings and other consumables was £2.71 per patient-week. The total annual cost of community, outpatient and primary care for ulceration is estimated at between £501.48 million and £626.84 million (Table 5).

Post-amputation care

The Royal National Orthopaedic Hospital NHS Trust estimated in 2010 that the mean annual cost of prosthesis provision and care was £2802 per person treated (£2968 in 2014–2015 prices). Annual expenditure on prosthesis services after diabetes-related amputation is estimated at £11.00 million. Estimated expenditure on physiotherapy, including NHS transport, is £6.30 million. The cost of wheelchair provision is estimated at £3.51 million.

Total expenditure on healthcare related to foot ulceration and amputation in diabetes in 2014–2015 in England is estimated at between £837.01 million and £962.38 million (Fig. 1). This is equivalent to 0.78%–0.90% of current NHS spending in England in 2014–2015 [30]. Further detail is given in Tables S2–S5.

Table 4 Estimated cost of inpatient care for ulceration and amputation, England 2014–2015

	Admissions	Annual cost (£)
Major amputations	3016	24 772 523
Minor amputations	4015	16 910 258
Procedures on stumps	376	2 114 851
Foot ulcers		
Grouped to ulcer-specific HRGs	38 290	125 479 594
Grouped to other HRGs	50 795*	145 448 882
Total	96 492	314 726 108

*Costs are counted for 48 143 admissions.
HRG, Healthcare Resource Group.

Table 5 Estimated cost of community, outpatient and primary care for ulceration, England 2014–15

	Estimated patients in any given week	Weekly cost per patient (£)	Annual cost (£)
Group A			
SINBAD score ≤ 2	31 332–39 165	79.14	128 935 174–161 168 968
Group B			
SINBAD score ≥3	26 939–33 673	265.95	372 539 535–465 674 419
Total	58 271–72 838		501 474 709–626 843 387

SINBAD, Site, ischaemia, neuropathy, bacterial infection, area and depth. Numbers are rounded.

Sensitivity analyses

Sensitivity analysis results are shown in Table 6.

Limitations

In addition to the healthcare costs considered here, there are indirect costs to individuals and society, including loss of income and associated tax and welfare impacts. It is a limitation of this study that we have been unable to estimate these costs. Further research is needed to estimate the non-healthcare costs of diabetic foot disease.

Our cost estimates for less severe ulcers are based on data from a study of dressing preparations. Although it is recognized that trial data often do not reflect routine care, in this instance the study states that the frequency of clinic

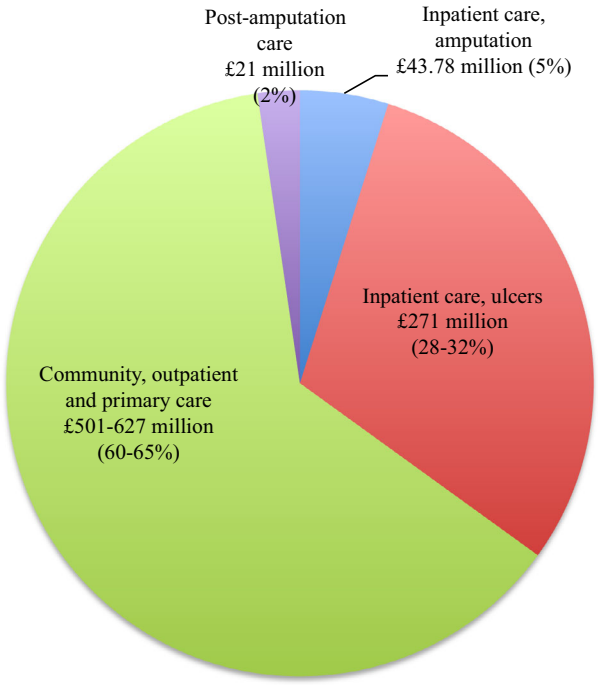

FIGURE 1 Total estimated healthcare expenditure on diabetic foot disease, England, 2014–2015.

Table 6 Sensitivity analysis results

Sensitivity analysis		Estimated impact on total costs
Sensitivity analysis 1	Proportion of severe ulcers = 50%	Increase by 2.55% to 2.77%
	Proportion of severe ulcers = 60%	Increase by 9.31% to 10.12%
Sensitivity analysis 2	Mean weekly cost for Group A reduced (increased) by 20%	Reduce (increase) by 3.08% to 3.35%
Sensitivity analysis 3	Mean weekly cost of clinic attendances, podiatry, prescribing, imaging, hospital outreach, NHS transport and orthotics for Group B = £195.23 (£274.22)	Reduce (increase) by 6.61% to 7.19%
Sensitivity analysis 4	Mean weekly district nurse cost for Group B = £13.72 (£43.32)	Reduce (increase) by 2.48% to 2.69%
Sensitivity analysis 5	Only excess bed day costs estimated for all ulcer admissions	Reduce by 1.02% to 1.17%
Sensitivity analysis 6	Ulcer prevalence = 3% of diagnosed diabetes population	Increase by 14.98% to 26.05%

visits was not affected by the trial, and that dressings were changed by the person with the foot ulcer, carers or nurses, according to usual procedure. Dressings, which were the focus of the study, account for ~ 2% of weekly costs.

In common with many economic studies, we have in some instances used prices as a proxy for cost (e.g. for inpatient care and pharmaceuticals). Prices do not always accurately reflect economic costs. Sensitivity analyses in this paper are deterministic and univariate. We do not examine the impact of simultaneous variation of input parameters.

Discussion

Our study indicates that, in addition to very high human costs, diabetic foot disease places a heavy financial burden on the healthcare system in England. The lower bound of our cost estimates is higher than combined NHS expenditure in England on breast, prostate and lung cancers. [31].

We previously estimated the cost of diabetic foot disease in England in 2010–2011 at £580 million, or 0.6% of the NHS budget (£602 million in 2014–2015 prices) [16]. Guest *et al.* estimated expenditure on 2012–2013 foot care in the UK at between £525 million and £728 million (£530–735 million in 2014–2015 prices) [32]. Caution should be exercised in comparing estimates across studies owing to differences in methodology. The estimates of Guest *et al.* were derived from general practitioner records for a sample of people with diabetes, whereas our study uses a whole population approach to inpatient care, examining national admission-level data for all ulcer and amputation admissions in diabetes, supplemented with local data for other care. We have obtained more detailed cost data on severe ulcer care since our previous study.

Even if exact comparison across studies is not possible, it appears that the cost of diabetic foot care, in absolute terms and as a proportion of healthcare spending, has increased substantially in recent years. Owing to increased diabetes prevalence, the number of diabetes-related amputations in England increased by 16% between 2009–2012 and 2012–2015, even as rates per 10 000 people with diabetes were reduced [2].

Recent systematic reviews point to high and increasing costs for diabetic foot disease in many countries, though the levels of cost vary considerably [33,34]. These differences are likely to arise not only from study and population heterogeneity, but also from variation in patterns of care and cost structures.

Our study estimates that 90% of diabetic foot care costs in England are related to ulcers. Although amputation unit costs are large, the much greater incidence of ulceration leads to higher aggregate costs. If the NHS were to reduce the prevalence of diabetic foot ulcers in England by one-third, the gross annual saving would be more than £250 million. Simultaneously reducing the proportion of severe ulcers would reduce costs still further.

For much ulcer care, such as district nursing and community podiatry, there are no patient-level data sets in England, and block contracts are used for funding. Thus, commissioners often do not know how resources are used.

It is hoped that in the future new integrated data sets providing details of patient-level resource use across care settings will support further analysis of diabetic foot disease care processes, outcomes and costs.

The existence of national data sets in the UK, and of a universal healthcare system, supports analysis of this kind. Although care structures and unit costs will vary from country to country, it is likely that as diabetes prevalence and risk factors for foot disease increase globally, so too do the costs of diabetic foot disease. It is hoped that by illuminating the hidden costs of foot care, and of ulcers in particular, this article will support decision-making on diabetic foot care, not only in England, but also more widely.

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Competing interests

None declared.

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Author contributions

All authors made substantial contributions to conception and design, revised the article critically for important intellectual content, and gave final approval to the version to be published. In addition, M.K. drafted and revised the article, and acquired, analysed and interpreted data. E.B., T.E., W.M.K., G.T. and M.S.S. made substantial contributions to acquisition of data, and analysis and interpretation of data. T.E. conducted the regression analysis.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Codes for identification of inpatient admissions related to ulceration or amputation in diabetes.
Table S2. Major amputation admissions and tariff expenditure, 2014–2015, by Healthcare Resource Group, England.
Table S3. Minor amputation admissions and tariff expenditure, 2014–2015, by Healthcare Resource Group, England.
Table S4. Foot ulcer-related Healthcare Resource Groups, admissions for people with diabetes and tariff expenditure, England 2014–2015.
Table S5. Estimated lifetime cost of post-amputation care for a 1-year cohort.