DIABETICMedicine

DOI: 10.1111/j.1464-5491.2012.03698.x

Article: Health Economics

Estimating the current and future costs of Type 1 and Type 2 diabetes in the UK, including direct health costs and indirect societal and productivity costs

N. Hex, C. Bartlett, D. Wright, M. Taylor and D. Varley

York Health Economics Consortium Ltd, University of York, York, UK

Accepted 25 April 2012

Abstract

Aims To estimate the current and future economic burdens of Type 1 and Type 2 diabetes in the UK.

Methods A top-down approach was used to estimate costs for 2010/2011 from aggregated data sets and literature. Prevalence and population data were used to project costs for 2035/2036. Direct health costs were estimated from data on diagnosis, lifestyle interventions, ongoing treatment and management, and complications. Indirect costs were estimated from data on mortality, sickness, presenteeism (potential loss of productivity among people who remain in work) and informal care.

Results Diabetes cost approximately £23.7bn in the UK in 2010/2011: £9.8bn in direct costs (£1bn for Type 1 diabetes and £8.8bn for Type 2 diabetes) and £13.9bn in indirect costs (£0.9bn and £13bn). In real terms, the 2035/2036 cost is estimated at £39.8bn: £16.9bn in direct costs (£1.8bn for Type 1 diabetes and £15.1bn for Type 2 diabetes) and £22.9bn in indirect costs (£2.4bn and £20.5bn). Sensitivity analysis applied to the direct costs produced a range of costs: between £7.9bn and £11.7bn in 2010/2011 and between £13.8bn and £20bn in 2035/2036. Diabetes currently accounts for approximately 10% of the total health resource expenditure and is projected to account for around 17% in 2035/2036.

Conclusions Type 1 and Type 2 diabetes are prominent diseases in the UK and are a significant economic burden. Data differentiating between the costs of Type 1 and Type 2 diabetes are sparse. Complications related to the diseases account for a substantial proportion of the direct health costs. As prevalence increases, the cost of treating complications will grow if current care regimes are maintained.

Diabet. Med. 29, 855–862 (2012)

Keywords diabetes, economics, epidemiology, prevalence, treatment

Introduction

Diabetes mellitus is amongst the most common chronic illnesses in the UK. Its prevalence is increasing and it has significant economic importance. As well as the direct costs of treating the illness and its associated complications, diabetes also has a number of indirect social and productivity costs, including those related to increased mortality and morbidity and the need for informal care. Diabetes UK reports that one in 10 people admitted to hospital have diabetes and approximately 15% of deaths per year are caused by diabetes.

Correspondence to: Nick Hex, Project Director, York Health Economics Consortium Ltd, Market Square, University of York, York YO10 5NH, UK.
E-mail: nick.hex@york.ac.uk

There are two primary forms of diabetes, which are more often than not implicitly grouped together, but the causes and costs of which are different. Type 1 diabetes is an autoimmune disease that affects 10–15% of those with diabetes [1]. It is caused by an absence of insulin produced in the body, with onset mostly before the age of 30 years, the exact cause being unknown. Type 2 diabetes affects 85–90% of those with diabetes and is caused by the body not effectively using the insulin it produces because its cells are resistant to the action of the insulin [1]. It is often caused by obesity, age and genetic risk factors, with onset usually after the age of 40 years. These two main subtypes of diabetes mellitus are rarely distinguished in the media and even in some academic studies.

A number of studies have put the broad cost burden of diabetes mellitus to the National Health Service (NHS) at

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

between 5 and 10%, but with no breakdown between Types 1 and 2 [2,3].

The primary method of mapping the economic impact of a disease is burden-of-illness analysis. The aims of this paper are: (1) to quantify the current direct costs to the NHS and indirect costs to society of diabetes mellitus in the UK; (2) to project the future direct and indirect costs of diabetes to the UK; (3) to provide a distinction between Type 1 and Type 2 diabetes in each of these analyses in order that they can be considered separately.

Methods

The study adopted a top-down approach, estimating the cost burdens for Type 1 and Type 2 diabetes from aggregated data sets, utilizing secondary research sources. These were identified through targeted literature searches in MEDLINE, reports from diabetes organizations and UK national statistics.

A comprehensive map of the factors contributing to the direct costs of diabetes was established, including: prevalence, incidence and mortality of those with diabetes; undiagnosed and newly diagnosed people with diabetes; lifestyle interventions; ongoing treatment and management; and secondary and tertiary care consultations for complications. The financial year 2010/2011 was taken as the baseline for estimating these costs.

Prevalence data

Prevalence data were sourced from the Association of Public Health Observatories (APHO) Diabetes Prevalence Model, identifying the prevalence of diabetes in various age groups aged 16 years and over [4]. Prevalence data for children up to 16 years were sourced from a 2009 UK study [5]. Prevalence data were applied to Office for National Statistics (ONS) population data for 2010 to estimate the UK population with diabetes. Prevalence of Type 1 and Type 2 diabetes was estimated on the basis of a split of 15 and 85%, respectively, of the overall population, or a split of 10 and 90%, respectively, for the adult population [6]. The Association of Public Health Observatories has projected diabetes prevalence up to the year 2030. These data were used, along with projected and extrapolated Office for National Statistics population data, to give a projected UK diabetes population estimate for the year 2035 [4]. Data relating to England only were adjusted to the UK level using an appropriate population ratio [7]. Approximately 150 000 people are diagnosed annually with Type 1 or Type 2 diabetes in the UK [8]. Approximately 850 000 people are estimated to have Type 1 or Type 2 diabetes but are undiagnosed; no direct costs were applied to this population [1].

Estimation of treatment costs

Cost data were obtained from either literature or national data sources such as NHS Reference Costs. Where appropriate, historic costs were projected forward to 2010 (base year) using the Hospital and Community Health Services index of inflation [9]. Costs for 2035/2036 were estimated based on the growth in prevalence of diabetes, with the effects of cost inflation over the intervening period being disregarded.

Diabetes treatment costs have been calculated on the basis of Hospital Episode Statistics (HES) data and prevalence data for Type 1 and Type 2 diabetes. The following treatment and intervention costs were estimated: (1) diagnosis testing; (2) primary care consultations; (3) prescribing (drugs, consumables and monitoring devices); (4) non-diabetic prescription drugs prescribed to people with diabetes with a medical exemption certificate; (5) insulin pumps and continuous glucose monitoring equipment; (6) structured education courses (diabetes education, smoking cessation). This is not an exhaustive list and there are other interventions for which costs were not obtained, such as foot care clinics, and the costs of monitoring tests in primary care. Therefore, treatment costs may be understated.

The economic burden associated with diabetes diagnosis was calculated by identifying the costs of screening, testing and primary care. The costs of testing items and the time of clinicians were obtained from the British National Formulary (BNF) and from health and social services unit costs respectively [10.11]. Screening for retinopathy was extracted from the national screening programme [12].

The excess primary care consultation rate for people with diabetes was estimated by subtracting the additional factor for diabetes patients from the national consultation rate [13,14]. This was applied to the costs of general practitioner and clinic consultations, which were apportioned based on NHS Information Centre data on trends in consultation rates [11,13]. Influenza immunization activity was sourced from Quality and Outcomes Framework data and the cost of the vaccine from British National Formulary data [10,11,15].

Prescription costs data for 2010/2011 were obtained for England from the NHS Information Centre and extrapolated for the UK. Each of the four elements of these data (short-acting insulins; intermediate and long-acting insulins; anti-diabetic drugs; diagnostic and monitoring devices, including consumables) was apportioned between Type 1 and Type 2 diabetes based on findings from targeted literature searches [16–19]. The NHS Information Centre was used to source the average cost and total number of non-diabetic prescription items claimed by people with diabetes holding a medical exemption certificate [20]. It was assumed that non-diabetic prescription items were only claimed by people with diabetes using their exemption certificate amongst the working age population, as everyone above and below that age group qualifies for free prescriptions. The cost of insulin pumps was calculated as an average of the range and the lifetime of the pump plus the annual cost of consumables [21,22]. The audit of insulin pumps by the National Diabetes Information Service gave estimates of the percentage of people with Type 1 or Type 2 diabetes who use an insulin pump and this was applied to the respective populations, along with associated education costs [23].

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

The costs of treatment for gestational diabetes were calculated by estimating the prevalence of gestational diabetes in pregnant women at between 2 and 5% [24], the costs for which were estimated by the Scottish Intercollegiate Guidelines Network (SIGN) [25–27].

The costs of education courses were estimated by extracting the number of attendees each year and the cost per course sourced from Dose Adjustment For Normal Eating (DAFNE) (course for Type 1 diabetes) and X-PERT (course for Type 2 diabetes) [28–30]. Smoking cessation activity and cost data were sourced from NHS Stop Smoking services, with the prevalence of smokers on the course with diabetes assumed to mirror that of the general population prevalence. Studies have shown that smoking enhances risk for micro- and macrovascular disease associated with diabetes [31].

Estimation of the costs of diabetes complications

Activity data for the incidence of diabetes-related ischaemic heart disease, myocardial infarction, heart failure and stroke were sourced using 2010/2011 Hospital Episode Statistics, data where diabetes was coded as a primary diagnosis [32]. These data were also used to estimate the number of people receiving ongoing treatment for diabetes-related complications that had developed in previous years. Cost data from National Institute for Health and Clinical Excellence (NICE) guideline CG66, based on the UK Prospective Diabetes Study (UKPDS), were used to estimate the cost burden of these complications [23]. Hospital Episode Statistics data were also used to estimate other diabetes-related episodes of cardiovascular disease, which were costed based on the findings of a burden-of-illness study [33]. The costs of renal replacement therapy as a result of renal failure attributable to diabetes were estimated using incidence and prevalence data from the UK Renal Registry and NICE cost data [34]. Other diabetes-related renal costs for microalbuminuria, overt nephropathy and kidney transplantation were estimated based on a burden-of-illness study [35].

Hospital Episode Statistics data were used to identify the incidence of ketoacidosis, hyperglycaemia, hypoglycaemia and retinopathy during 2010/2011 and NHS Reference Costs were applied to provide costs estimates for these complications [36]. The split of severe hypoglycaemia between patients with Type 1 and Type 2 diabetes, and the incidence of moderate hypoglycaemia in patients with Type 1 diabetes, were identified from an observational study [29]. The cost of moderate hypoglycaemia and its incidence in people with Type 2 diabetes was extracted from a different study [37]. The cost of emergency services for hypoglycaemia was included based on an observational study [38].

Neuropathy costs were sourced from a study that also split the cost between patients with Type 1 and Type 2 diabetes [39]. Foot care costs included the cost of ulcerations and amputations [23,40]. Incidence and prevalence data were sourced from studies and Diabetes UK [1,41–43]. The annual cost of and the number of men affected by erectile dysfunction was extracted from a study and a percentage of this cost attributed to men with diabetes [44,45]. The cost of dyslipidaemia was estimated by using the number of people in the UK who take statins and the average cost of annual treatment and applying diabetes prevalence data [46]. General diabetes prevalence data were applied to the known direct costs of depression in the population with diabetes [47]. For all complications, the incidence among the general population has been discounted from the diabetes cost estimate. The costs of complications resulting in fatalities have been taken into account.

According to NHS Diabetes, patients with diabetes admitted for routine surgery stay on average 2.6 days longer than those without diabetes [48]. To demonstrate the potential additional cost of excess inpatient bed days, estimates of the proportion of 'other medical' and 'non-medical' admissions were calculated, based on the NHS Diabetes Inpatient Audit [49]. These estimates were costed using the estimate of 2.6 additional days multiplied by the average NHS bed day price [50]. Outpatient costs were calculated based on Hospital Episode Statistics data and NHS Reference Costs.

Non-health service costs (indirect)

The economic costs of diabetes include both social and productivity costs. There is little literature on the non-health related costs of diabetes, but targeted literature searching identified some data that have been used to provide estimates. Mortality data for diabetes were obtained from the National Diabetes Audit and these were used to provide an estimate of the numbers of people who die prematurely from diabetes-related illnesses and the potential years of life lost [51]. This was used, along with an estimate of the average salary, to estimate the productivity cost of mortality from diabetes [52]. An Australian study concluded that approximately 38% of people with diabetes over the age of 45 years are not in employment and this was factored into the overall productivity loss cost [53]. Other productivity losses were estimated for sickness absence and presenteeism. Data on diabetes-related sickness absence were obtained from a National Audit Office report and these were extrapolated for the rest of the UK to provide an estimate of the productivity loss [54]. Presenteeism relates to the potential loss of productivity among people who remain in work and this is a more subjective calculation. Estimates were calculated for the burden of diabetes-related presenteeism, based on a US study, although it is acknowledged that this is an underdeveloped area of research and these estimates may not be reliable [55]. The estimates were based on the loss of productive time to ill health caused by diabetes among the working population, the loss being a burden to the individual or the employer. In respect of social costs, the economic burden of additional care for people with diabetes was estimated based on a US study, which identified the additional number of hours per week older people with diabetes receive [56].

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

Table 1 Estimated UK prevalence of diabetes 2010/2011 and 2035/2036

	2010/2011	2035/2036
Type 1 diabetes: adult	369 818	603 572
Type 1 diabetes: child	29 000	48 630
Type 1 diabetes: total	398 818	652 201
Type 2 diabetes: adult	3 419 142	5 636 924
Type 2 diabetes: child	585	800
Type 2 diabetes: total	3 419 727	5 637 724

Sensitivity analysis

Most of the cost estimates in this study were derived by taking estimates of incidence and prevalence and aggregating them using unit costs. In some cases, costs have been extracted from other studies. The two key variables for sensitivity analysis are incidence/prevalence and cost. A full sensitivity simulation was not carried out, but the variables were adjusted to reflect the underlying uncertainty that exists in the data. For diagnosis and treatment, sensitivity analysis of ± 20% was applied to incidence and prevalence. This is on the basis that there is variation in estimates of diabetes prevalence and incidence and approximately 20% of people with diabetes may be undiagnosed. Based on the premise that incidence and prevalence may vary ± 20%, sensitivity analysis of ± 10% was applied to the incidence of complications. This is because an increase in incidence and prevalence of the disease would not necessarily equate to a similar increase in complications, which tend to occur in people who have had diabetes for a number of years. The costs variable was adjusted by ± 20% to examine how sensitive the estimates are to fluctuations in cost.

Results

The prevalence of diabetes in the UK is estimated at approximately 400 000 people with Type 1 diabetes and 3 400 000 people with Type 2 diabetes [58]. Using Office for National Statistics projections, and assuming that there is no change in the way in which diabetes is treated, it is estimated that prevalence will rise to approximately 650 000 people with Type 1 diabetes and over 5 600 000 people with Type 2 diabetes by 2035/2036. Diabetes UK estimates that there are 150 000 people diagnosed with Type 1 or Type 2 diabetes annually. The cost estimate for screening and testing shown in Table 2 is based on the estimate of the numbers annually diagnosed.

The total cost of direct patient care for diabetes in 2010/2011 is estimated at £9.8bn. The indirect costs associated with diabetes are estimated at £13.9bn (Table 3). The direct costs of diabetes have been categorized as treatment/intervention and complications or adverse events. The cost of diagnosis/screening, treatment and interventions was over £2bn. The cost of complications experienced by those with Type 1 or Type 2 diabetes was estimated at £7.7bn. Peer-reviewed literature suggests that a significant proportion of these complications are caused directly by diabetes, although some may be caused by co-morbidities such as obesity.

The cost burden of diabetes in 2010/2011 was approximately 10% of total NHS resource expenditure [59]. If no changes are made to the way diabetes is treated by 2035/2036, this will rise to *c.* 17% of NHS expenditure. By the same rationale, the indirect costs of diabetes are likely to increase to over £22bn by 2035/2036.

Approximately 37 000 working years were lost from deaths from Type 1 diabetes and approximately 288 000 from deaths from Type 2 diabetes in 2010/2011. The cost of mortality was estimated at *c.* £0.6bn for Type 1 diabetes and £4.2bn for Type 2 diabetes.

An estimated 830 000 sickness days were taken for Type 1 diabetes and more than 7 million sickness days for Type 2 diabetes. The cost of sickness was over £94mn for Type 1 diabetes and over £850mn for Type 2 diabetes. The cost of presenteeism was over £91mn for Type 1 diabetes and £2.9bn for Type 2 diabetes.

An estimated 1 160 000 people with diabetes (over the age of 70 years) required informal care in the UK in 2010/2011 and over 336 million hours were used to care for them. The estimated cost of this was over £153mn for people with Type 1 diabetes and nearly £5bn for people with Type 2 diabetes. The cost of informal care is skewed towards Type 2 diabetes more so than other indirect costs because of the increasing prevalence of Type 2 diabetes with age.

Sensitivity analysis

The results of the sensitivity analysis (Tables 4 and 5) show that the cost estimates in this research are sensitive to changes in variables such as incidence and prevalence, and cost. The analysis shows a potential range for the overall cost of diabetes in 2010/2011 to be between £7.9bn and £11.7bn. For 2035/2036 the range was between £13.8bn and £20bn.

A US study has ascribed a cost burden to those people with undiagnosed diabetes. This study has not attempted to cost undiagnosed diabetes but, if the same rationale was applied to the UK, the cost would be approximately £1.5bn. This demonstrates the underlying uncertainty of providing an estimate of the costs of diabetes [60].

Discussion

The analysis of the treatment and complications costs for diabetes demonstrates that the estimate that the cost of diabetes accounts for approximately one tenth of NHS expenditure is accurate. This analysis also demonstrates that less than a quarter of that cost relates to the treatment and ongoing management of diabetes, with the rest being accounted for by the costs of treating the complications of diabetes. These are effectively 'adverse events' and are a significant area of expenditure for the NHS. The Scottish Diabetes Survey has shown that *c.* 38% of patients with

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

Table 2 Estimated UK costs of diabetes 2010/2011 and 2035/2036

	2010/2011			2035/2036		
Screening and testing	Type 1 diabetes (£)	Type 2 diabetes (£)	Total (£)	Type 1 diabetes (£)	Type 2 diabetes (£)	Total (£)
Diagnosis	1 442 501	8 174 172	9 616 673	2 420 086	13 713 821	16 133 907
Retinopathy screening	267 390	2 414 554	2 681 943	376 168	3 396 833	3 773 001
Total	1 709 891	10 588 726	12 298 616	2 796 254	17 110 654	19 906 908
Treatment and management	Type 1 diabetes (£)	Type 2 diabetes (£)	Total (£)	Type 1 diabetes (£)	Type 2 diabetes (£)	Total (£)
Primary care	98 081 332	950 713 826	1 048 795 159	174 078 027	1 517 045 735	1 691 123 762
Prescriptions	155 481 614	701 792 008	857 273 623	310 933 710	1 126 628 120	1 437 561 830
Insulin pump	19 940 905	143 452	20 084 357	32 956 690	237 086	33 193 776
Continuous glucose monitoring	570 063	0	570 063	955 938	0	955 938
Influenza immunization	5 738 559	49 206 159	54 944 718	9 213 678	82 923 101	92 136 779
Medical exemption	5 334 853	48 013 679	53 348 532	14 567 430	131 106 873	145 674 303
Education programmes	4 034 119	766 333	4 800 453	6 764 813	1 285 064	8 049 877
Smoking cessation programmes	644 265	5 524 345	6 168 610	1 080 367	9 263 773	10 344 139
Total	289 825 710	1 756 159 802	2 045 985 515	550 550 655	2 868 489 752	3 419 040 406
Complications	Type 1 diabetes (£)	Type 2 diabetes (£)	Total (£)	Type 1 diabetes (£)	Type 2 diabetes (£)	Total (£)
Hypoglycaemia (moderate)	19 186 916	22 614 644	41 801 561	31 710 560	37 986 266	69 696 826
Hypoglycaemia (severe)	13 942 854	16 433 734	30 376 589	19 155 289	21 462 166	40 617 455
Dyslipidaemia	2 746 194	24 715 746	27 461 940	7 591 501	68 323 506	75 915 007
Neuropathy	43 004 556	266 628 248	309 632 804	72 114 221	447 108 170	519 222 391
Erectile dysfunction	1 850 053	11 470 329	13 320 382	3 097 539	19 204 739	22 302 278
Ketoacidosis	15 957 160	0	15 957 160	26 758 556	0	26 758 556
Hyperglycaemia	5 644 425	50 799 826	56 444 251	9 465 134	85 186 209	94 651 343
Ischaemic heart disease	50 965 633	458 690 699	509 656 332	85 028 410	765 255 689	850 284 099
Myocardial infarction	29 272 208	573 797 013	603 069 221	48 619 363	953 042 070	1 001 661 433
Heart failure	30 815 781	277 342 025	308 157 806	51 544 764	463 902 877	515 447 641
Stroke	13 932 978	273 998 966	287 931 944	23 255 554	457 332 080	480 587 634
Kidney failure	135 061 944	379 004 594	514 066 538	226 416 514	635 359 572	861 776 086
Other renal costs	51 557 273	374 838 822	426 396 095	86 525 184	628 760 182	715 285 366
Retinopathy	5 774 184	51 967 658	57 741 842	9 682 727	87 144 546	96 827 274
Foot ulcers and amputations	111 594 920	874 005 362	985 600 282	216 268 111	1 888 596 612	2 104 864 723
Depression	3 320 927	29 888 347	33 209 275	4 841 398	43 572 579	48 413 977
Gestational diabetes	0	4 293 009	4 293 009	0	6 039 473	6 039 473
Other cardiovascular disease	165 485 511	1 489 369 602	1 654 855 114	284 845 714	2 563 611 422	2 848 457 136
Diabetic medicine outpatients	1 634 073	14 706 658	16 340 731	2 740 177	24 661 589	27 401 766
Excess inpatient days	17 357 369	1 805 472 271	1 822 829 640	29 106 626	3 027 597 751	3 056 704 377
Total	719 104 959	7 000 037 553	7 719 142 516	1 238 767 342	12 224 147 498	13 462 914 840

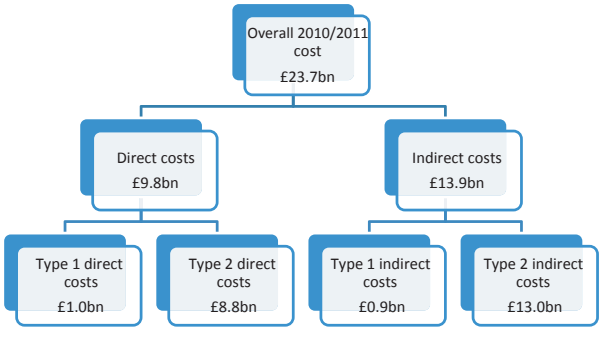

FIGURE 1 Breakdown of direct and indirect costs of diabetes in the UK for 2010/2011.

Type 1 diabetes and nearly 14% of patients with Type 2 diabetes in Scotland have poor glycaemic control. This suggests scope for improvement in the current approach to the treatment and management of diabetes and the potential for cost savings to be achieved.

This analysis has also apportioned the costs of diabetes between Types 1 and 2. One of the main problems in trying to identify the costs of diabetes is the variable nature of the data on the numbers of people with diabetes. There are various sources for estimates, but there is wide variation in those estimates. None of the sources provide an accurate indication of the numbers of people with Type 1 and Type 2 diabetes, with the exception of the Scottish Diabetes Survey [57].

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

Table 3 Indirect UK costs of diabetes 2010/2011 and 2035/2036

	2010/2011 (£)	2035/2036 (£)
Mortality—Type 1	560 343 917	737 832 017
Mortality—Type 2	4 203 544 262	5 611 608 152
Sickness absence—Type 1	94 557 277	141 242 443
Sickness absence—Type 2	851 015 494	1 271 181 991
Presenteeism—Type 1	91 045 606	374 734 092
Presenteeism—Type 2	2 943 807 935	3 372 606 827
Informal care—Type 1	153 291 454	1 134 246 562
Informal care—Type 2	4 956 423 686	10 208 219 059
Total—Type 1	899 238 255	2 388 055 114
Total—Type 2	12 954 791 376	20 463 616 029
Grand total	13 854 029 631	22 851 671 143

Table 4 Sensitivity analysis for Type 1 diabetes costs

Year	Variable	Sensitivity: lower value	Model value	Sensitivity: upper value
2010/2011	Incidence	£0.89bn	£1.01bn	£1.14bn
	Cost	£0.82bn	£1.01bn	£1.08bn
2035/2036	Incidence	£1.53bn	£1.79bn	£2.05bn
	Cost	£1.47bn	£1.79bn	£2.11bn

Table 5 Sensitivity analysis for Type 2 diabetes costs

Year	Variabler	Sensitivity: lower value	Model value	Sensitivity: upper value
2010/11	Incidence	£7.72bn	£8.79bn	£9.88bn
	Cost	£7.12bn	£8.79bn	£10.52bn
2035/36	Incidence	£13.00bn	£15.11bn	£17.26bn
	Cost	£12.36bn	£15.11bn	£17.86bn

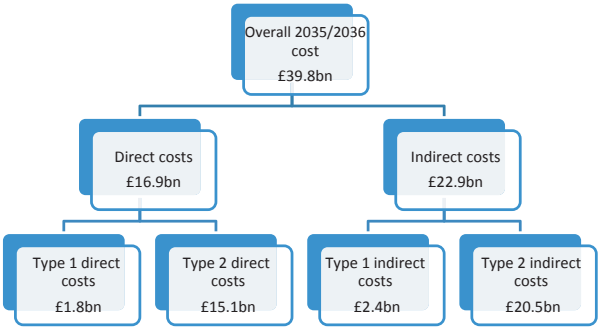

FIGURE 2 Breakdown of direct and indirect costs of diabetes in the UK for 2035/2036.

The indirect costs of diabetes are considerably higher than the direct costs and many relate to a cost to the individual with diabetes or their carers. Cost estimates for productivity and social costs are often opportunity costs, such as time lost that could be spent on other activities. Any improvements in the way that diabetes is treated that lead to better glycaemic control and fewer complications could have a significant impact on these costs, but this remains to be assessed.

The categorization of diabetes costs into treatment/intervention and complications provides a baseline model, which can be used to examine how changes to the way diabetes is treated might affect the overall cost burden for diabetes. If treatment or intervention costs are considered to be 'inputs' and complications are considered to be 'outcomes', it is possible to examine different treatment scenarios and how the cost of complications may change as a result. The costs estimated provide a measure of the cost burden associated with the current treatment model for diabetes and the associated cost of complications. Further research will be carried out to examine what the cost impact would be if NICE guidelines were fully adopted across the UK, including the extent of cost savings that could potentially accrue from reduced or delayed complications. This will allow the model to show how investment in effective treatment could potentially reduce the overall cost burden of diabetes.

Competing interests

This research was funded by Sanofi. CB is a member of the Juvenile Diabetes Research Foundation (JDRF) and Diabetes UK.

References

1 Diabetes UK. *Diabetes in the UK 2011/12: Key Statistics on Diabetes*. London: Diabetes UK, 2011. Available at http://www.diabetes.org.uk/Documents/Reports/Diabetes-in-the-UK-2011-12.pdf Last accessed 28 February 2012.

2 Yorkshire and Humber Public Health Observatory. *Diabetes Key Facts*. York: Yorkshire and Humber Public Health Observatory, 2006. Available at http://www.yhpho.org.uk/resource/view.aspx?RID=8872 Last accessed 28 February 2012.

3 Department of Health. *Turning the Corner: Improving Diabetes Care*. London: Department of Health, 2006. Available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4136141 Last accessed 28 February 2012.

4 Yorkshire and Humber Public Health Observatory. *APHO Diabetes Prevalence Model: Key Findings for England*. York: Yorkshire and Humber Public Health Observatory, 2010. Available at http://www.yhpho.org.uk/resource/view.aspx?RID=81124 Last accessed 28 February 2012.

5 Haines L, Kramer Z. *Growing up with Diabetes: Children and Young People with Diabetes in England 2009*. London: Royal College of Paediatrics and Child Health, 2009.

6 Department of Health. *National Service Framework for Diabetes*. London: Department of Health, 2001.

7 UK National Statistics. *Statistical Bulletin Annual Mid-Year Population Estimates, 2010*. Newport: UK National Statistics, 2010.

8 Diabetes UK. *Website*. 2012. Available at http://www.diabetes.org.uk Last accessed 28 February 2012.

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

9 Personal Social Services Research Unit. *Unit Costs of Health and Social Care, 2010*. Canterbury: Personal Social Services Research Unit, 2010. Available at http://www.pssru.ac.uk/ Last accessed 28 February 2012.

10 British National Formulary. *Website*. 2011. Available at http://bnf.org/bnf/index.htm Last accessed 28 Feburary 2012.

11 Personal Social Services Research Unit. *Unit Costs of Health and Social Care, 2010*. Canterbury: Personal Social Services Research Unit, 2010. Available at http://www.pssru.ac.uk/ Last accessed 28 February 2012.

12 UK National Screening Committee. *Annual Report English National Screening Programme for Diabtic Retinopathy*. Gloucester: UK National Screening Committee, 2011. Available at http://diabeticeye.screening.nhs.uk/getdata.php?id=11196 Last accessed 28 February 2012.

13 The Information Centre. *Trends in Consultation Rates in General Practice 1995/1996 to 2008/2009: Analysis of the QResearch Database*. 2009. Available at http://www.ic.nhs.uk/webfiles/publications/gp/Trends_in_Consultation_Rates_in_General_Practice_1995_96_to_2008_09.pdf Last accessed 28 February 2012.

14 Schellevis FG, Van De Lisdonk EH, Van Der Velden J, Hoogbergen SHJL, Van Eijk JTM, Van Weel C. Consultation rates and incidence of intercurrent morbidity among patients with chronic disease in general practice. *Br J Gen Pract* 1994; **44**: 259–262.

15 Quality and Outcomes Framework. *Quality and Outcomes Framework (QOF) 2010/11, England*. Available at http://www.ic.nhs.uk/qof Last accessed 28 February 2012.

16 The Health and Social Care Information Centre. *Prescribing for Diabetes in England: 2005/2006 to 2010/2011*. 2011. Available at http://www.ic.nhs.uk/webfiles/publications/prescribing%20diabetes%20200506%20to%20201011/Prescribing_for_Diabetes_in_England_20056_to_201011.pdf Last accessed 28 February 2012.

17 Holden SE, Poole CD, Morgan CL, Currie CJ. Evaluation of the incremental cost to the National Health Service of prescribing analogue insulin. *Br Med J* 2011; **1**: e000258.

18 The Hormone Foundation. *Type 1 and Type 2 Diabetes Treatment Options*. Maryland USA: The Hormone Foundation, 2012. Available at http://www.hormone.org/diabetes/treatment.cfm Last accessed 28 February 2012.

19 Belsey JD, Pittard JB, Rao S, Urdahl H, Jameson K, Dixon T. Self blood glucose monitoring in type 2 diabetes. A financial impact analysis based on UK primary care. *Int J Clin Pract* 2009; **63**: 439–448.

20 The Health and Social Care Information Centre. *Prescriptions Dispensed in the Community. Statistics for 1997 to 2007: England*. Leeds: The Health and Social Care Information Centre, 2008; Available at http://www.ic.nhs.uk/webfiles/publications/PCA%20publication/Final%20version%20210708.pdf Last accessed 28 February 2012.

21 Diabetes UK. *Insulin Pumps*. London: Diabetes UK, 2012. Available at http://www.diabetes.org.uk/insulin_pumps Last accessed 28 February 2012.

22 DiabetesWellBeing.com. Insulin Pump Price. Florida, USA: DiabetesWellBeing.com, 2012.

23 The National Collaborating Centre for Chronic Conditions. *Type 2 Diabetes. National Clinical Guideline for Management in Primary and Secondary Care (update)*. London: Royal College of Physicians, 2008. Available at http://www.nice.org.uk/nicemedia/live/11983/40803/40803.pdf Last accessed 28 February 2012.

24 NICE. *Diabetes in Pregnancy: Management of Diabetes and its Complications from Pre-Conception to the Postnatal Period*. NICE clinical guideline 63. London: National Institute for Health and Clinical Excellence, 2008.

25 National Diabetes Information Clearinghouse (NDIC). National Diabetes Statistics, 2011. Maryland, USA: National Diabetes Information Clearinghouse, 2011.

26 Office for National Statistics. *Maternity Statistics, England: 2010–2011*. London: Office for National Statistics, 2011.

27 SIGN. *Management of Diabetes: A Clinical and Resource Impact Assessment*. Edinburgh: Scottish Intercollegiate Guidelines Network, 2010.

28 X-PERT Health CIC. *X-PERT National Results. Organisation Comparison. How are you doing?* Hebdon Bridge: X-PERT Health CIC, 2011. Available at http://www.xperthealth.org.uk/images/stories/downloads/x-pert%20audit%20report%20feb%202011.pdf Last accessed 28 February 2012.

29 Leese G, Wang J, Broomhall J, Kelly P, Marsden A, Morrison W *et al*. Frequency of severe hypoglycemia requiring emergency treatment in type 1 and type 2 diabetes: a population-based study of health service resource use. *Diabetes Care* 2003; **26**: 1176–1180.

30 Gillett M, Dallosso H, Brennan A, Carey M, Campbell M, Heller S *et al*. Delivering the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed Type 2 diabetes: cost-effectiveness analysis. *Br Med J* 2010; **341**: 1–10.

31 Haire-Joshu D, Glasgow R, Tibbs T. Smoking and diabetes. *Diabetes Care* 1999; **22**: 1887–1898.

32 NHS Information Centre. *Hospital Episode Statistics HES (Admitted Patient Care) England 2010–2011*. Leeds: NHS Information Centre, 2011. Available at http://www.ic.nhs.uk/statistics-and-data-collections/hospital-care/hospital-activity-hospital-episode-statistics–hes/hospital-episode-statistics-hes-admitted-patient-care-england-2010-11 Last accessed 28 February 2012.

33 Luengo-Fernandez R, Leal J, Gray A, Petersen S, Rayner M. Cost of cardiovascular disease in the UK. *Heart* 2010; **92**: 1384–1389.

34 UK Renal Registry. *13th Annual Report*. Bristol: UK Renal Registry, 2010.

35 Gordois A, Scuffham P, Shearer A, Oglesby A. The health care costs of diabetic nephropathy in the USA and the UK. *J Diabetes Complications* 2004; **18**: 18–26.

36 NHS Information Centre. *NHS Reference Costs*. Leeds: NHS Information Centre, 2012.

37 Jonsson L, Bolinder B, Lundkvist J. Cost of hypoglycemia in patients with Type 2 diabetes in Sweden. *Value Health* 2006; **9**: 193–198.

38 Farmer A, Brockbank K, Keech M, England E, Deakin C. Incidence and costs of severe hypoglycaemia requiring attendance by the emergency medical services in South Central England. *Diabet Med* 2012; doi: 10.1111/j.1464-5491.2012.03657.x.

39 Scuffham P, Gordois A, Shearer A, Oglesby A. The health care costs of diabetic peripheral neuropathy in the UK. *Diabetologica* 2003; **46**: A445.

40 Hutton J, Harry M. *Orthotic Service in the NHS: Improving Service Provision*. York: York Health Economics Consortium, 2009.

41 White R, McIntosh C. Topical therapies for diabetic foot ulcers: standard treatments. *J Wound Care* 2008; **18**: 426–432.

42 Schofield C, Libby G, Brennan G, MacAlpine R, Morris A, Leese G *et al*. Mortality and hospitalization in patients after amputation: a comparison between patients with and without diabetes. *Diabetes Care* 2006; **29**: 2252–2256.

43 Information Services Division NHS Scotland. *The Amputee Statistical Database for the UK 2006/2007*. 2009. Available at http://www.limbless-statistics.org/documents/Report2006-07.pdf Last accessed 28 February 2012.

44 Plumb J, Guest J. Annual cost of erectile dysfunction to UK society. *Pharmacoeconomics* 1999; **16**: 699–709.

45 Library DI. *Information about Diabetes*. 2012. Available at http://www.diabeteslibrary.org/ Last accessed 28 February 2012.

46 Carlyle R. *Statins*. Folkestone: SAGA, 2012. Available from: http://www.saga.co.uk/health/medicines/statins.aspx Last accessed 28 February 2012.

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK

47 Thomas C, Morris S. Cost of depression among adults in England in 2000. *Br J Psychiatry* 2003; **183**: 514–519.
48 NHS Diabetes. *Areas of Care—Inpatient and Emergency*. London: NHS Diabetes, 2012. Available at http://www.diabetes.nhs.uk/areas_of_care/emergency_and_inpatient/ Last accessed 29 February 2012.
49 NHS Diabetes. *National Diabetes Inpatient Audit 2010*. London: NHS Diabetes, 2011.
50 NHS—Institute for Innovation and Improvement. *Length of Stay—Reducing Length of Stay*. Coventry: NHS—Institute for Innovation and Improvement, 2008. Available at http://www.institute.nhs.uk/quality_and_service_improvement_tools/quality_and_service_improvement_tools/length_of_stay.html Last accessed 28 February 2012.
51 NHS Information Centre. National Diabetes Audit Mortality Analysis 2007–2008. Leeds: NHS Information Centre, 2011. Available at http://www.ic.nhs.uk/webfiles/Services/NCASP/Diabetes/200910%20annual%20report%20documents/NHS_Diabetes_Audit_Mortality_Report_2011_Final.pdf Last accessed 28 February 2012.
52 Office for National Statistics. *2011 Annual Survey of Hours and Earnings*. 2011. Available at http://www.ons.gov.uk/ons/dcp171778_241497.pdf Last accessed 28 February 2012.
53 Schofield D, Percival R, Passey M, Shrestha R, Callander E, Kelly S. The financial vulnerability of individuals with diabetes. *Br J Diabetes Vasc Dis* 2010; **10**: 300–304.
54 National Audit Office. *Tackling Obesity in England*. London: National Audit Office, 2001. Available at http://www.nao.org.uk/publications/0001/tackling_obesity_in_england.aspx Last accessed 28 February 2012.
55 American Diabetes Association. Economic costs of diabetes in the US in 2007. *Diabetes Care* 2008; **31**: 1271.
56 Langa K, Vijan S, Hayward R, Chernew M, Blaum C, Kabeto M *et al*. Informal caregiving for diabetes and diabetic complications among elderly Americans. *J Gerentol B Psychol Sci Soc Sci* 2002; **57**: S177–S186.
57 Scottish Diabetes Survey Monitoring Group. *Scottish Diabetes Survey 2010*. Available at http://www.diabetesinscotland.org.uk/Publications/SDS%202010.pdf Last accessed 28 February 2012.
58 Royal College of Paediatrics and Child Health. *Growing up with Diabetes: Children and Young People with Diabetes in England*. London: Royal College of Paediatrics and Child Health, 2009.
59 Department of Health. Department of Health—Spending Review 2010. London: Department of Health, 2010. Available at http://www.dh.gov.uk/en/MediaCentre/Pressreleases/DH_120676 Last accessed 28 February 2012.
60 Zhang Y, Dall T, Mann S, Chen Y, Martin J, Moore V *et al*. The economic costs of undiagnosed diabetes. *Popul Health Manag* 2009; **12**: 95–101.

© 2012 The Authors.
Diabetic Medicine © 2012 Diabetes UK