

Type 1 diabetes in adults: diagnosis and management

Economic modelling for continuous glucose
monitoring in adults with type 1 diabetes

NICE guideline NG17

Economic model report

March 2022

Final

*Commissioned by the National Institute for
Health and Care Excellence*

Disclaimer

Healthcare professionals are expected to take NICE clinical guidelines fully into account when exercising their clinical judgement. However, the guidance does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of each patient, in consultation with the patient and/or their guardian or carer.

Copyright

© NICE 2022. All rights reserved. Subject to [Notice of rights](#).

Contents

HE1 Introduction	5
HE2 Methods	6
HE2.1 Model overview	6
HE2.1.1 Population(s).....	6
HE2.1.2 Interventions	6
HE2.1.3 Type of evaluation, time horizon, perspective, discount rate	7
HE2.2 Model structure.....	7
HE2.3 Parameters.....	7
HE2.3.1 Cohort parameters	8
HE2.3.2 Economics	11
HE2.3.3 Treatments.....	17
HE2.3.4 Clinical	20
HE2.3.5 Other management	21
HE2.4 Sensitivity analyses	21
HE2.4.1 Deterministic sensitivity analyses	22
HE2.4.2 Probabilistic sensitivity analyses	22
HE3 Results	24
HE3.1 Base-case cost–utility results	24
HE3.2 Deterministic sensitivity analyses	24
HE3.3 Probabilistic sensitivity analysis	25
HE3.4 Discussion	26
HE3.4.1 Principal findings.....	26
HE3.4.2 Weaknesses of the analysis.....	26
HE3.4.3 Comparison with other CUAs	27
HE3.5 Conclusions.....	27
HE4 References.....	28

HE1 Introduction

Given the costs and impact on health-related quality of life associated with hypoglycaemia and long-term complications of type 1 diabetes and unstable HbA1c control, the cost-effectiveness of real-time continuous glucose monitoring (rtCGM) and flash glucose monitoring (isCGM) versus conventional self-monitoring of blood glucose (SMBG) was identified by the guideline committee as an area of priority for economic analysis.

The review question addressed in this analysis is:

- In adults with type 1 diabetes, what is the most effective method of glucose monitoring to improve glycaemic control:
 - continuous glucose monitoring
 - flash glucose monitoring
 - conventional self-monitoring of blood glucose (also sometimes called intermittent capillary blood glucose monitoring)?

The decision problem this analysis is designed to address is summarised in Table , with the full protocol for the clinical review available in appendix A of the evidence review for the guideline update.

In the economic literature review two cost-utility analyses (CUAs) were identified looking at the cost-effectiveness of glucose monitoring methods to improve glycaemic control in adults with type 1 diabetes in the UK context. Healthcare Improvement Scotland¹ assessed the Freestyle Libre flash glucose monitoring method for both type 1 and type 2 diabetes patients, while Roze et al² examined the cost-effectiveness of real-time continuous glucose monitoring among people with type 1 diabetes. Both studies showed that automated glucose monitoring methods are likely to be cost effective compared with SMBG. However, both of these analyses were only based on a single RCT, rather than all the available clinical evidence, and therefore the committee agreed there was value in additional work being undertaken.

Table HE001: Health economic decision problem

Population	Adults (aged 18 years and older) with type 1 diabetes
Intervention	Method of glucose monitoring to improve glycaemic control: • real-time continuous glucose monitoring • flash glucose monitoring
Comparator	Conventional self-monitoring of blood glucose
Outcomes	Costs QALYs

HE2 Methods

HE2.1 Model overview

3 The previously published IQVIA CORE Diabetes model (CDM) version 9.5, which has been
4 validated against clinical and epidemiological data, was used for the analysis. This was
5 decided on due to the need for a model accounting for the long-term complications of
6 diabetes within a lifetime time horizon, as agreed upon by the guideline committee. Given the
7 complexity of modelling type 1 diabetes and the timeline constraints associated with this
8 clinical guideline development, the committee agreed this was a more robust approach than
9 attempting to develop a new model framework from scratch.

10 The CDM is a lifetime Markov simulation model predicting the progression of diabetes over
11 time using a series of interlinked and interdependent Markov sub models for diabetes related
12 complications. The model allows for transition probabilities and management strategies to be
13 differentiated by type of diabetes. In our analysis, type 1 diabetes data was used where
14 available.

15 In addition to reducing the occurrence of short-term complications such as hypoglycaemic
16 events, automated glucose monitoring methods can also improve the stability of HbA1c
17 levels, hence reducing long-term complications. Therefore, an economic analysis was
18 undertaken to evaluate the cost-effectiveness of blood glucose monitoring methods, taking
19 into account the benefits of lowering HbA1c levels and reducing severe and non-severe
20 hypoglycaemic events. In addition, diabetes-specific and broader psychological benefits were
21 also considered in the model as the technologies have a potential to enhance people's ability
22 to manage their glucose levels and help them regain a sense of personal control over the
23 condition.

HE2.1.1 Population(s)

25 The primary analysis looked at a cohort of adults representing average individuals with type
26 1 diabetes in the UK.

HE2.1.2 Interventions

28 The analysis simulates the following methods of glucose monitoring:

- 29 • real-time continuous glucose monitoring
- 30 • flash glucose monitoring
- 31 • self-monitoring of blood glucose

32 Analyses of real-time continuous glucose monitoring versus self-monitoring of blood glucose,
33 and flash glucose monitoring versus self-monitoring of blood glucose were conducted.

34 The committee agreed an analysis of real-time versus flash monitoring would not be useful.
35 This was because of the limited clinical data available for this comparison, and because the
36 choice of device often depended on individual characteristics of the person, and therefore the
37 average cost-effectiveness across the population may not be particularly useful. In particular,
38 they noted that for various parameters data was only available for one type of device or the
39 other (for example, fear of hypoglycaemia data only being available for rtCGM, and 'process'
40 utility data only being available for isCGM). Whilst this was not a major limitation when
41 comparing to SMBG, as the committee were happy in places to extrapolate data from one
42 type of device to the other, it would make modelling comparisons between the two devices
43 less useful, as in places they would be based on the same set of effectiveness data.

HE2.1.3 Type of evaluation, time horizon, perspective, discount rate

2 A time horizon of 80 years was used in the base case since this was deemed sufficient to
3 consider lifetime costs and outcomes (note that the IQVIA CDM model requires the number
4 of years to be specified to define a time horizon). Costs and quality-adjusted life years
5 (QALYs) were considered from a UK NHS perspective. The analysis follows the standard
6 assumptions of the NICE reference case including discounting at 3.5% for costs and health
7 effects.

HE2.2 Model structure

9 The IQVIA CDM is a tool used to simulate disease progression in type 1 and type 2 diabetes
10 patients over their lifetime. The type 1 diabetes version of the model has been previously
11 validated³ against epidemiological and clinical studies of type 1 diabetes. A more detailed
12 description of IQVIA CDM has been published by Palmer et al⁴.

13 The IQVIA CDM can account for a range of interventions aimed at diabetes related
14 complications. These include intensive or conventional insulin therapy, oral hypoglycaemic
15 medications, screening and treatment strategies for microvascular complications, treatment
16 strategy for end stage complications and multifactorial interventions.

17 Diabetes progression with the IQVIA CDM is simulated using a series of interlinked, inter-
18 dependent sub-models which simulate the following complications:

- 19 • angina
- 20 • myocardial infarction
- 21 • congestive heart failure
- 22 • stroke
- 23 • peripheral vascular disease
- 24 • diabetic retinopathy
- 25 • macular oedema
- 26 • cataract
- 27 • hypoglycaemia
- 28 • ketoacidosis
- 29 • lactic acidosis
- 30 • nephropathy and end-stage renal disease
- 31 • neuropathy
- 32 • foot ulcer
- 33 • amputation
- 34 • non-specific mortality

35 The Markov sub models listed above use time, state, and diabetes type-dependent
36 probabilities from published sources. Interactions between these sub models are moderated
37 by employing Monte Carlo simulations using tracker variables.

38 The IQVIA CDM was chosen for this analysis as it is a pre-validated model which accounts
39 for long-term diabetes related complications across a time horizon extending to the lifetime of
40 the patient.

HE2.3 Parameters

42 Model input parameters in the IQVIA CDM model are grouped under the following
43 databases:

- 44 1. Cohort
- 45 2. Economics

- 1 • Costs
 - 2 • Quality of life
 - 3 3. Treatment
 - 4 • Treatment effects of insulin therapy
 - 5 • Treatment algorithm - a sequence of alternative treatments in the event a
 - 6 treatment is discontinued
 - 7 • Treatment costs
 - 8 4. Clinical
 - 9 5. Other Management
- 10 The default model input parameters for type 1 diabetes in the IQVIA CDM model were
- 11 validated with the committee and, if found appropriate, were used. In a scenario where more
- 12 reliable or recent UK specific sources were identified, these were used instead. Table HE002
- 13 to Table HE010 list the input parameters used in our analysis, with detail about the sources,
- 14 calculations and rationale for selection listed in the sections below.
- 15 Where parameter values other than the IQVIA CDM default values were used, these were
- 16 identified using the standard methods listed in the NICE guidelines manual. These include
- 17 taking values from established routine national data sources, identifying relevant published
- 18 studies through citation searching of the studies identified through the cost-effectiveness
- 19 literature review, targeted literature searches, and through studies identified by committee
- 20 members.

HE2.3.1 Cohort parameters

HE2.3.1.1 Baseline cohort characteristics

- 23 Within the IQVIA CDM model the baseline population needs to be defined in terms of
- 24 patient's demographics, baseline risk factors, and pre-existing complications. These
- 25 characteristics were sourced from a range of UK specific type 1 diabetes populations (and
- 26 aimed to be representative of the full population of people with type 1 diabetes in the UK).
- 27 Characteristics not reported in these sources were either set at default IQVIA CDM or kept at
- 28 0 due to a lack of data representative of UK population values (this generally applies to
- 29 proportions of people having suffered a previous event that would be likely to be uncommon
- 30 in the age range of the starting population simulated). The baseline cohort characteristics
- 31 used alongside their sources are listed in Table HE002.
- 32 The REPOSE trial⁶, which was used to source a number of the baseline characteristics listed
- 33 below, is a cluster randomised trial of 267 adults with type 1 diabetes in the UK who were
- 34 recruited from November 2011 to December 2012, and reported detailed baseline data for a
- 35 range of the characteristics needed to populate the model. The inclusion criteria included
- 36 requiring participants to be aged 18 or over and have had type 1 diabetes for at least 12
- 37 months at the time of undertaking a DAFNE course. Hence the baseline population of the
- 38 trial was judged similar to that of our review question. This study was identified through a
- 39 targeted search of HTA reports on type 1 diabetes, undertaken due to the fact that HTA
- 40 reports tend to give more detail on baseline characteristics than are present in a standard
- 41 journal article.
- 42 We have used these baseline characteristics to simulate a cohort of 1,000 patients using the
- 43 IQVIA CDM. Note that for characteristics where the standard deviation was kept at 0, the
- 44 mean values were kept static when patient cohort was simulated. The simulated patient
- 45 cohort also does not take into account correlations between risk factors.

46 Table HE002: Baseline cohort characteristics

Baseline characteristic	Mean	SD	Source/ Comments
Patient demographics			

Baseline characteristic	Mean	SD	Source/ Comments
Age (years)	46.53	12.13	National Diabetes Audit 2019-20 ⁵ Type 1 Diabetes Report: age and duration of diabetes were calculated by obtaining weighted averages since they were reported for categories of patients, rather than as a single mean age.
Duration of Diabetes (years)	21	13.48	
Prop. Male	0.569	n/a	
Baseline risk factors			
HbA1c (%)	9.1	1.7	REPOSE ⁶ – a cluster randomised trial of 267 adults with type 1 diabetes in the UK recruited from November 2011 to December 2012. Conversion to mmol/mol: mean 75.96mmol/mol.
Systolic blood pressure (mmHg)	131.3	16.3	REPOSE ⁶
Diastolic blood pressure (mmHg)	80	0	IQVIA CDM default value ⁷
Total Cholesterol (mg/dL)	90	16.2	REPOSE ⁶ ; Conversion to mmol/l: mean 2.33mmol/l; SD 0.42mmol/l.
High density cholesterol (mg/dL)	28.8	7.2	REPOSE ⁶ ; Conversion to mmol/l: mean 0.74mmol/l; SD 0.19mmol/l.
Low density cholesterol (mg/dL)	50.4	16.2	REPOSE ⁶ ; Conversion to mmol/l: mean 1.30mmol/l; SD 0.42mmol/l.
Triglyceride (mg/dL)	25.2	18	REPOSE ⁶ ; Conversion to mmol/l: mean 0.28mmol/l; SD 0.20mmol/l.
Body mass index (kg/m ²)	27.2	5	REPOSE ⁶
estimated glomerular filtration rate (ml/min/1.72m ²)	78.58	13.24	REPOSE ⁶ - calculated by obtaining weighted averages since they were reported for categories of patients
Haemoglobin (gr/dl)	14.5	0	IQVIA CDM default value ⁸
White blood cell count (10 ⁶ /ml)	6.8	0	IQVIA CDM default value ⁸
Heart rate (bpm)	72	0	IQVIA CDM default value ⁸
Waist to hip ratio	0.93	0	IQVIA CDM default value ⁸
Waist circumference	87.84	n/a	IQVIA CDM default value ⁹
Urinary Albumin creatinine ratio (mg/mmol)	4.78	10.19	REPOSE ⁶ - calculated by obtaining weighted averages since they were reported for categories of patients
Serum Creatinine (mg/dL)	1.1	0	IQVIA CDM default value ⁹ ; Conversion to µmol/L: mean 97.24 µmol/l.
Serum Albumin (g/dl)	3.9	0	IQVIA CDM default value ⁹ ; Conversion to g/l: mean 39g/l.
Prop. Smoker	0.192	n/a	REPOSE ⁶
Cigarettes/ day	15	n/a	Health Survey for England 2017 & 2018 ¹⁰ – calculated from the subset of individuals with diabetes
Alcohol consumption (Oz/week)	7.7	n/a	WHO status report on alcohol 2018 ¹¹ (converted from l/year to oz/week)
Prop. Physical activity	0.620	n/a	Health Survey for England 2017 & 2018 ¹⁰ – calculated from the subset of individuals with type 1 diabetes
Fasting glucose	180.72	n/a	IQVIA CDM default value
Prop. Family history stroke	0.0436	n/a	IQVIA CDM default value
Prop. Family history CHD	0.1474	n/a	IQVIA CDM default value
Prop. China Northern region	n/a	n/a	n/a

Baseline characteristic	Mean	SD	Source/ Comments
Prop. China rural area	n/a	n/a	n/a
Racial characteristics			
Prop. White/ other	0.942	n/a	National Diabetes Audit 2019-20 ⁵ Type 1 Diabetes Report
Prop. Black	0.023	n/a	
Prop. Asian/ Pacific islander	0.035	n/a	
Baseline CVD complications			
Prop. MI	0.022	n/a	REPOSE ⁶
Prop. Angina	0.012	n/a	REPOSE ⁶
Prop. Peripheral vascular disease	0	n/a	Assumption
Prop. Stroke	0.003	n/a	REPOSE ⁶
Prop. Heart failure	0.006	n/a	REPOSE ⁶
Prop. Atrial Fibrillation	0	n/a	Assumption
Prop. Left ventitucular hypertrophy	0	n/a	Assumption
Baseline renal complications			
Prop. Microalbuminuria (MA)	0.12	n/a	REPOSE ⁶
Prop. Gross proternuria (GPR)	0.045	n/a	REPOSE ⁶
Prop. End stage renal disease (ESRD)	0	n/a	Assumption
Baseline retinopathy complications			
Prop. Background retinopathy (BDR)	0.348	n/a	REPOSE ⁶
Prop. Proliferative diabetic retinopathy (PDR)	0.093	n/a	REPOSE ⁶
Prop. Severe vision loss (SVL)	0	n/a	Assumption
Baseline macular edema			
Prop. Macular Edema	0	n/a	Assumption
Baseline cataract			
Prop. Cataract	0	n/a	Assumption
Baseline foot ulcer complications			
Prop. History of ulcer	0	n/a	Assumption
Prop. History of amputation	0	n/a	Assumption
Baseline neuropathy			
Prop. Neuropathy	0.071	n/a	REPOSE ⁶

HE2.3.12 Mortality

- 2 The IQVIA CDM offers four options to account for mortality within the model. These include
3 the non-combined mortality approach where event and health state specific mortality are
4 used to estimate fatal events (there is a lack of clarity about how non-event specific mortality
5 is accounted for in this option), 2 UK specific approaches; the UKPDS 68 and UKPDS 82
6 approaches, and the Western Australia mortality approach where the data was sourced from
7 an Australian population. Given that the UKPDS 68 and UKPDS 82 approaches were from
8 UK specific populations, these were considered in more detail.
- 9 The UKPDS 68 approach uses 2 separate equations to predict the 1st and subsequent year
10 mortality risks for diabetes related complications using information from the UKPDS
11 population. This approach requires non-specific mortality risks stratified by ethnicity, gender,

- 1 and age to be uploaded manually. However, given the unavailability of disease specific
 2 mortality (which is required to calculate non-specific mortality) by these stratifications for the
 3 relevant population in the UK, this approach was not used.
- 4 The UKPDS 82 approach uses four separate equations to estimate the incidence of death
 5 following “no history and no event”, “no history and event”, “history and no event”, and
 6 “history and event”. With it being clear that the excess mortality in the UKPDS 82 approach is
 7 reflective of a UK population due to it being sourced from the UKPDS, the UKPDS 82
 8 approach was used. While the UKPDS is a type 2 diabetes population, the committee agreed
 9 there was no robust evidence to suggest that event specific and non-event specific mortality
 10 differed between type 1 and type 2 diabetes patients (e.g. the mortality associated with
 11 having a stroke would be expected to be similar, regardless of whether the person has type 1
 12 or type 2 diabetes, assuming their other characteristics are similar).

HE2.3.2 Economics

HE2.3.2.1 Cost

- 15 Default values for costs of chronic and recurrent conditions, and complication costs in the
 16 IQVIA CDM model were updated to reflect those of contemporary clinical practice in the UK.
 17 Costs for medicines were taken from the NHS Drug Tariff, whilst costs associated with
 18 complications were sourced from other relevant NICE guidelines if available, or otherwise
 19 from either published papers or based on committee knowledge. No indirect costs were
 20 included in the analysis with these parameters set to 0 in the IQVIA CDM, as the indirect
 21 costs that can be included in the IQVIA CDM fall outside the NICE reference case.
- 22 The values used for resource use and costs are listed in Table HE003 with their relevant
 23 sources. All costs from earlier than 2019/20 were inflated to 2019/20 values using the Unit
 24 Costs of Health and Social Care 2019¹⁵. For the probabilistic analysis values were altered
 25 within a range of plus/minus 10%. Note that IQVIA CDM only allows for a single measure of
 26 variability across all cost parameters.

27 **Table HE003: Management and complication costs**

Input variables	Mean cost per year*	Source/ Comments
Management costs		
Statins	£27.38	Atorvastatin 80 mg tablets x 28 days (unit price: £2.10) - NHS Electronic Drug Tariff June 2021 ¹²
Aspirin	£16.43	Aspirin 75 mg tablets x 28 days (unit price: £1.26) - NHS Drug Electronic Tariff June 2021 ¹²
ACE-I/ARB	£22.84	Weighted (by use as reported by Prescription Cost Analysis data March 2021 ¹³) average costs of: ACE-I/ARB (Source: NHS Electronic Drug Tariff June 2021 ¹²) Enalapril (10mg x 28; Unit price: £7.04) Lisinopril (10mg tablets x 28; Unit price: £1.08) Perindopril arginine (10mg tablets x 30; Unit price: £10.65) Ramipril (10mg tablets x 30; Unit price: £1.42) Candesartan (8mg tablets x 28; Unit price: £1.54) Eprosartan (600mg tablets x 28; Unit price: £18.16) Losartan (50mg tablets x 28; Unit price: £1.45) Telmisartan (40mg tablets x 28; Unit price: £2.69)
Screening for micro-albuminuria	£4.25	Cost of ACR/PCR testing from Kerr et al (2012) ¹⁴ who sourced patient numbers from Quality and

Input variables	Mean cost per year*	Source/ Comments
Screening for gross proteinuria	£4.25	Outcomes Framework (QOF) for General Practice and costs from PSSRU
Stopping ACE-I/ARB due to AEs	£39.23	Assumed as the cost of a GP visit as sourced from unit costs of health and social care 2020 ¹⁵
Eye Screening	£54.37	Local estimate provided via an ophthalmologist involved in the guideline on the 25 th of January 2021 (no published data were available for this parameter).
Annual cost of CVD complications		
MI 1st year	£4,076	NICE Cardiovascular disease risk guideline, CG181 The guideline calculates costs for management of CVD complications during the first 6 months for event states and 1-year post-event states. Costs calculated by using information from NHS Drug Tariff ¹² , procedure costs from NHS Reference costs, PSSRU Unit Costs of Health & Social Care ¹⁵ and the British National Formulary. Assumptions made: 1st year costs were assumed to be cost of first 6 months in event state plus half of 1-year post event state costs. 2nd year costs were assumed to be 1-year post-event state costs. Cost of stroke death within 30 days was assumed to be the cost of a cardiovascular death as reported in CG181. Assumed that one third of angina episodes are stable, and two thirds unstable, based on expert opinion in NG17. This assumption was validated by the committee, with no objections raised. Peripheral arterial disease (PAD) costs from CG181 assumed to be the same as PVD costs.
MI 2nd+ years	£861	
Angina 1st year	£6,999	
Angina 2nd+ years	£315	
CHF 1st year	£3,928	
CHF 2nd+ years	£2,837	
Stroke 1st year	£4,555	
Stroke 2nd+ years	£169	
stroke death within 30 days	£1,283	
PVD 1st year	£1,329	
PVD 2nd+ years	£578	
Renal Complications		
Haemodialysis 1st year	£33,579	Estimate sourced from 2021 update of the NICE chronic kidney disease guideline
Haemodialysis 2nd + years	£33,579	Estimate sourced from 2021 update of the NICE chronic kidney disease guideline
Peritoneal dialysis	£30,209	Estimate sourced from 2021 update of the NICE chronic kidney disease guideline
Peritoneal dialysis 2nd + years	£30,209	Estimate sourced from 2021 update of the NICE chronic kidney disease guideline
Renal transplant (1st year)	£21,012	Estimate sourced from 2021 update of the NICE chronic kidney disease guideline
Renal transplant (2nd year)	£8,332	Estimate sourced from 2021 update of the NICE chronic kidney disease guideline
Acute events		
Non-severe hypoglycaemic events	0	Information from Geelhoed et al ¹⁶ shows that the costs associated with a non-severe hypoglycaemic event (NSHE) are minimal, with only 2.3% of patients experiencing a NSHE contacting a healthcare professional, and a NSHE only resulting in roughly 0.72 additional SMGB tests per week. Hence a cost of 0 was assumed.
Severe hypoglycaemic event	£370	Based on information from Hammer et al ¹⁷ who reported results from 101 T1D patients in the UK.

Input variables	Mean cost per year*	Source/ Comments
		Here direct resource use costs included both in-hospital and outside of hospital (ambulance services, drugs administered, admission and care treatment, follow-up care, attendance by HCP) at the time of SHE and in follow-up (additional doctor visits, SMGB tests, further education in self-management). Unit costs were sourced from country specific and obtained from local health tariffs, formularies, and office for national statistics. The other potential source for hypoglycaemic was a study by Heller et al¹⁸ which reported resource use of severe hypoglycaemic events in 15 phase 3a trials. Given that this study only reported resource used (and not costs) a separate micro costing was needed to identify potential UK specific costs for ambulance, emergency room, non-medical assistance costs, etc. Given a lack of clarity about reliable sources for these costs we decided to use the data from Hammer et al, especially as the committee saw no significant limitations in the study by Hammer et al¹⁷. Note: The IQVIA CDM offers inputs for a second class of severe hypoglycaemic events to account for severe hypoglycaemic events which required medical assistance (if it is decided to keep these separate from events not requiring medical assistance). However, as we have decided to keep severe hypoglycaemic events which required medical assistance and did not require medical assistance in the same category to match the way the cost data were reported, this was kept at 0.
Cost of eye disease		
Laser treatment	£145	NHS Reference Costs 2018/19 Currency code BZ86B - Non-surgical ophthalmology with interventions.
Cataract operation	£927	NHS Reference Costs 2018/19 Currency codes: BZ84A/BZ84B/BZ84C (Phacoemulsification Cataract Extraction and Lens Implant - CC Score 4+, 2-3, 0-1)
Following cataract operation	£203	NHS Reference Costs 2018/19 Currency code: WF01A (Non-admitted face to face attendance, ophthalmology follow-up)
Blindness - year of onset	£7,570	NICE Glaucoma guideline, NG81
Blindness - following years	£7,314	Cost calculated by calculating costs of blind registration, low vision rehabilitation, community care, and residential care. These costs are then multiplied by the proportion of patients experiencing blindness who use these services. .
Cost of neuropathy/ foot-ulcer/ amputation		
Neuropathy 1st year	£37.10	Duloxetine (Zentiva) 60mg x 28 days priced at £2.77 (source: NHS Electronic Drug Tariff ¹²)
Neuropathy 2nd year onwards	£37.10	
Active ulcer	£3,520	Kerr et al (2019) ¹⁹ - The cost of diabetic foot ulcers and amputations to the NHS in England. HES data (2014-15) used to calculate relevant inpatient

Input variables	Mean cost per year*	Source/ Comments
		activity, with costs of these activities calculated using reference costs.
Amputation event	£8,440	NICE Diabetic foot problems guideline, NG19 Amputation costs sourced from NHS reference costs. Amputation event costs calculated by combining amputations with and without major complications by using reported information on the probability an amputation is major.
Post amputation	£25,677	NICE Peripheral arterial disease guideline, CG147 Reported as the annual cost of care in subsequent years. Costs included: care home costs (£986/ week), community care costs (£296/ week), and wheelchair costs.

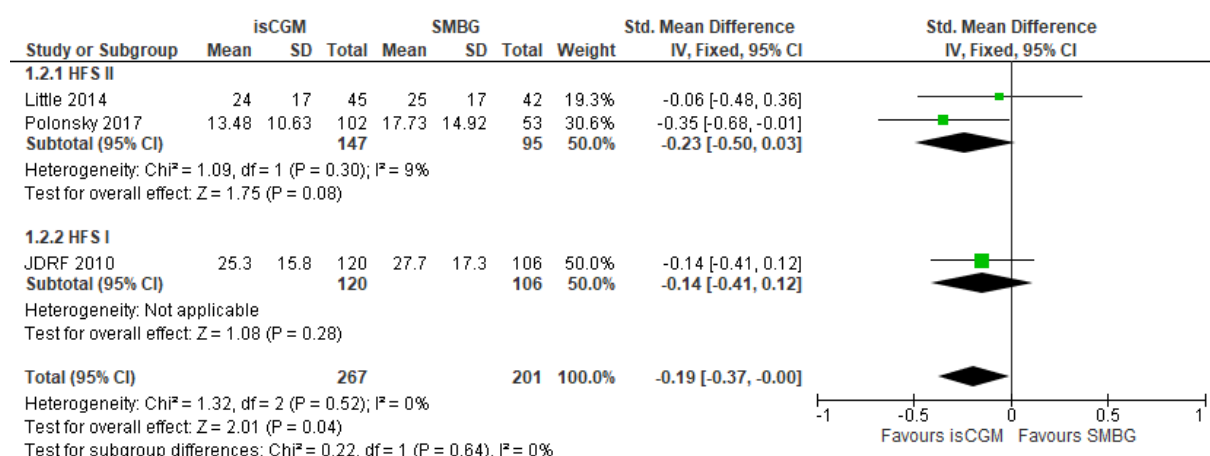
1 *Older costs have been inflated to current prices

HE2.3.22 Quality of life parameters

- 3 Quality of life parameters were set at default IQVIA CDM parameters values, except in the
4 case of the impact on quality of life from severe and non-severe hypoglycaemic events
5 (which were expected to be key drivers of the model).
- 6 Sources for impact of quality of life by severe and non-severe hypoglycaemic events were
7 identified by looking at primary sources for quality-of-life parameters from our systematic
8 review of economic evidence. The most commonly used sources in the literature were
9 studies by Currie et al²⁰ and Evans et al²¹.
- 10 Currie et al²⁰ sourced information from two surveys conducted in 2000 and 2004 among
11 1,305 respondents with diabetes. Impact on quality of life was measured using the EQ-5D
12 instrument with the fear of hypoglycaemia measured using the Hypoglycaemia Fear Survey
13 (HFS). Results were based on a multivariate analysis with pooled data used to explore the
14 relationship between frequency of hypoglycaemic events and fear of hypoglycaemia (HFS
15 values). Then the HFS values in conjunction with other independent variables was used to
16 predict the EQ-5D values. Currie et al²⁰ reported results for severe, symptomatic, and
17 nocturnal hypoglycaemic events with symptomatic events defined as mild or moderate event
18 that did not require external assistance. However, the impact of QoL by nocturnal events
19 were not reported by severity. Therefore, results from this study were not considered to fulfil
20 all the desirable criteria for this analysis.
- 21 Evans et al²¹ performed a web-based time trade-off (TTO) study where respondents are
22 asked to “trade off” a portion of their remaining life span for an improved health state when
23 compared to a hypothetical health state. 8,286 respondents were included from the UK,
24 USA, Canada and Germany, which included 551 type 1 and 1,603 type 2 diabetes patients.
25 Impact on QoL was reported for severe day time, severe nocturnal, non-severe daytime and
26 non-severe nocturnal hypoglycaemic events, with results reported by country. Hence Evans
27 et al reported information on all four categories of hypoglycaemic events required, and was
28 therefore used in our analysis. The IQVIA CDM allows to account for diminishing non-severe
29 hypoglycaemic utility (i.e. that the quality of life loss associated with having 2 non-severe
30 hypoglycaemic events is less than twice the loss associated with 1 non-severe event) and for
31 this information from Lauridson et al²² was used as it was based on the same data set as
32 Evans et al²¹.
- 33 A direct utility benefit associated with using a isCGM device is included in the model, with the
34 utility data derived from Matza et al²³, which aimed to quantify the ‘process utility’ associated
35 with isCGM compared with SMBG (i.e. the direct quality of life benefits from using isCGM,

based on people's preferences for using the device, over and above the benefits from improved clinical outcomes such as HbA1c and hypoglycaemic events). In time trade-off interviews, the researchers asked general population participants in the United Kingdom (London and Edinburgh) to value health states that were drafted and refined on the basis of literature, clinician input and a pilot study. The health states had identical descriptions of diabetes and insulin treatment, differing only in glucose monitoring approach. This study showed a small but measurable utility benefit for isCGM. No similar study is available for continuous glucose monitoring. However, the committee were confident that the same 'process utility' benefits would occur for rtCGM as for flash, and felt it was reasonable to assume the same benefit to isCGM.

For rtCGM, an additional utility benefit associated with reduced fear of hypoglycaemia (FoH) was also considered, assessed by the Hypoglycaemia Fear Survey (HFS). The HFS was first developed in 1987 for adults with type 1 diabetes and has been significantly revised in the following years to be the HFS-II. Both surveys consist of two subscales: 1) Behaviour (HFS-B) that measures behaviours to prevent low blood glucose; 2) Worry (HFS-W) that measures the hypoglycaemia fear. The utility value was derived only from the worry subscale measured by the HFS and then mapped to the EQ-5D based on a published study²⁴. The meta-analysis included three studies identified from the clinical review that compared fear of hypoglycaemia between rtCGM and SMBG based on HFS-I and HFS-II surveys^{25,26,27} (see the forest plot below).



Another study that adopted the Swedish version of the HFS survey was excluded since the average response values appeared to be quite different from the other two studies, and it was unclear how this questionnaire differed from the English language version²⁸. Since the included studies measured the fear of hypoglycaemia using different versions of HFS questionnaires, standardised mean differences (SMD) were used to transform the results to a uniform scale before combining them in the meta-analysis. SMD expresses the difference in means as a proportion of the standard deviation, so that we can combine measures that were based on different scales measuring the same underlying construct. We then converted the results from meta-analysis back to mean differences based on the HFS-I scale using the pooled standard deviation calculated from the study that used the HFS-I questionnaire. The underlying reason is that the mapping study used HFS-I survey to attach utility values based on the EQ-5D questionnaire, and therefore all the values ultimately needed to be on the HFS-1 scale. It was noted that whilst FoH was an important issue for people with diabetes, there was a potential issue with double counting utility gains when this was included (utility gains associated with hypoglycaemic events may capture some of the FoH as well). Therefore, two versions of the base-case analysis were conducted for the rtCGM – one with the utility gains associated with the reduction in FoH included, and one with them excluded.

No equivalent fear of hypoglycaemia data were available for isCGM, and therefore no equivalent analysis including this benefit was undertaken for isCGM.

1 **Table HE004: Quality of life values**

Input variables	Mean utility	Se	Source/ Comment
No complications	0.839	0.0048	Default value in IQVIA CDM which was sourced from Peasgood et al. ²⁹
Disutility of MI event	-0.055	0.005	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ Within this systematic review, these relevant parameters were sourced from Clarke et al. ³¹ . QoL post MI was assumed to be baseline utility minus disutility of MI from Beaudet et al. ³⁰ A similar calculation was done to obtain QoL post stroke and post amputation.
Utility post MI	0.784	0.007	
Utility CHF	0.6770	0.01	
Disutility of Stroke event	-0.164	0.008	
Utility post Stroke event	0.675	0.009	
Disutility amputation event	-0.280	0.011	
Utility post amputation	0.559	0.012	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ . Within this systematic review, these relevant parameters were sourced from Bagust et al. ³²
Utility PVD	0.7240	0.008	
Utility gross proteinuria	0.7370	0.008	
Utility neuropathy	0.7010	0.008	
Disutility of ulcer	-0.1700	0.0189	
Utility haemodialysis	0.6210	0.029	
Utility peritoneal dialysis	0.5810	0.03	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ . Within this systematic review, these relevant parameters were sourced from Wasserfallen et al. ³³
Utility background diabetic retinopathy (BDR)	0.7450	0.021	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ . Within this systematic review, these relevant parameters were sourced from Fenwick et al. ³⁴
Utility BDR wrongly treated	0.7450	0.022	
Utility macular edema	0.7450	0.021	
Utility renal transplant	0.7620	0.118	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ . Within this systematic review, these relevant parameters were sourced from Kiberd et al. ³⁵
Utility cataract	0.7690	0.016	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ . Within this systematic review, these relevant parameters were sourced from Lee et al. ³⁶
Utility proliferative diabetic retinopathy (PDR) laser treatment	0.7150	0.022	Default value in IQVIA CDM which was sourced from a systematic review by Beaudet et al. ³⁰ .
Utility PDR no laser	0.7150	0.022	
Utility angina	0.6950	0.01	
Utility microalbuminuria	0.7850	0.007	
Disutility NSHE daytime	-0.005	0.00077	UK patients from a TTO survey in five countries (UK, USA, Canada, Germany & Sweden) from Evans et al. ²¹ . This study was based hypothetical health states, with the description of health states to all
Disutility NSHE nocturnal	-0.008	0.00102	
Disutility SHE daytime	-0.062	0.00433	

Input variables	Mean utility	Se	Source/ Comment
Disutility SHE nocturnal	-0.066	0.00485	respondents (T1D, T2D and non-diabetic) being the same (meaning even people with T1D were not asked to report on how bad their own events are, but how bad it would be to suffer the hypothetical event described). It should be noted that this approach leads to larger estimates of QoL loss than when people are asked to rate their own events (mainly due to adaptation effects – people tend to get used to the events they suffer and so how bad they feel they are can reduce over time, even if the events themselves are just as bad). The descriptions of these health states were derived from a survey of 247 UK patients with diabetes. Hence given that all respondents answered the TTO survey based on the described hypothetical health states, no differences should be assumed between categories of patients. A more important distinction to make is that of results between specific countries, given the differences in the perception of a full health states between countries. Hence given that this analysis is done for a UK population, the UK specific value set was used. Note that the lower CI for NSHE nocturnal was reported as 0.06 which was assumed to be an error, and 0.006 was used when calculating the standard error
Disutility for 1 unit increase in BMI above 25 kg/m ²	-0.0061	n/a	Default value in IQVIA CDM - sourced from Bagust et al ³²
Utility gain of using isCGM (direct utility benefit)	0.03	n/a	Matza et al ²³ .
Utility gain of using rtCGM (direct utility benefit)	0.03	n/a	Committee assumption
Utility gain related with the reduced fear of hypoglycaemia (rtCGM)	0.02536	n/a	Clinical review

HE2.3.3 Treatments

HE2.3.321 Treatment effects of glucose monitoring devices

3 Treatment effects for the outcomes listed below were based on the meta-analyses performed
4 as part of the clinical evidence review for this topic (see appendices F and G of the evidence
5 review for the guideline update).

6 Reduction in HbA1c levels

7 The reduction in HbA1c levels, calculated as the mean change from baseline are listed in
8 Table HE005. The mean change for SMBG was taken from the [economic modelling](#)
9 undertaken for comparing different insulin therapies, using the numbers estimated for

detemir twice daily insulin, as that was the primary treatment recommended in the guideline. The committee noted it was unlikely that the cost-effectiveness of different monitoring techniques would change considerably based on differences in the underlying insulin regimen used, as the benefits of rtCGM and isCGM would be expected to accrue for all insulin regimens. Some of the studies included participants using continuous subcutaneous insulin infusion, but the committee agreed it was appropriate to model a population of people starting with multiple daily insulin injections, since this is how most people with type 1 diabetes start treatment, and therefore represents the point at which the initial decision on whether to offer automated blood glucose monitoring needs to be made.

The estimated differences between SMBG and rtCGM and isCGM were then applied to this baseline value for SMBG to estimate changes from baseline in HbA1c for rtCGM and isCGM (no difference was found in HbA1c between isCGM and SMBG). All studies with a follow-up of longer than three months were included as part of this calculation, regardless of the type of insulin being used. Full details of the analyses from which these values were derived are given in appendix F and G of the guideline evidence review.

Table HE005: Reduction in HbA1c levels

Treatments	Change in HbA1c	Se	Source
rtCGM	-0.8344	0.0638	Clinical review
isCGM	-0.4544	0.1174	Clinical review (no difference found in review)
SMBG	-0.4544	0.1174	Insulin guideline NG17: Detemir twice daily

Severe hypoglycaemic events

As for modelling HbA1c values, rates of severe hypoglycaemia for the SMBG arm of the model were taken from the [economic modelling](#) undertaken for comparing different insulin therapies, using the numbers estimated for detemir twice daily insulin.

Severe hypoglycaemic event rates for the rtCGM arm were calculated by applying the relative risks obtained from the meta-analysis of severe hypoglycaemic events in the clinical evidence review to the rate of severe hypoglycaemic events in the SMBG arm. To apply the relative risk to annualised rate data, the rates first need to be converted to probabilities at one year, the relative risk applied, and then the number converted back to a rate. The clinical review excludes the Riveline et al³⁷ study from the meta-analysis of severe hypoglycaemic events rates due to differences in the inclusion criteria for that study (in particular, it recruited a population of people with poorly controlled diabetes at baseline). A sensitivity analysis was also conducted including that study as part of the meta-analysis (see the section on sensitivity analyses below).

Severe hypoglycaemic event rates for the isCGM arm were based on Bolinder et al³⁸, the only study included in the clinical review that reported data on hypoglycaemia for isCGM versus SMBG in people with type 1 diabetes. The study reported the number of events when glucose fell below various threshold values. As a proxy for severe hypoglycaemia, an outcome of sensor glucose values <2.2mmol/L (40 mg/dL) per 24-hour period was used. The number of times per day that glucose fell below this threshold reduced for both study groups but the extent of reduction was greater for the isCGM group, representing a statistically significant ($p<0.0001$) 55% reduction in the number of events when participants' glucose levels fell in this hypoglycaemic range compared with the SMBG group.

Severe hypoglycaemic event rates (per 100 patient years) used in the base-case analysis are listed in table HE006.

Table HE006: Severe hypoglycaemic event rates

Treatments	Event rate (per 100 patient years)
rtCGM	18.55
isCGM	13.5765
SMBG	30.17

Non-severe hypoglycaemic events

As for modelling HbA1c and severe hypoglycaemia, rates of non-severe hypoglycaemia for the SMBG arm of the model were taken from the [economic modelling](#) undertaken for comparing different inulin therapies, using the numbers estimated for detemir twice daily insulin.

Non-severe hypoglycaemic events for rtCGM were mostly reported as mean differences in number of events (usually defined as sensor glucose values <3.9mmol/L [70 mg/dL]). Therefore, to estimate a percentage reduction in events, a meta-analysis was conducted for the SMBG arms of the rtCGM trials, to estimate a baseline rate of hypoglycaemic events, and the reduction in numbers of events with rtCGM was then applied to estimate a percentage reduction in events (estimated at 21.5%).

Non-severe hypoglycaemic event rates for the isCGM arm were based on Bolinder et al³⁸, the only study included in the clinical review that reported data on hypoglycaemia for isCGM versus SMBG in people with type 1 diabetes. The study reported number of events when glucose fell below various threshold values. As a proxy for non-severe hypoglycaemia, an outcome of sensor glucose values <3.9mmol/L (70 mg/dL) was used. The number of times per day that glucose fell below this threshold reduced for both study groups but the extent of reduction was greater for the isCGM group, representing a statistically significant ($p<0.0001$) 25.8% reduction in the number of events when participants' glucose levels fell in this hypoglycaemic range compared with the SMBG group.

Non-severe hypoglycaemic event rates (per 100 patient years) used in the base-case analysis are listed in table HE007.

Table HE007: Non-severe hypoglycaemic event rates

Treatments	Event rate (per 100 patient years)
rtCGM	2053.902
isCGM	1941.688
SMBG	2616.83

Nocturnal hypoglycaemic events

The clinical evidence review found no strong evidence to suggest the proportion of nocturnal hypoglycaemic events differs based on the type of monitoring used. Thus, if a device reduces the amount of hypoglycaemic events, it is likely to reduce both daytime and nocturnal events by approximately the same proportion, and therefore a single proportion of nocturnal events was applied across all the treatment arms. This proportion (13.96%) was taken from the [economic modelling](#) undertaken for comparing different insulin therapies, using the numbers estimated for detemir twice daily insulin.

HE2.3.32 Treatment algorithm

The IQVIA CDM allows to define a treatment algorithm for each intervention in the event of treatment failure. Given the lack of evidence of differences between glucose monitoring methods with regard to the discontinuation of treatments, no treatment failure was assumed in this analysis.

HE2.3.313 Treatment costs**2 Monitoring device costs**

3 We derived the cost for isCGM from NHS England's national arrangements³⁹, which outline
4 the cost to the NHS of isCGM glucose monitoring. The cost of each sensor is £35 and each
5 lasts two weeks. The annual cost is therefore 26 x £35 = £910.

6 For rtCGM, our base case assumes an annual cost of £2,000. This is the ceiling price listed
7 in the NHS England and NHS Improvement funding document (September 2020)⁴⁰. This
8 ceiling price is only directly applicable for pregnant women, but the committee agreed that it
9 was a reasonable proxy for the prices that may be paid for rtCGM for non-pregnant
10 population as well, assuming rtCGM was widely rolled out for people with type 1 diabetes.
11 This cost is also similar to the costs estimated when individual rtCGM devices are considered
12 (for example, Roze et al². estimated an annual cost of £1,850 for rt-CGM).

13 Table HE008: Annual costs of monitoring approaches

Treatments	Cost
isCGM	£910
rtCGM	£2000

14

15 SMBG costs

16 In the absence of a glucose monitoring device, SMBG is the sole method used to determine
17 blood glucose levels. When a device is used, some self-monitoring will still be required.
18 The model estimates SMBG costs by multiplying the daily frequency of self-monitoring by the
19 unit cost of strips and lancets (£0.26 combined). We obtained this cost from the average of
20 all the strips and lancets reported as first-line diabetic equipment in the NHS Electronic Drug
21 Tariff¹².

22 We identified data regarding frequency of SMBG among people with type 1 diabetes from
23 previous literature, shown in Table HE011. The committee advised that although the
24 following numbers reflect the average frequency in SMBG use among T1DM people, there
25 might be some variations since some tend to use SMBG more often than others. We account
26 for the uncertainty in SMBG use in the sensitivity analyses described below.

27 Table HE009: SMBG resource use

Parameter name	Value (95% CI)	Source
Daily self-monitoring		
SMBG	4.6	Roze et al ² .
isCGM	0.46	Healthcare Improvement Scotland ¹
rtCGM	0.15	Roze et al ² .

HE2.314 Clinical

29 The clinical module with the IQVIA CDM contains data that describes the natural history of
30 diseases. Default parameters for the type 1 diabetes were used in this module. The clinical
31 parameters and the clinical progression parameters (transitional probabilities) used in the
32 default version for type 1 diabetes patients are explained in more detail in the IQVIA CDM
33 manual.

34 Whilst default parameters in the clinical module were used, decision relating to the clinical
35 module were required to be made across other modules. Decisions to be made in the
36 treatment module included choosing the progression equations for HbA1c, systolic blood
37 pressure, diastolic blood pressure, total cholesterol, LDL, HDL, triglycerides, BMI, eGFR and

- 1 waste to hip ratio in the treatment module (in our analysis the clinical database option which
 2 was the only to source information from a type 1 diabetes population was used), and risk
 3 adjustments for statins and ACE-I/ARB were used (selected option “yes”).

HE2.3.5 Other management

- 5 Table HE012 lists the input parameters used for proportions of patients who were managed
 6 for various chronic and recurrent conditions.

7 Table HE010: Other management parameters

Input parameter	Mean	Source/ comments
Concomitant medications		
Proportion on aspirin for primary prevention	0.59	Sourced from EUROASPIRE II Study group and Kotseva et al
Proportion on statins for primary prevention	0.474	
Proportion on ACE-inhibitors for primary prevention	0.213	
Proportion on aspirin for secondary prevention	0.887	Sourced from Kotseva et al
Proportion on statins for secondary prevention	0.841	
Proportion on ACE-inhibitors for secondary prevention	0.755	
Screening and patient management proportions		
Proportion screened for eye disease	1.00	No UK data, assumed to be standard management, in line with the UK diabetes eye screening programme
Proportion screened for renal disease	1.00	Assumed as recommended by NICE CG66, and should reflect current practice
Proportion receiving intensive insulin after MI	1.00	Sourced from Bydureon NICE TA submission
Others		
Sensitivity of eye screening	80%	Sourced from Lopes-Bastida 2007
Specificity of eye screening	97%	
Sensitivity of gross proteinuria screening	85%	
Sensitivity of micro albuminuria screening	75%	Sourced from Cortes-Sanabria 2006
Specificity of micro albuminuria screening	97%	

HE2.4 Sensitivity analyses

- 9 No evidence was identified from the clinical review suggesting differences in treatment
 10 effectiveness in different patient subgroups (for example by ethnicity or age) and therefore no
 11 sensitivity analyses were conducted looking at these subpopulations.

HE2.41 Deterministic sensitivity analyses

- 2 A number of deterministic sensitivity analyses were performed to test for the robustness of
 3 our base case results, and they were conducted under the base case scenario for both
 4 rtCGM (with utility gains from reduced fear of hypoglycaemia) and isCGM. These scenarios
 5 were:
- 6 1. **Diabetes duration:**
 7 Duration of diabetes was set to 0 to mimic a type 1 diabetes population at initial
 8 diagnosis. Information with regard to age, gender, ethnicity and proportion of smokers
 9 in a type 1 diabetes population at initial diagnosis was obtained from the National
 10 diabetes audit.
 - 11 12 2. **Time horizon:**
 13 Reducing the time horizon on the analysis from lifetime (80 years) to 1 year, 10 years
 14 and 25 years.
 - 15 16 3. **HbA1c progression approach:**
 17 In the base analyses, it was assumed that the difference in HbA1c levels between
 18 rtCGM/isCGM and SMBG arms remained constant over time. In sensitivity analyses,
 19 the UKPDS progression approach was adopted, assuming that the difference in
 20 HbA1c between study arms reduced over time.
 - 21 22 4. **Higher daily usage of SMBG**
 23 A higher frequency of SMBG (10 times per day) was assumed for both the SMBG
 24 arm (10 times per day) and rtCGM/isCGM arms (3 times per day) to represent a
 25 subgroup of people who use a substantial amount of SMBG, even when using other
 26 monitoring devices (for example, people who continue to test at meal times).
 - 27 28 5. **Higher severe hypoglycaemic event rate in the rtCGM arm by including Riveline**
 29 **et al. 2020**
 30 After including the Riveline et al. 2020, the meta-analysis gives a higher estimate of
 31 severe hypoglycaemic events in the rtCGM arm, at a level of 25.36 per 100 patient
 32 years.
 - 33 34 6. **Lower/Higher annual cost of rtCGM**
 35 Based on discussions with the committee and providers, the annual cost was lowered
 36 to £1,600 per year to represent a potential price decrease in the future with
 37 widespread use of rt-CGM across NHS England, and was increased to £3,000 per
 38 year to represent an upper bound assuming the full prices in the NHS supply chain
 39 catalogue are paid, with no discounts, for individuals requiring the full technology (i.e.
 40 people requiring a receiver device as they do not have a smartphone that can fulfil
 41 this function).

HE2.42 Probabilistic sensitivity analyses

- 43 The IQVIA CDM allows for a probabilistic analysis to account for the uncertainty surrounding
 44 the model input parameters listed above. The probability distributions around each parameter
 45 are set by default in the IQVIA CDM, as explained in the document available in the IQVIA
 46 CDM website. When the probabilistic version of the model is run, values are randomly
 47 selected simultaneously for each model input parameter from its respective probability
 48 distribution. These values are then used to calculate the respective costs and QALYs. This
 49 was repeated 1,000 times (1,000 bootstraps) for the base case, and then mean costs and
 50 QALYs calculated across those samples.

- 1 The following variables were left deterministic, due to the IQVIA CDM not accounting for
2 uncertainty surrounding them:
- 3 • Costs of monitoring devices
 - 4 • The cost-effectiveness threshold (defined as fixed by NICE)
- 5 Note that the deterministic version of IQVIA CDM also has an element of stochastic
6 variability in it due to a baseline cohort of 1,000 patients being simulated to run the economic
7 analysis on.

HE3 Results

HE3.1 Base-case cost–utility results

There are two versions for the base case analyses: scenario 1 does not include the additional utility benefit associated with reduced fear of hypoglycaemia (FoH), while scenario 2 does include this benefit. The committee noted that because isCGM was already found to be clearly cost-effective without the inclusion of this additional benefit, it was unnecessary to run a version of the model including this benefit for isCGM (given the lack of data on fear of hypoglycaemia with isCGM monitoring).

The base case results in scenario 1 (Table HE011) showed that isCGM was a cost-effective treatment compared with SMBG under a threshold of £20,000 per QALY, while rtCGM only appeared cost effective at the £30,000 threshold. In scenario 2 rtCGM was cost-effective compared with SMBG at a threshold of £20,000 per QALY.

Table HE012: Base-case deterministic cost–utility results (without utility benefits associated with reduced FoH)

Treatments	Absolute		Incremental		
	Costs (£)	QALYs	Costs (£)	QALYs	ICER (vs SMBG)
SMBG	52,979	11.641			
rtCGM	75,668	12.569	22,688	0.928	24,436
isCGM	61,156	12.446	8,177	0.805	10,157

Table HE013: Base-case deterministic cost–utility results (with utility benefits associated with reduced FoH)

Treatments	Absolute		Incremental		
	Costs (£)	QALYs	Costs (£)	QALYs	ICER (vs SMBG)
SMBG	52,979	11.641			
rtCGM	75,668	13.028	22,688	1.388	16,351

HE3.2 Deterministic sensitivity analyses

Results of the sensitivity analyses performed are shown in Tables HE014 and HE015. isCGM remained cost-effective at a threshold of £20,000 per QALY except when changing the HbA1c progression method. rtCGM (based on the analysis including fear of hypoglycaemia) was mostly cost-effective at £20,000 per QALY except when reducing the time horizon to one year, changing the HbA1c progression approach and increasing the price of rtCGM to £3,000 per year. However, the ICERs of rtCGM in these scenarios were still below the £30,000 per QALY threshold. The committee agreed the analysis with reducing benefit of CGM over time was not particularly concerning, as unlike with a drug there was no clinical reason to expect the benefits of rtCGM would reduce over time, provided a person continued to make use of the device.

Table HE016: Summary findings of sensitivity analyses (rtCGM vs. SMBG)

Sensitivity analyses	Costs		QALYs		ICER (vs SMBG)
	rtCGM	SMBG	rtCGM	SMBG	
New onset diabetes	123,658	101,985	15.79	14.14	13,103

Sensitivity analyses	Costs		QALYs		ICER (vs SMBG)
	rtCGM	SMBG	rtCGM	SMBG	
Time horizon 1 year	2,303	823	0.75	0.69	22,968
Time horizon 10 year	22,771	10,760	6.14	5.56	20,834
Time horizon 25 year	54,761	34,861	11.07	9.97	18,091
HbA1c progression UKPDS approach	84,729	52,979	12.73	11.64	29,152
Higher SMBG use	80,653	62,179	13.03	11.64	13,249
Higher SHE rate in rtCGM	76,114	52,979	12.95	11.64	17,630
Lower annual cost for rtCGM: £1,600	75,668	52,979	13.03	11.64	16,351
Higher annual cost for rtCGM: £3,000	93,769	52,979	13.03	11.64	29,396

Table HE017: Summary findings of deterministic sensitivity analyses (isCGM vs. SMBG)

Sensitivity analyses	Costs		QALYs		ICER (vs SMBG)
	isCGM	SMBG	isCGM	SMBG	
New onset diabetes	111,860	101,985	15.11	14.14	10,159
Time horizon 1 year	1,263	823	0.73	0.69	10,162
Time horizon 10 year	14,466	10,760	5.93	5.56	10,159
Time horizon 25 year	41,736	34,861	10.65	9.97	10,156
HbA1c progression UKPDS approach	67,075	52,979	12.28	11.64	22,014
Higher SMBG use	65,484	62,180	12.45	11.64	4,104

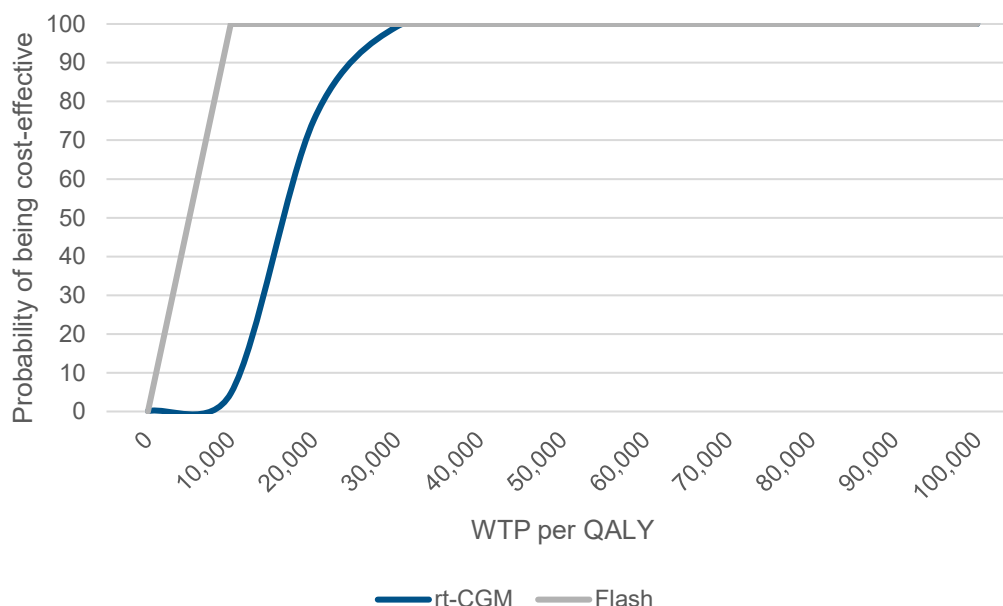
HE3.3 Probabilistic sensitivity analysis

Probabilistic sensitivity results were reported below in tables HE018, and the cost-effectiveness acceptability curves (CEAC) are shown in figure HE001. Both rtCGM and isCGM were cost-effective in probabilistic sensitivity analyses. If the threshold exceeded £30,000 per QALY, both devices appeared to be cost-effective compared with the SMBG. With a lower threshold value at £20,000 per QALY, isCGM remained consistently cost-effective while the probability of rtCGM being cost-effective was around 75%.

Table HE019: Summary findings of probabilistic sensitivity analyses

Treatments	Absolute		Incremental		ICER (vs SMBG)
	Costs (£)	QALYs	Costs (£)	QALYs	
SMBG	59,177	11.035			
rtCGM	80,584	12.306	21,406	1.271	16,846
isCGM	66,868	11.792	7,691	1.186	10,155

Figure HE002: Cost-effectiveness acceptability curve in probabilistic sensitivity analyses



HE3.4 Discussion

HE3.4.1 Principal findings

In the base analysis where the utility gains associated with reduced FoH were not considered, isCGM was cost effective compared with SMBG at a threshold of £20,000 per QALY, while rtCGM was only cost-effective at a threshold of £30,000 per QALY. When incorporating utility gains from reduced fear of hypoglycaemia for the rtCGM arm, it also became cost-effective compared with SMBG at a threshold of £20,000 per QALY. The cost-effectiveness results were mostly robust across different scenarios except when limiting the time horizon to one year, changing the HbA1c progression approach and increasing the rtCGM price to £3,000 per year. However, under a threshold of £30,000 per QALY, both devices are cost-effective across all scenarios.

HE3.4.2 Weaknesses of the analysis

As common with economic analysis of this nature, there was uncertainty around the model input parameters. Therefore, a number of deterministic and probabilistic sensitivity analyses were conducted along with two versions of base case scenarios. Flash remained cost-effective across all scenarios, while rtCGM was likely to be cost-effective in the majority of the cases.

In our analysis the baseline factors were sourced from various UK specific sources. However, the lack of a single data source to obtain all baseline risk factors meant that covariances between baseline risk factors could not be accounted for. This particularly hampered our sensitivity analysis among newly diagnosed diabetes people where in an ideal situation all associated baseline risk factors would have changed through associated covariances once the baseline risk factor specific to this subgroup was changed.

When sourcing data of model input parameters, an attempt was made to include data applicable to a type 1 diabetes population where appropriate. However, in some cases data from type 2 populations had to be used due to a lack of reliable type 1 data sources. This included the data sources from impact on quality of life from long-term diabetes related

1 complications. These data sources were however checked with committee who advised that
2 the impact on quality of life from long-term diabetes related complications are unlikely to
3 change between type 1 and type 2 patients.

HE3.4.3 Comparison with other CUAs

5 The literature review of economic evidence identified 2 CUAs in the context of the UK, one
6 for isCGM and one for rtCGM. There were a number of differences between our study and
7 previous literature. Healthcare Improvement Scotland¹ used a simple two-stage model
8 structure that consisted of alive and death. The study only accounted for hypoglycaemic
9 events and did not consider HbA1c levels as the health outcome. Roze et al² also used
10 CORE diabetes model, but their clinical estimates were withdrawn from a single trial. Despite
11 these differences in modelling and data source, our results were consistent with both studies
12 that showed rtCGM and isCGM devices are cost effective compared with SMBG for people
13 with type 1 diabetes.

HE3.4.5 Conclusions

15 Our economic analysis was based on information from the systematic review of current
16 clinical evidence and a range of other model input parameters including costs and quality of
17 life which were sourced following input from the committee. A number of deterministic and
18 probabilistic sensitivity analyses were considered to account for uncertainty surrounding the
19 model inputs.

20 isCGM was cost-effective compared with SMBG at a threshold of £20,000 per QALY, while
21 rtCGM was only cost-effective when incorporating utility gains from reduced fear of
22 hypoglycaemia in the economic models. Results remained robust across the majority of
23 sensitivity analyses, except when reducing the time horizon to one year, changing the HbA1c
24 progression approach and increasing the rtCGM price to £3,000 per year. However, at a
25 threshold of £30,000 per QALY, both types of devices are cost-effective across all scenarios.

26

HE4 References

- 2 1. Healthcare Improvement Scotland. "What is the clinical and cost effectiveness of
3 Freestyle Libre flash glucose monitoring for patients with diabetes mellitus treated
4 with intensive insulin therapy? What is an evidence note?". SHTG Advice on health
5 technologies: In response to an enquiry from the Scottish Diabetes Group (SDG).
6 2018.
- 7 2. Roze, S., et al. "Long-term cost-effectiveness of dexcom G6 real-time continuous
8 glucose monitoring versus self-monitoring of blood glucose in patients with type 1
9 diabetes in the U.K." *Diabetes care* 2020; 43(10): 2411-2417.
- 10 3. McEwan P, Foos V, Palmer JL, Lamotte M, Lloyd A, Grant D. Validation of the IMS
11 CORE diabetes model. *Value Health* 2014;17(6):714-724.
- 12 4. Palmer AJ, Roze S, Valentine WJ, et al. The CORE Diabetes Model: projecting long-
13 term clinical outcomes, costs and costeffectiveness of interventions in diabetes
14 mellitus (types 1 and 2) to support clinical and reimbursement decision-making.
15 *Current Medical Research and Opinion*. 2004;20(sup1):S5-S26.
- 16 5. NHS Digital. National Diabetes Audit (NDA) 2019-20 Type 1 Diabetes report –
17 Supporting Information. Published online 12th August 2021. [https://digital.nhs.uk/data-
18 and-information/publications/statistical/national-diabetes-audit/national-diabetes-
19 audit-2019-20-type-1-diabetes](https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-audit/national-diabetes-audit-2019-20-type-1-diabetes).
- 20 6. Heller S, White D, Lee E, et al. A cluster randomised trial, cost-effectiveness analysis
21 and psychosocial evaluation of insulin pump therapy compared with multiple
22 injections during flexible intensive insulin therapy for type 1 diabetes: the REPOSE
23 Trial. *Health Technology Assessment*. 2017; 21(20):1-278.
- 24 7. The ACCORD Study Group. Effects of Intensive Blood-Pressure Control in Type 2
25 Diabetes Mellitus. *N Engl J Med* 2009; 362:1575-1585.
- 26 8. Hayes AJ, Leal J, Gray AM, Holman RR, Clarke PM. UKPDS outcomes model 2: a
27 new version of a model to simulate lifetime health outcomes of patients with type 2
28 diabetes mellitus using data from the 30 year United Kingdom Prospective Diabetes
29 Study: UKPDS 82. *Diabetologia* 2013; 56(9):1925-33.
- 30 9. Aaron R. Folsom et al. Prediction of Coronary Heart Disease in Middle-Aged Adults
31 With Diabetes. *Diabetes Care* 2003; 26(10): 2777–2784.
- 32 10. NHS Digital. Health Survey for England 2017 & 2018. Published online 4th December
33 2018 & 3rd December 2019. [https://digital.nhs.uk/data-and-
34 information/publications/statistical/health-survey-for-england](https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england)
- 35 11. World Health Organisation. Global status report on alcohol and health 2018.
36 Published online 2018.
37 [https://apps.who.int/iris/bitstream/handle/10665/274603/9789241565639-
38 eng.pdf?ua=1&ua=1](https://apps.who.int/iris/bitstream/handle/10665/274603/9789241565639-eng.pdf?ua=1&ua=1)
- 39 12. National Health Service. Electronic Drug Tariff. Published 2021. Accessed June 22,
40 2021. <https://www.drugtariff.nhsbsa.nhs.uk/#/00157519-FA/FA00157076/>
- 41 13. National Health Service. Prescription Cost Analysis (PCA) data March 2021.
42 Published online 2021. [https://www.nhsbsa.nhs.uk/prescription-data/dispensing-
43 data/prescription-cost-analysis-pca-data](https://www.nhsbsa.nhs.uk/prescription-data/dispensing-data/prescription-cost-analysis-pca-data)
- 44 14. Kerr M, Bray B, Medcalf J, O'Donoghue DJ, Matthews B. Estimating the financial cost
45 of chronic kidney disease to the NHS in England. *Nephrol Dial Transplant*.
46 2012;27(suppl_3):iii73-iii80.
- 47 15. Personal Social Services Research Unit. Unit Costs of Health and Social Care 2020.
48 Published online 2020. <https://www.pssru.ac.uk/project-pages/unit-costs/>
- 49 16. Geelhoed-Duijvestijn PH, Pedersen-Bjergaard U, Weitgasser R, Lahtela J, Jensen
50 MM, Östenson C-G. Effects of patient-reported non-severe hypoglycemia on
51 healthcare resource use, work-time loss, and wellbeing in insulin-treated patients with
52 diabetes in seven European countries. *J Medical Economics*. 2013;16(12):1453-
53 1461.

- 1 17. Hammer M, Lammert M, Mejías SM, Kern W, Frier BM. Costs of managing severe
2 hypoglycaemia in three European countries. *Journal of Med Economics*.
3 2009;12(4):281-290.
- 4 18. Heller SR, Frier BM, Hersløv ML, Gundgaard J, Gough SCL. Severe hypoglycaemia
5 in adults with insulin-treated diabetes: impact on healthcare resources. *Diabet Med*.
6 2016;33(4):471-477.
- 7 19. Kerr M, Barron E, Chadwick P, et al. The cost of diabetic foot ulcers and amputations
8 to the National Health Service in England. *Diabet Medicine*. 2019;36(8):995-1002.
- 9 20. Currie CJ, Morgan CL, Poole CD, Sharplin P, Lammert M, McEwan P. Multivariate
10 models of health-related utility and the fear of hypoglycaemia in people with diabetes.
11 *Curr Med Res Opin*. 2006;22(8):1523-1534.
- 12 21. Evans M, Khunti K, Mamdani M, et al. Health-related quality of life associated with
13 daytime and nocturnal hypoglycaemic events: a time trade-off survey in five
14 countries. *Health Quality of Life Outcomes*. 2013;11(1):90.
- 15 22. Lauridsen JT, Lønborg J, Gundgaard J, Jensen HH. Diminishing marginal disutility of
16 hypoglycaemic events: results from a time trade-off survey in five countries. *Quality*
17 *Life Research*. 2014;23(9):2645-2650.
- 18 23. Matza, L. S., Stewart, K. D., Davies, E. W., Hellmund, R., Polonsky, W. H., & Kerr, D..
19 Health State Utilities Associated with Glucose Monitoring Devices. *Value in Health*.
20 2017;20(3):507-511.
- 21 24. Currie, C. J., Morgan, C. L., Poole, C. D., Sharplin, P., Lammert, M., & McEwan, P..
22 Multivariate models of health-related utility and the fear of hypoglycaemia in people
23 with diabetes. *Current Medical Research and Opinion*. 2006;22(8):1523-1534.
- 24 25. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study
25 Group, Beck RW, Lawrence JM, Laffel L, Wysocki T, Xing D, Huang ES, Ives B,
26 Kollman C, Lee J, Ruedy KJ, Tamborlane WV. Quality-of-life measures in children
27 and adults with type 1 diabetes: Juvenile Diabetes Research Foundation Continuous
28 Glucose Monitoring randomized trial. *Diabetes Care*. 2010 Oct;33(10):2175-7.
- 29 26. Little SA, Leelarathna L, Walkinshaw E, Tan HK, Chapple O, Lubina-Solomon A,
30 Chadwick TJ, Barendse S, Stocken DD, Brennand C, Marshall SM, Wood R, Speight
31 J, Kerr D, Flanagan D, Heller SR, Evans ML, Shaw JA. Recovery of hypoglycemia
32 awareness in long-standing type 1 diabetes: a multicenter 2 × 2 factorial randomized
33 controlled trial comparing insulin pump with multiple daily injections and continuous
34 with conventional glucose self-monitoring (HypoCOMPaSS). *Diabetes Care*. 2014
35 Aug;37(8):2114-22.
- 36 27. Polonsky WH, Hessler D, Ruedy KJ, Beck RW; DIAMOND Study Group. The Impact
37 of Continuous Glucose Monitoring on Markers of Quality of Life in Adults With Type 1
38 Diabetes: Further Findings From the DIAMOND Randomized Clinical Trial. *Diabetes*
39 *Care*. 2017 Jun;40(6):736-741.
- 40 28. Lind M, Polonsky W, Hirsch IB, Heise T, Bolinder J, Dahlqvist S, Schwarz E,
41 Ólafsdóttir AF, Frid A, Wedel H, Ahlén E, Nyström T, Hellman J. Continuous Glucose
42 Monitoring vs Conventional Therapy for Glycemic Control in Adults With Type 1
43 Diabetes Treated With Multiple Daily Insulin Injections: The GOLD Randomized
44 Clinical Trial. *JAMA*. 2017 Jan 24;317(4):379-387. doi: 10.1001/jama.2016.19976.
- 45 29. Peasgood T, Brennan A, Mansell P, Elliott J, Basarir H, Kruger J. The impact of
46 diabetes-related complications on preference-based measures of health-related
47 quality of life in adults with type I diabetes. *Medical Decision Making*.
48 2016;36(8):1020-1033.
- 49 30. Beaudet A, Clegg J, Thuresson P-O, Lloyd A, McEwan P. Review of utility values for
50 economic modeling in type 2 diabetes. *Value in Health*. 2014;17(4):462-470.
- 51 31. Clarke P, Gray A, Holman R. Estimating utility values for health states of type 2
52 diabetic patients using the EQ-5D (UKPDS 62). *Medical Decision Making*.
53 2002;22(4):340-349.
- 54 32. Bagust A, Beale S. Modelling EuroQol health-related utility values for diabetic
55 complications from CODE-2 data. *Health Economics*. 2005;14(3):217-230.
- 56 33. Wasserfallen J-B, Halabi G, Saudan P, et al. Quality of life on chronic dialysis:

- 1 comparison between haemodialysis and peritoneal dialysis. *Nephrology Dialysis*
2 *Transplant*. 2004;19(6):1594-1599.
- 3 34. Fenwick EK, Xie J, Ratcliffe J, et al. The impact of diabetic retinopathy and diabetic
4 macular edema on health-related quality of life in type 1 and type 2 diabetes.
5 *Investigative Ophthalmology & Visual Science*. 2012;53(2):677-684.
- 6 35. Kiberd BA, Jindal KK. Screening to prevent renal failure in insulin dependent diabetic
7 patients: an economic evaluation. *BMJ*. 1995;311(7020):1595-1599.
- 8 36. Lee WJ, Song K-H, Noh JH, Choi YJ, Jo M-W. Health-related quality of life using the
9 EuroQol 5D questionnaire in Korean patients with type 2 diabetes. *Journal of Korean*
10 *Medical Science*. 2012;27(3):255-260.
- 11 37. Riveline, J.P., et al. Assessment of patient-led or physician-driven continuous glucose
12 monitoring in patients with poorly controlled type 1 diabetes using basal-bolus insulin
13 regimens: a 1-year multicenter study.; *Diabetes care*. 2012;35 (5); 965-71.
- 14 38. Bolinder, J. et al. Novel glucose-sensing technology and hypoglycaemia in type 1
15 diabetes: a multicentre, non-masked, randomised controlled trial.; *Lancet* (London,
16 England); 2016;388(10057);2254-2263
- 17 39. NHS England. Flash glucose monitoring: national arrangements for funding of
18 relevant diabetes patients. 2019. Available from:
19 [www.england.nhs.uk/publication/flash-glucose-monitoring-national-arrangements-for-](http://www.england.nhs.uk/publication/flash-glucose-monitoring-national-arrangements-for-funding-of-relevant-diabetes-patients)
20 [funding-of-relevant-diabetes-patients](http://www.england.nhs.uk/publication/flash-glucose-monitoring-national-arrangements-for-funding-of-relevant-diabetes-patients)
- 21 40. NHS England and NHS Improvement. Type 2 Diabetes Prevention Programme and
22 Type 1 diabetes glucose monitoring: Continuous glucose monitors – pregnancy.
23 2020. Available from: [https://www.england.nhs.uk/wp-](https://www.england.nhs.uk/wp-content/uploads/2020/10/C0770-dpp-and-cgm-letter.pdf)
24 [content/uploads/2020/10/C0770-dpp-and-cgm-letter.pdf](https://www.england.nhs.uk/wp-content/uploads/2020/10/C0770-dpp-and-cgm-letter.pdf).