NICE National Institute for Health and Care Excellence

CARE AND SUPPORT FOR OLDER PEOPLE WITH LEARNING DISABILITIES

Appendix C2: Economic report

This report was produced by the Personal Social Services Research Unit at the London School of Economics and Political Science. PSSRU (LSE) is an independent research unit and is contracted as a partner of the NICE Collaborating Centre for Social Care (NCCSC) to carry out the economic reviews of evidence and analyses.

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1 Background and rationale for economic work on annual health checks

The aim of the economic work was to contribute to the development of the guideline 'Care and support for older people with learning disabilities' by providing evidence on the cost-effectiveness for 1 or several areas covered by this guideline. Areas were chosen based on the expected costs and outcomes, the expected contribution from doing additional economic work, and feasibility. All criteria were strongly influenced by the availability of evidence. This section provides a brief background outlining the main issues faced by this population that affect their quality of life and which can also have an impact on costs. It is then explained why annual health checks presented an important area for this guideline and why this was chosen as an area for further economic analysis.

The existence of serious health problems starting at an early age has been found to be a major contributor to a low quality of life experienced by people with learning disabilities (Bigby et al 2004), as well as a driver for public sector costs (Strydom et al. 2010). Physical health problems are common and often complex, with studies reporting that people with learning disabilities have 2.5 times more health problems than the general population of older people (Haveman et al. 2010; McCarron et al. 2013). Multi-morbidity for this population is much higher and ageing-related conditions occur at an earlier age compared with the general population (Cooper et al. 2014, McCarron et al. 2013). Mortality for people with moderate and severe learning disabilities has been found to be 3 times higher than in the general population (Tyrer et al. 2007). Reasons for such health inequalities are manifold. Unhealthy lifestyles over the life course and genetic components have been linked to a higher prevalence of conditions such as diabetes, hypertension and dementia (Bigby 2004; Cooper 1997; Emerson and Baines 2010; Holland et al 1998).

Access to appropriate healthcare has been found to be a particular issue for this population, contributing to large health inequities (Strydom et al. 2005, Emerson et al. 2012). For example, people with learning disabilities have been found to be at much higher risk of death from preventable and treatable illness (Heslop et al. 2013), and they are less likely to access cancer screening and health promotion support (Alborz et al. 2005; Ali et al. 2013, Osborn et al. 2012, Heller and Sorenson 2013). This is particularly relevant for people as they age, since most screening is carried out in (late) adulthood. Screening requires people with learning disabilities to undertake procedures they might find difficult to follow (such as providing stool tests). Changes in family carers (who might be unable to continue to care as they age or die) or changes in residence are more likely to happen as people grow older, adding to challenges in accessing health services (Bigby 2004). In addition, studies show the challenges of identifying health conditions early on in this population due to diagnostic overshadowing (a process by which physical and mental health symptoms are misattributed to the learning disability) and difficulties in distinguishing health conditions from normal age-related changes (Bowers et al. 2014).

Interventions that support an earlier identification of health problems and access to services might lead to potentially large improvements in health-related quality of life and in wellbeing more generally. In addition, an earlier identification might reduce the need for more intensive and unplanned health services later on, and thus reduce

costs (Haveman et al. 2010; Ryan and Sunada 1997). For example, a Canadian study found that people with learning disabilities were 2.6 times more likely than the general population to be hospitalised for what were considered preventable conditions (Balogh et al. 2015). In addition, there might be potential savings to social care: an English study found that decisions about whether a person needed residential care were most commonly made because of deteriorating health (Williams and Battleday 2007), suggesting that meeting health needs earlier might potentially reduce some social care costs.

Health checks, which specifically address the needs of people with learning disabilities, have been introduced nationally and internationally to address some of those inequalities and inequities that people with learning disabilities experience. They seek to improve detection, treatment and prevention of new health conditions in this population, who are much less likely to seek help proactively and be offered the care they need (for example, see Robertson et al. 2014). Lennox and Robertson (2014: 195) described health checks as " (…) the systematic gathering of a comprehensive health history that includes the person's current and past health information, and their psycho-social context. This history is reviewed by a primary care health professional, considered and clarified where necessary, and leads to a directed, systematic physical and mental health examination which results in identification of any unmet health needs that are documented and optimally acted upon. The process optimally includes specific information about commonly missed and syndrome-specific health conditions to inform the person with intellectual disabilities, their caregivers and the health professional."

In England, annual health checks for all adults with learning disabilities were introduced nationally in 2008 in the form of the Learning Disabilities Health Check Directed Enhanced Service (DES). The national scheme allows practices to opt in and receive a financial reward for providing annual health checks. GP practices which decide to opt into the scheme have to undergo training. NHS England provides the contract and frameworks for the provision of annual health checks and the Royal College of General Practitioners provides guidance for practitioners. The NICE guideline for people with learning disabilities recommends annual health checks for the general adult population and this has been recently extended to young people from 14 years upwards. Despite such recommendations and financial incentives, uptake of the scheme is still low, with only 52% of eligible people receiving them, and there are large local variations (Glover and Niggebrugge 2013). In addition, the quality of annual health checks is likely to vary between practices and regions, although not much information is available on this. The tool currently used by GP practices which opt in to provide annual health checks under the DES is the Cardiff Health Check. During the development of this guideline, NHS England introduced a new tool for annual health checks, the National Electronic Health Check, which incorporates all aspects of the Cardiff Health Check plus additional features such as bowel cancer screening and tests for osteoporosis, mental health and dementia. It comprehensively covers a wide range conditions including those related to ageing.

A range of evaluations has been carried out on annual health checks, in the UK as well as internationally (in particular in Australia and Canada). A recent systematic review summarised the effectiveness studies available in English from 1989 to August 2013 (Robertson et al. 2014). The review concluded that annual health checks consistently led to identification of unmet health needs, including

unrecognised life-threatening conditions, and led to more referrals, relevant health procedures and tests. This has been confirmed by a recent UK longitudinal cohort study (Buszewicz et al. 2014), which analysed data from The Health Improvement Network (THIN) database.

There are also some studies which evaluated costs or cost-effectiveness of annual health checks. For example, a Scottish cost study, which evaluated service use and costs for n=50 adults with learning disabilities found that there were no significant differences in service use and mean costs between annual health check versus standard care groups (Romeo et al. 2009). However, the study population included all adults with learning disabilities, referred to a relatively small sample size and only measured short-term costs. A recent cluster randomised controlled trial (RCT) in Scotland (Cooper et al. 2014), which measured the short-term cost–utility of annual health checks carried out by practice nurses, found that annual health checks led to improvements in health-related quality of life – expressed in quality adjusted life years (QALYs) – and a reduction in costs. However, as the authors explain in the paper, the study had a number of limitations including a small sample size, a limited cost perspective (with a focus on primary care costs) and challenges in applying the outcome measures to establish QALYs for this population. A study by Carey et al. (2017), which analysed data from a large English primary care database – the Clinical Practice Research Datalink (CPRD) – found no difference in overall hospital emergency admissions linked to practices which carried out more annual health checks versus those that carried out less. However, it found that certain types of emergency admission, namely those that were considered more preventable, were reduced. Limitations of the studies referred to those of matching, which meant that baseline characteristics might have been different between practices as well as individuals in the 2 groups. None of the studies looked at annual health checks for older people specifically.

Generally, the gap in economic evidence has been highlighted recently (Buszewicz et al. 2014; Cooper et al. 2014; Robertson et al. 2014). The gap refers in particular to the long-term impact on costs and health outcomes, which remains currently unknown. For example, most studies in this area used process measures such as changes in the health conditions identified and health needs met (for example, referrals initiated) rather than final health outcomes. In addition, there has been no evaluation of annual health checks for older people specifically.

The aim of additional economic analysis carried out for this guideline was to address this gap in evidence and thus help inform the recommendations of the Guideline Committee. This included the aim to generate information that would allow a better understanding of the circumstances under which annual health checks could be recommended for this population on cost-effectiveness grounds. More specifically, the objective was to develop a decision-analytic Markov model to estimate long-term health and the economic consequences of annual health checks. It was hypothesised that an earlier identification of conditions due to annual health checks would lead to health improvements and potential cost reductions; the latter were expected due to prevention of treatments for health conditions at a more severe stage. However, an increase in costs was also expected, linked to more preventative service use and the costs of annual health checks.

2 General approach

A number of steps were carried out iteratively, which are described briefly below. More detail on the methods is provided in the subsequent sections.

2.1 Literature review and consultation with experts

A wide range of literature searches was carried out to identify

- prevalence and incidence of health conditions
- the impact of annual health checks on process and intermediate outcomes (that is, evidence of changes in identification or management of health conditions through annual health checks)
- costs of annual health checks
- evidence of the link between early identification or better management of health conditions and health outcomes (measured in the form of health-related quality of life and mortality)
- evidence on costs linked to identification and management (treatment) of health conditions (including costs of early versus late identification and treatment).

This included the following data sources:

- latest NICE guidelines and guidelines from professional associations
- economic evaluations including decision analytic or population modelling studies
- systematic reviews and meta-analyses (single, high-quality randomised RCTs were considered if there was no recent meta-analysis or systematic review).

Searches were pragmatic and focused on studies that were from the UK and published in recognised sources that followed standardised methods (such as health technology assessments, NICE guidelines, Cochrane systematic reviews). Searches were done using citation mining. In addition, leading researchers in this field were contacted for references to studies in this field. This included one Guideline Committee member (Dr Laurence Taggart, Reader in School of Nursing at Ulster University), who is also a leading researcher is the field. Other leading researchers that were contacted included: Dr Andre Strydom, Senior Lecturer in the Mental Health Sciences Unit at University College London; Dr Renee Romeo, Senior Lecturer in Health Economics at King's College London; Prof Christopher Hatton, Professor of Psychology, Health and Social care at the Centre for Disability Research at University of Lancaster; Prof Martin Knapp, Professor of Social Policy and Director of Personal Social Services Research Unit (PSSRU) at London School of Economics and Political Science.

2.2 Establishing costs of annual health checks

First, the costs of providing annual health checks were established. Under the national incentive scheme of the Directed Enhanced Services (DESs), GPs can claim a certain amount for providing annual health checks, which is currently £140 (Ferguson et al. 2010; McConkey et al. 2015)[1]. This incentive might or might not cover the costs of providing annual health checks. Two UK studies estimated costs that considered some of the resource inputs, including the time taken to deliver the intervention. Romeo et al. (2009) combined the time spent by a low grade GP nurse in delivering the annual health check with the unit cost per hour of a professional's time administering the intervention. The valuation of time associated with the administration of the intervention included salaries, salary on-costs (such as superannuation), direct overheads (such as stationery and clerical support), indirect overheads (such as finance, maintenance and electricity), capital overheads (such as physical land and premises) and estimates for travel costs. The final estimate of costs was £82 per annual health check. Cooper et al. (2014) estimated nurse-led intervention costs at £51, which was based on 1 hour of a nurse's time. The study did not provide any detail on whether this accounted for salary on-costs, overheads and travel costs but, considering the value, it was unlikely that they had been included. Neither of the cost estimates from the Romeo and Cooper studies included elements such as GP time for examining the results from annual health checks and discussing them with the nurse. They also did not include the costs of other paid staff typically involved in annual health checks such as social workers, the community disabilities team and support workers.

In order to address this gap, the Guideline Committee estimated resource inputs that they thought were required for providing an annual health check in practice. The Committee agreed in smaller groups and plenary discussions the activities that needed to be carried out by different professionals as well as by support workers. At the following meeting, Committee members were presented with the cost estimates, which had been calculated by the economist, based on this information and national unit costs. The Committee discussed and agreed changes, which then informed final estimates of costs.

2.3 Selection of health conditions

Next, the health conditions that would inform the model were identified. It is important to note that models are simplifications of reality; thus it was not the aim of the analysis to model all possible economic consequences of annual health checks. Instead, the model focused on the health conditions that were covered by current checklists and considered most important for this specific population, in terms of their

[1] Information provided though communication with NHS England state that the terms of the DESs are discussed and agreed as part of the annual contract negotiations between NHS England and the General Practitioners Committee of the British Medical Association (BMA). The Learning Disabilities Health Check DES, which was originally negotiated, agreed and introduced in the 2008/09 contract at £100 per annual health check now provides £140 per annual health check.

economic impact. A number of criteria were used to make this choice. The starting point for the selection was evidence from evaluation studies of annual health checks, which identified the impact of annual health checks on the (early) identification and management of conditions (measured in the form of process measures or intermediate outcomes). Other criteria included the expected economic impact linked to (early) identification and management of conditions. This included a focus on the most common conditions and evidence of the cost-effectiveness of screening or treatment of those conditions. The focus of the model was thus on health conditions which were supported by evidence that annual health checks led to their early identification and where their early identification led to changes in health or costs.

It is important to note that the selection of health conditions was an iterative process, which included close consultation with Guideline Committee members and sought additional information from other experts in the field. This process was important in order to address gaps in the evidence.

Double counting for overlapping conditions (coronary heart disease, diabetes, high blood pressure, stroke) was avoided as follows: 1) only high blood pressure and diabetes were included (with stroke and CHD as assumed consequences of those); 2) the prevalence rates for diabetes and high blood pressure were adjusted for to avoid double counting economic consequences between the two. The approach is explained in detail under the sections for each of these conditions.

2.4 Modelling economic consequences

For each of the selected health conditions a cost–utility model was developed that estimated the lifetime costs and changes in QALYs linked to earlier identification due to annual health checks. The cost perspective taken was that of the NHS. It is important to note that because of a lack of evidence on the impact of annual health checks on social care, the perspective was limited to healthcare.

Although the method for each model varied depending on the availability of evidence (each model will be described in detail in 5.1 to 5.8), the general approach across all models was as follows.

Hypothetical cohorts of 1000 people with learning disabilities were followed from when they were 40 years until everyone died. Whereas people in the first cohort were invited to annual health checks every year, people in the second cohort were only offered standard primary care without such annual health checks. The starting age was decided by the Guideline Committee in line with the scope of this guideline and informed by evidence on the earlier onset of some ageing-related conditions in this population. However, depending on the nature of the health condition (and age criteria used by national screening programmes), older ages were used in some of the models. The cycle of each model was 1 year. The choice of the cycle was based on the nature of the intervention, which was offered annually.

In each model, a certain number of people developed the respective health condition each year. The model focused on the new occurrence (incidence) of conditions and did not consider conditions that existed before the person reached the age of 40 years – this approach ensured that the modelling examined the cost-effectiveness of annual health checks for older people specifically. Data on the incidence of conditions were taken from the Intellectual Disabilities Supplement to the Irish

Longitudinal Study on Aging (IDS-TILDA; McCarron et al. 2014). In IDS-TILDA, information on the presence of 12 health conditions was collected for n=753 people with learning disabilities aged 40 years and over. Data were collected at 2 time points (waves 1 and 2; difference between time points was 3 years) using a standardised protocol administered in face-to-face interviews with people and their carers. This study was a unique data source, which addressed an important gap in evidence on prevalence and incidence data of many health conditions of older people with learning disabilities.

People in both cohorts had different probabilities that their health conditions were identified (people receiving annual health checks had a greater probability). Probabilities were informed by evidence from evaluations of annual health checks, as well as by Guideline Committee estimates on expected uptake of annual health checks if they followed good practice. The Committee estimates were particularly important in order to address some of the limitations of existing evaluations of annual health checks, which focused on the effects of checks as implemented in current practice rather than their effects if implemented following good practice.

During each cycle, people could either develop the health condition, remain without the health condition or die. At the end of each cycle, people were either alive with or without the condition or dead. Depending on the nature of the health condition, a further distinction was made between death from the health condition (either directly or indirectly if the health condition led to another, more serious condition) and death from other causes. Annual transition probabilities from alive to dead were used across all models and derived from the National Life Table for England 2010 to 2012 published by the Office for National Statistics. Mortality rates were adjusted for people with learning disabilities, reflecting the 3 times higher mortality rate for this population found in the literature (for example, Emerson and Baines 2011).

Costs and outcomes values were assigned to health states of individuals; costs to the NHS (for example, for treatment) were assigned to events (for example, costs of being referred to an optometrist) and health states (for example, costs of being treated for heart disease). All costs were uprated to 2015/16 prices using the Hospital and Community Health Services (HCHS) price index. Outcomes were valued by attaching health utilities to the different health states including death (which has a health utility of zero). More details to the kind of health utilities used, and their sources is provided for each health conditions in sections 5.1 to 5.8. QALYs were calculated by multiplying health utilities by the length of time someone was in a health state. Costs and outcomes (measured in the form of QALYs) were discounted at 3.5%. In sensitivity analysis, scenarios were explored in which costs were discounted at 3.5% and outcomes were not discounted.

For each model, incremental cost-effectiveness ratios (ICERs) were calculated which showed the lifetime cost per QALY gained. The results of each model were then combined to reflect the overall ICER (before the costs of the intervention were considered). The present value of costs of annual health checks (that is, measured over the lifetime of individuals) was calculated based on the yearly cost of annual health checks. The overall ICER (after cost of the intervention) was then presented.

Probabilistic sensitivity analysis (PSA) was carried for all parameters. In PSA, the full value range rather than a single value is considered for each parameter. This was done by determining the distributions that a value could take for each parameter and

then running a large number (here 1000) of Monte Carlo simulations, which produced the results of different combinations of random draws. The choice of distributions followed standard practice (Sculpher 2004). Briefly, these were as follows: beta distribution for probability parameters, gamma distribution for cost and utility parameters and normal distributions for parameters that reflected intervention effects. In addition, sensitivity analysis was applied for values that were particularly uncertain and where much higher or lower values were explored to understand the impact of this change on the results (measured in the form of ICERs).

3 Costs of annual health checks

3.1 Delivery of the intervention

In order to estimate the costs of annual health checks, the Guideline Committee discussed the process of delivering a 'good practice' annual health check in terms of the activities that needed to be carried out by different professionals.

In regard to the process from the perspective of the person, the Committee thought that it was good practice that each person be informed about and invited to annual health checks with user-friendly, easy-to-read letters, which needed to be sent to the person as well as their carer. A person should also be offered further help to understand the letter and be reminded about an appointment with another letter and personal call. The person should be supported to visit the GP practice for their annual health check. The Committee discussed some of the challenges for people needing to visit GP practices for annual health checks and agreed that while the focus needed to be on removing barriers that prevented the person from going to their GP practice, sometimes the person would need to be visited in their home. In regard to the actual visit, the Committee agreed that it was good practice that the person was given the opportunity to have the annual health check carried out in 2 appointments rather than 1. In regard to the questions asked as part of the annual health check, the Committee agreed that in addition to the health conditions covered by the Cardiff Health Check, additional questions should be included for conditions that were particularly relevant to an ageing population. These included, for example, questions related to prostate, cataract, bowel cancer, osteoporosis and dementia. This was also supported by the introduction of the new tool currently introduced by NHS England, which covers a much wider range of conditions, the Learning Disability Annual Health Check electronic clinical template[2].

The Committee agreed that the role of the nurse and GP in general practice was to invite people with learning disabilities, carry out annual health checks and inform people about the results. While the nurse would carry out all relevant tests, the GP would be responsible for explaining the test results to the person and discussing any

[2] https://www.england.nhs.uk/publication/a-summary-and-overview-of-the-learning-disability-annual-health-check-electronic-clinical-template-2017/

need for further action. The Committee estimated that appointment(s) required 1 hour face-to-face of the nurse's time and 20 minutes of face-to-face time with a GP.

The Committee also agreed that support workers had an important role in helping the person to read and understand the letter and the nature of annual health checks; in attending annual health checks with the person; in helping them to understand the results; and in providing follow-up support (such as attending appointments). It was estimated that this required on average 8 hours of the support worker's time. The Committee also discussed that it was possible that someone from the community learning disabilities team could provide support instead of a support worker (if people did not have a support worker). The Committee agreed that this support should last on average 1 hour.

Furthermore, the Committee decided that social workers in contact with older people with learning disabilities had a responsibility to ask the person about their annual health check; the Committee estimated that this prompt would take, on average, about 5 minutes. This assumed that the social worker was already in contact with the person.

3.2 Cost estimations

Yearly costs of annual health checks were estimated at £257. This referred to 5 minutes of social worker contact valued at £79 per hour, 8 hours of contact with a support worker valued at £17 per hour, 1 hour of general practice nurse time valued at £43 per hour and 20 minutes of GP time valued at £216 per hour. Source for unit costs were – with the exception of the support worker – the PSSRU Unit Cost for Health and Social Care and all costs reflected 2015/16 prices.

Unit cost estimates from the PSSRU source reflected client-related time for the social worker, which meant that they included preparation and follow-up time. For GPs, unit costs referred to face-to-face patient contact and included average costs for surgeries, clinics, telephone consultations, home visits, referral letters, arranging admissions, general administration and external meetings with other bodies (continuing education/development, research, teaching etc.). The unit costs for nurses did not include additional time for other activities – as there was no such estimate provided and unit costs in the PSSRU source referred to an hour of nurse's time (rather than face-to-face time). No additional adjustment was carried out in the model here as it was assumed that costs were sufficiently included in the GP unit cost estimate, which included the costs of administrative activities of practice staff. Unit cost estimates for GPs, nurses (in GP practices) and adult social workers also included staff qualifications (thus including the costs of the training required to deliver annual health checks). All unit costs included overheads and salary on-costs.

The Committee decided to estimate the unit costs of support workers differently because their positions often fell outside formal public sector or even third sector employment. The Committee agreed that support workers were usually not employed by local authorities and could include family members or friends; they estimated their unit costs (including overheads) at £17 per hour. The Committee agreed that the

support worker was required on average for 8 hours to provide the necessary support before, during and after annual health checks.

In a second scenario, a cost was estimated that did not include the help of a support worker but instead included 1 hour of support provided by a staff member of the community disabilities team. The yearly costs of annual health checks in this second scenario were lower at £165. The estimate was taken from the PSSRU source and included overheads and salary on-costs.

The lifetime costs of annual health checks were calculated by assigning the yearly costs for people who were alive during the cycle. Lifetime costs of annual health checks were £4,791 in the base case scenario (based on 8 hours of support worker time) and £2,626 in the alternative scenario (based on 1 hour of support provided by the community disabilities team).

4 Health conditions included in the modelling

Table 1 presents the various health conditions that were discussed with the Guideline Committee for inclusion in the modelling. For each health condition, the decision is shown whether or not the health condition was included in the model and a rationale is given for the decision.

Table 1 Health conditions included and excluded from the modelling

Health condition	Included/ excluded	Rationale
Cervical cancer screening	Excluded	Guideline Committee members agreed that while it was important to offer smear tests to women and provide information about the pros and cons of screening for cervical cancer (and to carry out smear tests), prevalence of cervical cancer in this population was very low (in particular due to much lower sexual activity than in the general population) and the expected impact on costs and outcomes was thus low.
Prostate cancer	Excluded	Prevalence was not well known for this population but likely to be high; in the general population, prostate cancer is one of the most common cancer types in male older people (12.8% of all cancers – Cancer Research UK 2014). However, there is currently no screening programme for prostate cancer because of the lack of a reliable test (current test is for Prostate Specific Agent, PSA). Side effects for overtreatment are substantial and the current conclusion in clinical guidelines is that the benefits do not outweigh the risks. There is a debate about treatment for people with elevated PSA levels. Possible strategies include MRS/MRI sequences. Cost-effectiveness evidence from recent health technology assessment (Mowatt et al. 2013) shows a high degree of uncertainty surrounding key parameters for any such strategy and so no clear recommendation was made. The Committee agreed that it was important to offer PSA tests to older men with learning disabilities as part of annual health checks (currently about 60% of people with learning disabilities get checked for prostate according to IDS-TILDA) but agreed that modelling was difficult to the uncertainty in the data about prevalence and best treatment options.
Breast cancer (screening via mammogram)	Included	Breast cancer is a common cancer, representing 15% of all cancers according to national statistics (ONS). Rates are expected to be the same or higher for older people with learning disabilities compared with the general population (Davies and Duff 2001; Hogg and Truff-Wijne 2008; Truesdale-Kennedy et al. 2011). Despite the national NHS Breast Cancer Screening programme, uptake of mammograms is a particular issue in this population with rates in uptake being much lower (50%) than in the general population (80%;

		IDS-TILDA; Truesdale-Kennedy et al. 2011). It has been suggested that there are many missed opportunities in primary care for proving reminders and better information about screening (Alborz et al. 2005; Davies and Duff 2001; Glover and Ayub 2010, Wilkinson et al. 2011). The many barriers to breast screening as well as the importance of GPs and GP staff in reminding women and their carers opportunistically about breast cancer screening have been suggested in the literature (McIlfratrick et al. 2011; Wilkinson et al. 2011). The expected impact on costs and outcomes is high due to the evidence that screening of this type of cancer is feasible and cost-effective (hence the national screening programme) and evidence that additional information provided by GPs can increase uptake.
Bowel cancer screening	Included	Bowel (= colorectal) cancer is a common cancer and represents 11.3% of all cancers in the general population (ONS); furthermore, it is the second leading cause of cancer death in the general population (McAfee et al. 2008). Prevalence is not known for people with learning disabilities but death rates from bowel cancer have been found to be higher in this population (Glover et al. 2016). RCTs have shown that screening for bowel cancer (using the fecal occult blood test – FOBt) can reduce mortality by 16% in people offered screening and up to 25% in those accepting it (Hewitson et al. 2008; Logan et al. 2012; Towler et al. 1998); it is proven to be highly cost-effective in different high-income countries including the UK (Landsdorpe-Vogelaar et al. 2011; Tappenden et al. 2007). An evaluation of the national Bowel Cancer Screening Programme in England showed that the uptake of FOBt in the general population ranged from 40 to 60% (Logan et al. 2012). Generally, low uptake is a major public health concern especially among certain populations such as those at socioeconomic disadvantage, ethnic minorities and people with a learning disabilities (NDTI 2013). Expected impact on costs and outcomes was high due to the high prevalence, the availability of a national screening programme, the deathly nature of the condition and the evidence of (cost-) effectiveness of treatment. The Committee agreed that bowel cancer should be included in the model.
Lung cancer/smoking	Excluded	Not much is known about the prevalence of lung cancer in this population; in the general population, 12.7% of all cancers are lung cancer, and it is likely that rates are similar for this population. There is no national screening programme since no test has been found to be sufficiently robust in detecting lung cancer. Generally, early identification has been found to be difficult. Interventions on smoking cessation for people with learning disabilities lack theoretical frameworks and clear outcome measures (Kerr et al. 2012). Based on this, the Committee agreed to not include lung cancer in the model.

Blood pressure (identification and management)	Included	There is a high prevalence of objectively measured blood pressure – 18.1% in IDS-TILDA (McCarron et al. 2013). People in the annual health check group were more likely to be identified with hypertension (= high blood pressure) and more likely to receive blood pressure management (Buszewicz et al. 2014; Cooper et al. 2014). The expected impact on costs and outcomes was high: high blood pressure is a major risk factor for life-threatening and costly conditions including coronary heart disease (CHD) and stroke (see for example, Kannel 2009); there is strong (cost-)effectiveness evidence for blood pressure management which can reduce the risk of developing long-term conditions, in particular stroke and heart disease; and robust evidence shows that treating blood pressure in older adults reduces stroke, cardiac events and mortality (Weiss et al. 2015). The Committee thus agreed to include blood pressure in the model.
Diabetes (management)[3]	Included	Prevalence of diabetes was 9.3% in IDS-TILDA (McCarron et al. 2014), which is slightly higher than in the general population (MacRea et al. 2015; McVilly et al. 2014). There is evidence of similar identification rates of diabetes in annual health check vs. standard care groups, but differences in how diabetes is managed in the 2 groups (for example, Buszewicz et al. 2014; Cooper et al. 2014). For example, Taggart et al. (2013) found in their UK-based study that the majority of people with learning disabilities had poorly controlled diabetes and only 32% of people 50 years and older had blood glucose levels of under 6.4% (which is considered the threshold that marks whether diabetes is controlled or not). They also found that 10% of the population with diabetes had attended an emergency department in the last 12 months for a diabetes-related condition, including hyper- and hypoglycaemia. This suggests that better management could lead to potential cost saving. The expected impact on costs and outcomes was medium to high due to the evidence that annual health checks could lead to better management of chronic conditions such as diabetes and the

[3] Note that the focus in the modelling was on Type 2 diabetes, which is the type is that usually managed in GP practices. It is important to note that diabetes Type 1 also applies to this population because of genetic predisposition, in particular for people with Down's syndrome. However, treatment is in the hands of specialist providers and can be assumed to be initiated at much younger ages so there is a limited role for health checks in improving health or reducing costs to care (see also Taggart et al. 2013).

		cost-effectiveness of controlling blood glucose levels. The Committee agreed to include diabetes in the model.
BMI, cholesterol, weight	Excluded	Prevalence of overweight is as high as 42.5% (this referred to a subsample who engage in height and weight measurement). The Committee agreed that health promotion in the form of advice on nutrition and physical exercise was an important area but that the responsibility of GP practices and the role of annual health checks in improving health promotion was not clear. Committee members with lived experience reported gaps in provision. They felt that in order for health promotion advice concerning obesity to be effective it needed to be provided in ways that were accessible to people and personalised to their situation. Furthermore the Committee agreed that the effectiveness of annual health checks was limited without the availability of further support in the community, which they thought was likely to be lacking or patchy. There was a lack of evidence on (cost-)effectiveness of health promotion interventions (for example, Brooker et al. 2015). Generally, research suggests that it is difficult to achieve health promotion targets (such as a healthy diet to reduce obesity which is more common) among people with learning disabilities (Taggart et al. 2013) although there is some evidence that education about exercise and nutrition might lead to changes in health attitudes (Heller and Sorenson 2013).
Heart disease and stroke	Included (indirectly)	Hypertension and diabetes have been found to be predictors of stroke and heart disease (for example, Morrissey et al. 2014). The issue of strong overlap between these conditions means that modelling each of them separately was not appropriate as they are on the same pathway for the majority of people. These conditions were thus indirectly addressed through work on diabetes and hypertension.
Glaucoma	Included	Prevalence of glaucoma was 2.7% in IDS-TILDA (McCarron et al. 2014). Evidence from evaluations of annual health checks for people with learning disabilities consistently shows that people in annual health check groups are more likely to get eye exams (for example, Buszewicz et al. 2014; Lennox et al. 2007; Robertson et al. 2014). Expected impact on costs and outcomes was high: although difficult to quantify, the impact of vision impairments is expected to be larger than for the general population, reducing more substantially their abilities to communicate, carry out practical tasks and be socially active. Vision impairments can contribute substantially to lower quality of life, social isolation, independence and physical

		health problems (Robertson et al. 2014). They can often be easily treated and promise cost-effectiveness. The Committee therefore agreed to include glaucoma in the model.
Cataract	Included	The prevalence of cataract was 19% in this population (IDS-TILDA, McCarron et al. 2014). This is much higher than the prevalence found in the general population of 10% (IDS-TILDA, McCarron et al. 2014). Evidence shows that vision problems such as cataract often remain unrecognised without annual health checks (Robertson et al. 2014). Evaluations of annual health checks for people with learning disabilities consistently found that people in the annual health check group were more likely to get eye exams (for example, Buszewicz et al. 2014; Lennox et al. 2007; Robertson et al. 2014). The expected impact on costs and outcomes was medium to high: although difficult to quantify, the impact of vision impairments was expected to be larger than for the general population, reducing substantially people's ability to communicate, carry out practical tasks and be socially active. Cataract is thought to contribute to lower quality of life, social isolation, loss of independence and physical health problems (Robertson et al. 2014). Cataract can often be easily treated. Based on this information, the Committee agreed to include cataract in the model.
Hearing impairment	Included	Prevalence has been found to be at least 40% (Bent et al. 2015). A study found that most people have not had their hearing tested (Hardy et al. 2011). Evaluations of annual health checks for people with learning disabilities found that people in the annual health check group were more likely to get earwax removed, hearing assessments and hearing aids than people in the standard care group (for example, Buszewicz et al. 2014; Lennox et al. 2007; Robertson et al. 2014). There are expected high impacts in regard to costs and outcomes: evidence shows that the cost impact hearing impairment in the general population of older people is very large (Shield et al 2006) and the substantial health gains of earwax removal and hearing aids (Bent et al 2015). Although difficult to measure in quantitative terms, wider benefits such as a reduction in social isolation and an increase in mobility, along with physical health improvements are expected to be larger than in the general population (Felce et al. 2008).
Thyroid	Excluded	The prevalence of thyroid problems was 21% in IDS-TILDA (McCarron et al. 2014). Evidence shows that annual health checks lead to an increased number of thyroid function tests. This refers specifically to

		hypothyroidism, which is particularly common for people with Down's syndrome. The rate of hypothyroidism in people with learning disabilities is 2.9 times that in the general population (NHS Digital 2016). Regular (annual) monitoring is already incentivised by a quality and outcome framework. National data suggest that up to 96% of patients with hypothyroidism had received thyroid function tests in 2010/11. Current guidelines suggest that people with Down's syndrome should be screened annually for hypothyroidism. The Committee agreed that thyroid conditions should be checked for all older people with learning disabilities, not just people with Down's syndrome. Overt hypothyroidism is linked to quality of life impairments and can lead to mortality. However, while diagnosis is relatively straightforward, treatment in older people is complex and does not necessarily lead to improved health-related quality of life in practice: up to half the population on thyroid replacement therapy were being over- or undertreated and there are substantial side effects of treatment. Evidence suggests that despite regular monitoring the dose often remains unchanged when people age, and 20% of older people are over-treated, which increases the risk of fractures (Turner et al. 2011). The most common drug used for thyroid replacement therapy is levothyroxine, which is a low cost drug, so that the impact on costs is likely to be small. There is an overall lack of evidence suggesting that expected impact of identification or monitoring through annual health checks is likely to have a large impact on costs or health outcomes.
Arthritis	Excluded	Prevalence was found to be 17% in IDS-TILDA. There was no evidence that annual health checks change identification rates. There were different types of arthritis and with no standard treatment currently recommended the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO), it was concluded that there was a need to define a reference case for osteoarthritis and achieve consensus on what constitutes 'standard optimal care'. Despite high prevalence, expected impact on costs and outcomes was likely to be only low or medium due to uncertainties around identification and management. Arthritis was thus excluded from the modelling.
Osteoporosis (screening)	Included	IDS-TILDA found a prevalence of 16.4% for older people with learning disabilities, which is higher than the prevalence found in the general population of 14.3% (McCarron et al. 2014). Srikanth et al. (2011) found a very high prevalence of risk factors in this population, with 64% being on anti-epileptics, 23% being immobile and 20% (11%) having had falls (fractures). Findings from IDS-TILDA suggest that prevalence of falls might be up to 32% in women. Women are at particular risk of fracture following menopause (with 1 in 2 women having a fracture) and women with learning disabilities experience menopause earlier, which suggest that

		earlier identification in this group is particularly important. They are also less likely to report symptoms (Martin et al. 2003). The disease burden of osteoporosis is particularly high and 20% of older people die within a year of a fracture (Zethraeus et al. 2007). There is evidence that treatment can reduce the risk of fractures and even mortality (Zethraeus et al. 2007). Older people with learning disabilities are less likely to understand and report symptoms, so they often fail to receive treatment (Srikanth et al. 2011). While there is currently no national screening, the NICE guideline recommends risk assessment with tools like the FRAX in high-risk groups. The Committee agreed that older people with learning disabilities should be risk assessed (from age 50 years). This was considered important because of the many risk factors for osteoporosis in this population and because people are less likely to report these, so screening is very important. The expected impact on costs and outcomes was considered medium to high due the high prevalence and the availability of screening tools that can lead to identification and the potential reduction in costly fractures. However, treatment persistence has also been found to be an issue, even in the general population, so this might reduce some of the potentially large positive impacts on fracture risk. The Committee agreed to include osteoporosis in the modelling work, although it was recognised that work was explorative due the uncertainties, including whether standard screening tools could be applied for this population (Srikanth et al. 2011).
COPD and asthma	Excluded	Prevalence data on asthma were not established in IDS-TILDA. There was a lack of evidence that annual health checks led to differences in identification and management of asthma or COPD (for example, a systematic review by Robertson et al. 2014 did not mention asthma or COPD).
Epilepsy	Excluded	The nature of epilepsy can change for older people, and people can also develop new epilepsy in older age (IDS-TILDA; Burke et al. 2014); NICE recommends the same therapies and interventions for older people as for other ages, but possibly lower doses of anti-epileptic drugs. There was some evidence that drugs could help older people to become seizure-free at least for a certain period (Stephen and Brodie 2000). The impact on costs and outcomes was expected to be large, considering that that 30% of acute seizures (those with status epilepticus) carried a mortality of 40% (Brodie and Kwan 2005). However, data were from dated, small studies and could not be used to inform the modelling.

Immunisation status	Excluded	IDS-TILDA found that vaccination levels to prevent influenza were over 90%. Older people with learning disabilities are targeted by a national screening programme and GP practices are incentivised through other means. This suggested a more limited role of annual health checks in further improving uptake. Based on this information, the Committee agreed to not include immunisation in the model.
Mental health	Excluded	In IDS-TILDA nearly 60% of older people with learning disabilities had received a diagnosis of a mental health condition (Mulryan et al. 2014), which is even higher than previous estimates in the adult population of 40% (Cooper et al 2007). Anxiety was the most prevalent (39.2%) followed by depression (26.7%) and manic depression (4.7%). A recently published NICE guideline recommends that mental health needs should be reviewed in annual checks alongside physical health needs. Annual health checks include questions about behaviour changes which can help to understand mental health needs. Evidence suggests that in practice people with learning disabilities commonly get the wrong diagnosis and are over-prescribed drugs in primary care (Glover et al 2015). The majority of evaluations of annual health checks did not report on mental health (for example, the systematic review by Robertson et al. 2014 did not mention mental health problems), suggesting that a focus on mental health as part of annual health checks is still relatively new. In addition, the few feasibility studies available on evidence on (cost-)effectiveness of interventions refer to the general adult population and general evidence on effective treatment is inconclusive (Bouras and Holt 2004; Jahoda et al. 2015). Altogether there was not sufficient evidence to inform modelling in this area.
Dementia	Excluded	Prevalence of dementia is much higher than in the general population, in particular for people with Down's syndrome. In IDS-TILDA the prevalence was 30% in people with Down's syndrome (dementia was not measured for people without Down's syndrome). Onset of dementia can be earlier than in the general population, in particular for people with Down's syndrome. NICE recommends that dementia should be assessed, however, there are many uncertainties concerning what effective identification should look like and who should be doing it. Evidence on effectiveness of interventions for adults with learning disabilities might not necessarily apply to older people, in particular those with dementia. For example, evidence for people with dementia from recent health technology assessment (Banarjee et al. 2013) found that anti-depressants are not effective in reducing depression for people with dementia. Leong et al. (2014) found that evidence is at best inconclusive; Power et al. (2015) found no preventative effect of statins on dementia. It was thus not possible to include dementia in the model.

5 Modelling economic consequences (by health condition)

5.1 Hypertension (= high blood pressure)

Population

Starting age of the cohorts was 40 years and people were followed until everyone had died.

Pathway

In the annual health check and standard care cohorts, people had different probabilities to be identified with new hypertension. Every person identified with hypertension was offered blood pressure treatment in the form of medication and people could either accept/adhere to treatment or not. During each cycle people could develop stroke or coronary heart disease (CHD) or they could die from hypertension (in addition to death from other causes). A distinction was made between people with unmanaged hypertension dying, those with managed hypertension dying and those without hypertension dying. At the end of each cycle a person could either be alive with managed or unmanaged hypertension, alive without hypertension or dead.

Costs and outcomes

Costs included in the model were those of diagnosing hypertension, management of hypertension, the costs of treating stroke (acutely and post-stroke) and of treating heart diseases. Calculations of QALYs reflected health-related quality of life for older people without any event, for people living with coronary heart disease and for people living after stroke. Furthermore, QALY calculations reflected changes in mortalities linked to an increased risk of death for people in the first year after stroke and to the ongoing risk of death for people with CHD.

Parameters and data sources

All parameters and their data sources that informed the model are shown in Table 2.

Annual probabilities for developing hypertension in older people with learning disabilities were derived from 3 years of incidence rates found in IDS-TILDA. Data referred to objectively measured blood pressure. In order to avoid potential double counting of economic consequences (that is, costs or QALYs) between diabetes and hypertension (both of which are highly overlapping as present risk factors for the same conditions such as heart disease, stroke and mortality), annual probabilities for diabetes were subtracted from annual probabilities for developing hypertension. This

approach ensured that the economic consequences linked to the 2 conditions were estimated conservatively.

The probabilities that high blood pressure was identified during annual health checks and in standard care were taken from Buszewicz et al. (2014). The probability estimate in the annual health check group was 95.3% in the published study. The probability that hypertension was identified in standard care was derived from the adjusted odds ratio published in the same study and the probability in the annual health check group.

The probability for a person with high blood pressure to accept and adhere to treatment was taken from Moran et al. (2015), which was 75% but referred to the general population of older adults. The Committee agreed that this estimate could be applied to people with learning disabilities although they emphasised that this was based on the assumption that people had the appropriate support from family, carers or support workers.

Probabilities for people to develop heart disease or stroke in the 2 groups were based on data on the age-specific incidence of these conditions for older people with learning disabilities from IDS-TILDA, which were multiplied by an increased risk of developing stroke and CHD for people with hypertension (Padwal et al. 2001; Straus et al. 2002). The estimate of an increased risk of death for people with hypertension was taken from Tancredi et al. (2015). Their data (which showed an additional risk of death per year of 1.33) referred to excess mortality due to CHD in people with diabetes. This was considered the best available source since no data were found on excess mortality in people with hypertension.

Risk reductions of developing stroke and CHD for people receiving hypertension treatment were derived from data on average reduction in blood pressure linked to taking medication (Law et al. 2003) and age-specific reductions in risk of developing stroke, CHD and death (from any cause) per 10mmHg reduction in systolic or 5mmHg reduction in diastolic blood pressure (Moran et al. 2015). While data from Law et al. (2003) showed that average reductions in systolic (diastolic) blood pressure for people who take 2 drugs (which is the number of drugs most people start with) were higher than 10mmHg (5mmHg). The latter values were assumed as average reductions following a conservative approach.

Costs of diagnosis and annual treatment of hypertension were taken from Lovibond et al. (2011), which presents economic analysis carried out for a NICE guideline on hypertension but shows different details of the data. Costs referred to average costs of treating hypertension, which included the use of several drugs (1 to 3) estimated with a Dirichilet distribution. Costs of stroke and for CHD were taken from the published NICE guideline. To derive the average costs for CHD, the costs for heart failure, angina and heart attack (= myocardial infarction) were weighted with the respective probabilities that if a person with CHD would have heart failure (51%), angina (21%) or myocardial infarction (28%); probabilities were from prevalence data in IDS-TILDA (McCarron et al. 2014).

Data on health utilities were taken from Lovibond et al. (2011) and Dyer et al. (2010). As with costs of CHD, weighting was applied for the health utilities of the 3 different heart conditions in order to derive an average CHD health utility value. Data on costs and health utilities for stroke and CHD as well as many of the other parameters were available from the previous NICE guideline on hypertension, which was also

published in Lovibond et al. (2011). Another important data source was Moran et al. (2015), which published data on average risk reductions for stroke, CHD and death for people with managed and unmanaged blood pressure. Their data stemmed from the same sources as that taken for NICE guideline, which included a systematic review of 147 trials (Law et al. 2009).

Table 2 Parameters, values and data sources for hypertension model

Parameter	**Base case**	**Value range**	**Source and details**
Annual probability of developing hypertension (diabetes excluded), 40 to 49 years	0.74%	0.35 to 1.14%	Derived from IDS-TILDA data (McCarron et al. 2014)
Annual probability of developing hypertension (diabetes excluded), 50 to 64 years	1.82%	1.56 to 2.28%	As above
Annual probability of developing hypertension (diabetes excluded), 65 years+	3.63%	2.39 to 4.76%	As above
Annual probability that (new) hypertension is identified in annual health check group	95.3%	85% to 95.3%	Buszewicz et al. (2014)
Annual probability that hypertension is identified in standard care	87.8%	71.4% to 87.8%	Buszewicz et al. (2014)
Adherence to blood pressure management	75%	In SA: 50%	Moran et al. (2015)
Increased risk of death for people with hypertension	1.33	In SA: 1.1	Tancredi et al. (2015), refers to excess mortality of CHD in people with diabetes
Average risk reduction for stroke, managed vs. unmanaged blood pressure, 40 to 59 years	0.64	0.61 to 0.66	Moran et al. (2015); data taken from Law et al. (2009) and SHEP trial
Average risk reduction for CHD managed vs. unmanaged blood pressure, 40 to 59 years	0.73	0.72 to 0.74	As above

Average risk reduction for death, managed vs. unmanaged blood pressure, 40 to 59 years+	0.86	0.83 to 0.89	As above
Average risk reduction for stroke, managed vs. unmanaged blood pressure, 60 years +	0.69	0.66 to 0.71	As above
Average risk reduction for CHD, managed vs. unmanaged blood pressure, 60 years +	0.77	0.74 to 0.78	As above
Average risk reduction for death, managed vs. unmanaged blood pressure, 60yrs +	0.91	0.91 to 0.92	As above
Annual probability of stroke for people with learning disabilities, 40 to 49 years	0.17%	0 to 1.11%	IDS-TILDA (McCarron et al. 2014)
Annual probability of stroke for people with learning disabilities, 50 to 64 years	0.57%	0.23% to 1.13%	As above
Annual probability of stroke for people with learning disabilities, 65yrs +	1.15%	0.44% to 2.85%	As above
Annual probability of CHD for people with learning disabilities, 40 to 49 years	0	0	As above
Annual probability of CHD for people with learning disabilities, 50 to 64 years	0.30%	0.07% to 0.91%	As above
Annual probability of CHD for people with learning disabilities, 65 years +	1.16%	0.44% to 2.82%	As above
Increased risk of stroke in people with hypertension	4	3 to 5	Straus et al. (2002)
Increased risk of CHD in people with hypertension	2.5	2 to 3	Padwal et al. (2001)
Annual probability of stroke, managed blood pressure	40 to 49 years: 0.43;	Beta distribution	Derived from data above: annual probabilities of stroke for people with learning disabilities, increased risk of stroke in

	50 to 60 years: 1.46%; 61 to 64 years: 1.57%; 65 years+: 3.16%		people with hypertension and average risk reduction
Annual probability of stroke, unmanaged blood pressure	40 to 49 years: 0.67%; 50 to 60 years: 2.28%; 61 to 64 years: 2.28%; 65 years+: 4.59%	Beta distribution	Derived from data above: annual probabilities of stroke for people with learning disabilities and increased risk of stroke in people with hypertension
Annual probability of CHD, managed blood pressure	40 to 49 years: 0% 50 to 60 years: 0.55% 61 to 64 years: 0.58% 65 years+: 2.09%	Beta distribution	Derived from data above: annual probabilities of CHD for people with learning disabilities, increased risk of CHD in people with hypertension and average risk reduction
Annual probability of CHD, unmanaged blood pressure	40 to 49 years: 0% 50 to 60 years: 0.75% 61to 64 years: 0.75% 65 years+: 2.87%	Beta distribution	Derived from data above: annual probabilities of CHD for people with learning disabilities, increased risk of CHD in people with hypertension and average risk reduction
Risk of death for people with stroke (first year)	12%	10.8% to 13.2%	Lee et al. (2011)

Additional risk of death for people with CHD (annual)	1.33	1.19 to 1.46	Tancredi et al. (2015); refers to additional death (excess mortality) due to cardiovascular disease for people with diabetes
Additional risk of death for people with hypertension	1.33	SD 1.1	As above
Costs, in £ 2015/16			
Costs of diagnosis of high blood pressure	£59	£29 to £89	Lovibond et al. (2011), inflated with Hospital and community health services (HCHS) price index
Costs of blood pressure management (in £, 2015/16)	£68	£34 to £102	As above
Costs of treating stroke initially (first 3 months), (in £, 2015/16)	£11,267	£5,633 to £16,901	As above
Costs of subsequent treatment of stroke (3 months after initial treatment), (in £, 2015/16)	£1,237	£619 to £1,856	As above
Costs of treating CHD initially (in £, 2015/16)	£3,708	£1,854 to £5,561	As above; includes costs of heart failure (£2,929), angina (£3,273), heart attack = myocardial infarction, MI (£5,455); weighted by their prevalence proportions in relation to all CHD conditions: heart failure (51%), angina (21%), MI (28%)
Costs of subsequent treatment of CHD (3 months after initial treatment) (in £, 2015/16)	£285	£143 to £428	As above; includes costs of heart failure (£311), angina (£187), heart attack = myocardial infarction, MI (£312); weighted by their prevalence proportions in relation to all CHD conditions: heart failure (51%), angina (21%), MI (28%)
Health utilities			

Stroke	0.63	0.31 to 0.94	Lovibond et al. (2011); refers to general adult population in England derived from Health Survey for England 2006
CHD	0.704	0.55 to 0.79	Lovibond et al. (2011); refers to general adult population in England derived from Health Survey for England 2006; weighting of different CHD conditions based on Dyer et al. (2010): weighted average of health utility values for heart failure (0.645), angina (0.77) and MI (0.76)
Without cardiovascular event	0.806	0.704 to 0.909	Lovibond et al. (2011); refers to general adult population in England derived from Health Survey for England 2006

5.2 Diabetes (Type 2)

Population

The starting age of the cohorts was 40 years and people were followed until everyone had died.

Pathway

It was assumed that in both groups, annual health check and standard care, everyone with diabetes was identified; however, people in the 2 groups had different probabilities in regards to whether their diabetes (i.e. blood glucose levels) was closely managed: people with diabetes in both groups were, with different probabilities, checked for their blood glucose level on a regular basis and had thus different probabilities of achieving blood glucose control (defined as HbA1c of less than 6.5%). For the model, it was thus assumed that controlled blood glucose levels were achieved with intensive management (an assumption made also by other studies, which investigated the cost-effectiveness of screening for diabetes). Furthermore, in line with the approach taken by Clarke et al. (2005) a distinction was made for intensive blood glucose management with sulphonylurea or insulin for non-overweight persons and with metformin for overweight persons

The rational for this pathway was based on the following evidence: first, findings from recent evaluation studies of annual health checks in the UK (for example, Buszewicz et al. 2014) suggest that due to the financial incentives provided to GPs for identifying diabetes – as part of the Quality and Outcomes Framework (QOF) – the vast majority of people registered in primary care with learning disabilities were identified with diabetes in standard care. Second, evidence showed that rates of poorly controlled diabetes in standard care for this population was as high as 50% (Taggart et al. 2013) and that annual health checks could lead to more effective treatment of diabetes (Robertson et al. 2014) reflected in higher health monitoring rates (Cooper et al. 2014) [4]. Third, in terms of interventions, there was only limited evidence that better management (measured in form of glycaemic or metabolic control) can be achieved with patient education or self-management (for example, Walwyn et al. 2015) and no evidence that it could be done (cost-)effectively for this population. Instead there was good cost-effectiveness evidence for intensive glucose control – usually achieved with insulin therapy (Gray et al. 2000; Rosenblum and Kane 2003).

Costs and outcomes

The costs and outcomes referred to differences in costs and QALYs for people who were on intensive blood glucose control (due to regular monitoring) versus those who were not. It has been found that uncontrolled blood glucose leads to or increases the risk of micro- and macro-vascular complications, which have an adverse impact on health-related quality of life, and their management is a major source of health and social care expenditure (Liebl et al. 2015). Costs included in the model were the costs of treatment (including those related to complications) and visits to a nurse or GP. QALYs referred to differences in complications and death. Excess death in diabetes patients was primarily due to cardiovascular disease.

Parameters and data sources

All parameters and their data sources are shown in Table 3.

Annual probabilities of people with learning disabilities to develop new diabetes were derived from 3 years' incidence data of IDS-TILDA (McCarron et al. 2014) for different age groups (43 to 49 years; 50 to 64 years and 65 years and above). Since the starting age of the cohort was 40 years, incidence data for the age group 43 to 49 years were applied to 40 to 49 years. IDS-TILDA was the only source that provided incidence data for diabetes; the absence of other studies that investigated incidence data for diabetes was also found in recent systematic reviews (MacRea et al. 2015; McVilly et al. 2014).

Identification rates of diabetes were 100% for both groups (see explanation above). The probabilities that people with diabetes had controlled blood glucose were taken from Cooper et al. (2014) and Taggart et al. (2013). For the annual health check

[4] Note that while higher monitoring rates referred to all (chronic) conditions, data were likely to play an important role for (Type 2) diabetes as a highly prevalent condition managed in primary care.

group, probabilities referred to those having health monitoring needs met (Cooper et al. 2014). For the standard care group, a value range was taken based on probabilities that health monitoring needs were met from the same source (Cooper et al. 2014) as well as that people with diabetes had their blood glucose monitored over the past 12 months (Taggart et al. 2013).

Cost parameters referred to differences in costs over a person's lifetime (discounted at 3.5%) between people who had higher levels of controlled blood glucose due to access to intensive management and those who did not (Clarke et al. 2005). This included costs of treatment and costs of complications for those who were overweight or those with normal weight. A weighted average of those costs was derived based on the proportion of people with overweight from IDS-TILDA (33.5%). QALYs taken from Clarke et al. (2005) referred to lifetime QALYs per person (discounted at 3.5%) between people who had higher levels of controlled blood glucose due to access to more intensive management versus those who did not. The study by Clarke et al. (2005) was a cost–utility study based on patient-level data from an RCT involving 4209 persons (mean age 53 years) with newly diagnosed Type 2 diabetes carried out as part of the UK Prospective Diabetes Study (UKPDS). While the study was not of recent date, it is the largest UK study on diabetes thus far. The economic evaluation by Clarke et al. (2005) presented lifetime cost-effectiveness of intensive blood glucose management versus standard care for people with overweight and without overweight.

Table 3 Parameters, values and data sources for diabetes model

Parameter	Base case	Value range	Source and details
Annual probability of developing diabetes 43 to 49 years	0.17%	0 to 1.11%	IDS-TILDA (McCarron et al. 2014)
Annual probability of developing diabetes 50 to 64 years	0.57%	0.03% to 1.32%	IDS-TILDA (McCarron et al. 2014)
Annual probability of developing diabetes 65 years +	0.47%	0.07% to 1.83%	IDS-TILDA (McCarron et al. 2014)
Probability that blood glucose level is managed/controlled in annual health check group	69.9%	SD 34.2	Cooper et al. (2014); refers to proportion of people whose health monitoring needs are met
Probability that blood glucose is managed standard care group	56.8%	SD 29.4	Cooper et al. (2014); refers to proportion of people whose health monitoring needs are met

Proportion of older people with learning disabilities who are obese	33.5%	/	IDS-TILDA (McCarron et al. 2014)
Costs, in 2015/16 £			
Present value of additional total costs controlled vs. uncontrolled glucose in patients treated with insulin	£1,115	–£609 to £2,839	Clarke et al. (2005); refers to total costs of treatment and complications; as they occur during study period and projected long term; discounted with 3.5%; in 2014/15 prices
Present value of additional total costs controlled vs. uncontrolled glucose in overweight patients treated with metformin	–£1,288	–£5,414 to £2,838	As above
Health utility			
Present value of total QALY gain controlled vs. uncontrolled diabetes in persons without obesity	0.008	–0.07 to 0.22	Clarke et al. (2005); refers to QALY value for intensive versus standard blood glucose management during study period and projected; refers to general population
Present value of total QALY gain controlled vs. uncontrolled diabetes in persons with obesity	0.22	–0.04 to 0.48	As above; refers to general population

5.3 Bowel cancer (screening)

Population

One cohort of 1000 people started when persons were age 60 years. The model followed them until everyone had died. The starting age was chosen because the NHS Bowel Screening Programme is currently offered to men and women aged 60 to 74 years every 2 years.

Pathway

It was assumed that every person received a 2 guaiac-based FOBt toolkits as part of the National Screening Programme (a second was sent out in case the first was not returned). While there are different screening options, the option currently offered by the NHS as part of screening is the FOBt. It was assumed that older people who received annual health checks were given a reminder and additional information from their GP about the benefits of bowel screening and about how to complete and return the toolkits. People who did not receive annual health checks were not provided with this additional information and reminder. Of those people, who returned the toolkit, a certain proportion tested positive. Among those, some attended the additional investigation (colonoscopy) that was offered to everyone with abnormal test results. Some of those investigated were then identified with pre-stage cancer or 1 of the 4 stages of bowel cancer (Duke stages). Any pre-cancer polyps were removed immediately during the colonoscopy. People with identified cancer were offered treatment depending on the stage.

Costs and outcomes

It is important to note that this model was different from the others in that it modelled only the incremental costs and outcomes i.e. the model only reflected the differences in costs and outcome. This approach was technically different from the other models as it did not measure the total costs and outcomes in both cohorts (annual health check and standard care) and then derived the differences but instead only analysed the differences from the beginning. The reason for this difference in approach was the lack of reliable data on uptake of bowel cancer screening for this population. Data on uptake showed very large variation. For example, information from local NHS commissioners (available online) suggested that the variation was particularly large, with reported uptakes in this population of as low as 2 to 3% in some areas.[5] According to the Guideline Committee this figure could not be taken as representative of a national average. However, there was evidence from a wide range of national and international studies (including RCTs) that GP involvement can increase uptake. Currently there is no organised GP involvement in bowel screening: the screening is delivered by regional hubs and operates independently from GP practices (until the screening result is available at which point it is passed on to the GP). It has been found that the lack of GP involvement is a substantial barrier to uptake (Weller et al. 2006 and that endorsement by a GP can enhance screening uptake between 5 and 20% (Cole et al. 2002; Hewitson et al. 2011; Zajac et al. 2010). While none of the studies specifically looked at (older) people with learning disabilities, the vast majority were concerned with people from populations that did not engage well in screening, such as from socioeconomically deprived and ethnic minority populations. They found that such additional incentives work for these populations as well as for the general population. Hewitson et al. (2011) was the only England-based RCT that looked specifically at GP endorsement, although another trial is currently underway (Damery et al. 2012). They found that GP endorsement increased participation by at least 5.8% (95% CI 4.1–7.8%). While data were only available on the additional uptake that can be potentially achieved the Committee

[5] www.ndti.org.uk/uploads/files/Screening_Services_Strategy_Toolkit_final.pdf, p22.

agreed that this was an important area in which annual health checks could have an important contribution. The conservative estimate by Hewitson et al. (2011) thus informed the analysis.

So instead, only the increase in uptake was estimated and the costs and outcomes linked to such increase were modelled. In regards to costs, the model included those linked to the additional number of people participating in screening due do the information provided during annual health checks. This included additional costs for: screening (for 2 FOB tests), investigation through colonoscopy for those testing positive, admission due to bleeding as a potential side effect of colonoscopy, identifying and removing pre-cancer adenomas. In addition to increases there were also reductions in costs included in the model, which were due to on average less costly treatment for cancer identified at an earlier stage. In regards to QALYs, the analysis included changes in mortality as well as in health-related quality of life linked to the less severe cancer stages for those who participated in the screening due additional GP encouragement during annual health checks.

Parameters and data sources

All parameters and their data sources are shown in Table 4.

First, annual probabilities of developing bowel cancer were derived from 3 years' incidence data provided in the IDS-TILDA study. IDS-TILDA only presented incidence data for all cancer types. The incidence for bowel cancer was thus derived: this was done by multiplying the annual probabilities of developing any cancer (for different age groups) with the probability that a new case of cancer was bowel cancer. This was based on the proportions of different cancer types in the general population in the UK (ONS 2015). It is important to note that this assumed that the proportion of bowel cancer among cancer types for older people with learning disabilities was the same in the general population.

Next, probabilities of people screening positive and requiring further investigation were multiplied by the additional probability for a person in the intervention group to engage in screening that is, complete and return 1 of the 2 FOB tests). Probabilities for people with positive results to attend further investigation (colonoscopy) and for those who underwent further investigation to have pre-cancer or cancer were assumed to be the same as for the general population and taken from recent RCTs (Logan et al. 2012; Raine et al. 2016). The study by Logan et al. (2012) was a national evaluation of the national Bowel Screening Programme.

The probability of someone requiring hospital admission because of bleeding (a rare but possible side effect of colonoscopy) was assumed to be the same as in the general population and taken from Tappenden et al. (2007). Tappenden et al. (2007) developed a Markov model of bowel screening that informed the roll-out of the Bowel Screening Programme, and thus some data are very particularly suitable to inform this model.

The reduction in mortality risk linked to screening for bowel cancer was taken from longitudinal studies (Hewitson et al. 2007, 2008; Scholefield et al. 2002) and, after transforming those into annual data, applied to the age specific annual probabilities of death for people with learning disabilities. QALYs linked to reductions in mortality

were calculated based on probabilities of death and health utilities for the general population of people living with cancer.

Furthermore, QALYs were derived from data of health utilities for cancer (all stages), and for the 4 different cancer stages (also called Duke stages). Average health utilities were derived for people identified with bowel cancer earlier through screening and those identified later in a clinical setting presenting with symptoms. This was based on probabilities of people to be in different stages of cancer depending on whether they were identified through screening or not, which were multiplied by health utilities for those different cancer stages. Health utility data were taken from 2 sources. One was Whyte et al. (2012) and presented pooled Health Survey England data; the value referred to people with cancer with a mean age of 60.9 years and was thus considered particularly suitable to value the health of people for whom cancer mortality was reduced. The second source was Tappenden et al. (2007), which provided health utilities for different cancer stages, which were used to value health-related quality of life gains for those identified with cancer at an earlier stage (calculations as described elsewhere).

Estimating the changes in costs of cancer treatment required some additional steps: data on average cancer treatment costs for people identified at different cancer stages (from Cancer Research UK) were multiplied by data on probabilities from Scholefield et al. (2002) that person identified through screening (versus clinically) were in 1 of the 4 cancer stages. Scholefield et al. (2002) provided data from a 20-year follow up of the largest England RCT of bowel screening.

The cost of the FOB was assumed to include the costs of the 2 tests and an additional administration cost. The cost of colonoscopy was taken from the NHS reference costs. Resources and costs were sourced from the literature and complemented with expert clinical opinion. The price year was 2003 and thus costs were updated to the current price year. Where available, latest (2015/16) NHS reference costs were taken to inform the analysis. These included the most important (largest) unit costs for colonoscopy (diagnostic for those without adenoma and therapeutic for those with adenoma) and hospital treatment for bleeding. Costs for treating cancer when identified at an earlier stage through screening versus when identified at a later stage were derived from a recent report commissioned by Cancer Research UK (2014). The report analysed the costs of colon and rectal cancers by mapping treatment pathways based on published national guidance and assigning unit costs from national data sources. Within each stage of the pathway, the proportion of patients receiving each option had been estimated using information from national datasets and clinical audits, as well as feedback from clinical experts.

Table 4 Parameters, their values and data sources for bowel cancer model

Parameter	Base case	Value range	Source and details
Annual probability of developing bowel cancer, 50 to 64 years	0.57%	0.24% to 1.28%	Derived from 3 years incidence of cancer (all types from IDS-TILDA and proportion of bowel cancer among all cancer

			types in general population) (Cancer Research UK 2014)
Annual probability of developing bowel cancer, 65 years +	0.91%	0.3% to 2.49%	As above
Absolute percentage difference in bowel screening uptake (return of FOBt) in annual health check vs. standard care group	5.8%	4.1% to 7.8%	Hewitson et al. (2011); refers to increase in bowel screening uptake due to additional GP involvement in form of letters or leaflets
Annual reduction in bowel cancer mortality for people participating in screening	1.01%	/	Derived from Scholefield et al. (2002), which found reduced bowel cancer mortality of 18% (mean follow-up 19.5 years)
Probability of people screening positive (i.e. requiring further investigation)	/	1.84% to 2.1%	Raine et al. (2016)
Probability of person with positive result attending specialist clinic for further investigation	83%	74.7% to 91.3%	Logan et al. (2012)
Probability that person undergoing further investigation has bowel cancer	10.1%	9.09% to 11.11%	Logan et al. (2012)
Probability that person undergoing further investigation had pre-cancer polyps	27.2%	24.48% to 29.92%	Logan et al. (2012)
Probability that person undergoing further investigation needed to be admitted for bleeding	0.44%	0.39% to 0.48%	Tappenden et al. (2007)
Costs (in 2015/16 prices)			
Cost of FOBT 92 tests)	£17	£16 to £19	Tappenden et al. (2007); inflated to 2015/16 prices
Cost of colonoscopy	£521	£469 to £573	National Schedule for Reference Costs 2015–

			16; refers to diagnostic colonoscopy
Cost of removing adenoma (as part of colonoscopy)	£136	£122 to £149	National Schedule for Reference Costs 2015–16; refers to additional costs of therapeutic colonoscopy
Cost of admittance for bleeding	£792	£712 to £870	National Schedule for Reference Costs 2015–16; refers to costs for inpatient treatment for gastrointestinal bleeding
Cost of bowel cancer treatment detected through screening	£6,634	£5,971 to £7,298	Own calculations, described above
Cost of bowel cancer treatment clinically detected	£8,646	£7,782 to £9,511	Own calculations, described above
Health utility			
Utility with cancer	0.697		Whyte et al. (2012); from Health Surveys England, mean age 60.9 years; refers to general population
Utility Duke's A, B, C, D	0.74, 0.70, 0.5, 0.25		Tappenden et al. (2007)

5.4 Breast cancer (screening)

Population

Starting age of the cohort of 50 years was used because this is the age when national screening is recommended and implemented for the general population (until 70 years). Effects on mortality were assumed to last up to 10 years after the end of the screening programme so that the model followed women until 80 years. Women were invited for a mammogram every 3 years.

Pathway

In annual health checks, women were asked about whether breast cancer screening in the form of mammography was offered to them, thus increasing their probability of taking up screening. In the standard care group women were invited by mail to visit a breast cancer screening unit without additional encouragement from their GP. The NHS Breast Screening Programme is coordinated nationally and regionally; regional breast screening centres across England were responsible for inviting eligible women

(aged 50 to 69) through their GP practices. Women were then invited to a specialised screening unit, which could be hospital based, mobile, or permanently based in another convenient location such as a shopping centre.

Costs and outcomes

Costs captured in the model included the cost of the mammogram (taken from different sources including from data of National Breast Screening Programme), the costs of diagnosing and treating cancer, which referred to the additional costs linked to over-diagnosis and treatment data linked to screening, as well as the differences in costs between treating a clinically detected patient with breast cancer compared with the cost if the person had been identified through screening and treated earlier. Differences in QALYs between the 2 groups referred to differences in mortality and in health-related quality of life of women linked to the different cancer stages of women.

Parameters and data sources

All parameters and their data sources are shown in Table 5.

First, annual probabilities for women to develop breast cancer in different age groups (50 to 60 years; 65 years +) were derived from 3 years' incidence data provided in IDS-TILDA. IDS-TILDA only collected data on all cancer types combined. The incidence for breast cancer was thus derived. This was done by multiplying the annual probabilities of developing any cancer (for different age groups) with the probability that a new case of cancer was breast cancer; the latter was based on the proportion of different cancer types in the general population in the UK (ONS 2015). It is important to note that this assumed that the proportion of breast cancer among cancer types for older people with learning disabilities was the same in the general population.

Probabilities for uptake of mammography in the annual health check and standard care groups were based on the probability for uptake in the standard care group (from IDS-TILDA) as well as an estimated increase in probability of the annual health check group.[6] The estimated increase was due to the additional encouragement provided in annual health checks and taken from data on the absolute increase in the uptake of mammography found in a recent meta-analysis of studies, which evaluated (among others) interventions in primary care (Gardner et al. 2013).[7] Interventions referred to encouragement from health professionals in the form of additional information provided in writing, by phone or face-to-face. While the study referred to a population on low incomes and with a history of low uptake and not specifically women with a learning disabilities, the Guideline Committee agreed that the figures were applicable. Because the study referred to a wide range of interventions,

[6] Data collected from the General Practice Extraction service (GPES) and published by NHS Digital and Public Health England found similar uptakes of 44% (50 to 54 years), 57.2% (55 to 59 years) and 54.5% (65 to 69 years)

[7] Work carried out in Cornwall by Norah Fry Research Centre on behalf the National Development Team for Inclusion found that the introduction of a screening nurse post achieved an increase in uptake from 36% to 69% (NDTI). However, the nurse post provided a wide range of additional incentives that would not be provided as part of annual health checks so that large increase in uptake they found was not considered suitable for this model.

including multiple ones (which were found to be more effective), the lowest value was taken for the modelling.

The probability that mammography correctly identified breast cancer was taken from sensitivity data of a meta-analysis for older women (Sinclair et al. 2011).

Probabilities that mammography led to over-diagnosis and treatment were taken from Pharoah et al. (2013), which referred to the relative risk of over-diagnosis in screened versus non-screened populations.

The reduction in mortality risk linked to screening for breast cancer was taken from a meta-analysis of 11 randomised trials, which evaluated breast screening mammography using long-term follow-ups (Pharoah et al. 2013). After transforming those into annual data, they were applied to the age-specific annual probabilities of death for people with learning disabilities. Following the approach taken by Pharoah et al. the impact on mortality was assumed to start after the first 5 years of commencement of the screening programme and to last up to 10 years after the end of screening.

QALY gains due to reductions in mortality were calculated by multiplying the changes in probabilities of death with health utilities of someone living with cancer. Health utilities for being free of (breast) cancer and for living with breast cancer were taken from Whyte et al. (2012), which derived data from the Health Survey England and referred to a mean age of 60.9 years.

Costs of mammography and costs for treating 1 case of over-diagnosis were taken from Pharoah et al. (2013). Costs of the treatment for breast cancer were taken from Laudicella et al. (2016) and reflected the differences in costs of early versus late stage cancer. In this England-based study, estimates had been established by matching cost of care data to population-based, patient-level data on breast cancer patients. The data that informed the model reflected the incidence costs of breast cancer over 9 years in people (18 to 64 years and 65 years+) for early stage breast cancer (cancer stage 1 or 2) versus those identified with cancer at a later stage (cancer stage 3 or 4). Estimates for the model were derived based on their annual cost data over 9 years, which were discounted.

Table 5 Parameters, values and data sources for breast cancer model

Parameter	**Base case**	**Value range**	**Source and details**
Annual probability of new breast cancer in women 43 to 49 years	0.03%	0% to 0.16%	IDS-TILDA for incidence of all cancers and Cancer Research UK (2014) for proportion that relates to breast cancer
Annual probability of new breast cancer in women 50 to 64 years	0.09%	0.04% to 0.19%	IDS-TILDA for incidence of all cancers and Cancer Research UK (2014) for proportion that relates to breast cancer

Probability of mammogram in standard care	49.5%	47% to 52%	IDS-TILDA
Absolute increase in uptake of mammogram with annual health check	8.9%	7.3% to 10.4%	Refers to absolute increase in uptake of mammogram achieved with additional incentives (Gardner et al. 2013)
Probability of mammogram in annual health check group	56.8%	54.3% to 59.3%	Probability of mammogram in annual health check group plus absolute increase in uptake with annual health checks
Probability that breast cancer is identified through mammography	85.6%	73.3% to 93.8%	Sinclair et al. (2011)
Relative risk of breast cancer mortality for women invited to regular mammogram screening	0.8	0.73 to 0.89	Pharoah et al. (2013)
Relative risk of over diagnosis related to screening (mammogram)	1.19	/	Pharoah et al. (2013)
Cost of treating an over-diagnosis of breast cancer	2274	2,047 to 2,501	Pharoah et al. (2013)
Cost difference early versus late stage cancer, under 65 years	13,043	11,739 to 14,347	Laudicella et al. (2016)
Cost difference early versus late stage cancer, under 65 years	7115	6404 to 7827	Laudicella et al. (2016)
Costs of mammogram per woman invited for screening	25	14 to 36	Pharoah et al. (2013)
Health utility			
Health utility, cancer free	0.798	0.718 to 0.878	Whyte et al. (2012), from Health Surveys England, mean age 60.9 years; refers to general population
Health utility, breast cancer	0.697	0.627 to 0.767	As above; refers to general population

5.5 Osteoporosis (screening)

Population

The model covered cohorts of 1000 women above the age of 50 years and followed them until death. While the Guideline Committee agreed that both men and women should be risk assessed, the model only referred to women because evidence on cost-effective treatment was focused on women (during and after menopause). The Committee agreed to use 50 years as starting age for screening due to the rise in prevalence from that age onwards (5.2% from 43 to 49 years vs. 13.3% from 50 to 64 years according to IDS-TILDA). In addition, evidence suggests that treatment effects wane off after 15 to 20 years so that treatment at a younger age is considered less beneficial (Shepstone et al. 2012).

Pathway

For the group that received annual health checks, it was assumed that all women were risk assessed for osteoporosis using FRAX, a tool recommended in NICE guideline 'Osteoporosis: assessing the risk of fragility fracture' (NICE 2017a). It is important to note that this did not reflect current practice but the Committee agreed that this should be part of a best practice annual health check due the many risk factors prevalent in this group and the high risk of under-reporting of falls (as 1 of the risk factors). Studies have also suggested that this type of screening should be recommended for this population (Srikanth et al. 2011). Women identified as at risk were offered standard care, which included a bone mineral density assessment (using DXA) and the prescription of drugs for those identified with osteoporosis (or at major risk thereof). In the standard care group, women in the comparison group were investigated for osteoporosis as per current practice, which included bone mineral density assessment (with DXA) and prescription of drugs for those testing positive. The nature of the processes in the 2 groups followed those described in Shepstone et al. (2012) for women post-menopause.

Cost and outcomes

Based on findings from the SCOOP study, a recent large pragmatic randomised UK trial, which evaluated screening plus treatment as usual versus treatment as usual, the main impact simulated in this model was the expected reduction in hip fracture linked to screening and the associated costs and health-related quality of life improvements. Costs included in the model were those of DXA (including GP consultation), prescribed anti-osteoporosis drugs and hospital treatment of HIP fracture. While other studies on effectiveness of screening or treatment for osteoporosis also found effects on other types of fractures and on mortality, this was not included in the model following a conservative approach (in line with findings from this large, most recent, England-based study).

Parameters and data sources

All parameters and their data sources are shown in Table 6.

Probabilities of women developing osteoporosis were derived from 3 years' incidence data as shown in IDS-TILDA. IDS-TILDA provided age-specific incidence data only for men and women combined (rather than for women only). However, it provided data on incidence for women and men separately across the different age groups. In order to derive women-specific probabilities of developing osteoporosis, the additional risk for all older women above that for all older people with a learning disabilities (men and women) was multiplied by the yearly incidence for different age ranges (i.e. 50 to 64 years and 65 years +).

Probabilities that women were identified with osteoporosis in the annual health check group versus standard care were derived as follows: the probability that women with new onset osteoporosis received further investigation in the annual health check group came from Guideline Committee estimates and referred to the uptake of annual health checks if they followed best practice (mean value of 90%). Since the Committee considered this parameter highly uncertain, the impact of a much lower value of 60% was applied in sensitivity analysis. The probability that women in standard care would be investigated for and identified with osteoporosis was derived from data on the relative difference between the 2 groups (Lennox et al. 2007, 2011, Lennox and Robertson 2014) and the estimated probability in the annual health check group. The Australian studies by Lennox et al. were the only studies that provided data on how osteoporosis was investigated in annual health checks. This lack of data might be explained by the fact that osteoporosis was not investigated as part of the Cardiff Health Check tool, which is the tool currently used in the English primary care system.

The probability that women, once identified with DXA as having osteoporosis, were then prescribed drugs was based on the SCOOP study, which showed that almost all women (99.5%) identified were prescribed drugs. It is important to note that persistence to treatment has been found to be a particular issue for anti-osteoporosis medication (Hiligsmann et al. 2012); in the SCOOP study, about 30% of women were still using drugs 5 years on.

The effectiveness of treatment was modelled by looking at the differences in the risk of HIP fracture in the annual health check and standard care groups. The hazard ratio over 5 years from Shepstone (2016 – HR=0.72; 95% CI 59–89) was converted in an annual probability (and range thereof for PSA). Data for the annual probability of HIP fracture in the standard care group were derived from IDS-TILDA, which provided 3 years' incidence data for HIP fracture for the different age groups of older people with a learning disabilities.

In regard to the FRAX assessment, it was assumed that this was carried out as part of the annual health checks and that therefore no additional costs occurred. Data on DXA scan were taken from NICE guidance on osteoporosis fragility fracture risk (NICE 2012). The costs of HIP fracture treatment were taken from a recent England-based large cohort study (Leal et al. 2016). Data from this UK representative study were sourced from Hospital Episodes Statistics (HES). Costs of HIP fracture were

applied in the year of HIP fracture and the year after, which is where the largest bulk of costs occur (Leal et al. 2016).

Costs of treatment in the form of drugs were derived from the NICE guideline (NICE 2017b). Oral bisphonates – such as alendronate, etidronate and risedronate – are the most commonly prescribed drugs for osteoporosis. For example, in the SCOOP study about 80% of women received oral bisphonates (personal communication with author of study). For the model, value ranges were based on drugs commonly prescribed and recommended in NICE guidelines including alendronate, etidronate, risedrinate, raloxifene and strontium ranelate. For the baseline a mid-value was taken between the lowest and highest price.

Health utilities were applied to people who were alive with and without out HIP fracture, in the year of the HIP fracture. Data on health utilities were taken from documents produced for a NICE technology assessment, which investigated the cost-effectiveness of a particular drug in a population of post-menopausal women (NICE 2010).

Mortality probabilities were applied in the model following the general approach described earlier but instead of a female and male combined mortality, only that for the female population was taken.

It is important to note that this model was subject to many uncertainties because it referred to a screening intervention that has only been recently tested in England for the general population of post-menopausal women.

Table 6 Parameters, values and data sources for osteoporosis model

Parameter	**Base case**	**Value range**	**Source and details**
Annual probability new osteoporosis in women 50 to 64 years	4.1%	2.8% to 5.9%	Derived from IDS-TILDA
Annual probability new osteoporosis 65 years +	7.5%	4.8% to 11.2%	Derived from IDS-TILDA
Probability of osteoporosis investigated in annual health check group	90%	85% to 95%	Guideline Committee estimate
Probability that osteoporosis investigated in standard care group	75.6%	66.2% to 86.8%	Derived from Lennox et al. (2011),
Probability that person with identified osteoporosis	99.6%		Derived from findings of SCOOP study presented by Shepstone at National

(DXA) gets prescribed drugs			Osteoporosis Society conference 2016
Baseline probability of HIP fracture in standard care group, 50 to 64 years	0.19%	0.07% to 0.55%	Derived from IDS-TILDA
Baseline probability of HIP fracture in standard care group, 65 years +	0.35%	0.08% to 1.11%	Derived from IDS-TILDA
Reduction in probability of HIP fracture, annual health check vs. standard care group	97.3%	94.8% to 98.8%	Derived from Shepstone (2016)
Costs (in £ 2015/16)			
Cost of DAX scan and GP consultation	£125	£113 to £137	NICE (2017a)
Prescribed anti-osteoporotic medication	£194	£54 to £334	NICE (2017a)
Treatment for HIP fracture, first year	£14,641	£14,481 to £14,800	Leal et al. (2016)
Treatment of HIP fracture, second year	£2,211	£2,160 to £2,272	Leal et al. (2016)
Health utilities			
HIP fracture, first year	0.7	0.64 to 0.77	NICE (2010); refers to general population
Without HIP fracture, 50 to 60 years	0.82	0.6 to 0.85	NICE (2010); refers to general population
Without HIP fracture, 60yrs +	0.78	0.55 to 0.82	NICE (2010); refers to general population

5.6 Cataract

Population

The cohort start age was 40 years and the model followed people until everyone died.

Pathway

People in both the annual health check and standard care groups were asked with different probabilities by their GP about their eyesight and referred to a specialist eye

exam if it was indicated that the person had an eye problem. During the specialist assessment (provided by an optometrist), the cataract was corrected for some people with prescription glasses while others were offered surgery, which is currently the only effective treatment for cataract if a correction with glasses is not an option.[8] However, the Guideline Committee agreed that older people with learning disabilities were currently not always offered surgery due to circumstances linked to their disabilities. Committee members reported that people were discriminated against as assumptions were made about their ability to have or to benefit from surgery.

Cost and outcomes

The model included the costs of specialist eye assessment in the community as well as lifetime costs and QALYs linked to cataract surgery. Lifetime costs of cataract surgery were taken from an existing economic modelling study published as part of a health technology assessment (Frampton et al. 2014).

Parameters and data sources

All parameters and their data sources are shown in Table 7.

Annual probabilities of people developing a new cataract were derived from 3 years incidence data for cataract provided in IDS-TILDA (McCarron et al. 2014). The probabilities that a person was referred to an optometrist in the annual health check and standard care groups were derived from Guideline Committee estimates and data on the relative difference in the 2 groups measured in the form of odds ratios provided by Buszewicz et al. (2014). The Committee estimated that the probability of a person receiving an annual health check was 90% and that every person with eye problems was referred to and attended an eye exam (the Committee agreed that this was realistic with the help of a support worker). Considering the uncertainty of this estimate, a lower value of 50% was used in sensitivity analysis. Probabilities that a referral was made in the standard care group were derived from data on the probability in the annual health check group (estimated by the Committee at 90%) and the relative difference of referrals to eye exams between the 2 groups provided by Buszewicz et al. (2014).

The probability that for a person attending the eye exam cataract was corrected with glasses was taken from Lennox et al. (2011), which referred specifically to people with learning disabilities. The Committee estimated that the probability that a person with cataract was referred to cataract surgery was less than 10%; values between 5% and 9% were applied in probabilistic sensitivity analysis.

Costs of the eye exam in the form of an initial test and a diagnosis test were taken from national sources and Burr et al. (2007). Lifetime QALY gains and costs linked to cataract surgery were taken from Frampton et al. (2014). Their economic model evaluated the cost-effectiveness of second-eye cataract surgery. The values are likely to be conservative as first-eye cataract surgery is likely to be more cost-

[8] https://www.rcophth.ac.uk/wp-content/uploads/2015/03/Commissioning-Guide-Cataract-Surgery-Final-February-2015.pdf.

effective. Frampton et al. (2014) provided a gain in health utility of 0.08 and this was used in the analysis. The authors reported clinical consensus that this improvement was permanent and lasted until the person died. Costs included those of cataract surgery (taken from NHS reference costs) and outpatient and GP visits before and after surgery. Costs also included those of treating any post-surgical complications.

Table 7 Parameters, values and data sources for cataract model

Parameter	**Base case**	**Value range**	**Source and details**
Annual probability that person develops cataract 40 to 49 years	1.76%	0.9% to 0.03%	IDS-TILDA (McCarron et al. 2014), derived from 3 years incidence data; data on 43 to 49 years was applied to the 40 to 49 years
Annual probability that person develops glaucoma 50 to 64 years	2.10%	1.32% to 3.2%	IDS-TILDA (McCarron et al. 2014), derived from 3 years incidence data
Annual probability that person develops glaucoma 65yrs +	2.11%	1.04% to 4.09%	IDS-TILDA (McCarron et al. 2014), derived from 3 years incidence data
Probability that person in annual health check group gets referred to eye exam (if needed)	90%	/	Guideline Committee estimate
Odds ratio for difference in referral to eye exam in annual health check vs. standard care group	12.98	4.48 to 37.1	Buszewicz et al. (2014)
Probability that person in standard care group gets eye exam (if needed)	58.9%	/	Derived from probability in annual health check group as estimated by Guideline Committee and odds ratio from Buszewicz et al. (2014)
Probability that person referred to eye exam for cataract has problems corrected with glasses	58.5%	50% to 67%	Lennox et al. (2011)
Probability that person referred to eye exam with cataract problems get surgery	7%	5% to 9%	Guideline Committee estimate

Costs, in £ 2015/16			
Costs of initial optometrist test	£21	/	DH (2016)
Costs of optometrist diagnosis test	£158	£92 to £472	Burr et al. (2007)
Lifetime costs linked to cataract surgery	£5,176	£1,218 to £9,211	Frampton et al. (2014)
Health utility			
Lifetime QALY gain linked to cataract surgery	0.547	0.084 to 0.963	Frampton et al. (2014); refers to general population

5.7 Glaucoma

Population

The starting age of the cohort was 40 years and people were followed until everyone had died; each cycle was 1 year. The starting age was based on that used in other studies, such as Burr et al. (2007).

Pathway

People in both groups were referred by their GP to an optometrist for an eye exam, although with different probabilities depending on whether or not they were in the annual health check or standard care group. This was based on data by Buszewicz et al. (2014) and Guideline Committee estimates, which together informed the different rates of eye examinations in the 2 groups. People identified to have glaucoma during their eye examination accepted and adhered to glaucoma treatment or remained without treatment (Okeke et al. 2009). People with glaucoma could progress from mild to moderate, from moderate to severe and from severe to permanent vision impairment (Burr et al. 2007). Progression rates were different for those who received treatment versus those who did not (Burr et al. 2007). At the end of each cycle of 1 year people would remain alive or die. Of those alive, people were living with or without glaucoma. Of those alive with glaucoma people could be in 1 of the following states:

- in treatment with mild glaucoma
- in treatment with moderate glaucoma
- in treatment with severe glaucoma
- in treatment with vision impairment
- not in treatment with mild glaucoma
- not in treatment with moderate glaucoma
- not in treatment with severe glaucoma

- not in treatment with vision loss.

Cost and outcomes

Costs included in the model were those of initial assessment (optometrist test) and ophthalmologist diagnosis test (Burr et al. 2007), of treatment of mild, moderate and severe glaucoma as well as those linked to permanent vision impairment (eyesight loss). QALYs calculated in the model referred health-related quality of life loss linked to the different stages of glaucoma, that is, mild, moderate and severe glaucoma as well permanent vision impairment (Burr et al. 2007). No impact was found of glaucoma on mortality so that no additional adjustment of mortality data was carried out.

Parameters and data sources

All parameters and their data sources are shown in Table 8.

Annual probabilities for developing new glaucoma were derived from 3 years' incidence data for glaucoma provided in IDS-TILDA for different age groups following the approach described above. Probabilities for a person with new glaucoma to be referred to the optometrist for an eye exam in the annual health check group and standard care group were derived from odds ratios provided in Buszewicz et al. (2014) as well as Guideline Committee estimates: the Committee estimated that 90% of people received an annual health check and that the probability of someone with an eye problem being referred to an optometrist was 100%; this was based on best practice assumptions which assumed that all people were correctly assessed during annual health checks as requiring further tests. Since this estimate was uncertain, a lower estimate of 50% was used in sensitivity analysis. The identification of glaucoma in the standard care group was derived from the probability in the annual health check group as well as the odds ratio between the 2 groups for a referral to an eye exam identified by Buszewicz et al. (2014). This approach meant that even if the absolute referral rates for people with glaucoma were uncertain, the relative difference, which was known, was applied, thus leading to robust incremental estimates. The probability that a person identified with glaucoma accepted and adhered to glaucoma treatment was taken from Okeke et al. (2009), which refers to the general population. The Committee thought that this figure could be used for the model – assuming the help of a support worker was available for older people with learning disabilities. Annual probabilities of disease progression with and without treatment were taken from Burr et al. (2007).

Health utilities for the different glaucoma stages were taken from Burr et al. (2007) and assigned to the different health states people had reached at the end of each cycle (without glaucoma, with mild glaucoma, with moderate glaucoma, with severe glaucoma, with vision impairment). Costs for the treatments were applied to the different glaucoma stages. Data from Burr et al. (2007), which was a health technology assessment carried out in the UK, were from a detailed economic evaluation. While the study was about understanding the cost-effectiveness of screening for glaucoma, it provided useful data for many of the parameters, including

disease progression with and without treatment, costs of treatment for different glaucoma stages and health utilities for different glaucoma stages.

Table 8 Parameters, values and data sources for glaucoma model

Parameter	**Base case**	**Value range**	**Source and details**
Annual probability that person develops glaucoma 40 to 49 years	0.12%	0% to 1.2%	IDS-TILDA, derived from 3 years incidence data,
Annual probability that person develops glaucoma 50 to 64 years	0.4%	0.14% to 1.1%	IDS-TILDA, derived from 3 years incidence data
Annual probability that person develops glaucoma 65 years +	0.2%	0% to 0.15%	IDS-TILDA, derived from 3 years incidence data
Probability that person with glaucoma referred to eye exam in annual health check group	90%	/	Guideline Committee estimate
Odds ratio for difference in referral to eye exam in annual health check vs. standard care group	12.98	4.48 to 37.1	Buszewicz et al. (2014)
Probability that person in standard care group gets eye exam (if needed)	58.9%	SD 0.24	Derived from probability in annual health check group as estimated by Guideline Committee and odds ratio from Buszewicz et al. (2014)
Probability that person accepts and adheres to glaucoma treatment	71%	63.9% to 78.1%	Okeke et al. (2009); value range was developed by +/-10%
Annual progression from mild to moderate for people (not) in treatment	22% (25%)	Beta	Burr et al. (2007)
Annual progression from moderate to severe for people (not) in treatment	7% (11%)	Beta	Burr et al. (2007)
Annual progression from severe to vision	6% (10%)	Beta	Burr et al. (2007)

impairment for people (not) in treatment			
Costs, in £ 2015/16			
Costs of initial optometrist test	£21	/	DH (2016)
Costs of optometrist diagnosis test	£15	£92 to £472	Burr et al. (2007)
Cost of treatment for mild glaucoma per year	£517	£259 to £777	As above
Cost of treatment for moderate glaucoma per year	£583	£325 to £875	As above
Cost of treatment for severe glaucoma	£464	£232 to £695	As above
Cost of visual impairment per year	£825	£721 to £927	As above
Health utility			
Health utility, glaucoma mild	0.80	0.72 to 0.88	As above; refers to general population
Health utility, glaucoma moderate	0.74	0.67 to 0.82	As above; refers to general population
Health utility, glaucoma severe	0.71	0.64 to 0.78	As above; refers to general population
Health utility, vision impairment	0.54	0.48 to 0.59	As above; refers to general population

5.8 Hearing impairment

Population

Starting age of the cohort was 40 years and people were followed until everyone had died.

Pathway

Depending on whether people were in the annual health check or standard care group, they had different probabilities of being asked by their GP (or GP nurse) about whether they had hearing problems. People with a hearing problem identified in GP practice were either treated for blocked earwax or referred to a specialist hearing

assessment in the community. It is important to note that blocked earwax is a common, often not detected, cause of hearing impairment for this population. It was assumed that if earwax was the cause of the hearing problem, the GP or GP nurse would offer treatment. If the hearing problem was not due to blocked earwax, the person was referred to a specialist hearing assessment. The person was then prescribed a hearing aid and either accepted and started using the hearing aid or not.

Costs and outcomes

Costs included in the model were those of earwax removal in primary care, of a specialist referral and of a hearing aid (initial and follow-up care). Outcomes measured in form of QALYs included health-related quality of life gains linked to earwax removal, and linked to a hearing aid. No impact was found on mortality due to hearing problems so that general and not disease-specific mortality data were applied.

Parameters and data sources

All parameters and their data sources are shown in Table 9.

Annual probabilities for developing new hearing problems were not available from IDS-TILDA and thus estimates had to be derived using other sources. Carvill (2001) estimated a prevalence of 40% and this figure has been cited by other studies (for example, Emerson and Bains 2010) so that this estimate was taken as the mean value. Kerr et al. (2003) found that 28% had moderate to severe hearing impairment and that as many as 89% of older people with learning disabilities were affected by some form of hearing impairment. These values were taken as lower and upper bound values. In order to derive yearly incidence data from these (and without having further information about the duration of the condition), relationships between prevalence and incidence were applied as observed in IDS-TILDA for cataract.

As for the models on glaucoma and cataract, the Guideline Committee estimate of uptake of annual health checks of 90% was taken to inform the probability that a person in the annual health check group would be asked about and correctly identified with a hearing problem by their GP. The probability in the standard care group was derived based on the Committee estimate and the odds ratio from Buszewicz et al. (2014), which measured the relative difference of hearing problem identified in the 2 groups. Probabilities that identified hearing problems were due to earwax were taken from different sources, including Robertson et al. (2014) and Clegg et al. (2010), which identified values ranging from 15.7% to 50%; these informed the parameter distribution for PSA (calculated mean value was 32.3%).

For people whose hearing problems was not due to earwax and who were referred to a hearing assessment, the probability that that the person was identified with hearing loss was taken from Lennox et al. (2007), which referred specifically to older people with a learning disabilities. The probability that people accepted and started using hearing aids was derived from data by Morris et al. (2013). The period over which the use of hearing aids was evaluated in Morris et al. (2013) was 5 years and it was

assumed in the absence of further data that people who still used hearing aids after 5 years continued using them for the rest of their lives.

Health (dis)utilities were taken from Morris et al. (2013); this referred to the health disutility due to temporary hearing loss (due to earwax) and the health utility gain from having a hearing aid.

Cost data were taken from different sources: the costs of earwax removal were taken from Clegg et al. (2010); the costs of specialist hearing assessment were taken from Morris et al. (2013); the costs of an audiology assessment for hearing aids and follow-on costs were taken from national tariffs.

Table 9 Parameters, values and data sources for hearing impairment model

Parameter	Base case	Value range	Source and details
Annual probability of new hearing problem, all ages	4.1%	2% to 13.4%	Derived from prevalence taken from Carvill (2001) and Kerr et al. (2003); prevalence/incidence relationship taken from eye problems (cataract), average across age groups
Probability of hearing assessment in annual health check group	90%	/	Guideline Committee estimate
Odds ratio of hearing assessment, annual health check group vs. standard care	23.9	11.5 to 49.8	Buszewicz et al. (2014)
Probability of hearing assessment in standard care group	27.3%	27.6% to 33%	Derived from probability of hearing assessment in annual health check group and odds ratio from Buszewicz et al. (2014)
Probability that hearing problem is due to blocked earwax	32.9%	15.7% to 50%	Range of sources including Robertson et al. (2014), Clegg et al. (2010)
Probability that hearing problem is not due to blocked earwax and referral	67.1%	50% to 84.3%	Derived from the above (1-p)

is made to specialist hearing assessment			
Probability that person attends assessment	85%	80% to 90%	Guideline Committee estimate
Probability that person assessed by specialist is identified in need of hearing aid	46.9%	42.2% to 51.6%	Lennox et al. (2007)
Probability that person accepts and starts using hearing aid	59.4%	36.8% to 86%	Morris et al. (2013)
Costs, in £ 2015/16			
Cost of ear wax removal in primary care	£40	£36 to £44	Clegg et al. (2010)
Cost of audiology hearing aid assessment	£40	£36 to £44	National tariff
Cost of audiology specialist assessment	£57	£46 to £68	National tariff
Cost of audiology hearing aid	£53	£48 to £58	National tariff
Cost of initial hearing aid	£319	£268 to £370	National tariff
Cost of hearing aid follow-on care	£25	£23 to £28	National tariff
Health utilities			
Health utility gain from removed earwax	0.006	0.0054 to 0.0066	Morris et al. (2013); refers to general population
Health utility gain from hearing aid	0.068	0.035 to 0.105	Morris et al. (2013); refers to general population

6 Results of the economic modelling

The results of the different models for each health conditions were aggregated in terms of their present values of lifetime costs and lifetime QALY gains. The net present value of the costs of annual health checks was added to those aggregated costs to derive a final present value of costs.

The results of the economic modelling are presented in incremental lifetime costs and lifetime effects at present value. Effects were measured in QALYs gained. 'Incremental' refers to the difference in costs or effects between the 2 groups, that is, between people who were offered annual health checks and those who were not. Incremental cost-effectiveness ratios (ICERs) set the costs and effects in relation to one another; they are calculated by dividing incremental costs by incremental effects.

Findings are presented in Table 10 and relate to averages per person. Costs are presented in 2015/16 prices. Unless stated otherwise, costs and QALYs were discounted at the rate of 3.5%. Mean incremental lifetime costs per person were £119.50 when the costs of annual health checks were excluded from the analysis. Based on mean changes in QALYs of 0.0719, this led to an ICER of £1,700, meaning the additional or incremental cost per QALY gained was £1,700. Under standard willingness-to-pay thresholds in the UK of £20,000 to £30,000 per QALY, the finding would suggest that annual health checks could be highly cost-effective. However, this estimate did not include the costs of annual health checks, which the Guideline Committee had estimated at £258 if they were provided under good practice assumptions. If this cost was included in the analysis then total lifetime costs amounted to £4,910.80 and based on a QALY gain of 0.0719 led to an ICER of £89,200. Thus, under standard willingness-to-pay thresholds, annual health checks could no longer be considered cost-effective.

Table 10 Results from economic model (annual health checks vs. standard care), all prices in £ 2015/16, per person

	Incremental costs (excluding costs of annual health checks)	**Incremental total costs**	**Diff. in QALYs**	**ICER (excluding costs of annual health checks)**	**ICER**
Mean	£119.5	£4,910.80	0.0719	£1,669.60	£89,200.30
Standard deviation	£221.80	£221.80	0.0409	£3,034.40	£47,568.60
95% confidence interval	£105.80 to £341.30	£4,897 to £5,133	0.0695 to 0.113	£1,481.50 to £4,703.90	£86,251.90 to £136,768.80

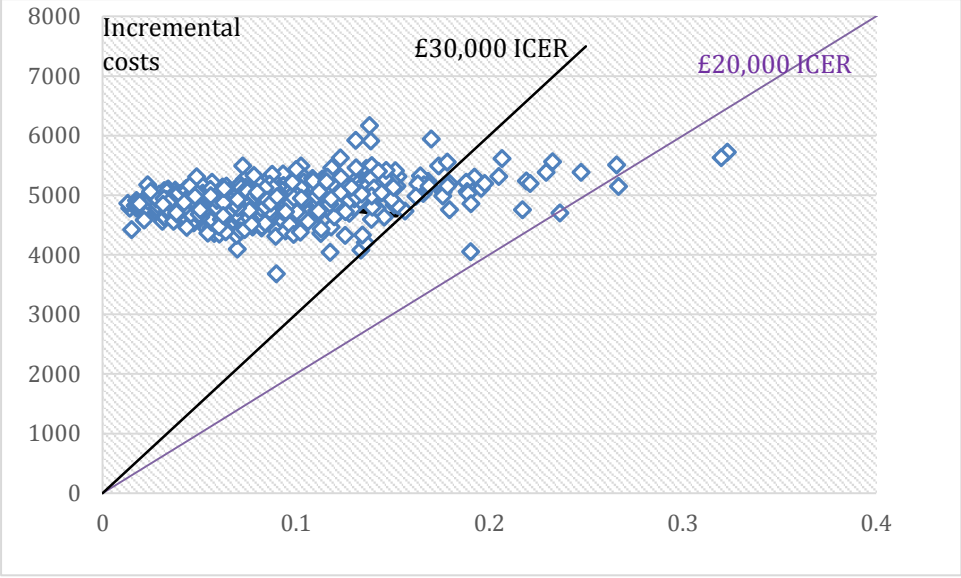
Table 11 shows the ICER for a scenario in which outcomes remained undiscounted, assuming no preference for present over future in regard to health-related quality of life. In this scenario the ICER reduced to £51,971, which is still above the willingness-to-pay of governments in most countries including the UK.

Table 11 QALY gains (undiscounted) and ICER if QALYs undiscounted

	Incremental effects (QALYs, undiscounted)	**ICER (QALYs undiscounted)**
Mean	0.134	£51,971
Standard deviation	0.088	£31,436
95% confidence interval	0.1285 to 0.222	£50,022 to £83,406

Another way of presenting the findings from the economic analysis that employs probabilistic sensitivity analysis (that is, results are provided in ranges rather than point values) is shown in Graph 1. The graph shows the incremental effects (measured in QALYs) on the x-axis and incremental costs on the y-axis. The dots represent the results of 1000 Monte Carlo simulations. As can be noted, only a few dots lie below the lines that provide the thresholds for cost-effectiveness (at £20,000 and £30,000). The vast majority of dots are centred at incremental costs of £5,000 and incremental QALY gains of less than 0.1, suggesting ICERs of above £50,000 and higher.

Graph 1 Probabilistic sensitivity results presented as scatter plot (cost-effectiveness plane)



The probabilities of annual health checks being cost-effective are shown for different scenarios in Table 12. If the costs of the intervention were excluded, then annual health checks had a 100% probability of being cost-effective (scenario 1). If costs of annual health checks were included, probabilities reduced to less than 6% for a willingness-to-pay threshold of £30,000 and to less than 1% at a threshold of £20,000 (scenario 2). If QALYs were not discounted, then those probabilities increased to 30% and 12% but remained under 50% (scenario 3).

Table 12 Probabilities that annual health checks were cost-effective for different scenarios

ICER	Probability of cost-effectiveness at £20,000	Probability of cost-effectiveness at £30,000
Scenario 1: excluding costs of annual health checks, costs and outcome discounted at 3.5%	100%	100%
Scenario 2: including costs of annual health checks, costs and outcomes discounted at 3.5%	<1%	<6%
Scenario 3: including costs of annual health checks, costs discounted at 3.5%, outcomes undiscounted	<12%	<30%

Since the cost of the intervention was an important parameter, which decided whether or not annual health checks could be provided cost-effectively, sensitivity analysis was used to explore the cost threshold at which annual health checks could still be considered cost-effective. Table 13 shows different costs of annual health checks and their associated ICER, and probabilities that annual health checks were cost-effective. The findings show that if annual health checks could be provided at £50 they had a probability of 88% to be cost-effective, whereas if their costs were £75 the probability reduced to 64% and at £100 and above they would no longer be cost-effective (that is, their probability to be not cost-effective was at 53% and thus higher than the probability that they were cost-effective, which was 47%).

Table 13 One-way sensitivity analysis for different costs of annual health checks

Cost of the intervention	Mean ICER (95% CI)	Probability of cost-effectiveness
£50	£18,613 (£17,981 to £28,791)	88%
£75	£26,674 (£25,773 to £41,211)	65%
£100	£34,959 (£33,818 to £53,363)	47%

7 Discussion

7.1 Interpretation

The findings of the analysis suggest that it might be difficult to carry out annual health checks cost-effectively from a NHS cost perspective for older people with learning disabilities. This was the case even if the costs of annual health checks were much below the estimated costs, which reflected good practice as agreed with the guideline committee. That meant that, following an economic rationale, annual health checks (if provided in a good practice manner as agreed by the guideline committee) were not likely to be cost-effective from a NHS cost perspective.

While this study found that annual health checks led to improvements in health-related quality of life and even reductions in mortality, changes were generally small. In terms of cost consequences, those were also small, meaning that additional identification and treatment did not lead to large cost increases. Costs of additional diagnosis and earlier treatment were at least partly offset by a reduced need for more intensive treatment. This economic study applied wide ranges in values to reflect the uncertainty of some of the parameters. Only the costs of annual health checks but no other parameter had an impact on the cost-effectiveness to such an extent that it could change the conclusion if the intervention could be considered cost-effective.

7.2 Limitations

The study had a number of limitations. In particular, it is important to note that the study was explorative in nature due to the many gaps in evidence. Responding to those gaps in evidence, the analysis applied probabilistic sensitivity analysis (using value ranges around parameters instead of single values).

It is also important to note that a highly conservative approach was used to establish values. First, costs of the intervention referred to the costs if the process was followed in a good practice manner, while outcomes related to average effects of practices (which would include good and less good practice in relation to annual health checks). It is possible and likely that effects are larger when good practice is followed but no studies have been carried out to evaluate the effect of good practice annual health checks over and above current practice standards. Researchers leading evaluation studies in this area conclude that variations in the nature of annual health checks and activities carried out as part of annual health checks are likely to be large (Buszewicz et al. 2014; Carey et al. 2017; Robertson et al. 2014). In regard to variations in activities carried out by different professional groups, in some of the Australian studies it was the GP nurses who tested vision in primary care, whereas in UK studies the GP nurse more commonly asked about vision difficulties and testing and referred people with problems to an optometrist (Cooper et al. 2014). This detail of how annual health checks are provided was also not well reported which made it

difficult to come to reliable conclusions about the relationships between the process of annual health checks and health outcomes and costs.

Second, effects linked to the introduction of the Quality and Outcomes Framework were as far as possible excluded from this analysis. This was done to avoid overestimating effects that were linked to a different policy. However, there was some evidence that suggests that the introduction of annual health checks had enhanced some of the benefits of the Quality and Outcomes Framework: for example, people in practices carrying out annual health checks were more likely to be included in the routine call and recall system offered through the Quality and Outcomes Framework (Chauhan et al. 2010). People might thus have experienced positive, indirect effects through annual health checks that were not included in this analysis.

Third, as with most modelling studies for complex interventions, there are challenges in valuing the economic consequences linked to number of outcomes, which are potentially overlapping. In this analysis, for health conditions that were known to have strongly overlapping economic consequences, this was considered by adjusting prevalence rates (see sections on diabetes and high blood pressure). More generally, however, it was assumed that costs and QALYs were additive. So the costs of treating one person with two or multiple conditions (comorbidity) was assumed to be the same as if several people had one of these conditions each. Similarly, the health disutility experienced by one person who had two or several conditions, was assumed to be the same as if several persons had one of those conditions each. This is a simplification of reality because it is possible that the sum of the health burden experienced by a person living with more than one condition is greater or smaller than the health burden experienced by different persons living with one of these conditions each. Similarly it possible that certain costs would be different as conditions might be treated in combined form rather than individually (if integrated care structures would be available).

Important gaps in evidence referred also to the knowledge about incidence and prevalence data for health conditions in older people with learning disabilities. Although IDS-TILDA was the best available source for incidence data, the study had some limitations that are important to acknowledge. First, the study was carried out in Ireland and while overall prevalence and incidence are likely to be similar in England, it is possible that there are also differences. Second, for most health conditions the study relied on self-report, which was likely to lead to some under-reporting and lower frequency of common diseases. The difficulties of accurately identifying health conditions in this population – in particular because of diagnostic overshadowing (a process by which physical and mental health symptoms are misattributed to the learning disability) – are discussed in the literature (for example by Doody et al. 2012; Robertson et al. 2014).

Although, as far as possible, the study sought to use data that specifically related to older people with learning disabilities, often such data were not available and assumptions had to be made in consultation with the Guideline Committee about the transferability of data to this population. This primarily referred to evidence on the costs and outcomes of health interventions. Those assumptions were again made conservatively, thus restricting the focus of the work on health conditions and treatment options. A particular challenge was related to the fact that – as agreed by the Committee – older people with learning disabilities were likely to experience

health-related quality of life differently than the general population of older people. The Committee thought that there were additional health dis-utilities linked to the discrimination experienced by this population. In particular, the Committee thought that a person with a learning disabilities would experience lower health-related quality of life compared with a person without learning disabilities even if they had otherwise similar characteristics in terms of age and health conditions. Similarly, costs for diagnosis and treatment were likely to be different than those for the general population because health professionals would have to spend more time explaining tests and treatment options. Not much is currently known about the additional costs that are required to carry out such additional support. The Committee also agreed that spending additional time during appointments might help to prevent some costs, such as those linked to missed appointments or unnecessary repeat appointments, or existing over-prescription of drugs. Person-centred discussions during assessments and reviews, which included the person as well as their family and carer, were seen as key to an accurate diagnosis.

7.3 Implications

The study raised awareness of important gaps in evidence for this population. At the moment, many evidence gaps remain in regard to how best identify ageing-related conditions in this population and how to ensure that this population gets cost-effective treatment. In addition, the study findings raise important ethical questions and highlight the need to align ethical considerations with economic ones. As recognised in current NICE guidelines and in English and UK policies, annual health checks have an important role in reducing health inequalities. However, their provision might require additional resources that are currently not available, which would increase access to treatment. This refers not only to resources that support the delivery of annual health checks, but also to resources that create capacities for screening, diagnosis and treatment of health conditions for this population. In addition, the findings of the study might also suggest that alternative ways of identifying health problems might be as, or even more, cost-effective as annual health checks. Committee members suggested the important role of well men and women clinics but also the need for collaborative care more generally.

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