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Four Case Studies to Explore the Added Value of Oxford AHSN

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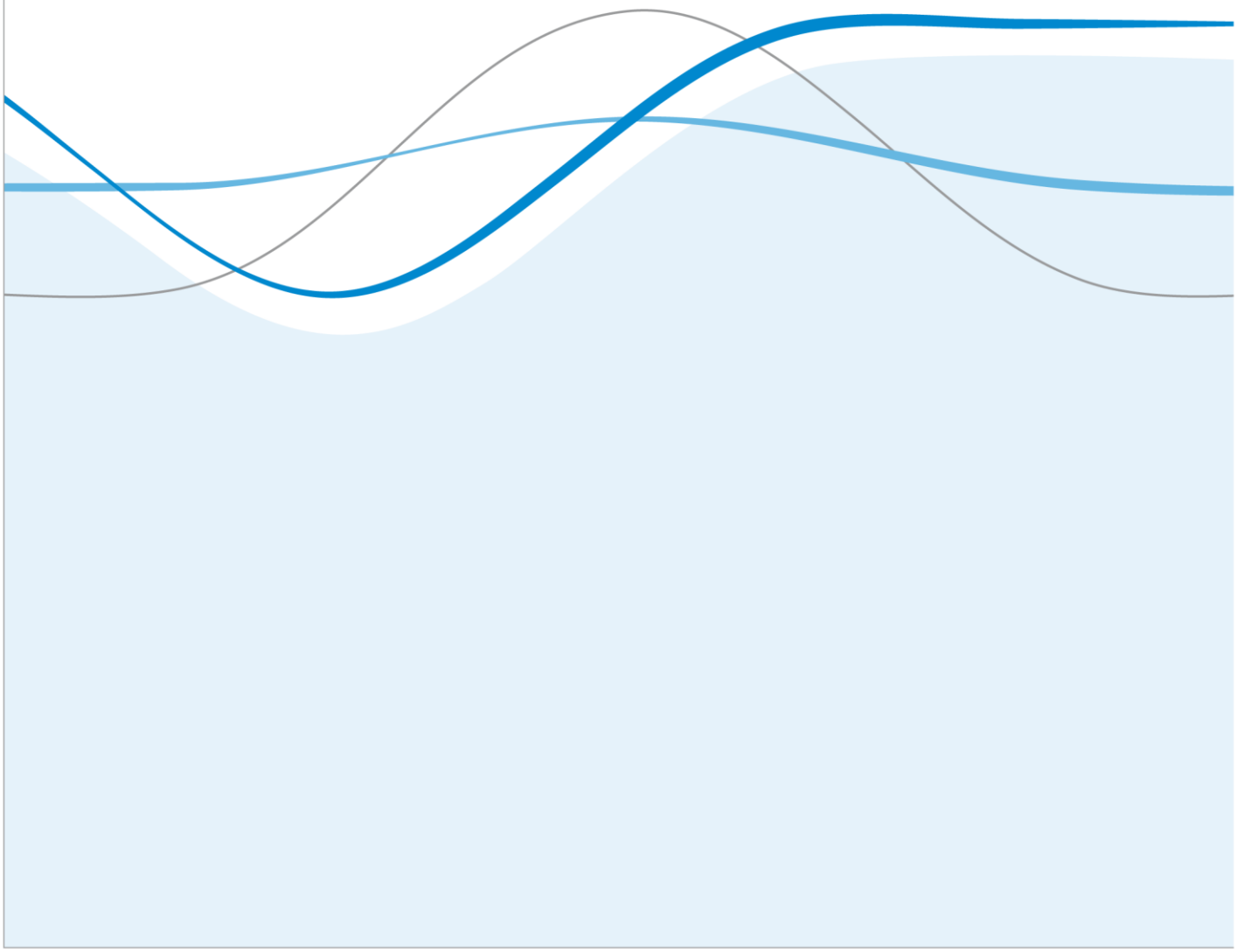
Grace Marsden[a], Adam Martin[b], Bernarda Zamora[a],

Jo Exley[b], Jon Sussex[b] and Adrian Towse[a]

[a]Office of Health Economics [b]RAND Europe



Four Case Studies to Explore the Added Value of Oxford AHSN

Grace Marsden[a], Adam Martin[b], Bernarda Zamora[a],
Jo Exley[b], Jon Sussex[b] and Adrian Towse[a]

[a]Office of Health Economics [b]RAND Europe

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Submitted by:
OHE Consulting Ltd
(a registered company number 09853113)
Southside, 7th Floor
105 Victoria Street
London SW1E 6QT
United Kingdom

For further information please contact
Adrian Towse
Director
Tel: +0044(0)207 747 1407
Or: +0044(0)7801 142 472
atowse@ohe.org

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EXECUTIVE SUMMARY

The Oxford Academic Health Science Network (Oxford AHSN) wishes to demonstrate the value of the various projects and programmes that the network has developed and implemented since it was established in 2013. In order to do this, OHE Consulting and RAND Europe conducted scoping assessments of six pre-specified case studies and organised a workshop with the Oxford AHSN management team to explore methods of attributing the value of the Oxford AHSN.

Based on the workshop, four case studies were selected for further analysis as 'phase two' of the project:

1. **Anxiety & Depression Clinical Network**: A targeted 5% improvement in recovery rates
2. **Maternity Clinical Network**: Improving referral pathways for preterm babies
3. **Energy project**: Quantifying the value of energy savings and carbon reduction
4. **Intermittent Pneumatic Compression (IPC)**: increasing utilisation of IPCs in immobile stroke patients.

The four case studies were chosen as examples of areas in which the Oxford AHSN has played a crucial role in improving patient care, and areas in which analysis of added value is feasible. The analyses were designed to assess the *added value of the Oxford AHSN* in relation to the case study projects, and not to assess the 'cost-effectiveness' of the treatments being used.

The Oxford AHSN Improving access to psychological therapies (IAPT) programme aimed to increase recovery rates in adult IAPT services by 5%. This has been achieved and surpassed. We estimate that from January 2014 to November 2015 the project has enabled an additional 3,199 patients to recovery (compared to what would have been expected if the national recovery rate had applied). Further, we estimate that two years after the end of treatment, an additional 1,631 people are still in recovery in the Oxford AHSN region as would have been had national recovery rates applied. The project has also led to an estimated net saving of £750,000 of NHS money, mainly through reductions in physical healthcare needs, and has helped an estimated 384 additional people return to work, as compared to the employment numbers if national recovery rates had applied. (Note that this estimate is subject to a lot of uncertainty: national data does not show a strong effect of IAPT therapy on employment status). These individuals will contribute to the economy, receive income, pay taxes, and may require lower disability benefits; such benefits go beyond the quality of life gains felt by the patients and their friends/family, and the aforementioned estimated monetary savings to the NHS from estimated reductions in physical healthcare needs. The Oxford AHSN has therefore has added significant value in this area, by improving patient lives, cutting NHS costs, and contributing to the wider economy.

The second case study looked at Oxford AHSN's project to improve the referral pathway for premature babies. The analysis found that the project had led to an improvement in the likelihood of survival of 5.2% percentage points (compared to survival rates before the project began), which translates into an increase of approximately 4 additional babies surviving per annum. Set against modest cost increases (or on the 'best case'

assumptions cost savings after three years), this project represents good value for money compared to conventional thresholds at which healthcare interventions are typically considered cost-effective.

The third case study examined Oxford AHSN's contribution to supporting the decision of five NHS hospital Trusts to work with partners to deliver investment in energy infrastructure and sustainability projects. Our study showed that there was a high degree of certainty about the value of these investments, in terms of energy and carbon savings, as well as a high financial rate of return. Assuming that the investment would not have gone ahead without Oxford AHSN's input, then set against the modest costs incurred by the Oxford AHSN, this project represents good value for money.

The fourth case study was of the Oxford AHSN's IPC implementation project which aimed to increase the utilisation of IPC therapy amongst adult stroke inpatients. The results show that the project was successful, leading to utilisation rates that are higher than elsewhere in the country. On the basis of the higher utilisation rates and evidence of the clinical effectiveness of IPC therapy, we estimate that the project prevented 22 DVTs, two PEs, and 12 deaths within an 18 month period, all for an estimated additional cost of approximately £31,000. Overall, compared to conventional thresholds at which healthcare interventions are typically considered cost-effective, this programme appears to have delivered good value for money, illustrating positive added value from the Oxford AHSN.

The limitations of all of the case studies mainly relate to data availability. Conservative assumptions were made where possible, meaning that overall we are more likely to have underestimated rather than overestimated the added value of the Oxford AHSN. In addition, the analyses of the three clinical projects (IAPT, maternity and IPC projects) were conducted from an NHS perspective, which means that there are additional societal benefits which have not been included, although we have given an estimate of the potential employment benefits of the IAPT programme.

Finally, our analyses are based on only four cases studies. There are many more projects being undertaken by the Oxford AHSN. This means that we have not analysed the overall costs and benefits of the Oxford AHSN, but rather a sub-set of successful projects. What this report therefore provides is evidence that the Oxford AHSN is capable of promoting high quality NHS care and delivering projects which improve patient outcomes, at a cost that appears to represent good value for money. Some projects, including at least one of the case studies presented here, have not only improved patient lives, but also saved money for the NHS.

1 INTRODUCTION

The Oxford Academic Health Sciences Network (Oxford AHSN) wishes to demonstrate the value of the various projects and programmes that the network has developed and implemented since it was established in 2013. The research will be used to signal to external stakeholders that the Oxford AHSN delivers value for money, and in some cases cost savings.

OHE Consulting and RAND Europe have been commissioned by Oxford AHSN to prepare evidence on the value of the network. The first stage involved scoping assessments of six pre-specified case studies and a workshop to explore methods of attributing the value of the Oxford AHSN with Oxford AHSN employees. The workshop was held at the Oxford AHSN in November 2015; a full report has been made available to Oxford AHSN.

Based on the workshop, four case studies were selected for further analysis as 'phase two' of the project:

1. **Anxiety & Depression Clinical Network**: 5% improvement in recovery rates
2. **Maternity Clinical Network**: Improving referral pathways for preterm babies
3. **Energy project**: Quantifying the value of energy savings and carbon reduction
4. **Intermittent Pneumatic Compression (IPC)**: Increasing utilisation of IPCs in immobile stroke patients.

Case studies 1 and 2 were selected for full economic analysis; case studies 3 and 4 were selected for a 'light touch' analysis (for full details see workshop report). The four case studies were chosen as examples of areas in which the Oxford AHSN has played a crucial role in projects to improve patient care, and areas in which analysis of added value is feasible. The analyses are based on local data collected within the Oxford AHSN region as far as possible.

This report begins with an introduction to economic analysis, and then describes in detail the methods and results for each of the case studies. Each case study section also provides a discussion of how the project demonstrates the added value of the Oxford AHSN.

2 ECONOMIC EVALUATION

At the workshop, the OHE and RAND Europe team led a discussion around the different types of economic evaluation and how 'added value' could be assessed. A brief summary of this information is provided here.

There are various different types of economic analysis (see Table 1 for a summary). The most appropriate form of analysis for each case study will vary depending on data availability and the nature of the condition. Cost utility analysis is preferred by the National Institute for Health and Care Excellence (NICE) for their economic assessments of new interventions and treatment pathways (NICE, 2013), but is also typically the most data and resource intensive type of analysis. Cost utility analysis is therefore not always necessary, feasible, or appropriate. Each case study section in this report explains the choice of economic analysis that has been employed.

Table 1: Types of economic evaluation

Type	**Output**
Cost effectiveness analysis	Results expressed as '*incremental cost per clinical outcome*' For example: Incremental cost per pressure ulcer avoided
Cost consequence analysis	Costs and health benefits presented separately
Cost utility analysis	Results expressed as '*incremental cost per quality adjusted life year*' (QALY[†])
Cost benefit analysis	All outcomes expressed in monetary terms
Cost comparison (or cost minimisation)	Only costs reported (outcomes assumed equivalent)

[†]The QALY is a measure of a person's length of life weighted by a valuation of their health-related quality of life (QoL) over that period. The weight used is called a utility value; this is a measurement of the preference for a particular health state, with a score ranging from 0 (death) to 1 (perfect health) (see Philips, 2009). The preferred method for determining utilities for NICE economic evaluations is the EuroQoL EQ-5D[1] questionnaire (NICE, 2013).

The following are key components of all economic analyses:

- **Intervention and comparator.** Economic modelling must always consider the new intervention compared to a next best alternative (usually *current practice* or *standard care*). It is important that the comparator is made explicit so that any *change* in health gains and any *change* in cost between the intervention and the comparator can be evaluated. When assessing the added value of the Oxford AHSN, it is important to consider that the Oxford AHSN facilitates rapid adoption of technologies. In some cases these technologies may still have been

[1]http://www.euroqol.org/ [Accessed March 2016]

implemented, albeit later, if the Oxford AHSN did not exist. In such cases, the appropriate comparator is the same intervention implemented a few years later.

- **Effectiveness data: health impact (including clinical benefits, harms, quality of life, remission).** This data is required to evaluate how much health benefit the intervention delivers. Relevant data can be gathered through randomised control trials (RCTs); observational data sets (including administrative data, cohort or case-control studies); experimental designs such as discrete choice experiments; through existing literature; or expert opinion.

- **Costs.** Costs should represent the *opportunity cost*, therefore labour and capital costs must be included alongside the cost of new investments. The data available and the sources used are likely to vary between the different case studies. The costs that should be included are dictated by the perspective of the study. There are three main perspectives which could be relevant here: NHS, public sector or societal. Taking an NHS perspective would mean that all costs which are borne by the NHS are included, but wider costs, such as those incurred by the patient, their friends and family or due to employee absence or sickness benefits, are excluded. Typically, NICE and NHS England would be most interested in an analysis conducted from the perspective of the NHS, whereas HM Treasury would be more interested in a wider public sector perspective and many other stakeholders in a societal perspective.

Data on **wider societal costs/impacts** can also be included if relevant. For example, in Case Study 1 (IAPTs recovery rates), there is likely to be an impact of recovery on patient and caregiver productivity and absenteeism. These effects are discussed in the case study sections where relevant.

Finally, it is worth noting that assessing the added value of the Oxford AHSN is slightly different to typical economic analyses. The Oxford AHSN facilitates implementation and adoption, activities through which it incurs costs of its own (for example Oxford AHSN employee staff time and overheads). When assessing the added value of the Oxford AHSN it is not enough to assess the cost-effectiveness of the interventions which are being implemented, but instead we must assess the cost-effectiveness of the intervention strategy as a whole[2]. For example, in Case Study 4, we do not wish to assess whether or not IPC therapy is cost-effective for the NHS, but whether the *Oxford AHSN IPC implementation project* has been good value for money overall. The implication of this is that we must include the cost of all implementation activities as well as the cost of the IPC treatment itself. To do this we treat costs to the Oxford AHSN (i.e. the staff costs of running the project) as costs to the NHS. This is a simplifying assumption which allows us to calculate the overall cost to the NHS, and is not an unreasonable assumption as Oxford AHSN funding comes from NHS England and ultimately affects the resources available for patient care.

[2]It has been argued that costs of implementation activities should be included in all economic analyses, as health care technologies which are found to be cost-effective are not automatically implemented within clinical practice. Indeed, if a technology is truly cost-effective, then imperfect implementation compromises efficiency within the health service (see Hoomans et al., 2009; Fenwick, Claxton and Sculpher, 2008). However this is not typically done in practice. Strictly, it is appropriate to look only at the cost-effectiveness of the intervention at the appraisal stage – unless the likelihood of implementation is so low as to call into question the point of doing the appraisal. When money is to be invested in implementation, it is appropriate to include this investment along with the costs of the intervention itself, and compare with the benefits.

3 CASE STUDIES

3.1 Anxiety & Depression Clinical Network: 5% improvement in recovery rates

3.1.1 Introduction

3.1.1.1 The Anxiety & Depression Clinical Network and Improving Access to Psychological Therapies (IAPT)

The Oxford AHSN's Anxiety & Depression Clinical Network is one of 10 clinical networks which were set up in 2014 (initially funded for two years) to promote best care. This particular network is linked to the nationwide Improving Access to Psychological Therapies (IAPT) programme, which aims to implement NICE-recommended talking therapies for adults with common mental health problems[3]. IAPT is open to patients who refer themselves, as well as those who are referred by GPs. Patients receive NICE-recommended therapies, such as cognitive behavioural therapy, brief psychodynamic therapy, couples therapy, and counselling (Layard and Clark, 2014). A lot of data is also collected: measurement of outcomes for recovery, for example, is highly standardised and captured in large national datasets.

The Oxford AHSN set a target to increase recovery rates in local adult IAPT services by a minimum of 5% between January 2014 and March 2016. To achieve this, a collaborative was established involving the clinical leads and data managers from all member IAPT services. This collaborative worked together to enhance patient recovery rates through workshops[4] and training events for clinical staff. The recovery rate improvement target has been achieved and exceeded, during a period in which national recovery rates have remained fairly stagnant. The purpose of this analysis was to assess the added value of the Oxford AHSN in this area, and not to assess the cost-effectiveness of IAPT therapy which has been demonstrated elsewhere[5].

3.1.1.2 The added value of Oxford AHSN

In order to assess the added value of the Oxford AHSN this analysis compares recovery rates and costs in the Oxford AHSN region to all non-Oxford AHSN IAPT service recovery rates and costs (i.e. national averages excluding the Oxford AHSN region).

There is a large database of recovery data; approximately 19,000 patients are treated annually across the Oxford AHSN, and 97% of these have their clinical outcomes recorded. However, quality of life data, relapse rates and physical healthcare usage data are not recorded, therefore some data was taken from the literature and was not Oxford AHSN specific. After discussion of data availability and feasibility at the November workshop, it was agreed that outcomes would be expressed as 'incremental cost per additional recovery'.

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[3] For more information on IAPT services see http://www.iapt.nhs.uk/iapt/
[4] During the workshops members of the collaborative discussed the latest findings from relevant research studies and national reports, shared examples of good practice and service initiatives and launched small scale research studies.
[5] IAPT services aim to implement NICE recommended therapies, therefore these treatments have already been demonstrated to be clinically and cost effective. Further cost-effectiveness analyses have also been undertaken, for example see Mukuria et al. (2013).

3.1.2 Methods

A cost-effectiveness model was developed to analyse the costs and benefits of Oxford AHSN in relation to the IAPT programme. This was a retrospective analysis using data from the beginning of the Oxford AHSN's intervention in January 2014 to the latest available data (November 2015).

3.1.2.1 Model overview

The model included all adult patients who completed treatment at an IAPT service within the study period.

The base case analysis[6] was conducted from an NHS perspective: this analysis included the direct costs of the programme to the Oxford AHSN (i.e. programme running costs), as well as any increased costs to the NHS as a result of the Oxford AHSN programme, and any savings to the NHS, for example from reductions in physical healthcare costs.

Due to the nature of anxiety and depression, there are also likely to be significant effects of treatment outside of the healthcare system. Successful treatment is highly likely to have a positive impact upon employment, in terms of both reduced absenteeism and presenteeism. These additional effects were therefore included in a sensitivity analysis[7].

The key clinical benefits included in the model were the recovery rates, as measured by the PHQ9 and GAD7.

Two strategies were compared:

- Strategy 1: The Oxford AHSN is not involved. We assume there is no cost of running the programme, and outcomes are in line with national recovery rates (excluding the Oxford AHSN region)
- Strategy 2: The Oxford AHSN takes on the IAPT project as part of its Anxiety and Depression clinical network. Strategy 2 represents the situation in reality.

The difference in costs and patient outcomes between the two strategies (Oxford AHSN project verses no Oxford AHSN project) was therefore driven by the changes in recovery rates at IAPT services in the Oxford AHSN region compared to nationally.

The analysis of the recovery rates was conducted in Stata. The cost-effectiveness model was developed in Microsoft Excel 2013 v15.0.4719.1002.

3.1.2.2 Model inputs and calculations

Recovery rates

Recovery is measured using two different scoring systems: PHQ9 (depression) and GAD7 (anxiety). The results are scored out of 27 and 21 respectively, with higher scores representing higher levels of depression or anxiety. There is an established clinical threshold for each test, above which the patient is considered to have depression or anxiety. The outcome measures are recorded when people first present at an IAPT service, at every treatment session, and at the end of treatment. A patient has

[6] The base case is the main analysis. It is based on the most plausible assumptions and most accurate (or likely) data inputs.
[7] Sensitivity analyses are undertaken to explore the effect that a change in assumptions or inputs, as compared to the base case, will have on the results of the analysis. Most economic analyses include several sets of sensitivity analyses to explore uncertainties.

recovered if they have a score above the threshold at the beginning of treatment, and a score below the threshold on both measures by the end of treatment.

Recovery data was obtained from the Health and Social Care Information Centre (HSCIC) for the period January 2014 – November 2015. This represents the period from the beginning of the Oxford AHSN IAPT project to the latest for which data is available. We calculated the average recovery rate (for each month) for the Oxford AHSN region and for all non-Oxford AHSN IAPT services in England (i.e. the national average excluding the Oxford AHSN area). All references to 'national average' refer to the English national average excluding the Oxford AHSN region.

Let N represent the number of patients who have completed treatment in the relevant area, and *C* represent the number of patients who were not above the clinical thresholds on the GAD7 and PHQ9 tests at the start of treatment[8]. *R* represents the number patients who have recovered[9]. Then, the recovery rate was calculated as:

$$recovery\ rate = \frac{R}{N - C}$$

Note that 'reliable recovery' is also included as a variable in the HSCIC dataset. This variable counts the number of people where pre and post treatment scores exceed the measurement error of the questionnaire *and* their score moves below the clinical cut-off. NHS England (2014) suggest that this measure indicates how many people have shown any degree of *real* improvement; minor, unreliable reductions in symptoms that cross the clinical/non-clinical boundary are not classified as reliable recovery. Whilst this may be the more robust measure of recovery, we were unable to use reliable recovery in our model as the data has not been presented monthly and by IAPT service for the whole study period. We do not expect this to have a large impact on the analysis.

Additional data on recovery in the Oxford AHSN area were also provided by the Oxford AHSN for the period January 2014 – May 2015. This data was collected directly from the local services and is considered by the Oxford AHSN to be more reliable than the data collected from HSCIC. The data provided by the Oxford AHSN are similar to those in the HSCIC database but not exactly the same. Such differences are common when comparing national and local datasets, and staff at the Oxford AHSN explained that there have been many problems with the HSCIC dataset over the years. Still, we chose to use the HSCIC data in our main analysis to calculate the recovery rates for the Oxford AHSN region and the national average, to ensure that the two recovery rates are truly comparable. A sensitivity analysis is conducted using the Oxford AHSN's data.

The recovery rates based on the HSCIC data and the data provided by Oxford AHSN are shown in Figure 1. It is clear from the graph that, whilst the recovery rates for the Oxford AHSN region are volatile, they are notably higher than the national average. There is also an increasing trend over time, greater than the increase demonstrated by the national rates over the same period. The graph also shows the similarity (but not equivalence) of the data reported by HSCIC and the Oxford AHSN.

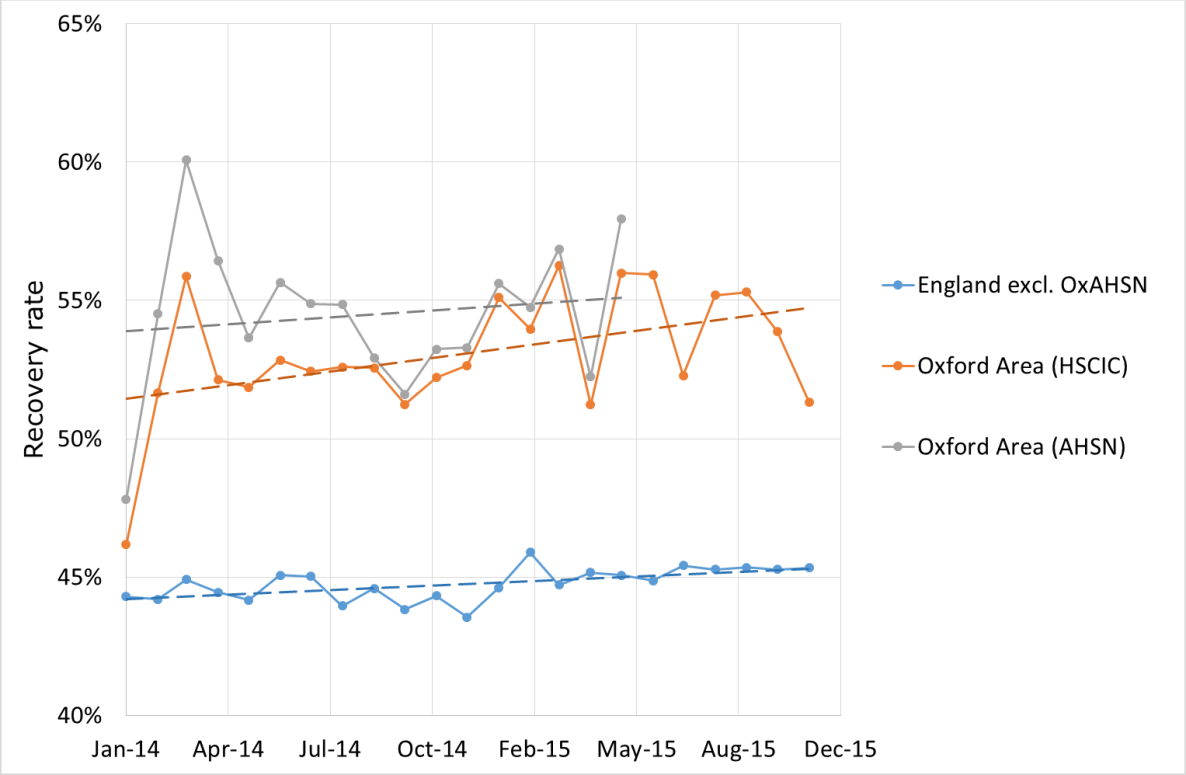
[8] These patients did not suffer from anxiety and/or depression at the start of treatment according to the clinical tests. This variable is reported in the dataset as 'no caseness'.
[9] These patients scored above the thresholds on the clinical tests at the beginning of treatment, and below the thresholds at the end of treatment.

At the beginning of the project the recovery rate in the Oxford AHSN region was 46.2%, and the national average was 44.3%. The difference was therefore less than 2 percentage points.

It is clear from the figure that the original target of increasing IAPT recovery rates by 5% was achieved quickly, and has been sustained throughout the study period: according to the HSCIC data the most recent value from November 2015 remains 5.2 percentage points greater than that in January 2014. According to the more reliable dataset collected by the Oxford AHSN, the most recent data (May 2015) suggests that the recovery rate then was 10.1 percentage points higher than that at the start of the programme. This should be interpreted with caution however, as the HSCIC dataset shows a decline in recovery rates between May 2015 - November 2015, and it is likely (based on the similarities earlier in the dataset) that the locally collected data will reveal the same once it is available. We cannot, therefore, assume that the 10 percentage point improvement has been sustained.

The greatest improvement in recovery rates in the Oxford AHSN region was seen at the beginning of the programme, between January 2014 and March 2014. The highest recorded recovery rate in the HSCIC dataset was 56.3% in March 2015; the highest in the Oxford AHSN dataset was 60.1% in March 2014; the highest in the national dataset was 45.9% in February 2015.

Figure 1: IAPT recovery rates for the Oxford AHSN region and nationally (January 2014 – November 2015)



Note: dotted linear lines represent trend lines
Source: OHE analysis of Oxford AHSN and HSCIC data, 2016

In order to estimate the number of additional recoveries which are associated with the Oxford AHSN IAPT project, we:

1. calculated how many recoveries we would have expected if the national average had been applied in the Oxford AHSN region (total recoveries for Strategy 1), and
2. calculated the difference between this and the actual number of recoveries in the Oxford AHSN region (total recoveries for Strategy 2).

The following calculations were performed:

Let N_t^A represent the number of patients who completed IAPT treatment in the Oxford AHSN region in month t (t = January 2014 – November 2015), and r_t^A represent the recovery rate in month t (according to the HSCIC data). Then, the number of recoveries in Strategy 2 is:

$$Total\ number\ of\ recovered\ patients\ in\ the\ AHSN\ region\ during\ study\ period = \sum_t N_t^A . r_t^A$$

Next, let r_t^N represent the national recovery rate. Then, the total number of recoveries in Strategy 1 is:

$$Estimated\ number\ of\ recovered\ patients\ in\ the\ AHSN\ region\ if\ national\ recovery\ rate\ had\ applied\ during\ study\ period = \sum_t N_t^A . r_t^N$$

The additional number of recoveries due to the Oxford AHSN IAPT project between January 2014 and November 2015 (Strategy 2 – Strategy 1) is therefore calculated as:

$$Additional\ recoveries = \sum_t N_t^A . r_t^A - \sum_t N_t^A . r_t^N$$

We repeated this calculation with the data supplied by the Oxford AHSN (using t = January 2014 – May 2015).

Quality of life

Quality of life data has not been recorded as part of the programme and construction of QALYs is outside of the scope of this analysis.

One recent economic evaluation of an IAPT service was identified which included calculations of QALYs (Mukuria et al., 2013). The utility values were constructed using the SF-6D (an alternative health related quality of life instrument to the EQ-5D). The comparison was between an IAPT site (Doncaster) and two comparator sites which did not have IAPT services (Wakefield and Barnsley). The study found that the IAPT site had small improvements over the comparator sites in terms of SF-6D. These improvements were not statistically significant at four months and disappeared by eight months. However, these small and short-lived improvements did translate into small QALY gains and the service was found to be cost-effective at conventional cost-effectiveness thresholds.

Since this paper, another study has been published which sought to assess the appropriateness of the SF-6D and EQ-5D for measuring health related quality of life amongst people with mental health problems. They note: "*There are concerns that generic measures have been primarily designed for physical health problems and miss important aspects of the impact of mental health problems on the quality of people's lives*" (Brazier et al., 2014). The authors take a mixed-methods approach, and ultimately conclude that these generic measures of health related quality of life do not capture many of the concerns of importance to people with mental health problems. This raises concerns about the validity of the results presented by Mukuria et al. (2013), specifically

that QALY gains may have been underestimated. The implication here is that if quality of life is to be measured by IAPT services in the future, care must be taken when choosing the appropriate tool by which to measure this outcome.

Costs to the Oxford AHSN

The costs to the Oxford AHSN are approximated based on the amount of Oxford AHSN staff input time that has been invested in this programme. The costs of staff time are proxied using the costs of wages and overheads; these costs are included to represent the opportunity cost of staff time.

The project manager at the Oxford AHSN estimated that one tenth of a full-time equivalent (FTE) at NHS band 8b was used for 15 months, and three sessions (one session is one half day) per month at clinical lead academic time grade E82 (40-50) was used for 23 months. The total cost of this was estimated to be £29,043 (see Table 2 and Table 3).

Table 2: Oxford AHSN staff costs for IAPT programme (Band 8b)

Component	**Value**
Salary	£55,276
Salary oncosts[1]	£14,269
Overheads[2]	£43,604
Capital overheads[3]	£2,185
Annual total[4] (A)	**£111,874**
Working time dedicated to IAPT programme (B)	10%
Months worked (C)	15
Total cost to Oxford AHSN (A x B x C/12)	**£13,984**

Reference: Values for band 8b, scientific and professional staff (Curtis and Burns, 2015)
[1]Essential associated costs, for example the employer's national insurance contributions
[2]Management and other non-care staff overheads include administration and estates staff
[3]Includes costs for office, travel/transport and telephone, education and training, supplies and services (clinical and general), as well as utilities such as water, gas and electricity. This has been halved as the relevant employee works from home.
[4]With non-London multiplier applied

Table 3: Oxford AHSN staff costs for IAPT programme (clinical lead academic)

Component	**Value**
Salary[1]	£10,476
Annual total (A)	**£10,476**
Working time dedicated to IAPT programme[2] (B)	75%
Months worked (C)	23
Total cost to Oxford AHSN (A x B x C/12)	**£15,059**

References: University of Oxford, 2016; Curtis and Burns, 2015
[1]This member of staff is an employee of the University rather than the Oxford AHSN. The Oxford AHSN play a flat rate (see salary field) for one session of his time per week. No additional payments are made for oncosts or overheads.
[2]This value represents the proportion of this individual's *Oxford AHSN-funded* time (not their total time) which is spent working on this project.

In addition, approximately £600 has been spent on venue costs for workshops and training/development events within the project period. This takes the total estimated cost to the Oxford AHSN to £29,643.

Costs to the NHS

The net cost impact on the NHS (other than the Oxford AHSN) is made up of three components:

1 – **Direct medical costs**: the cost of delivering the IAPT therapy;

2 – **Non-medical costs**: The costs of time spent in training or undertaking audit activities;

3 – **Cost savings**: these arise from the reduction in other health care costs (for example physical healthcare costs).

IAPT services in the Oxford region have received no additional funding during the duration of the project. In addition, the main changes brought about by the Oxford AHSN's involvement in IAPT services relate to communication and training (rather than supplying additional clinical staff or new treatments), therefore the direct medical costs are likely to be similar between strategy 1 and strategy 2, as the same IAPT treatments are being provided in both strategies. These costs are therefore redundant in an incremental analysis and are not included here. This is equivalent to assuming that the Oxford AHSN IAPT project has not increased the direct medical costs of IAPT services in the Oxford AHSN region any more than would have been incurred in Strategy 1 (no Oxford AHSN involvement). This assumption is relaxed in a sensitivity analysis.

The Oxford AHSN has taken approximately 250 staff members through advanced skills training in the treatment of post-traumatic stress disorder, social anxiety disorder and couples therapy, as well as training in assessment and problem descriptors. Costs were based on the estimates of staff cost per hour (non-patient contact time) for Band 6 and Band 7 staff in Curtis and Burns (2014) (see Table 4).

Table 4: Cost of NHS staff time spent in additional training as a result of the Oxford AHSN IAPT programme

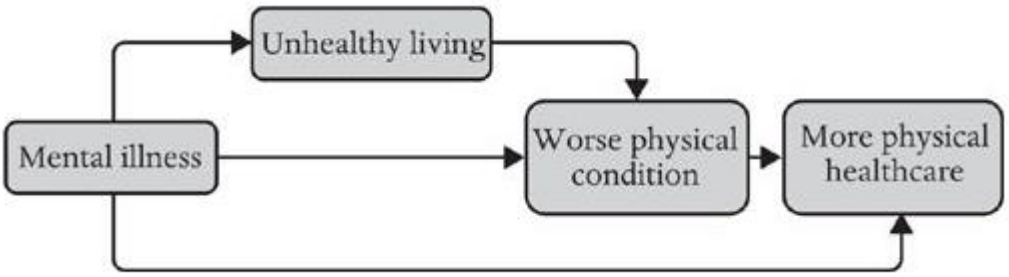
	Hourly rate[a]	Daily rate[b]	Number of full days[c]	Sub-total
Band 6	£43	£302	80	£24,192
Band 7	£105	£732	120	£87,898
Total				**£112,090**

[a]Non-London multiplier applied to non-patient contact hourly rate
[b]A day is assumed to be 7 hours. Note that this is the number of hours for a training day, not a 'shift'
[c]Calculated based on 40 half days plus 60 full days for band 6, and 60 half days plus 90 half days for band 7 (i.e. total of 100 half days; 150 full days training)
Source: Curtis and Burns (2014).

Savings from the reduction in other health care costs are likely to be substantial. Layard (2014) provides a summary of the literature in this area: the Centre for Mental Health (2010) estimates that mental illness increases the cost of physical healthcare (for a given condition) by 50%, and Welch et al. (2009) found that depressed patients had significantly higher treatment costs than non-depressed patients across 11 chronic comorbid diseases. In addition, Naylor et al. (2012) note that 12-18% of all NHS expenditure on long-term conditions in England (between £8 billion and £13 billion) is linked to poor mental health and wellbeing.

Layard and Clark (2014) explain that this is because mentally ill people do not look after themselves well (for example less exercise) and are also more likely to worry and therefore go to the see the doctor. In addition, a stressed mental state can have direct physiological effects. These mechanisms are summarised in Figure 2.

Figure 2: Mechanisms by which depression increases the cost of physical healthcare



Source: Layard and Clark, 2014

Consequently, treating mental health problems is expected to reduce physical healthcare costs. Layard and Clark (2014) provide a summary of the literature in this area[10]: A US meta-analysis of 91 trials found that psychological interventions reduced annual healthcare costs by 20% (Chiles et al., 1999), and in 93% of these studies the cost of psychological intervention was less than the physical healthcare costs which were saved. Cognitive behavioural therapy (CBT) has also been found to reduce hospital admissions for angina (Moore et al., 2007) and reduce the recurrence of cardiovascular disease (Gulliksson et al., 2011). In addition, an analysis by a GP practice in the UK found that IAPT services saved £1,050 in physical healthcare costs per patient who had had full treatment, and £500 per patient who had had partial treatment[11] (Layard and Clark, 2014), compared to patients with the same psychological problems who were not treated by IAPT. The savings were due to fewer outpatient sessions; fewer hospital admissions; and fewer appearances at Accident and Emergency wards.

In order to capture the savings associated with recovery, we include an estimate of the reduction in physical healthcare resource utilisation per person who recovers. Unfortunately, data on local resource use has not been captured within the Oxford AHSN IAPT programme, and the above studies do not provide a breakdown of the cost per *recovered* patient, only the savings per person *treated*. We were unable to find any reliable estimates of the cost of physical health care which is saved when an individual recovers from mental illness. Note that the Oxford AHSN is currently looking at the effect of the IAPT service on physical health care treatment, but unfortunately no resource use data will be available within the timescales of this project.

Layard and Clark (2014) provide an alternative estimate of a saving of £2,000 per recovered patient (see Box 1 for calculation).

[10] Note that this summary is not based on a systematic review and there may be additional relevant studies in the literature.
[11] Definitions of full and partial treatment are not provided

Box 1: Estimated savings per recovered patient (Layard and Clark, 2014)

The total cost of physical healthcare in England (2013) is around £75 billion per year.

This is spent on 18 million people who have physical complaints, of whom 4 million are also mentally ill.

Mentally ill patients cost 50% more in physical healthcare than those who are not mentally ill (Katon 2003; Hutter et al. 2010; Naylor et al. 2012).

These numbers suggest that the cost per person is roughly £6,000 per year for those which co-morbid mental illness, and £4,000 per year for those without.

When a person recovers from mental illness, we expect a saving of £2,000 per year.

In order to be conservative in our assumptions, we used the aforementioned estimate by the GP practice of £500 and £1,050 of savings due to partial and full treatment respectively (see page 15), as this is lower than the estimate in Box 1. In the absence of full definitions, we assume that "full treatment" means the patient has recovered due to their treatment at the IAPT service, and "partial treatment" means that the patient has undergone IAPTs treatment but has not recovered. The additional savings when a patient recovers are therefore (£1,050-£500) £550[12]. In the absence of detailed data, we assume (conservatively) that this cost saving is only realised if the patient does not relapse within two years (see section below on relapse rates). We also assume that this saving is the same for patients who recover in the Oxford AHSN region and for patients who recover elsewhere in England: thus the difference in the total costs saved will be solely due to the difference in the number of recovered patients.

Total costs (base case)

The total costs of the two strategies were therefore calculated as follows:

First we calculate the costs for Strategy 2 (where RNR^A represents the number of patients who have recovered in the Oxford AHSN region and have not relapsed within two years):

$$Total\ cost\ (Strategy\ 2\ ) = cost\ of\ AHSN\ staff\ time + cost\ of\ training\ activities - \sum_t £550\ .RNR^A$$

Similarly, to calculate the cost of Strategy 1:

$$Total\ cost\ (Strategy\ 1\ ) = -\sum_t £550\ .RNR^N$$

Note that the costs of delivering the IAPT therapy itself are assumed equal between the two strategies and are therefore not included in this incremental analysis (this assumption is relaxed in the sensitivity analyses).

The incremental cost between the two strategies, and therefore the overall net cost of the Oxford AHSN's IAPT programme is calculated as:

$$Incremental\ cost = Total\ cost\ (strategy\ 2) - Total\ cost\ (strategy\ 1)$$

[12] The year that these values were collected in is not reported. As such, we have not updated them to 2015/16 values.

The incremental cost per recovery is calculated as:

$$Incremental\ cost\ per\ recovery = \frac{incremental\ cost}{\sum_t N_t^A . r_t^A - \sum_t N_t^A . r_t^N}$$

Relapse rates

Due to the nature of psychological conditions, patients may relapse once recovered. However, no evidence on relapse is collected within the IAPT dataset, as the majority of services stop collecting information on patients once they have had their last treatment session. The Oxford AHSN have planned a project to look at relapse rates, but results will not be available within the timelines of this project.

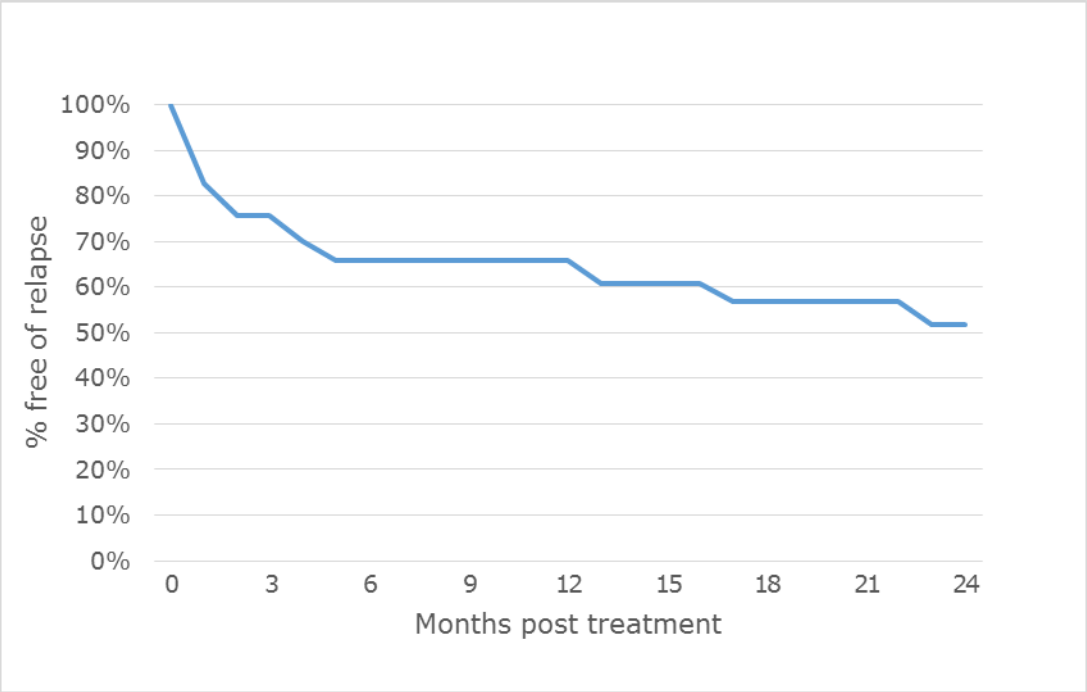
Limited evidence does exist within the literature on relapse rates following IAPT therapy: Clark et al. (2009) conducted a follow-up of patients who had been treated at Doncaster and Newham IAPT services. Patients who had completed treatment and had had at least two treatment sessions were eligible to take part in the survey. The average time elapsed since the patients' last treatment sessions was 42 weeks in both the Doncaster and Newham groups (Doncaster: range 16–72 weeks; Newham: range 17-74 weeks). In Doncaster, the recovery rate at follow-up was 50%, compared to 56% post treatment, suggesting a relapse rate of 11%. In Newham, the equivalent figure was 42%, compared to 57% post treatment, suggesting a relapse rate of 26%. Note that these estimates are most likely the best available relating to IAPT services, but are not specific to the Oxford AHSN and likely to be subject to respondent self-selection bias.

Further evidence is available in the literature on relapse following various cognitive disorders: evidence presented by Clark et al. (2003) suggests that treatment gains were maintained at 12-month follow up following treatment for social phobia with cognitive therapy and with fluoxetine plus self-exposure. In addition, research by Mörtberg et al. (2011) found that, amongst patients who had been treated for social phobia with intensive group cognitive therapy or individual cognitive therapy, treatment effect was largely sustained after five years. However, a less favourable randomised trial presented by Dobson et al. (2008) showed that, amongst adults with major depression, 34% patients had relapsed after one year post exposure to cognitive therapy. By two years this had increased to 49% (see Figure 3). Based on a review of the literature, Hollon et al. (2006) suggest that cognitive therapy has "produced the most consistent evidence of enduring effects" amongst patients with depression and anxiety, with a relapse rate around half that seen amongst patients treated with medication.

As IAPT services cover all anxiety disorders as well as depression, none of these studies were directly applicable to the model. Therefore, in order to be conservative, we accounted for relapse in line with the values presented in Figure 3. Note that as we are not considering quality of life, this only effects the cost per recovery calculation through the impact on the cost savings from physical healthcare (we assume that cost savings from reduced physical healthcare usage are only realised if the patient does not relapse within two years). This is likely to be an overestimate of relapse rates (and therefore underestimate the benefit of the Oxford AHSN's actions) as the trial population had, on average, more several cognitive illness than the IAPT population, and the other (aforementioned) studies found lower relapse rates (the next highest was the IAPT specific study (Clark et al., 2003) which found a relapse rate of 26% after 42 weeks).

We also assume that the relapse rates are the same for recovered patients in the Oxford AHSN area and recovered patients in the rest of the country.

Figure 3: Cumulative proportion of treatment responders who survived without relapse over the two years of follow-up (Dobson et al., 2008)



Source: Adapted from Dobson et al., 2008 (figures estimated from graph).

3.1.2.3 Model assumptions

The assumptions made in the model have been explained throughout the methods section, and are summarised here:

- We assume that there is no cost of running the project in Strategy 1, or, equivalently, that all costs that are borne by IAPT services in England are also borne by the Oxford AHSN region, and that all Oxford AHSN resource use is in addition to these costs. This is a conservative simplifying assumption, and if incorrect will bias against the cost-effectiveness of the Oxford AHSN's intervention. This means that we are more likely to underestimate the added benefit of the Oxford AHSN than overestimate it.
- We do not consider any clinical benefit post November 2015 or into the future. Once again this is likely to bias against the cost-effectiveness of the Oxford AHSN's intervention as it does not include the improved clinical outcomes which are accrued after these cut offs. This assumption was necessary due to limited data availability.
- The per patient costs of delivering the IAPT therapy itself in the Oxford AHSN region and the rest of England are assumed to be equal and are therefore not included in this incremental analysis. This is equivalent to assuming that the Oxford AHSN IAPT project has not increased the direct medical costs of IAPT services more than would be seen elsewhere in the country, and that the improvements in recovery rates are due to improved communication and additional training in the Oxford AHSN region. This assumption was explored in sensitivity analyses.

- We assume that, based on the study reported in Layard and Clark (2014), the additional savings to the NHS when a patient recovers (from reduction in resource use linked to physical care) are therefore £550. We assume that these cost savings are only realised if the patient does not relapse within 2 years. Overall we expect that these savings are an underestimate of the true savings to the NHS. An alternative estimate reported in Layard and Clark (2014) suggests a much greater saving of £2,000 (although this may not be maintained if the patient relapses), therefore we are mostly likely underestimating the added value of the Oxford AHSN.
- We assumed that relapse rates following treatment at an IAPT service were the same in the Oxford AHSN region and the rest of England. This assumption was necessary in the absence of any specific local data on relapse rates.

3.1.2.4 Sensitivity analyses

There is a lot of uncertainty surrounding this analysis, both in terms of assumptions made and parameter values which have been used. Where possible we have used conservative assumptions and estimates which are likely to bias against the estimated cost-effectiveness of the Oxford AHSN's intervention (meaning we are more likely to underestimate than overestimate the added value of the Oxford AHSN), and we also conducted the following sensitivity analyses to explore uncertainty further:

SA1: Alternative data on recovery rates

We conducted an additional analysis using the recovery rates provided by the Oxford AHSN. These data are considered to be a more accurate reflection of the true picture in Oxford, but are not necessarily commensurate with the national dataset. The costs were also adapted to allow for the shorter time duration (the latest Oxford AHSN-provided data available is May 2015 compared to November 2015 for HSCIC data in the base case).

SA2: Societal perspective

Our base case analysis is undertaken from the perspective of the NHS, and therefore does not include costs and savings which occur outside the health sector. We therefore sought to expand the perspective of our evaluation (to a societal perspective) in a sensitivity analysis so that these additional impacts could be captured. Evidence suggests that mental health issues are costing Britain £70bn a year (roughly 4.5% of GDP) as a result of productivity losses, higher welfare benefit payments and the increased cost to the NHS (OECD, 2014). Logically, we therefore expect that successful treatment of mental health conditions could reduce this burden. Indeed, Layard and Clark (2014) claim that the net cost of providing IAPT services is likely to be zero once savings on disability benefits, crime, social services and additional physical healthcare are taking into account.

In order to explore the feasibility of conducting the analysis from a societal perspective and to identify data inputs, we reviewed the literature on the societal impact of mental health. We also consulted the HSCIC database to see if there were any variables in the national dataset which we could use to model these aspects. Specifically we looked for information on employment, disability benefits and productivity (including absenteeism and presenteeism). Unfortunately these sorts of benefits are not typically included in UK

health economic analyses[13], and therefore data is sparse. The relevant information that we did identified was as follows:

- **Employment**: Mental health is likely to impact an individual's ability to find a job and/or stay in work (Layard and Clark, 2014). In 2007, only around four in ten of the UK population aged 15-64 with a severe mental disorder was employed. For patients with common mental health problems the equivalent figure was 64%, compared to 76% for patients with no mental disorder (OECD, 2014). Unemployment is costly to the individual, who foregoes wages (meaning they are at a greater risk of income poverty), and also to the economy, which may forego their output (depending on whether that job is filled by someone else) and there is a cost to the Exchequer in terms of disability or sickness payments.

  Data on employment status is collected by the Oxford AHSN, although unfortunately this data was not available within the timescale of this project. The HSCIC dataset also includes information on the number of patients who have come off sick pay (although not the number who were originally on sick pay) and the amount of 'employment therapy' sessions by CCG. There is also data on the on the impact of IAPT treatment on employment at a national level, but the data is not presented by CCG so we cannot calculate comparable values for the Oxford AHSN area. There is also a lot of missing data: the employment status is recorded for 33,964 patients before treatment, and 53,870 after treatment. Table 5 shows the national data (including the Oxford AHSN region) for the year 2014/2015.

[13] Because HTA conducted by organisations such as NICE is typically concerned with the efficient allocation of the healthcare budget, and is not concerned with benefits/costs that fall outside of this remit.

Table 5: People with a finished course of IAPT treatment in England by employment status (2014/2015)

Status	Total at start of treatment (%)	Total at end of treatment (%)
Employed	237,986 (50.1)	226,592 (48.3)
Unemployed and seeking work	60,834 (13.0)	54,482 (11.6)
Students who are not working or actively seeking work	23,806 (5.1)	21,747 (4.6)
Long term sick or disabled, or in receipt of benefit payments	37,479 (8.0)	38,049 (8.1)
Home maker who is not working or actively seeking work	26,088 (5.6)	26,076 (5.6)
Not receiving benefits and not working or actively seeking work	10,304 (2.2)	8,868 (1.9)
Unpaid voluntary work and not working or actively seeking work	1,592 (0.3)	1,729 (0.4)
Retired	36,828 (7.9)	37,468 (8.0)
Invalid code	17,176 (3.7)	34,883 (7.4)
Not stated	16,788 (3.6)	18,987 (4.1)

Source: HSCIC (2015)

The table shows that the number and percentage of people in employment actually decreased slightly after treatment had been completed, although so did the number and percentage of people unemployed and looking for work. The percentage of people on long term sick leave or in receipt of benefit payment stayed roughly the same. This evidence on the impact of IAPT services on employment status is inconclusive.

Parry et al. (2011) also provide some data of relevance here (see section on disability benefits below).

- **Disability benefits:** Disability benefits are costly to the Exchequer, although they are transfer payments from a national societal perspective: in 2009 the UK spent £13.8billion (equivalent to 1% of GDP) on sickness and disability programmes. A significant proportion of these are related to mental health problems: in 2010, 38% of new disability claims were made on the grounds of mental ill-health (OECD, 2014), and government figures from 2011 indicate that

43% of people on long-term benefits due to health issues have a mental health problem (HM Government, 2011). Receipt of income support and housing benefit is also up to three times higher amongst people with a common mental disorder (compared with those without) and up to six times higher for people with a severe disorder (OECD, 2014).

Parry et al. (2011) provide some data on the impact of IAPT services on employment and benefits as part of their service evaluation of IAPT services in Doncaster and Newham. They found:

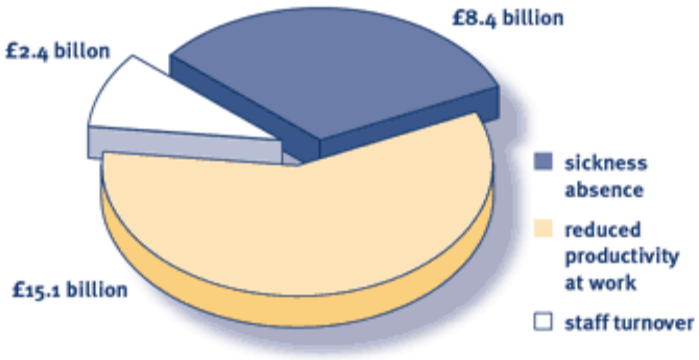
- There were small increases in the proportions of patients working full-time (6.5% in Newham, 3.4% in Doncaster) as a result of IAPT treatment. Amongst those who were unemployed at first contact, 6.1% in Newham obtained full-time employment, and 3.6% part-time employment by the time of last contact;
- The proportions of patients who were registered as unemployed reduced slightly in Doncaster (from 33.5% to 30.9%) and increased slightly in Newham (from 12.1% to 16%) between first and last contact;
- Amongst those who were in employment throughout treatment in Newham, fewer (number not reported) were taking time off sick by the time of last contact;
- 6.8% of patients in Newham moved out of employment and started receiving benefits between first and last contact; 9.7% stopped receiving benefits and moved into employment (either full- or part-time);
- When compared to non-IAPT matched comparator sites, the authors found that lost employment costs were higher in Doncaster than the non-IAPT comparators, but lower in Newham compared to the non-IAPT comparator.

The evidence on the impact of Newham and Doncaster IAPT services on employment (compared to non-IAPT controlled sites) is therefore mixed.

- **Productivity:** The Centre for Mental Health (Centre for Mental Health, 2007) states that "every organisation in Britain is affected by mental distress and ill health in the workforce". This is through absenteeism[14] and presenteeism[15], both of which lead to reduced productivity in the workplace. The total cost is estimated to be £26 billion a year in reduced productivity at work, a cost of over £1,000 per UK employee (Centre for Mental Health, 2007) (see Figure 4).
    - **Absenteeism:** An estimated one in six workers is experiencing mental health problems related to stress, and 91 million days are lost each year in the UK due to mental health problems. The average employee takes seven days off sick each year of which 40% are for mental health problems (Centre for Mental Health, 2007).
    - **Presenteeism:** This accounts for 1.5 times as much working time lost as absenteeism, amounting to a cost of £15.1 million per year. It is estimated to cost more to employers because it is more common among higher-paid staff (Centre for Mental Health, 2007).

[14] Absenteeism is when the employee does not attend work (or school)
[15] Presenteeism is "reduced productivity when employees come to work and are not fully engaged or perform at lower levels as a result of ill health" (Centre for Mental Health, 2007)

Figure 4: The business costs of mental ill-health



Source: Centre for Mental Health (2007)

Clearly, productivity losses due to mental health conditions are costly to employers and therefore the UK economy. Effective treatments for such conditions could help reduce this problem, and as such productivity gains could be an important benefit of the IAPTs programme. Unfortunately, no data is available on the impact of IAPT treatment on absenteeism and presenteeism (either from the Oxford AHSN region or nationally).

- Finally, it is worth noting that the impact of mental health upon productivity, employment and benefits may not just effect the individual, but could also have wider reaching consequences, impacting the employment or productivity for the individual's friends and family.

Note that there have been ethical concerns raised about including the effect of these wider societal benefits in economic evaluations, for example, that the inclusion of employment and productivity effects could bias towards interventions who help working age people back to work, at the expense of interventions that mainly benefit the elderly and children. Even if these effects are to be included, there are still methodological issues to be addressed around how to capture these benefits (for example, how to measure reductions in unpaid work that still contributes to society, such as informal caregiving or other voluntary work). These issues have been discussed at length elsewhere (for example see Lensberg et al., 2013). Note that consensus has not been reached over the best methods.

Given that the data in this area is limited and inconclusive, we performed a small sensitivity analysis. Based on the likelihood of patients being employed when they are suffering from a common mental health condition, compared to when they are not (64% and 76% respectively; see OECD (2014), reported above), we estimate the number of additional patients who are back in work as a result of the Oxford AHSN project. To do this we assume that all patients within the Oxford AHSN IAPT project have common (rather than severe) mental health conditions (once again this is a conservative simplifying assumption). Then,

$$Number\ returned\ to\ work\ as\ a\ result\ of\ the\ AHSN\ IAPT\ project$$
$$= \left(\sum_t N_t^A . r_t^A - \sum_t N_t^A . r_t^N\right) \times (0.76 - 0.64)$$

Please note that these calculations are performed to provide a rough indication of the magnitude of benefit, and are not considered to be precise estimations.

SA3: Average cost per recovery

We explored the average cost per recovery of IAPT therapy in the Oxford region and nationally using the estimation method presented by Radhakrishnan et al. (2013). The method is used to estimate the costs associated with a single therapy session, a treatment, and a recovery, for patients receiving IAPT treatment. The estimation is based on the distribution of the two tiers of IATP therapy corresponding to NICE step 2 and 3 for the treatment of depression and anxiety (NICE, 2011): Step 2 refers to low intensity treatments[16] and step 3 refers to high intensity treatments[17]. The basic cost framework assumption is shown in Figure 5.

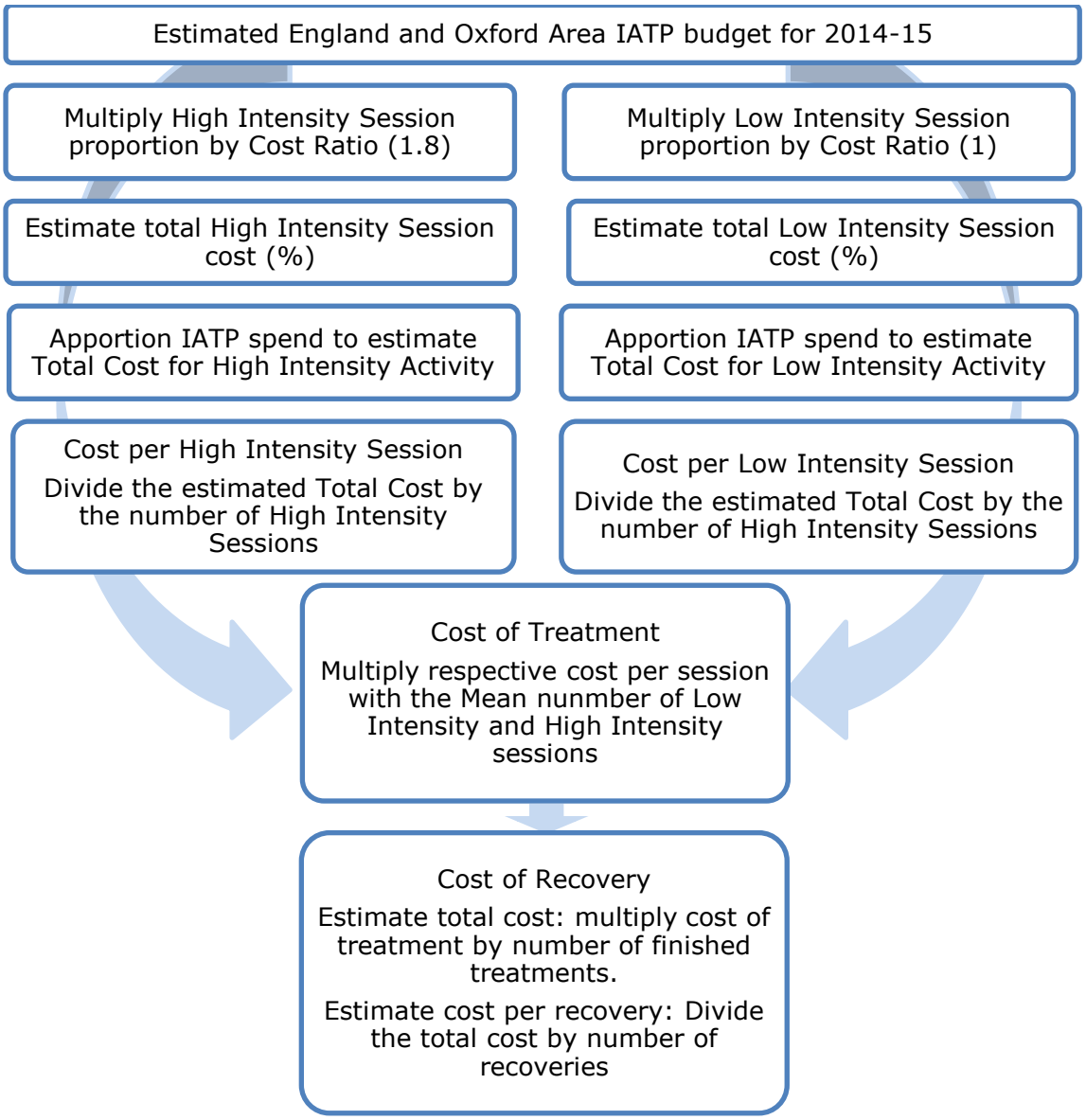
The first step was to estimate the total IAPT expenditure for England and for the 12 CCGs within the Oxford AHSN area. The only financial data that we were able to identify were those in the IATP three year report (Department of Health, 2012). The expenditure on IATP services in 2011/12 is reported to be £163m. We assume that this £163m remains constant in subsequent years and is on top of the additional budget allocated to IAPT in the 2010 spending review. Using these assumptions, we estimate that the 2014/15 IAPT service budget is £310m (the sum of £163 plus the planned additional £147m).

Separate financial data was not available for the 12 CCGs within the Oxford area, so we assigned the budget according to the percentage of finished treatments in the Oxford area and elsewhere (4.8% of the total IAPT treatments finished nationally between 1st April 2014 and March 2015 were with the Oxford AHSN region). Therefore, assuming that the budget is apportioned to the Oxford area at this rate, the annual IAPT expenditures in the Oxford area amounts to an estimated £14.8m.

The second step takes the total annual budget and several assumptions to apportion the total cost between high and low intensity sessions. The first assumption is that the "high intensity activity" cost 1.8 times more than "low intensity activity . Next, we take the data on the frequency of high intensity and low intensity sessions in the Oxford region and nationally from the HSCIC statistics. This suggests that "high intensity activity" represents a 74.4% and 76.6% of total costs in England and Oxford area, respectively. The weighted average of this ratio in the Oxford area (weighted by the proportion of attended appointments by CCG) results in 64.5% of high intensity activity. The equivalent figure for England is lower at 61.8%.

[16] Low intensity treatment mainly includes guided self-help. The type of sessions recorded at CCG level in the HSCIC data for the months July to November 2015 include: guided self-help by book and computer, non-guided self-help by book and computer, low intensity behavioural activation, structured physiological activation, ante and post-natal counselling, peer supported psycho-education, low intensity employment support, and other low intensity sessions.
[17] High intensity treatments address more severe cases. These treatments include: applied relaxation, high intensity behavioural activation, couple therapy, collaborative care, counselling, brief psychodynamic psychotherapy, eye movement desensitisation reprocessing, mindfulness, high intensity employment support, cognitive behavioural therapy, interpersonal psychotherapy, and other high intensity treatments.

Figure 5: Framework for estimating cost of session, treatment, and recovery



Source: Adapted from Radhakrishnan et al. (2013).

This suggests that high intensity activity is relatively more important in Oxford than the national average. These ratios form the base of our estimations.

SA4: Direct medical costs of delivering IAPT services

In this sensitivity analysis we relax the assumption that the direct medical costs of the IAPT services have not been influenced by the Oxford AHSN's involvement in IAPT. Data is available from the HSCIC database (for July 2015 – November 2015) on the mean number of high and low intensity sessions per person (reported at CCG level). Table 6 shows that the number of high (low) intensity sessions is higher (lower) in the Oxford AHSN region compared to nationally.

Table 6: Mean number of high and low intensity treatment sessions

	Mean number of high intensity sessions per person	Mean number of low intensity sessions per person
Oxford AHSN average	8.62	4.40
National average	7.66	4.74

Source: OHE analysis of HSCIC data, 2016

Next, we multiplied the mean number of sessions per patient by the cost per session. The costs of high and low intensity sessions were obtained from Radhakrishnan et al. (2013) and were £177 and £99 respectively. Let H^A represent the mean number of high intensity sessions in the Oxford region, and L^A the number of low intensity sessions. Then:

$$Mean\ cost\ per\ person\ (AHSN\ region) = H^A \times £199 + L^A \times £77$$

Similarly, using H^N and L^N:

$$Mean\ cost\ per\ person\ (nationally) = H^N \times £199 + L^N \times £77$$

The total direct medical costs were calculated by multiplying the cost per person by the number of people with finished treatments in the Oxford AHSN region during the study period.

We then incorporate these direct medical costs (alongside the costs of the Oxford AHSN staff time, clinical staff training, and cost savings to the NHS) and re-calculate the total net cost impact of the Oxford AHSN involvement in IAPT services.

SA5: No cost savings to the NHS when a patient recovers

In this sensitivity analyses we omit the £550 saving to the NHS (from reduced physical healthcare resource use) when a patient recovers (and does not relapse within two years). Consequently, we calculate the incremental cost per additional recovery based on the direct costs of the Oxford AHSN only (including Oxford AHSN staff time and additional training for clinical staff).

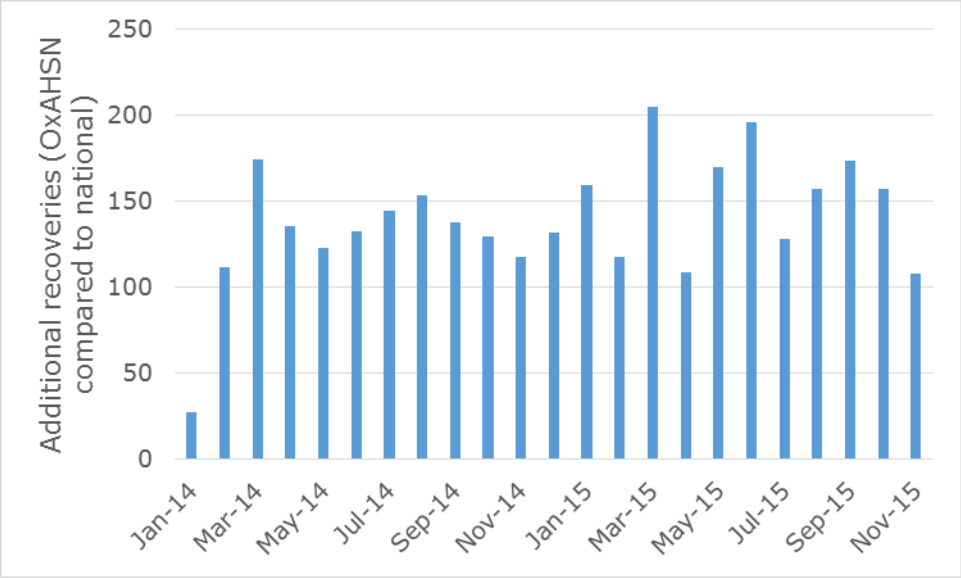
3.1.3 Results

3.1.3.1 Recovery rates

Between January 2014 and November 2015, 38,411 patients finished treatment within the Oxford AHSN IAPTs programme. A total of 20,395 patients recovered, which implies that an additional 3,199 patients recovered compared to what would have been expected if the national recovery rate applied (strategy 2 – strategy 1). An additional 2,659 patients have recovered than would have if the recovery rate remained at its pre-project level (46.2% in January 2014).

This indicates that the Oxford AHSN IAPT project has been effective in increasing the IAPT recovery rate in the Oxford AHSN region (compared to national recovery rates). The additional recoveries per month are shown in Figure 6.

Figure 6: Number of additional recoveries per month Strategy 2 compared to Strategy 1



Source: OHE analysis, 2016

3.1.3.2 Costs

The costs are shown in Table 7. The table illustrates that the incremental cost of Strategy 2 compared to Strategy 1 is negative. This means that, despite the additional cost of the Oxford AHSN involvement and additional training activities to staff in Strategy 2 compared to Strategy 1, Strategy 2 is still cost saving. This is due to the estimated cost saving in physical health care costs which arise when a mental health patient recovers combined with the increase in the number of recoveries. Note that these results are based on the lower of two national estimates on the costs of physical healthcare saved; in reality the savings may be even greater.

Table 7: Aggregate incremental costs components and results

	Strategy 1	**Strategy 2**	**Incremental**
Direct medical costs[a]	-	-	-
Oxford AHSN staff time	-	£29,643	£29,643
Additional NHS staff time spent in training as a direct result of Oxford AHSN involvement	-	£112,090	£112,090
Savings due to reduction in physical health care[b]	£4,823,570	£5,720,797	-£897,228
Total[c]	-£4,823,570	-£5,579,064	**-£755,494**

[a]Assumed equivalent in base case.
[b]As per the methods section these savings are calculated based on the best available data, but are not based on data from the Oxford AHSN region. No such data was available.
[c]This value is negative because we have not included the direct medical costs of IAPT (see note a above). It *does not* suggest that IAPT therapy in general is cost saving.

3.1.3.3 Relapse

Based on the assumption that 49% of patients relapse within two years, we estimate that two years after the end of treatment, an additional 1,631 people are still in recovery in the Oxford AHSN region than would be the case if the national recovery rates applied.

3.1.3.4 Cost-effectiveness

The base case analysis suggests that the Oxford AHSN IAPT project has improved recovery rates in the Oxford AHSN region (compared to national rates) and reduced total costs to the NHS (even when the costs of the Oxford AHSN involvement are included). This suggests that the Oxford AHSN has been extremely good value for money in relation to IAPT services.

As Strategy 2 is cost saving compared to Strategy 1 because of the assumptions we are making about the savings arising from reduced physical health care costs. In this situation, 'incremental cost per additional recovery' would not be a meaningful statistic and is not calculated.

3.1.3.5 Sensitivity analyses

SA1: Alternative data on recovery rates

Using the recovery rates provided by the Oxford AHSN, we estimate that between January 2014 and May 2015, 29,715 patients finished treatment within the Oxford AHSN IAPTs programme. A total of 14,439 patients recovered, an additional 3,544 patients recovered compared to what would have been expected if the national recovery rate applied (strategy 2 – strategy 1).

This indicates that the Oxford AHSN IAPT project has been effective in increasing the IAPT recovery rate in the Oxford AHSN region (compared to national recovery rates).

The costs are shown in Table 8. The table illustrates how that the incremental cost of Strategy 2 compared to Strategy 1 is still negative. However, the savings are lower than in the basecase. This is because the large cost of clinical staff training (£112,090) is still incurred, and there is less chance to recoup savings from recovered patients during the shorter time period studied. We know that the benefits of the Oxford AHSN's IAPT programme have continued past May 2015, and therefore capping the analysis at this point means we underestimate the added value of the Oxford AHSN.

Table 8: Costs for SA1: Alternative data on recovery rates

	Strategy 1	**Strategy 2**	**Incremental**
Direct medical costs	-	-	-
Oxford AHSN staff time	-	£19,467	£19,467
Additional NHS staff time spent in training as a direct result of Oxford AHSN involvement	-	£112,090	£112,090
Savings due to reduction in physical health care	£3,478,601	£4,050,140	-£571,538
Total[a]	-£3,478,601	-£3,918,583	**-£439,982**

[a]This value is negative because we have not included the direct medical costs of IAPT (see note a above). It *does not* suggest that IAPT therapy in general is cost saving.

SA2: Societal perspective

We estimate that an additional 384 people have been able to return to work due to the Oxford AHSN IAPT programme compared to if national recovery rates had applied. Given that up to 49% of the patients who recover may relapse within two years, we expect that not all of these employees would remain in work permanently.

Note that the national data on the effect of IAPT services on employment status does not indicate an increase, therefore these results must be interpreted with caution.

SA3: Average cost per recovery

The cost per high intensity session is £125 and the cost of a low intensity session is £37 in the Oxford AHSN region; the cost per high intensity session is £97 and the cost of a low intensity session is £47 elsewhere in England (see Table 9).

Finally, after aggregating the costs of treatment for the monthly figures of finished treatments, we obtain the average cost per recovery by dividing the total cost of treatment by the number of recoveries. Using these assumptions, the Oxford AHSN region has a lower average cost than the rest of England; of £2,594 versus the £2,895 obtained for England. Note that this does not take into account the savings that can arise from recovery, or the wider benefits (such as employment or productivity).

Table 9: Average Costs per Recovery Oxford area versus England

	Oxford AHSN Area	England
Total cost of IAPT services	£14,833,000	£310,000,000
Percentage High Intensity costs	76.56%	74.42%
Cost High Intensity Session	£125	£97
Cost Low Intensity Session	£37	£47
Average Cost per finished treatment	£1,237	£1,200
Average Cost per Recovery	£2,594	£2,895

Source: OHE analysis, 2016.

SA4: Direct medical costs of IAPT therapy

The total per person cost of treatment within an IAPT service was calculated to be £1,961 in the Oxford AHSN area, and £1,825 nationally.

Table 10 shows the results of the analysis when we included these differential medical costs. The table shows that Strategy 2 is more expensive than Strategy 1. This is the result of a higher proportion of high intensity sessions in the Oxford AHSN region compared to nationally, leading to a higher mean cost per person.

Table 10: Costs for SA4: allowing for different direct medical costs

	Strategy 1	Strategy 2	Incremental
Direct medical costs	£70,102,288	£75,336,107	£5,233,819
Oxford AHSN staff time	-	£29,643	£29,643
Additional NHS staff time spent in training as a direct result of Oxford AHSN involvement	-	£112,090	£112,090
Savings due to reduction in physical health care	-£4,823,570	-£5,720,797	-£897,228
Total	£65,278,718	£69,757,043	£4,478,325

Source: OHE analysis, 2016.

The incremental cost per additional recovery is £1,400. Unfortunately, as we have no estimate of QALY gain, we cannot say whether or not this would be considered cost-effective at conventional thresholds.

SA5: No cost savings to the NHS when a patient recovers

Table 11 shows the results of the analysis when we do not include the cost savings from reduced physical healthcare resource use.

Table 11: Costs for SA5: no cost saving from reduction in physical healthcare resource usage

	Strategy 1	Strategy 2	Incremental
Direct medical costs	-	-	-
Oxford AHSN staff time	-	£29,643	£29,643
Additional NHS staff time spent in training as a direct result of Oxford AHSN involvement	-	£112,090	£112,090
Savings due to reduction in physical health care	-	-	-
Total	-	£141,733	£141,733

Source: OHE analysis, 2016.

The incremental cost per additional recovery in this case would be £44.

3.1.4 Discussion

3.1.4.1 Limitations of this analysis

This analysis was subject to several limitations, most of which bias against Strategy 2, and therefore underestimate the added value of the Oxford AHSN. Notably, the model was based on several assumptions: for example, we do not include any benefits beyond November 2015 in our retrospective analysis. Assuming that recovery rates have remained above the national averages since then, this means that we have underestimated the added value of the Oxford AHSN. This means that more patients are likely to have recovered, and more costs been saved, than have been estimated in our analysis.

A methodological limitation of this analysis is that it did not calculate QALYs. This was not within the scope of this analysis, but based on our review of quality of life data it seems that this step would not have been feasible in any case. We also did not undertake discounting to allow for differential timing of costs and benefits; this was not

considered necessary due to the short time horizon and retrospective nature of this analysis.

Further limitations are linked to data availability. For example:

- The clinical outcomes data has been gathered from HSCIC. Staff at the Oxford AHSN expressed concerns that there were many problems with this dataset. The HSCIC dataset showed a higher recovery rate in the Oxford AHSN region than nationally, but still this was slightly lower than the recovery rate based on data provided by the Oxford AHSN. We conducted a sensitivity analysis to check whether this would have any substantial impact on the results: the cost savings and number of patients recovered actually decreased, due to the shorter time horizon that the local data was collected for. Given that the data for the Oxford AHSN region and the national comparator were both obtained from the same HSCIC dataset in the base case, we do not expect the problems with the dataset to have a large impact on our comparative analysis.
- The cost of IAPT therapy itself was assumed equal in Strategy 1 and Strategy 2; this is a simplifying assumption, but one that was felt to be realistic by staff at the Oxford AHSN. We explored this assumption further in sensitivity analyses.
- Data on relapse following treatment with IAPT therapy was not available. We therefore used the next best alternative, which was gathered from Dobson et al. (2008). We believe that this is likely to be an overestimate of relapse rates (and therefore bias against the Oxford AHSN) as the trial population had, on average, more severe cognitive illness than the IAPT population.

Our analysis from the societal perspective (SA2) was also hampered by a lack of data availability. This is not surprising, as such analyses are rarely undertaken in the UK, and thus the parameters are not widely used. What this means for this analysis is that we have not been able to fully demonstrate the added benefit of the Oxford AHSN IAPT project to society, only to the NHS, with an additional indication of the number who returned to work.

3.1.4.2 Added value of the Oxford AHSN

The results show that the Oxford AHSN's IAPT project is associated with increased recovery rates relative to the rest of England. We estimate that an additional 3,199 patients recovered compared to what would have been expected if the national recovery rate applied between January 2014 and November 2015, and an estimated £897,228 of NHS money may have been saved in that period due to reductions in physical healthcare expenditure. Even when taking into account the additional costs of clinical staff training within the IAPT services and staff time at the Oxford AHSN, the savings still total £755,494.

In addition, it is likely that the Oxford AHSN IAPT project has had further knock-on effects into society. We were able to approximate the number of patients who have returned to work due to the Oxford AHSN IAPT programme (an additional 384 people compared to Strategy 1)[18]. Whilst the total monetary value of this increase in employment is uncertain, as patients may once again relapse, we expect that it represents a benefit to society. These individuals will contribute to the economy, receive

[18] Note that this estimate is subject to a great deal of uncertainty: national data does not show a strong effect of IAPT therapy on employment status.

income, pay taxes, and will most likely come off disability benefits. These benefits are over-and-above the quality of life gains felt by the patients and their friends/family, and the aforementioned monetary savings to the NHS. In addition, amongst those who are employed (either as a result the treatment or otherwise) who have recovered, we expect that there has been an increase in productivity at work (for example through a reduction in sick days; 40% of sick days are thought to be related to mental health, see section 3.1.2.4), which will lead to further economic gains. Whilst we have been unable to quantify these benefits fully within the scope of this project, it is likely that the societal benefit of the increased recovery rates is positive, and as such reflects further added value of the Oxford AHSN's intervention.

Note that the Oxford AHSN also has several projects underway to look at the savings in physical health care from IAPT therapy, and the effects of IAPT on employment. Whilst this data was not available within the timeframe of this project, it will be important to include this analysis in the future.

The limitations of the study mainly relate to data availability. Conservative assumptions were made where possible, meaning that overall it is most likely that we have underestimated rather than overestimated the added value of the Oxford AHSN's intervention.

3.2 Maternity Clinical Network: Improving referral pathways for premature babies

3.2.1 Introduction

The aim of this case study was to assess the value of the Oxford AHSN in terms of their contribution to an improvement in the number of extremely premature babies being transferred in-utero to Level 3 (L3) maternity units that occurred in the Oxford AHSN maternity clinical network during 2015. This followed evidence that maternity units in the network area had much lower rates of in-utero transfer than comparable areas in England, and that this was likely having adverse consequences for survival and wellbeing.

This section includes a brief overview of the main issues, including definitions of key terms, and a description of the maternity clinical network. The case study then proceeds with Methods, Results and Discussion.

3.2.1.1 Neonatal networks in England

Since 2003, neonatal services across England have been organised into managed clinical networks (renamed 'Operational Delivery Neonatal Network' in 2013) (Marlow and Gill, 2007; NHS England, 2016). The Networks were introduced, in part, in response to the British Association of Perinatal Medicine's recommendation that hospitals should work together to ensure that the care of the smallest and sickest babies is concentrated in specialised hospitals, and because of safety concerns related to the unplanned transfer of pregnant women and neonates (Marlow and Gill, 2007). Within each network, care pathways have been developed to ensure that mothers and babies are treated and cared for in the most appropriate hospital unit (see Box 2).

Box 2: Designation of hospital unit with neonatal networks (Laing, 2012)

Hospitals units are designated according to the intensity of care provided:

Level 1 (L1) units provide special care but do not aim to provide continuing high dependency or intensive care;

Level 2 (L2) units provide high dependency care and some short-term intensive care; and

Level 3 (L3) units provide the whole range of medical and neonatal care, also referred to as a neonatal intensive care unit (NICU).

In order to minimise risk and reduce the number of babies that needed to be transferred within the first 24 hours post-birth, it is recommended that all high risk deliveries – including both premature and very low birthweight infants (see Box 3) – be conducted in a L3 unit (Phibbs, 2012; Gale et al., 2012).

Box 3: Definition of premature babies and low birthweight babies

PREMATURE BABIES: In England, all babies born before 37 weeks of pregnancy are classified as premature (NHS Choices, 2015), and those born before 27 weeks of pregnancy are classified as extremely premature (EPICure, 2011).[19]

LOW BIRTHWEIGHT BABIES: Low birth weight-babies are defined as those weighing less than 2,500 grams at birth. This can be further subdivided into very low birth weight babies (<1,500g) and extremely low birth weight babies (<1000g).

3.2.1.2 The Oxford AHSN maternity clinical network

The Oxford AHSN area is served by six maternity units which form a maternity clinical network (British Association of Perinatal Medicine, 2016). On average, there are 27,000 births in the area per annum.

The policy of the maternity clinical network is that extremely premature babies (<27 weeks gestation)[20] and extremely low birth weight babies weighing less than 800g should be delivered in a L3 unit (see Box 4). In 2013/14 (the most recent available annual data), 76 babies met these criteria (Oxford AHSN, 2015).

The Oxford AHSN area is currently served by one L3 maternity unit at the John Radcliffe Hospital, Oxford (Oxford University Hospitals NHS Foundation Trust), and five further maternity units which do not provide L3 services:

- Stoke Mandeville Hospital, Aylesbury (Buckinghamshire Healthcare NHS Trust)
- Wexham Park Hospital, Slough (Frimley Health NHS Foundation Trust)
- Milton Keynes General Hospital, Milton Keynes (Milton Keynes University Hospital NHS Foundation Trust)
- Royal Berkshire Hospital, Reading (Royal Berkshire NHS Foundation Trust)
- Horton General Hospital, Banbury (Oxford University Hospitals NHS Foundation Trust).

An audit of the area for the 24-month period April 2012 to March 2014 was completed by the Oxford AHSN in April 2015 (Oxford AHSN, 2015). The audit revealed that babies were not accessing L3 maternity services as appropriate. Of 146 babies that met the criteria for birth in a L3 unit, 67 (46%) were born in one of the five maternity units without L3 facilities. In these cases, in-utero transfer was attempted in only 14% of pregnancies, none of which resulted in an actual transfer. This was due to inefficiencies in the referral pathway. Nevertheless, in line with the current policy of units in the maternity clinical network, these babies[21] were all subsequently transferred to the L3 maternity unit at the John Radcliffe Hospital after birth (Oxford AHSN, 2015).

[19] Throughout this document, we use the English definitions to classify premature babies. However, international definitions for premature birth vary. For example, the World Health Organisation (WHO) defines "preterm" as babies born alive before 37 weeks of pregnancy and further distinguishes between extremely preterm infants born alive at less than28 weeks of gestation, very preterm infants born alive between 28 and 32 weeks of gestation, and moderate to late preterm infants born alive between 32 and 37 weeks of gestation.
[20] Or babies with less than 28 weeks gestation in the case of multiple pregnancies
[21] Excluding those which did not survive at least 12 hours after birth (4%) and a small number of special cases (7%) for whom delivery in a L2 unit was deemed suitable despite meeting the published criteria for delivery in a L3 unit.

Box 4: Criteria for delivery in a Level 3 Unit in the Oxford AHSN area

-Extremely premature baby (i.e. under 27 weeks gestation)
Or
-Under 28 weeks gestation in the case of a multiple pregnancy
And/or
-An extremely low birth weight of less than 800g (regardless of gestation)

In light of the Oxford AHSN audit, and the national landscape presented in 3.2.1.1, it was clear that improvements could be made to the referral pathway ('policy change') for the delivery of premature or extremely low weight babies in the maternity clinical network. These changes could be expected to lead to an improvement in survival rates, as well as other aspects of the health and wellbeing of mothers and their babies, whilst also potentially reducing the cost of post-birth transfers to L3 units.

3.2.1.3 The added value of the Oxford AHSN

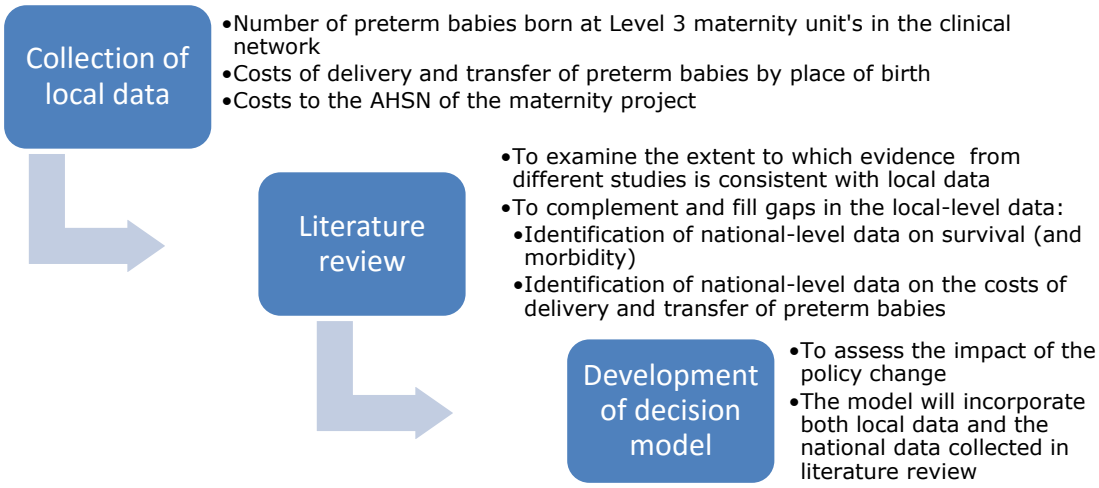
Following changes in early 2015 to the referral pathway and development of new guidelines for the Oxford AHSN maternity clinical network, it was agreed at the Oxford AHSN/OHE workshop in November 2015 that an assessment would be made of the added value of the Oxford AHSN given the effectiveness of those improvements in terms of additional live births, and the total cost (from the perspective of the NHS) of achieving them.

A before-and-after study design would be used to assess the numbers and proportion of preterm babies born at L3 maternity units within the maternity clinical network since April 2015 when compared to the data gathered for the Oxford AHSN audit during a 24-month period prior to the policy changes. This would be supplemented by a literature review which would identify national-level data to provide estimates of the likely impact on levels of mortality and, if possible, morbidity. An assessment would also be made of the changes in costs that occurred within the units of the maternity clinical network, and the project-related costs incurred by the Oxford AHSN.

3.2.2 Methods

The assessment of the policy change (i.e. changes to the referral pathway and development of new guidelines) in terms of changes in survival ('effectiveness') and costs comprised three stages (see Figure 7) which are described in turn in the rest of this section: collection of local data, literature review, and development of an Excel-based decision tree model (including model inputs, assumptions and proposed sensitivity analysis).

Figure 7: Overview of methods used in study on improving referral pathways for preterm babies



3.2.2.1 Collection of local data

Local data was collected in relation to both the effectiveness and costs of the policy change.

Effectiveness data:
Local data were collected from the existing Oxford AHSN audit for a 24-month period prior to the changes ('before') on:

- The number of live births at all six maternity hospitals within the maternity clinical network and related information (e.g. weeks of gestation at birth)
- The number of antenatal and neonatal transfers to the L3 unit at the John Radcliffe Hospital, subsequent early neonatal death rates, and other related information (e.g. the number of proposed transfers which were refused)

More recent data collected during 2015 ('after') was also sought through telephone and email contact with Katherine Edwards (Oxford AHSN Maternity Clinical Network Manager).

Cost data:
Recent data on the local cost of delivering preterm babies in L3 units when compared to L2 units, and the costs of transferring preterm babies between units (e.g. ambulance costs) in the maternity clinical network was sought through telephone and email contact with Katherine Edwards and Dr Eleri Adams (Clinical Lead for the network).

We also sought information from the Oxford AHSN on the costs, including staff time and overhead costs, of their contribution to the project.

3.2.2.2 Literature review

We undertook a 'best evidence review' of literature relevant to England. We sought to identify studies which had examined differences in rates of survival (and morbidity) and costs at L3 versus L2 units.

Specifically, the aim of the review was to identify:

- Data on survival (and morbidity) rates amongst premature babies born in L3 units when compared to L2 units.

- Studies which compared the cost (or resource use) related to delivery of premature babies in a L3 units compared to L2 units.

Effectiveness data:
A snowballing technique (Wohlin, 2014) was used, beginning with a paper published as part of the EPICure 2 study (EPICure, 2012). This paper reported on perinatal outcomes for extremely premature babies born between 22 and 26 weeks gestation and was based on data from all 182 maternity units in England (Marlow et al., 2014). This study was identified by maternity specialists at Oxford AHSN and the maternity clinical network and was cited in the Oxford AHSN audit as being highly relevant to the context (Oxford AHSN, 2015). We undertook forward and backwards citation searching: the reference list of included papers were screened for potentially relevant studies and citation searching was conducted in Google Scholar[22] to identify potentially relevant papers that had cited the included study. The search was restricted to post-2008 publications; this cut-off point was chosen based on the identification of a review and meta-analysis of relevant data by Lasswell et al. (2010) which had included literature published between 1976 and 2008 (Lasswell et al., 2010). This literature included studies published in Europe, North America and Australasia which had compared outcomes for premature babies (<32 weeks gestation in this case) and very low birthweight infants (i.e. <1,500 grams).

In addition we manually searched relevant websites: EPICure, the confidentiality enquiry into maternal and child health (CEMAH); and the Royal College of Paediatrics and Child Health using the terms 'audit' and 'preterm' and 'NHS'.

Cost data:
A snowballing technique was used beginning with a recent review of both the peer-reviewed literature and additional sources for information on the economic consequences of premature birth by Petrou et al. (2012). Forward and backwards citation searching for studies published post-2012 was performed.

3.2.2.3 Development of an Excel model

An Excel-based model was developed to analyse the impact of Oxford AHSN's maternity project in terms of (i) effectiveness (survival rates and, where possible, survival without morbidity) and (ii) associated costs.

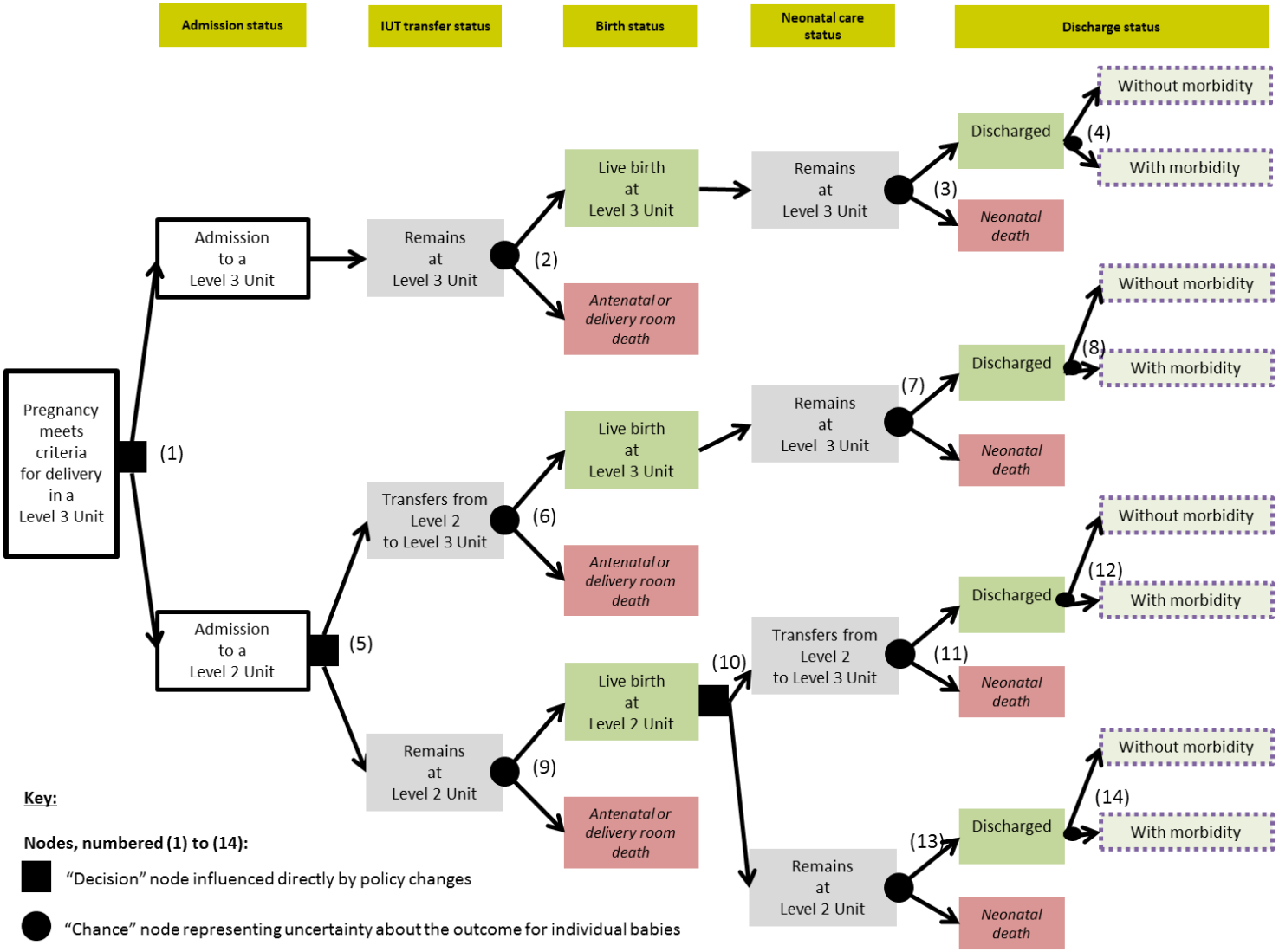
Model structure:
The structure of the model is shown in Figure 8 (a screen shot from the Excel is also provided in Appendix 1). It takes the form of a decision tree which is a widely used, if simplest form of decision modelling used in health economic evaluation (Drummond, 2005). The decision tree is designed to represent the full range of potential pathways for a pregnancy and subsequent birth that meets the criteria for delivery in a L3 unit in the maternity clinical network (see Box 4).

[22] Google Scholar, http://scholar.google.co.uk

The key features of the model are:

- Arrows which indicate pathways through the model (or routes through the tree) from admission to a L2 or L3 unit on the left, through to discharge with(out) morbidity on the right.
- Three 'decision' nodes at various stages, indicating a decision point between two alternative options concerning whether or not a L3 or L2 unit is chosen. For each baby, these decisions are expected to be influenced by the maternity clinical network's 'policy change' (i.e. a change in the referral pathway or relevant clinical guidelines).
- Multiple 'chance' nodes, which represent the uncertainty for each baby about what the outcome (successful discharge or neonatal death, for instance) will be.
- Boxes which indicate the various 'events' that can occur as the baby moves through the model. They represent admission status (to a L3 or L2 unit), in-utero transfer (IUT) status (remaining in the hospital of first admission, or transfer from a L2 unit to a L3 unit), birth status by place of birth (live birth, or antenatal or delivery room death), neonatal care status (remaining in the hospital of birth, or transfer from a L2 unit to a L3 unit), or discharge status (successfully discharged with or without morbidity, or neonatal death).
- Probabilities (ranging from 0% to 100%) are assigned to the arrows emanating from the 'decision' or 'chance' nodes, such that for each node, all probabilities sum to 100%. Moving from left to right in the model, the probability of admission to a L2 and L3 unit is represented by the first decision node. Subsequent probabilities in the model are conditional probabilities in that the likelihood of a given event (or outcomes) occurring are dependent on an earlier event (or outcome) having (or not having) occurred. Thus, in order to calculate the probability (known as 'joint probability') of any complete pathway in the model it is necessary to multiply the probabilities at each node on the pathway.

Figure 8: Overview of the decision model



Model inputs:
Required inputs to the model are:

- Probabilities at each 'decision' or 'chance' node
- The number of live births reported at L3 and L2 units
- Costs associated with delivery of babies at L3 and L2 units
- Cost associated with the transfer of babies between units

Where data were identified in literature published in earlier years, costs (or prices) have been adjusted for inflation using the 'composite price index' published by the Office for National Statistics and reported in £2016.

Model outputs:
There will be three iterations of the model:

(1) Using the national-level data from 182 maternity hospitals in England in 2006 reported in Marlow et al (2014)

(2) Using the local-level data from the 6 maternity hospitals in the clinical network reported in the Oxford AHSN audit ('before')

(3) Using the local-level data from 6 maternity hospitals in the clinical network collected for this study ('after')

Where there are gaps in data for the second and third model iterations, assumptions were made based on the national-level data used in the first model iteration (as shown in Table A, Appendix 1). A sensitivity analysis was used to alter some of the assumptions made in third iteration, where there was a particular shortage of data (typically this sensitivity analysis would involve altering the assumptions so that they matched the second iteration, rather than the first iteration; these are discussed in further detail in the Results section below). Limitations associated with this approach are assessed in the Discussion section below.

For each of the three model iterations, the primary output of interest is the probability of survival 'after' the policy change (i.e. the third model iteration) compared to the probability of survival 'before' the policy change (i.e. the second model iteration). Other secondary model outputs are explored below in the Results section.

3.2.3 Results

In this section, we first report on the data which was identified through local contacts and the literature review. We then provide the outputs of the model.

3.2.3.1 Collection of local data

Effectiveness data:
Table 12 to Table 14 show the data which was collected from the Oxford AHSN and maternity clinical network.

Table 12 shows the number of babies meeting antenatal transfer criteria (as reported in Box 3) who were delivered in L2 and L3 units in the clinical network for the 24-month period 01/04/2012-31/03/2014 ('before') and a ten-month period 01/04/2015-31/12/2015 ('after'). These numbers were annualised (e.g. number of babies born during a six-month period would be doubled, whereas number of babies born in a two-year period would be halved) to support a comparison between periods.

The annualised figures showed that, whilst there were estimated to be fewer total births per annum meeting antenatal transfer criteria overall (n=73 'before' and n=60 'after'), there had been an increase in the proportion of those babies being delivered at the L3 unit (John Radcliffe Hospital) from 54% to 78% (as well as in absolute terms - n=39.5 'before' and n=46.8 'after').

The magnitude of change that occurred 'before' and 'after' the policy change was much greater than the changes that were observed when comparing the first 12 months to the second 12 months of the 24-month 'before' period. For example, the proportion of babies meeting the criteria who were born in a L3 unit fell by seven percentage points between 2012/13 and 2013/14 (from 57% to 50%).

Table 12: Number of infants meeting transfer criteria who were delivered in Level 2 and Level 3 units 'Before' and 'After' the policy change

	'Before'				**'After'**	
	2012/13 (12 months)	2013/14 (12 months)	2012-2014 (24 months)*	Annualised	2015 (10 months)	Annualised
Total births	70	76	146	73	50	60
Level 3 births	41 (59%)	38 (50%)	79 (54%)	39.5 (54%)	39 (78%)	46.8 (78%)
Level 2 births	29 (41%)	38 (50%)	67 (46%)	33.5 (46%)	11 (22%)	13.2 (22%)
Source	Oxford AHSN audit				Personal communication	

*this column sums data from the previous two columns

Table 13 provides a summary of the available data from the Oxford AHSN audit on the transfer status of the babies born in L2 units during the 24-month period 'before' the policy change. Whilst none of the potentially eligible babies were transferred from L2 to L3 units prior to birth, an attempted transfer was made in 13.6% of cases (however in all these cases, the transfer request was refused). A post-hoc review of case notes completed for the Oxford AHSN audit indicated that, in a further 40.9% of cases, a transfer could have been feasible (whereas in the remaining cases a transfer would have been unworkable due to the mother being in established labour, for example) (Oxford AHSN, 2015).

Table 13: Transfer status of infants meeting transfer criteria who were born in Level 2 units 2012-14

	Of 44 pregnancies[1]	Of 57 babies born[1]	Proportion of babies or pregnancies[1]
In-utero transfer			
Attempted but refused	6	n/a	13.6%
Did not occur	38	n/a	86.4%
Could have been attempted	*18*	*n/a*	*40.9%*
Neo natal transfer			
Occurred	n/a	51 [2]	89.5%
Did not occur	n/a	6 [3]	10.5%

Source: Oxford AHSN audit, 2015

[1]The Oxford AHSN audit reviewed the notes of 57 babies (of 67 babies born) associated with 44 (of 54 pregnancies). Thus data was missing for 18.5% of all pregnancies and 7.5% of babies born

[2] Of the 51 babies were neo-natal transfer occurred, 60% survived and 40% died

[3] Of the 6 babies where neo-natal transfer did not occur, 2 died within 12 hours of birth, and 4 were twins which were deemed suitable for birth in a L2 unit despite meeting the criteria for birth in a L3 unit

Cost data:

Our discussion with a representative of the maternity clinical network (on 26th February 2016) confirmed the finding from our own initial inspection of NHS Reference Cost data that had revealed no relevant information on differences in the cost of delivering preterm babies at L3 and L2 units.

In the view of our representative, the most significant change in cost which had arisen as a result of the policy change was a reduction in neonatal ambulance transfers which, per transfer, were reported through the personal communications of our representative to be £1,101.

It was argued that any additional costs of delivering infants at the John Radcliffe L3 unit which would otherwise have been delivered at a L2 unit were insignificant. This was because it was reported that the John Radcliffe Hospital had spare capacity sufficient to manage the observed rise in cases (which amounted to an additional 7.3 babies per annum, a rise of 18.4%, according to the calculations in this study - see Table 1).

Costs to the Oxford AHSN:

Table 14 provides an estimate of the costs to the Oxford AHSN which were approximated based on the amount of staff input time the Oxford AHSN reported as having contributed to the maternity project.

We proxied the costs of staff time using the costs of wages and overheads; these costs are included to represent the opportunity cost of staff time. We were informed by Oxford AHSN that the total time charged to this project was equivalent to 75% of a full-time equivalent at NHS band 8a over a 12 month period. Thus the total cost of this was estimated to be £70,825.

Table 14: Oxford AHSN staff costs for the maternity project

Component	Value
Salary±	£45,081
Salary oncosts[1,†]	£11,701
Overheads[2,†]	£36,202
Capital overheads[3,†]	£4,370
Annual total (A)	**£97,354**
Non-London Multiplier (B)	0.97
Working time dedicated to the maternity project (C)	75%
Total staff cost to Oxford AHSN (A x B x C)	**£70,825**

Reference: Curtis and Burns, 2015
[1]Essential associated costs, for example the employer's national insurance contributions
[2]Management and other non-care staff overheads include administration and estates staff
[3]Includes costs for office, travel/transport and telephone, education and training, supplies and services (clinical and general), as well as utilities such as water, gas and electricity
±Mean annual basic pay per FTE by Agenda for Change band 8a
†Approximated by values for Band 8a scientific and professional staff

3.2.3.2 Literature review

Effectiveness data:

In total we identified 11 studies which reported on differences in mortality and morbidity for premature or very low birthweight babies by place of birth (Gale et al., 2012; Lasswell et al., 2010; Binder et al., 2011; Boland et al., 2015; Chung et al., 2011; Jensen and Lorch, 2015; Lapcharoensap et al., 2015; Lorch et al., 2012; Marlow et al., 2014; Watson et al., 2014; Zeitlin et al., 2010). In addition to comparing outcomes by place of birth, three studies also looked at difference based on level of hospital activity. Half of the studies were conducted in the US (n=5), three were conducted in the UK, one in Australia and one in France. A meta-analysis by Laswell et al. (2010) included 41 studies published between 1976 and 2008; the vast majority were conducted in North America.

In the text below we summarise findings related to extremely premature babies (i.e. <27 weeks gestation) and/or extremely low birthweight (i.e. <1,000 grams), as defined in Box 2. A complete report of the literature review is provided in Table B, Appendix 1.

Two studies found an improvement in mortality outcomes following the reorganisation of neonatal services to increase regionalisation (Gale et al., 2012; Zeitlin et al., 2010). Zeitlin et al. (2010) found that the greatest gains in in-hospital mortality were made for extremely premature babies (24 to 27 weeks gestation). In both studies, there are challenges in distinguishing the reorganisation from underlying temporal trends.

In terms of direct comparisons between L3 and L2, for extremely premature and/or extremely low birthweight there was evidence that the odds of mortality increased for babies born in a L2 compared to L3 unit (Lasswell et al., 2010; Binder et al., 2011; Boland et al., 2015; Marlow et al., 2014; Watson et al., 2014), but with a more mixed-picture for morbidity (Binder et al., 2011; Lapcharoensap et al., 2015; Marlow et al., 2014; Watson et al., 2014).

Three out of four studies that examined in-hospital mortality (from birth to discharge) found a significant improvement in mortality for babies born in a L3 unit (Lasswell et al., 2010; Binder et al., 2011; Marlow et al., 2014). The meta-analysis by Lasswell et al.

(2010) found an 80% increase in the odds of pre-discharge mortality for extremely low birth weight (i.e. <1,000 grams) infants born in a non-L3 hospital compared with those born in L3 (OR 1.80 [95%CI 1.31, 2.46]).[23] The UK study by Marlow et al. (2014) found that births of extremely premature babies in a L3 unit were associated with a 27% reduction in overall mortality (aOR 0.73 [95%CI 0.59, 0.90]);[24] this was the result of significant reductions in mortality around the time of delivery (aOR 0.53 [95%CI 0.37, 0.77]) and during the first week of life (aOR 0.69 [95%CI 0.51, 0.94]). Likewise, the second UK study (Watson et al., 2010) found a significant reduction in odds of mortality for extremely premature babies (<27 weeks gestation) during the neonatal period (first 28 days of life) associated with being born in a L3 unit (OR 0.65 [95%CI 0.46, 0.91]), but found no difference in-hospital (deaths before discharge) between units (OR 0.78 [95%CI 0.57, 1.06]).

Finally one study conducted in Australia (Boland et al., 2015) found increased odds of mortality within the first year of life for extremely premature babies born in a non-tertiary hospital compared to a tertiary hospital (OR 3.16 [95%CI 2.52, 3.96]).

The two studies conducted in the UK (Marlow et al., 2014; Watson et al., 2014) also reported a significant association between mortality and hospital activity, in both cases a reduction in odds was observed in higher activity units. Watson et al. (2014) found a significant reduction for extremely premature babies in both neonatal mortality (OR 0.62 [95%CI 0.44, 0.87]) and in-hospital mortality (OR 0.71 [95%CI 0.52, 0.97]). While Marlow et al. found no evidence for differences in time-specific mortality, overall in-hospital mortality was lower in higher activity L3 units (aOR 0.68 [95%CI 0.52, 0.89]). This finding was supported by two studies from the US (Chung et al., 2011; Jensen and Lorch, 2015) that looked at very low birth weight (500g-1,500g) infants. Chung et al. (2011) found no difference in the odds of mortality during the first year by place of birth but found that increasing volume of activity was associated with progressive reductions in the odds of mortality, with those units caring for less than 10 very low birth weight babies per annum having an 80% higher odds of mortality compared to units caring for more than 100 babies (aOR 1.79 [95%CI 1.38, 2.13]). Jensen and Lorch (2015) assessed the impact of a hospital's activity and NICU level and found that the annual volume of deliveries of very low birthweight infants had a greater effect on mortality within the first 24 hours of life than NICU level; among hospitals that deliver fewer than 50 very low birthweight or very premature infants per year the odds of death was 25% to 64% higher after controlling for NICU level.

Marlow et al. (2014) found that morbidity (defined as having one or more of: retinopathy of prematurity requiring retinal surgery; moderate or severe bronchopulmonary dysplasia; a severe brain injury; or necrotising enterocolitis managed by laparotomy) did not vary by place of birth and that improved survival was not associated with significantly increased morbidity (aOR 1.27 [95%CI 0.93, 1.73]). Conversely one study in the US (Binder et al., 2011) found increased odds of morbidity in L2 compared to L3 units for babies with extremely low birthweight of 500g to 900g for all four outcomes measured (bronchopulmonary dysplasia or death; intracranial haemorrhage or death; retinopathy of prematurity or death; and necrotising enterocolitis or death). A second US study (Lapcharoensap et al., 2015), which looked only at bronchopulmonary dysplasia,

[23] OR: Odds ratio
[24] aOR: Adjusted odds ratio

reported an increased odds at 36 weeks for premature babies (22 to 29 weeks gestation) born in L2 units compared to L4[25] (OR 1.23 [95%CI 1.02, 1.49]). Finally, one further UK study found that extremely premature babies (<27 weeks gestation) born at a L3 unit were at increased odds of developing bronchopulmonary dysplasia compared to babies born in a L2 unit (OR 1.50 [95%CI 1.11, 2.01]), but found no difference in the odds of developing either necrotising enterocolitis or retinopathy of prematurity by place of birth.

Only one of the studies identified had considered the impact of being transferred between units (Marlow et al., 2014). Marlow et al. (2014) found that extremely premature babies who were born in a L2 unit were at 44% increased odds of mortality compared to those babies which were transferred to a L3 unit prior to birth (aOR 1.44 [95%CI 1.09, 1.90]). Transfer after birth was found not to improve mortality outcomes compared to babies who remained in n L2 unit (aoR 1.08 [95%CI 0.83, 1.41]), and babies transferred from a L2 to a L3 unit after birth were less likely to survive without morbidity than babies born at a L3 unit (aOR 0.72 [95%CI 0.48, 1.08]).

Cost data:

The review on the economic consequences of premature birth by Petrou et al. (2012) revealed three studies that had used UK data. These were categorised as follows: studies of the costs associated with the initial hospitalisation, studies of the costs following the initial hospital discharge, and economic models of the economic costs throughout childhood. However, none of these had included any estimate of the difference in costs associated with delivery in different units.

A further study which was identified by Mistry et al. (2009) drew comparisons on the average cost of care for babies with extremely low birth weight (i.e. <1,000g) being cared for in L2 and L3 units. Whilst the study concluded that costs were greater for care in L3 units when compared to L2 units (e.g. the cost was £26,815 (s.d. £19,558) at L3 and £13,431 (s.d. £16,777) at L2),[26] this was due to the sickest babies being quickly transferred out of L2 units and differences in case mix (i.e. the sickest babies may have been more likely to be admitted to L3 units before birth). The study did not assess the total cost of care for babies born in a L2 unit (including their care after transfer in a L3 unit) when compared to babies born in a L3 unit.

Implications of the literature review for the decision model:

Overall there is evidence to suggest that being born in a L3 unit is associated with increased survival but the impact on morbidity is less clear. While the majority of evidence comes from outside the UK, in their meta-analysis, Lasswell et al. (2010) suggested that although there is the possibility of variation between health systems, they found no significant between-group difference for studies conducted in different settings. The lack of clarity on the impact on morbidity was suggested to be a result of higher mortality in non-L3 units, limiting the ability to determine the impact of hospitals factors on morbidity (Jensen and Lorch, 2015). Where morbidity was higher in a L3 unit this was suggested to be as a result of a survival bias.

There is some evidence to suggest that the level of hospital activity might be a more important determinant of mortality than the hospital level. This finding is supported by

[25] Level of care was defined according to the Committee on Fetus and Newborn of the American Academy of Pediatrics policy statement. Neonatal levels of care are currently classified as well newborn nursery (L1), special care nursery (L2), NICU (L3), and regional NICU (L4).
[26] S.d.: Standard deviation

Poets et al (2004), which recommended that neonatal units need to be caring for at least 36 to 50 very low birth weight infants to achieve best outcomes.

For the purpose of building the decision model, the data available on costs was very limited since no study provided an estimate of the total cost of delivery of a baby in a L3 unit (necessary for our 'after' scenario) when compared the total cost in a case where the infant is born in a L2 unit but later transferred to a L3 unit (necessary for our 'before' scenario).

Considering the evidence on effectiveness and cost together, this review thus identified only one study which assessed the impact of being transferred between units. The remaining studies reported outcomes only by place of birth and did not consider the impact of any subsequent transfers between hospital units. The study by Marlow et al suggested that a transfer to a L3 unit should occur prior to birth in order to improve mortality outcomes. Given that the model aimed to determine the costs associated with the entire care pathway i.e. based on babies discharge status, we considered that only this study by Marlow et al. provided relevant information which could be used directly in the decision model.

3.2.3.3 Decision model

Model inputs and running the model:
Data on the number and proportion of births at L2 and L3 units were derived from the Marlow et al study (iteration 1), data in the Oxford AHSN audit ('before'; iteration 2; see Table 12), and data released by Oxford AHSN for this study ('after'; iteration 3; see Table 12).

In the case of the study by Marlow et al., this data was sufficient to assign probabilities to each of the 14 'decision' and 'chance' nodes used for the first iteration of the model (these are reported in Table A, Appendix 1).

Where probability data was missing in either the second or third iterations of the model, the probabilities from the study by Marlow et al. (i.e. the first iteration) were used instead.

A sensitivity analysis was also completed for the third iteration of the model (the 'after' scenario). This analysis used probabilities that were available in the 'before' but not the 'after' data. These probabilities were substituted in the sensitivity analysis for the Marlow et al. probabilities that had been used in the main analysis (See Table A, Appendix 1). For example, we have assumed in the main analysis that the proportion of babies meeting the maternity clinical network's criteria who were transferred to L3 after birth in a L2 unit (chance node 11, Figure 8) would fall from 89.5% ('before') to 56.3% ('after', based on the national-level data in the study by Marlow et al.). This may be realistic because babies that were previously transferred after birth are now more likely to be antenatal transfers, thus a smaller proportion of L2 babies would be expected to be transferred after birth. Nevertheless, the sensitivity analysis assumes that the proportion remains unchanged at 89.5%. In this respect, the sensitivity analysis would thus be expected to provide a larger expected impact on survival rates since more preterm babies are receiving care in the L3 unit than in the main analysis.

Model outputs:
The model outputs for the three iterations of the model and the sensitivity analysis are shown in Table 15. The primary model output shows that, for babies who met the

maternity clinical network's transfer criteria, the probability of survival increased from 40.7% prior to the policy change to 45.9% after the policy change. This is similar in magnitude to what would be expected should the Oxford AHSN area be consistent with the national picture reported in Marlow et al (2014) where the overall likelihood of survival was 45.2%.

The sensitivity analysis which had substituted data from the Marlow study in the 'after' scenario for data in the 'before' scenario, suggested that the improvement was slightly smaller: the probability of survival increased from 40.7% to 43.4%. However, this was mainly due to a smaller proportion of babies being transferred from a L2 to a L3 unit prior to birth. Thus the sensitivity analysis provided a conservative estimate of the impact of the policy change.

Other results from the model indicated that the likelihood of antenatal death fell from 34% to 29% and the likelihood of being discharged without morbidity increased from 6% to 9%.

Cost implications:

In the model, there was an estimated reduction in the number of post-natal ambulance transfers required per annum from 30.0 to 7.4 (from 89.5% to 56.0% of annual births in a L2 unit). Thus, based on the local data provided by Oxford AHSN on the cost of neonatal ambulance transfers, we estimated that there would be potential annual cost reductions of £24,883 (=£1,101*(30.0 - 7.4)).

Whilst it was clear from our discussion with the Oxford AHSN that there could be very low short run marginal costs associated with the increased number of births at the L3 unit (due to spare capacity), we nonetheless cannot presume that the spare capacity would be available indefinitely. Furthermore, if not immediate financial costs, then there are clearly opportunity costs associated with the use of the L3 facilities (since these resources could have been reallocated to other uses, including premature babies born after 28 weeks, for example). Thus we used the data from the study by Mistry et al. to calculate the annual cost of the additional births (= 46.8-39.5 = 7.3 births; see Table 14) which occurred at the L3 unit after the policy changes as amounting to £263,654 (where the unit cost was £36,117, after adjustment for 2016 prices). Also using the data reported in the study by Mistry et al., we calculated the corresponding annual cost reductions at the L2 units as amounting to £139,167 (where the unit cost was £19,064).

Overall, when combined with the cost to the Oxford AHSN reported in Table 14, these estimates suggest that there could have been an increase in costs attributable to the policy of £170,429 per annum in the first year (falling to £99,604 in later years; see Table 16). However, we emphasise that this should be considered a 'worst case' cost scenario. In reality, the cost is likely to be much lower since the costs we have used for birth in a L3 unit are not directly comparable to the estimates of a birth in a L2 unit due to limitations in the data available to us (as discussed in 3.2.3.2 above; no other suitable cost data was identified). In a 'best case' cost scenario, where the assumption suggested in conversations with the maternity clinical network that the transfer of births from L2 units to L3 units did not result in an increase in costs, the cost to the Oxford AHSN of the policy change (£70,825, Table 13) is roughly equivalent to the savings that would be achieved from reductions in neonatal ambulance transfers over a three year period (which amount to £24,883 per annum). We suggest that the most likely cost scenario falls between these two extremes.

Table 15: Outputs for three iterations of the model

Probability of survival at discharge		Secondary outcomes											
		Baby meets antenatal criteria (see Box 2)	Total live births	Live birth at Level 3 unit		Live birth at Level 2 unit		Antenatal death		Neonatal death		Discharged without morbidity	
%		N	N	N	%	n	%	n	%	n	%	n	%
Model iteration 1: Real data reported in the Marlow study (for comparison)													
	45.2%	2216	1543	1031	47%	512	23%	673.0	30%	540.8	24%	189.4	9%
Model iteration 2: 'Before' the policy change													
	40.7%	110.4	73	39.5	36%	33.5	30%	37.4	34%	28.1	25%	6.7	6%
Model iteration 3: 'After' the policy change													
Main analysis	**45.9%**	84.3	60	46.8	55%	13.2	16%	24.3	29%	21.3	25%	8.0	9%
Sensitivity analysis*	43.4%	85.9	60	46.8	55%	13.2	16%	22.7	30%	22.7	26%	7.3	8%

% refers to the proportion of all babies meeting antenatal criteria (i.e. joint probabilities calculated once a complete pathway from the left hand side through to the right hand side has been competed)

* In the main analysis, gaps in the local data were filled with national-level data from the study by Marlow et al. The sensitivity analysis instead uses some of the local data available in the 'Before' period (iteration 2; see Table A, Appendix 1 for details)

Table 16: Estimated change in annual costs which could be attributed to the policy changes

	'Worst-case' scenario	'Best case' scenario
Increased costs		
Cost to the Oxford AHSN	£70,825*	£70,825*
Increased number of L3 births	£263,654	£0
Cost savings		
Decreased number of L2 births	£139,167	£0
Decreased number of neonatal transfers	£24,883	£24,883
Total change in cost		
Total	£170,429 increase	£45,942 increase
Excluding costs to the Oxford AHSN*	£99,604 increase	£24,883 saving

* Costs to the Oxford AHSN are reported in Table 14. Note that these would arise only in the first year.

3.2.4 Discussion

Main findings:

The main finding of this analysis has been the estimated improvement in the likelihood of survival after the policy change of 5.2% percentage points (as shown in column 1, Table 14), rising from 40.7% prior to the policy change to 45.9% after the policy change. Based on our estimate of 84.3 babies meeting the maternity clinical network's criteria for transfer to a L3 unit per annum, this translates into an increase of approximately 4 babies surviving per annum than would have been the case prior to the policy change (our more conservative estimate provided in the sensitivity analysis suggests an increase of approximately 2 survivals). These improvements in survival are set against our estimates of changes in cost in Table 17. Given the improvement in survival that is identified in our model (and supported by the wider literature), we suggest that the policy change (and Oxford AHSN's contribution to the policy change) does represent good value for money.

The literature review identified some evidence that, in addition to the improvement in survival which is likely to be attributable to a transfer of extremely premature babies from L2 to L3 units, there is also likely to be an improvement in survival attributable to the transfer of extremely premature babies from low-volume units to high-volume units. Further exploration of this point was beyond the scope of this study. However, given the very small numbers of babies meeting the transfer criteria which were previously being born each year in L2 units (e.g. for the Oxford AHSN area, n<8 was reported in all 5 of the L2 units in at least one of the two years for which we have data, including n<4 in 2 of those units in 2012-13), this could be a further significant factor supporting the policy change which has occurred.

Table 17: Summary of main findings

	'Worst-case'*	'Best case'*
Change in survival		
Increase in live births per annum	2.3	4.4
Change in cost		
Total cost per annum	£170,429 increase	£45,942 increase
Excluding costs to the Oxford AHSN**	£99,604 increase	£24,883 saving

*The 'worst case' reports costs at the higher end of our estimates, and additional live births that occurred in the sensitivity analysis used in our model. The 'best-case' reports costs at the lower end of our estimates, and additional live births that occurred in the main outputs of our model.
**Note that costs to the Oxford AHSN would arise only in the first year.

Limitations:

Our findings are based on the best available evidence and, to the extent that it was possible to alter some of the assumptions made in the main analysis, our sensitivity analysis also showed an improvement (albeit smaller) in survival rates based on more conservative assumptions. Nevertheless, all the reported findings in this study are subject to significant caveats arising from limitations in the data and methodology used.

Related to the effectiveness data:

- As shown in Table A (Appendix 1), local data was not available for many of the 'decision' and 'choice' nodes. Hence it was necessary to make assumptions which were based on national data. We recommend that the maternity clinical network continue to collect data over a longer period of time related to each of the pathways in the decision model (Figure 8) so that a more complete assessment of the improvement in survival can be made in the future.
- Even with complete data, the sample sizes used in this analysis remain very small, due not only to the short period of follow-up since the policy change, but also because of the relatively small number of babies who meet the criteria for transfer to L3 units. As a result it is not possible to conclude whether or not the results reported in our analysis were statistically significant. This is a substantial limitation. Hence in this study we included evidence from the literature review to support our findings wherever possible. In particular we suggest that the reported findings on survival with/without morbidity be treated with caution since these are based on very small sample sizes and the evidence from the literature on differences in morbidity between places of birth have mixed results. Nevertheless, the evidence from the literature on survival overall when comparing L3 to L2 units is stronger, and thus supports the results reported here from the decision model.
- The primary outcome measure used in the decision model was survival at discharge. This is a relatively crude measure, considering the other health and wellbeing benefits that could have arisen as a result of the policy change for mother and baby. Furthermore we have not considered the longer term impact on the health and life chances of the baby (although some studies have attempted to assess this using economic modelling (Petrou and Khan, 2012). Based on our reading of this literature, we suggest that inclusion of these additional measures

would increase (rather than decrease) the likelihood that the policy change represented good value for money.

Related to the cost data:

- There was a significant shortage of data (at the local and national levels) on the cost of care for premature babies in L3 units when compared to preterm delivery of babies in L2 units and their subsequent transfer to L3. Nevertheless, whilst we provided two extreme scenarios ('best case' and 'worst case'), set against the improvement in survival we do not consider that the choice of scenario would have a significant impact on assessing whether or not the policy change represented good value for money.

Insights from the literature review:

- The study by Marlow et al. was used extensively throughout this study. Whilst this analysis is supported by a large sample size (all maternity units in the UK), it is nonetheless based on data which is ten years old and from a single source. Ideally we would have been able to use more recent data and data from a wider range of sources. Unfortunately the study by Marlow et al. was the only study to provide detailed information on all of the potential pathways in the decision model (Figure 8). Despite having identified some other sources of evidence which support the main findings of the study by Marlow et al. (although as stated above we are aware that the evidence on morbidity particularly is quite mixed), it is the more specific evidence related to particular pathways in the model which is missing from other studies.

3.3 Energy project: Quantifying the value of energy savings and carbon reduction

Please note that this case study was originally based on some commercially sensitive data provided by the Carbon and Energy Fund. All sensitive data has been removed for the purpose of this report.

3.3.1 Introduction

The aim of this case study was to assess the value of the Oxford AHSN in terms of their contribution to supporting the decision of five NHS organisations to work with partners to deliver investment in energy infrastructure and sustainability projects. Whilst these projects are at an early stage, they are expected to result in future reductions in energy use and carbon emissions through a combination of improved energy generation and demand reduction.

Oxford AHSN began work on this project in October 2014. The purpose of the project was to support NHS organisations in the region to identify opportunities for realising cost and carbon savings from investment in energy infrastructure and sustainability projects.

Initially the Oxford AHSN engaged 10 NHS organisations in a 'rapid benchmarking analysis' and 'state of readiness' assessment which was undertaken in collaboration with **Zexu Limited**, a specialist energy and sustainability organisation.[27] This work led to the recommendation that five of these NHS organisations should engage in a more detailed, formal feasibility study which would assess the scope for investment in energy infrastructure and the potential energy savings and carbon reductions that could be achieved.

The five NHS organisations were:

- Buckinghamshire Healthcare NHS Trust
- Great Western Hospitals NHS Foundation Trust
- NHS Frimley Health Foundation Trust[28]
- Oxford Health NHS Foundation Trust
- Southern Health NHS Foundation Trust

The feasibility studies were undertaken and funded by the **Carbon and Energy Fund (CEF)**, a national not-for-profit organisation set up by the NHS and the Department of Health in 2011 to support NHS organisations in funding, facilitating and managing complex energy infrastructure upgrades.[29]

Following completion of the feasibility studies, the next stage for each of the five sites will be to select a suitable contractor to deliver the installations. The contractor is responsible for defining the full scope of the final scheme, within the broad parameters established in the feasibility study, and is selected through a competitive tendering process. At the time of writing the report (March 2016), it is expected that the CEF will continue to guide each NHS organisation through the commissioning and construction stages of the energy installations (e.g. through chairing monthly technical and project

[27] www.zexu.co.uk [Accessed March 2016]
[28] NHS Frimley includes Heatherwood, Wexham Park and Frimley hospitals
[29] www.carbonandenergyfund.net [Accessed March 2016]

board meetings), with support lasting for the lifetime of the energy installation (up to 27 years).[30]

We understand that the CEF provides a unique procurement route for the NHS organisations involved. All initial work, including the feasibility studies, is completed at no cost to the NHS organisations. Payments to the CEF occur only when the installation has been completed. These payments involve a share of the energy savings that have been realised, which are based on an independent measurement and verification (M&V) process. If energy savings fall below a guaranteed level, as set out in the contractual agreement between the CEF, contractor and the NHS organisation, then the NHS organisation will receive a payment for the shortfall.

At the time of writing (March 2016), we understand that just one of the five NHS organisations listed above (Great Western Hospitals NHS Foundation Trust[31]) has awarded preferred bidder status to a contractor prior to the construction phase. The other four NHS organisations are at an earlier stage of the commissioning process.[32] Thus the final scope of works (and associated cost savings) will likely differ to those documented in this report.

3.3.2 Methods

The purpose of this case study is to assess the potential long term cost and carbon savings of the decision of five NHS organisations to work with the CEF in commissioning new energy and sustainability infrastructure. Based on the description of the process of commissioning new energy installations described above, we have identified five potential sources of data for the NHS sites. These are summarised in Figure 9.

Ultimately, an assessment of the energy savings and carbon reductions that have been achieved will be possible for each of the five NHS organisations once the installations are in operation (i.e. using data source (5) in Figure 9).

In the meantime, we sought to produce a 'light-touch' assessment using the best evidence that is currently available. Our approach had four key stages:

Stage 1: Feasibility studies

We drew together all available evidence from the CEF, Oxford AHSN and Zexu Limited related to the rapid benchmarking analyses (data sources (1) and (2) in Figure 9) and feasibility studies (data source (3) in Figure 9) which have been completed to date for each of the five NHS organisations.

Stage 2: Contractor reports

For a selection of NHS sites which have signed contracts with a preferred bidder (including Great Western Hospitals NHS Foundation Trust, but also others from outside

[30] See www.carbonandenergyfund.net/how-it-works/ [Accessed March 2016] for further details of the support provided by the Carbon and Energy Fund.
[31] Since completion of this study (March 2016), we understand that the only schemes being taken forward by the Great Western Hospitals NHS Foundation Trust are the CHP installation and the LED lighting.
[32] Since completion of this study (March 2016), we understand that NHS Frimley Health Foundation Trust have decided not to progress with the CEF. However, a detailed feasibility study has been initiated for a CHP installation at Wexham that will produce a technical specification ready for a further tender exercise. The Trust intend to procure and fund a CHP project internally subject to the outcome of the feasibility.

the Oxford AHSN region), we drew together evidence from contractor reports in which full project specifications are reported prior to construction taking place (data source (4) in Figure 9). These were compared to feasibility studies (data source (3) in Figure 9) which had been completed by the CEF.

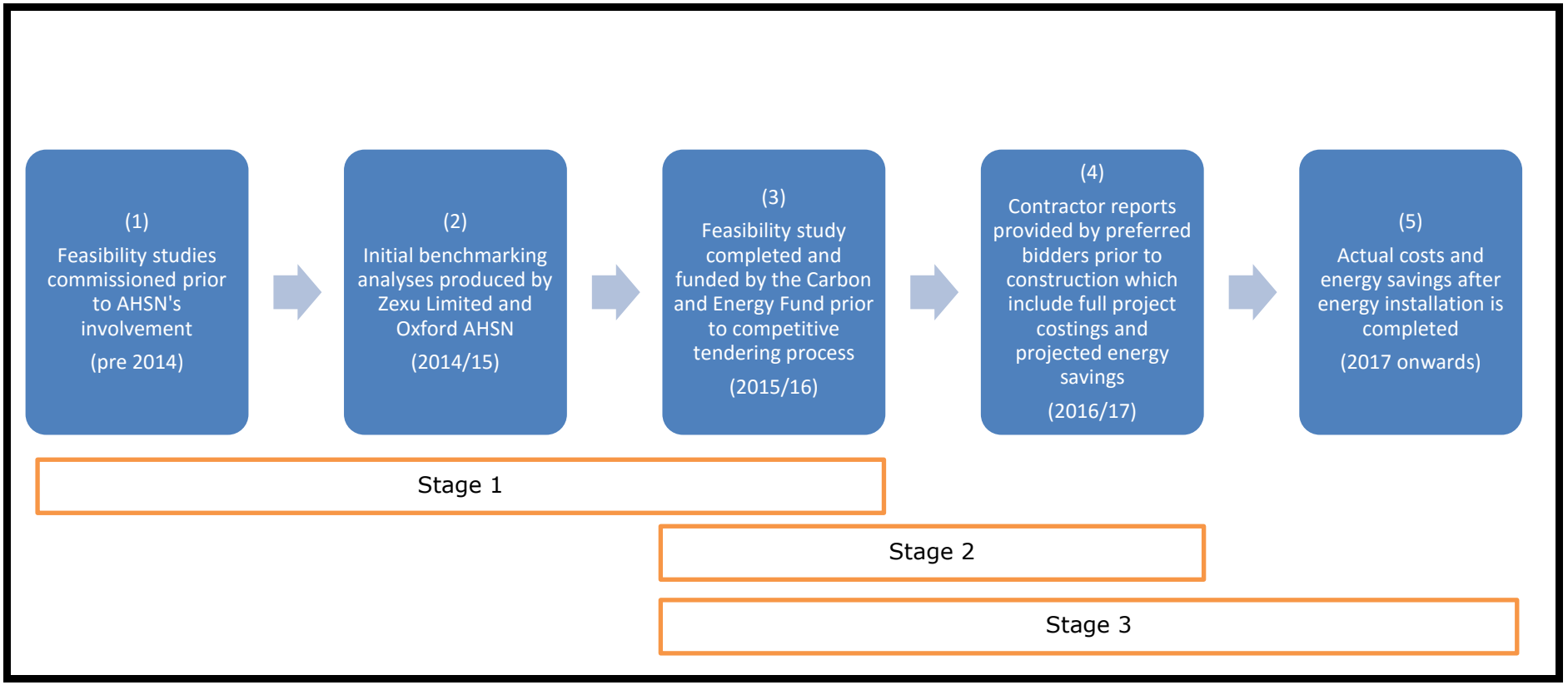
Stage 3: Actual costs and energy savings for completed installations

In the absence of evidence from the five NHS sites on actual energy and carbon savings (data source (5) in Figure 9), we sought to gather evidence from other NHS sites where it may be possible to compare a CEF-funded or contractor-provided feasibility study (data sources (3) and (4) in Figure 9) with actual energy and carbon savings achieved after the energy installations (data source (5) in Figure 9).

Stage 4: The Oxford AHSN's contribution

We sought to assess the contribution of the Oxford AHSN using available data from Oxford AHSN and Zexu Limited.

Figure 9: Overview of five sources of data which will be used to assess the costs and energy savings associated with energy installations



(1)-(5) refer to five different data sources used in this case study
Stage 1 to Stage 3 refers to the breakdown of the methods used in this study which are reported in the Methods section
Dates in brackets refer to the current timescales within the five Oxford AHSN sites (other comparable NHS sites analysed in Stage 2 and Stage 3 of this case study had already completed installation by 2016).

3.3.3 Results

3.3.3.1 Stage 1: Feasibility studies

Data from the Zexu Limited

Data from the initial rapid benchmarking analyses (data source (2) in Figure 9) were provided by Steven Heape, CEO of Zexu Limited. Table 18 provides a summary of the estimated energy savings associated with the proposed investment in energy generation and demand reduction measures for each of the five NHS organisations.

Across all organisations, a total projected investment of £23.6m is estimated to yield an annual return, in terms of energy savings, of £6.0m, and annual savings of 29,000 tonnes of carbon dioxide. Of all five organisations, Buckinghamshire Healthcare NHS Trust is the largest in terms of total projected investment (£9.2m or 39% of the total) and energy savings (£2.5m per annum or 41% of total). In contrast, the two smallest projects, Oxford Health NHS Trust and Southern Health NHS Trust, together account for less than 13% of total projected investment and annual energy savings.

Across all five organisations, we calculated the internal rate of return (IRR) assuming conservatively that the projected savings are earned for a 10 year period, as 21.9%,[33] with a payback period[34] of 3.9 years. If savings were achieved beyond 10 years, as is very likely in the majority of technologies installed, then the IRR would be higher. For each organisation, the IRR, calculated on the same basis of just 10 years of savings, ranged from 16.8% (Great Western Hospital) to 23.9% (Buckinghamshire Healthcare) and the payback period ranged from 3.7 to 4.7 years. Generally speaking, the higher a project's IRR, the more desirable it is to undertake the project. However, in these cases, the calculated rates of return are all well in excess of the 3.5% required of low risk public sector investments by HM Treasury (HM Treasury, 2011).

Table 19 reports the estimated capital costs, energy savings and IRR calculations for the five NHS organisations broken down for 10 different technologies.

[33] Internal Rate of Return (IRR) is a metric used in capital budgeting measuring the profitability of potential investments. Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project. The IRR is a discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. Hence IRR calculations rely on the same formula as NPV:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

Where Ct = net cash inflow during the period t; Co= total initial investment costs; r = discount rate, and t = number of time periods. To calculate IRR using the formula, the NPV is set zero and solved for the discount rate r, which in this case is the IRR.

[34] Payback period refers to the period of time required to reach the break-even point and is calculated using the formula: (Cost of initial investment / Annual gain from investment)

Table 18: Estimated capital cost, energy savings and carbon reductions across five NHS organisations

NHS organisation	Estimated capital costs		Estimated energy saving		IRR (internal rate of return)	Payback years	Estimated carbon dioxide reductions (tonnes)
	£	% total[1]	£ (annual)	% total[1]			
ESTIMATES FROM ZEXU LIMITED (data source (2) in Figure 9)							
Buckinghamshire Healthcare	£9.2m	39.0%	£2.5m	41.4%	23.9%	3.7	13,081
Great Western Hospitals	£4.8m	20.3%	£1.0m	16.9%	16.8%	4.7	4,950
NHS Frimley	£6,7m	28.4%	£1.8m	29.9%	23.7%	3.7	6,999
Oxford Health	£1.6m	6.8%	£0.4m	6.6%	21.1%	4.0	2,177
Southern Health	£1.3m	5.4%	£0.3m	5.1%	20.2%	4.2	1,793
TOTAL	£23.6m	100.0%	£6.0m	100.0%	21.9%	3.9	29,000
ESTIMATES FROM THE CARBON AND ENERGY FUND FEASIBILITY STUDIES (data source (3) in Figure 9)							
Great Western Hospitals	£3.2m		£0.7m		17.5%	4.6	2,000
Southern Health	£2.2m		£0.4m		12.5%	5.5	1,319

IRR: Internal Rate of Return calculated for a, conservative, ten year period of annual savings
[1] Refers to proportion of the total capital costs or energy savings across all five NHS organisations
[2] Carbon and Energy Fund feasibility studies were available for only two NHS organisations

The range of technologies proposed for each of the five NHS Trusts varied considerably. For example, energy generation measures (Combined Heat and Power, CHP,[35] and renewable energy) accounted for a third (34%) of the total investment in Buckinghamshire Healthcare NHS Trust, whereas they accounted for 62% of total investment at Great Western Hospitals NHS Trust. In contrast, the proposed investment at Southern Health NHS Trust is focused solely on demand reduction measures, and lighting in particular (lighting accounts for 59% of the proposed £1.3m investment).

The energy generation measures across all sites accounted for £10.5m of the total proposed investment. For CHP, a £5.5m investment is proposed, with an estimated IRR of 19.6% and a payback period of 4.3 years. An investment in renewable energy of £5.0m is proposed, although this has a slightly lower IRR than CHP of 16.3% (ranging from 0.9% to 26.1% between sites) and a payback period of 4.8 years.

The total investment in demand reduction measures is proposed to be £13.0m, spread across eight different technologies. The estimated IRR for the demand reduction measures vary considerably between technologies and sites. However, with the exception of building fabric improvements, all have healthy IRRs above 10% and payback periods of less than eight years. The installation of a Building Management System (BMS)[36] appears to represent the best value for money across all sites, with a payback period of less than one year at four of the five sites.

During a telephone conversation (on 24 March 2016), Mr. Heape explained that the assessment of potential cost and carbon savings was based on:

- National-level benchmarks (e.g. using industry standard CIBSE TM46[37] tools as well as analysis of comparable NHS hospitals in England)
- Local, site-specific information gathered through workshops and discussions with site representatives

The local, site-specific information included a review of existing feasibility studies which had been completed in recent years (i.e. data source (1) in Figure 9). In Mr. Heape's view, the issue was not that there was insufficient knowledge at the organisation-level about the potential for cost saving through new energy installations. However, given other significant pressures, including a challenging financial landscape and the structural re-organisation of the NHS following the 2012 Health and Social Care Act, organisations had (until now) typically been slow to make the up-front investment that was needed to realise these savings.

Data from the CEF

Data from the CEF feasibility studies (data source (3) in Figure 9) were provided for Great Western Hospitals NHS Foundation Trust and Southern Health NHS Foundation Trust (feasibility studies for the other three sites were not yet available). These are reported alongside the estimates provided by Zexu Limited in Table 18.

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[35] Combined Heat and Power (CHP) is an engine which produces electricity for the hospital from gas turbines, but also harnesses the heat for use in the hospital which would otherwise be lost to the hospital site

[36] A Building Energy Management System (BMS) is a computer-based system that helps sites to manage, control and monitor energy consumption across all technologies used in a building

[37] For further details see:
http://www.cibse.org/knowledge/cibse-tm/tm46-energy-benchmarks [Accessed March 2016]

Although the scope of the projects had changed between the estimates provided by Zexu Limited and those estimated by the CEF, and this is reflected in the change in total cost, the IRR remained high. For Great Western Hospitals, the IRR was 17.5% (compared to 16.8% in the Zexu study), and for Southern Health, the IRR was 12.5% (compared to 20.2% in the Zexu study). The payback periods were less than 6 years in both cases.

Table 19: Estimated capital cost, energy savings and carbon reduction associated with ten technologies across five NHS organisations

Technology	NHS organisation	Estimated capital costs		Estimated energy saving		IRR	Payback years	Estimated carbon reductions
		£	% total[1]	£ (annual)	% total[1]			
ENERGY GENERATION MEASURES[2]								
COMBINED HEAT AND POWER (CHP)	Buckinghamshire Healthcare	£983,500	10.7%	£231,100	9.3%	19.6%	4.3	980
	Great Western Hospitals	£1,915,100	40.0%	£450,100	44.1%	19.6%	4.3	1907
	NHS Frimley	£2,270,200	33.9%	£533,500	29.6%	19.6%	4.3	2260
	Oxford Health	£330,600	20.5%	£77,700	19.5%	19.6%	4.3	330
	Total	£5,499,400		£1,292,400		19.6%	4.3	5477
RENEWABLE ENERGY	Buckinghamshire Healthcare	£2,074,200	23%	£396,400	15.9%	13.9%	5.2	924
	Great Western Hospitals	£677,500	14%	£71,200	7.0%	0.9%	9.5	190
	NHS Frimley	£1,841,600	28%	£533,600	29.6%	26.1%	3.5	475
	Oxford Health	£385,600	24%	£40,500	10.1%	0.9%	9.5	108
	Total	£4,978,900		£1,041,700		16.3%	4.8	1697
DEMAND REDUCTION MEASURES								
AWARENESS RAISING CAMPAIGN[3]	Buckinghamshire Healthcare	£174,000	1.9%	£174,000	7.0%	99.9%	1.0	1,035
	NHS Frimley	£108,200	1.6%	£108,200	6.0%	99.9%	1.0	647
	Oxford Health	£51,700	3.2%	£51,700	13.0%	99.9%	1.0	315
	Southern Health	£75,000	5.8%	£75,000	24.3%	99.9%	1.0	444
	Total	£408,900		£408,900		99.9%	1.0	2441
BUILDING FABRIC IMPROVEMENT	Buckinghamshire Healthcare	£1,611,300	17.5%	£107,200	4.3%	-6.8%	15.0	789
	Great Western Hospitals	£350,200	7.3%	£17,900	1.8%	-10.7%	19.6	132
	NHS Frimley	£363,300	5.4%	£15,100	0.8%	-13.4%	24.1	111
	Oxford Health	£113,700	7.1%	£13,900	3.5%	3.8%	8.2	102
	Southern Health	£119,800	9.3%	£5,600	1.8%	-11.9%	21.4	41
	Total	£2,558,300		£159,700		-7.8%	16.0	1175

Technology	NHS organisation	Estimated capital costs		Estimated energy saving		IRR	Payback years	Estimated carbon reductions
		£	% total[1]	£ (annual)	% total[1]			
BUILDING MANAGEMENT SYSTEMS (BMS)	Buckinghamshire Healthcare	£252,000	2.7%	£469,900	18.8%	186.5%	0.5	2890
	Great Western Hospitals	£84,400	1.8%	£94,800	9.3%	112.3%	0.9	559
	NHS Frimley	£96,900	1.4%	£182,800	10.1%	188.6%	0.5	1073
	Oxford Health	£59,900	3.7%	£87,800	22.0%	146.6%	0.7	544
	Southern Health	£54,300	4.2%	£20,200	6.5%	35.4%	2.7	127
	Total	£547,500		£855,500		156.2%	0.6	5193
HEATING SYSTEMS	Buckinghamshire Healthcare	£1,037,300	11.3%	£306,600	12.3%	26.8%	3.4	2,257
	Great Western Hospitals	£266,300	5.6%	£74,100	7.3%	24.8%	3.6	546
	NHS Frimley	£414,000	6.2%	£100,700	5.6%	20.6%	4.1	743
	Oxford Health	£303,000	18.8%	£54,600	13.7%	12.4%	5.6	402
	Southern Health	£210,500	16.4%	£47,600	15.4%	18.5%	4.4	350
	Total	£2,231,100		£583,600		22.8%	3.8	4298
HEATING, VENTILATION AND AIR COND. (HVAC)[4]	Buckinghamshire Healthcare	£622,100	6.8%	£264,100	10.6%	41.1%	2.4	1,394
	Great Western Hospitals	£367,700	7.7%	£123,300	12.1%	31.3%	3.0	640
	NHS Frimley	£128,200	1.9%	£37,700	2.1%	26.6%	3.4	195
	Southern Health	£35,600	2.8%	£10,800	3.5%	27.7%	3.3	58
	Total	£1,153,600		£435,900		36.0%	2.6	2287
ICT	Buckinghamshire Healthcare	£27,500	0.3%	£40,200	1.6%	146.2%	0.7	207
	Great Western Hospitals	£400	0.0%	£8,500	0.8%	>2000%	0.1	44
	NHS Frimley	£45,100	0.7%	£56,300	3.1%	124.8%	0.8	290
	Oxford Health	£21,200	1.3%	£2,900	0.7%	6.1%	7.4	15
	Southern Health	£35,000	2.7%	£20,700	6.7%	58.6%	1.7	107
	Total	£129,200		£128,600		99.4%	1.0	663

Technology	NHS organisation	Estimated capital costs		Estimated energy saving		IRR	Payback years	Estimated carbon reductions
		£	% total[1]	£ (annual)	% total[1]			
LIGHTING	Buckinghamshire Healthcare	£1,822,500	19.8%	£306,300	12.3%	10.8%	5.9	1,580
	Great Western Hospitals	£1,131,400	23.6%	£180,700	17.7%	9.6%	6.3	932
	NHS Frimley	£1,425,400	21.3%	£233,900	13.0%	10.2%	6.1	1206
	Oxford Health	£274,400	17.0%	£46,200	11.6%	10.8%	5.9	238
	Southern Health	£754,800	58.7%	£129,200	41.8%	11.2%	5.8	666
	Total	£5,408,500		£896,300		10.4%	6.0	4622
VOLTAGE OPTIMISATION[5]	Buckinghamshire Healthcare	£595,400	6.5%	£198,500	8.0%	31.1%	3.0	1,024
	Oxford Health	£71,500	4.4%	£23,800	6.0%	31.1%	3.0	123
	Total	£666,900		£222,300		31.1%	3.0	1147

Estimates were provided by Zexu limited (data source (2) in Figure 9)

Note that for each technology, a different package of infrastructure improvements will be proposed for each site (based on an assessment of existing technology and potential for benefit). For example, for Lighting, outdated T20 tubes might be replaced with modern T5 fittings, or LED lighting, depending on local circumstances.

IRR: Internal rate of return calculated over a ten year period

ICT: Information and communications technology

[1] refers to proportion of total capital costs or energy savings for a particular NHS organisation (see Table 18 for totals for each NHS organisation)

[2] energy generation measures were not proposed for Southern Health

[3] awareness campaign was not proposed for Great Western

[4] HVAC was not proposed for Oxford Health

[5] Voltage optimisation was proposed only for Buckinghamshire Healthcare and Oxford Health.

3.3.3.2 Stage 2: Contractor reports

Data from the CEF

Data from contractor reports (data source (4) in Figure 9) were obtained for five NHS sites which have signed contracts with a preferred bidder. These NHS sites were the Great Western Hospital NHS Trust, York Teaching Hospital NHS Trust, and other NHS hospital sites in Dundee, Harrogate and Oxford. These are reported in Table 20 alongside data from the CEF feasibility studies (data source (3) in Figure 9).

In all cases, the data shows that the potential energy savings reported in the CEF feasibility studies were an underestimate of what was reported in the final contractor studies.

The data also showed that, in all cases, the capital cost of the scheme reported in the contractor study exceeded those estimated in the CEF feasibility study. This indicated the scope of the energy installations being approved by NHS Trusts tended to be larger than what had been originally envisaged in the feasibility studies.

In the case of the Great Western Hospital NHS Trust (the only Oxford AHSN site where a contractor report is available), there was also an increase in costs and potential energy savings when comparing the contractor report to both the CEF feasibility study (data source (3) in Figure 9) and the Zexu study (data source (2) in Figure 9).

In discussion with Peter Fairclough (Director of CEF), it was clear that these differences in costs and energy savings were because the feasibility studies sought to assess the viability of the proposed schemes, and were not intended to be reflective of the final scheme.

Given the higher costs reported in the contractor studies, which were only partially offset by higher energy savings, the IRRs were smaller for data reported in the contractor studies when compared to the feasibility studies. Nevertheless, the IRRs in the contractor studies remained in excess of the 3.5% required of low risk public sector investments by HM Treasury.

Table 20: Comparison of contractor- and CEF-estimated costs, energy savings and IRR for energy installations at CEF sites

Trust	Capital Cost (£)				Savings				IRR			Carbon Savings (tonnes pa)	
	Contractor report	CEF feasibility study	Difference	Zexu estimate	Contractor report	CEF feasibility study	Differ-ence	Zexu estimate	Contr-actor report	CEF feasib-ility study	Zexu estimates	Contr-actor report	CEF estimate
Great Western[1]	[redacted]	[redacted]	[redacted]	£4,793,000	[redacted]	[redacted]	[redacted]	£1,020,600	[redacted]	[redacted]	16.9%	[redacted]	[redacted]
Dundee	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	n/a	[redacted]	[redacted]
Harro-gate	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	n/a	[redacted]	[redacted]
Oxford	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	n/a	[redacted]	[redacted]
York Teach-ing Hospital[2]	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	[redacted]	n/a	[redacted]	[redacted]	n/a	[redacted]	[redacted]

[1] Great Western Hospital NHS Trust is the only organisation within the Oxford AHSN region to sign contracts with a preferred contractor. In this case the estimates provided by Zexu Limited are reproduced here for illustrative purposes from Table 18.

[2] A site visit was made to York Teaching Hospital NHS Trust (see Table 21).

Some of the data in this table has been withheld as it is commercially sensitive.

3.3.3.3 Stage 3: Actual costs and energy savings for completed installations

Data from York Teaching Hospital NHS Trust

With CEF's assistance we sought exemplar sites to visit. The one site where a visit could be arranged was York Teaching Hospital. There we met with Brian Golding (Energy Manager) and Jane Money (Sustainability Manager) on 23 March 2016, and reviewed relevant documents they had provided prior to the meeting.

York Teaching Hospital was built in the 1970s. With assistance from the CEF (as described in section 3.3.3.1), a £3.7m package of investments in energy generation and demand reduction measures was developed and put out to competitive tendering in 2012.[38] Working with the preferred bidder, Vital Energi,[39] the project was delivered in less than two years. A £2.5m CHP energy generation system was the centrepiece of the investment, accounting for 67% of the total investment. New energy-efficient lighting and a BMS together accounted for the remaining £1.2m of investment (See Table 21).

Table 21 includes a summary of actual cost and energy saving data for a 12-month period September 2014 to August 2015 (data source (5) in Figure 9) and is reported alongside estimates provided in the contractors study (Vital Energi) prior to the installation (data source (4) in Figure 9, corresponding with data also reported in Table 20).

The total upfront cost of the CHP installation (£2.51m) was slightly below the estimated cost (£2.63m), representing a reduction in the initial capital outlay of £123,218. There was also an annual service charge of £222,839 paid to Vital Energi who have taken operation of the maintenance of the CHP and related boiler systems. The total upfront cost of the demand reduction measures was as stated in the viability statements (£1.2m). The CEF viability statement represents a base case to the Trust and the final solution is then developed through the bidding process which encourages innovation through competition.

In contrast to the way in which the CEF normally works with NHS Trusts (as described in section 3.3.3.1), we were told that the York Teaching Hospital was atypical in that it chose to find its own funding through the Trust's loan arrangement but continued to use CEF as the project advisor and verifier of data and savings. Mr. Golding stated that the choice of the Trust's own loan facility was possible due to their Foundation Trust status, and the support of the Foundation Trust's Executive Board.

Mr Golding advised that working with the CEF model enabled the project to be completed more quickly than would otherwise have been the case. Mr. Golding reiterated the point made by Mr. Heape (above, section 3.3.3.1) that there was no prior shortage of local-specific evidence on the effectiveness of energy installations. Mr Golding also stated that a lack of predictable capital funding and a lack of guaranteed savings had prevented earlier attempts at investment. Nevertheless, he did not take the view that the barriers to investment in energy installations were larger in the NHS or public sector, when compared to private sector organisations, but that making a strong case to Executive Board members was a key requirement for success.

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[38] Further description of the project is provided in an article by Vital Energi, the contractor, at: http://www.vitalenergi.co.uk/casestudies/york-hospital-chp/ [Accessed March 2016]
[39] See http://www.vitalenergi.co.uk [Accessed March 2016]

The total energy savings associated with the completed CHP installation were 40% (£209,973) above the predictions in the feasibility study. Thus the actual IRR was 15.5%, compared to an original estimate of 2.4%. The energy savings attributable to the demand reduction measures were in line with the feasibility study (e.g. an IRR of 15% for lighting). Although the CHP exceeded expectations in performance, the Trust energy management procurement strategy made a significant contribution to the annual savings.

CEF provided valuable support during the early stages of the project development and the tendering process, and continues to support the Trust in delivering the anticipated benefits of the of the project for the next 15n years through CEF's independent monitoring and validation service.

Other comparator sites

We sought to gather further information from Barts Health NHS Trust, Royal Berkshire NHS Foundation Trust and Salisbury NHS Trust. Unfortunately none of this data has yet been made available.

3.3.3.4 Stage 4: The Oxford AHSN's contribution

Data from Oxford AHSN and Zexu Limited

We were informed that the cost to Oxford AHSN and Zexu Limited of running this overall project was £48,600, including staff time. We did not gather further break-down of this figure due to the commercially sensitive nature of the figures.

Table 21: Comparison of actual and contractor-estimated costs, energy savings and IRR for energy installations at York Teaching Hospital

	COSTS						**ENERGY SAVINGS**					**INTERNAL RATE OF RETURN (IRR)**	
Tech-nology	**Upfront capital costs**					Service charge (per annum)[2]	**Per annum**						
	Actual		Contractor report estimate	Difference			Actual		Contract-or report estimate	Difference		Actual	Contractor report estimate
	£	% of total[1]	£	£ (estimat-ed minus actual)	Ratio of actual cost to estimate d cost (%)		£	% of total[1]	£	£ (actual minus estimated)	Ratio of actual to estimated (%)		
ENERGY GENERATION MEASURES													
CHP	£2,507,161	67.1	£2,630,379	£123,218	95.3	£222,829	£731,821	81.1	£521,848	£209,973	140.2	15.5%	2.4%
DEMAND REDUCTION MEASURES													
BMS	£631,307	17.0	£631,307	£0	100.0	£0	£50,902	5.6	£50,902	£0	100.0	-3.7%	-3.7%
LIGH-TING	£597,886	16.9	£597,886	£0	100.0	£0	£120,192	13.3	£119,777	£414	100.3	15.2%	15.1%
TOTAL	£3,736,354	100	£3,859,572	£123,218	96.8	£222,829	£902,915	100	£692,527	£210,387	130.4	12.7%	3.7%

All figures refer to 12 month period September 2014 to August 2015
Estimated costs and energy savings were calculated by the Trust and reviewed by CEFBMS: Building management system
CHP: Combined heat and power
[1] Refers to proportion of total capital costs or energy savings for York Teaching Hospital
[2] The annual service charge is paid to the contractor for the boiler house/CHP service commitment (in this case the estimated cost is the same as the actual cost)

3.3.4 Discussion

There are three main findings from this 'light-touch' case study.

First, we have identified evidence from a variety of sources which indicated that investment in energy generation and demand reduction installations can represent good value for money for NHS Trusts, in terms of high IRRs and short payback periods. This evidence included the best available evidence related to the five NHS sites within the Oxford AHSN region where installations are not yet complete, as well as a wide range of data and information from other NHS sites where installations had been completed or were in full operation.

Second, where it has been possible to compare feasibility studies (data sources (2) and (3) in Figure 9) with contractor reports (data source (4)) and actual cost and energy savings (data source (5)) for particular sites, we found no evidence that the initial feasibility studies completed by Zexu Limited or the CEF had significantly over- or under-stated the case for investment. Whilst the limited evidence assessed in this case study showed that the initial feasibility studies had estimated a higher IRR than later estimates by contractors the evidence from York indicated that the contractor reports had underestimated the actual IRR achieved when the project was completed (suggesting that the earlier feasibility studies may have been more accurate). The CEF suggested to us that one plausible explanation for the higher IRR estimated in the feasibility studies when compared to the contractor reports is that the latter might include additional capital costs. These additional costs would arise if the Trust decided to use the opportunity to install additional plant and equipment in order to address backlog maintenance.

These two, albeit limited, findings support the decision to proceed with investment at the five NHS sites in the Oxford AHSN region. Nevertheless, further evidence will be required from those sites after the energy installations have been completed before a full assessment of the energy and cost savings can be made.

Third, it is clear from our discussions with Zexu Limited and the York Teaching Hospital NHS Foundation Trust that there is typically no shortage of site-specific knowledge about the potential gains to be made from investment in energy infrastructure. The CEF plays a valuable role in terms of guiding NHS Trusts through the full planning and competitive tendering processes, and in providing access to funding. From our discussions it appears that, without the support of the CEF, it is unlikely that these energy installations would have gone ahead (at least within the current time scales). The Oxford AHSN and Zexu Limited have therefore played an important role in completing the initial rapid benchmarking analyses and associated workshops to identify and support five NHS Trusts in the process of accessing the services provided by CEF. However, in attributing the proposed investments in energy installation to the Oxford AHSN, we must assume that the five NHS Trusts would not have independently accessed CEF services without the support or guidance of the Oxford AHSN. On this basis, it is clear that the cost of Oxford AHSN's contribution is minimal when set against the size of the energy savings and expected IRR that will likely be achieved after the installation has been completed.

A summary of our main findings are reported in Table 22.

Table 22: Summary of main findings

Costs to Oxford AHSN	**Estimated capital costs of energy installations in Oxford AHSN region**	**Reliability of cost estimates**	**Estimated energy savings from energy installations in Oxford AHSN region**	**Reliability of energy saving estimates**	**Internal rate of return (IRR)**	**Estimated payback period**	**Reliability of IRR and payback period**
£48,600	£23.6m	Based on our review of evidence, we expect that the costs reported by Zexu Limited are a realistic assessment of capital costs	£6.0m	Based on our review of evidence, we expect that the projected energy savings reported by Zexu Limited may be a cautious underestimate	21.9%	3.9 years	All the identified evidence suggested that the IRR would be well above what is usually acceptable for public sector investment

Limitations

-We were unable to gather data on completed energy installations from all the NHS sites that we had planned. It is possible that York Teaching Hospital NHS Foundation Trust does not represent the experience of other NHS Trusts.

-The data collected at York Teaching Hospital were for a one year period following the installation and it is unclear how much the energy savings will vary in future years.

-Whilst we have drawn general lessons about energy savings across multiple sites, it should be noted that the installations at each site differ in terms of the energy generation and demand reduction measures that have been installed or proposed. Furthermore, the small number of sites assessed in this case study may not be representative of all NHS sites.

In the future we recommend:

-Continued monitoring of the five NHS Trusts in the Oxford AHSN project after the energy infrastructure has been installed, in order to support a full economic analysis of the costs and benefits of the investment.

-Further analysis of the IRR for specific technologies, to guide future investment decisions towards those technologies which deliver the highest returns.

3.3.5 Conclusion

Evidence is limited but that which there is indicates that investment in energy generation and demand reduction installations can support significant energy savings and carbon reductions for NHS Trusts, and represent good value for money. Oxford AHSN has played a valuable role in identifying and supporting five NHS Trusts in the process of accessing the services provided by CEF to help them realise these energy savings in the future.

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3.4 Intermittent Pneumatic Compression (IPC): increasing utilisation of IPC therapy in immobile stroke patients

3.4.1 Introduction

3.4.1.1 Intermittent pneumatic compression (IPC)

IPC has been shown to reduce the risk of deep vein thrombosis (DVT) and reduce mortality at 6 months in immobile stroke patients (Dennis et al., 2015). This is a major finding as DVT and pulmonary embolism (PE) (collectively known as venous thromboembolism (VTE)), whilst potentially avoidable, are a major cause of death in this patient group (Bhalla and Birns, 2015). Consequently, IPC has important consequences for patient survival, quality of life, and costs to the health service.

IPC is a prophylactic therapy which is used to improve circulation in immobile patients. It involves using a pair of inflatable sleeves which wrap around the leg and are attached to a bedside electric pump (NHS, 2014). When in use, the pump fills the sleeve with air and compresses the limb, thereby encouraging blood and other fluids out of the pressurised area. When pressure is reduced, fluids flow back to the limb. The sleeves inflate and deflate intermittently, encouraging the flow of blood.

Clots in Legs Or sTockings after Stroke (CLOTS) 3 was a multicentre randomised controlled trial of 2,876 UK patients which compared routine care to routine care plus IPC (Dennis et al., 2015). IPC was used for 30 days, and patients were followed up for six months. Patients were required to be admitted to hospital within 3 days of acute stroke and immobile on the day of admission. The trial showed an absolute risk reduction of developing the primary outcome (proximal DVT[40]) of 3.6% when treated with IPC (95% confidence interval: −5.8 to −1.4), as well as significant reductions in 'any DVT' (symptomatic or asymptomatic involving proximal or calf veins ($p < 0.001$)) and symptomatic DVT (including proximal or calf ($p = 0.045$). The trial also showed a reduction in the occurrence of PE, although this was not significant ($p = 0.453$), and fewer deaths from all causes within 30 days among those allocated to IPC, although again the difference did not reach conventional statistical significance ($p = 0.057$). Using a Cox model, and adjusting for baseline covariates, there was a significant reduction in the hazard of death at six months for the IPC group ($p = 0.042$).

Following publication of these results, NICE revised their guideline on reducing the risk of VTE to include the following recommendation: *"Consider intermittent pneumatic compression (IPC) for VTE prophylaxis in immobile patients who are admitted within 3 days of acute stroke"* (NICE, 2015)[41]. In addition, NHS Improving Quality (NHS IQ) made available £1million 'pump priming' money in 2014 to fund six months' supply of

[40] Proximal DVT is a DVT effecting the popliteal, femoral, or iliac veins (above-knee).
[41] Interestingly, at the same time, NICE issued the following costing statement: "*Following review of this guidance in 2015 no significant costs are anticipated as a result of implementation of the update of this guidance*" (see https://www.nice.org.uk/guidance/cg92/resources/costing-statement-433715437 [Accessed 01/03/16]. This suggests that NICE do not expect there to be any significant increase in resource use as a result of the additional recommendation to consider use of IPC sleeves.

IPC sleeves for all stroke units in England. This was part of a major national programme to improve outcomes for stroke patients (NHS, 2014).

3.4.1.2 IPC in the Oxford AHSN region

In the Oxford AHSN region, the national IPC programme was picked by the Oxford AHSN Clinical Innovation Adoption Programme (see Figure A, Appendix 2 for details of this process). The overarching aim of the project was "*to implement and embed the technology across all stroke units in the region so that the benefits noted in the CLOTS trial can be realised*" (Oxford AHSN, 2016).

The Oxford AHSN facilitated the uptake of IPC, providing project management support, coordination and data analysis. The Oxford AHSN set specific targets for IPC utilisation, and helped stroke units to develop business cases to bring the IPC devices into the Trusts. The project has been successful, resulting in a higher take up than that which has been achieved nationally; for full details see the section 3.4.3.1 below.

Immobility was defined in the CLOTS 3 trial as 'being unable to walk to the toilet without help', a definition by which approximately 50% of stroke patients are immobile on admission (information provided by Oxford AHSN). In addition, the trial found that outcomes were most improved when sleeves were fitted within three days of admission to a stroke unit. Based on this evidence, two objectives were set for the project:

- Application of IPC sleeves to 50% of total admitted stroke patients;
- Application of all IPC sleeves within 72 hours of admission.

The Oxford AHSN also set a third objective to provide a local target utilisation rate:

- Achievement of 80% utilisation of IPCs within the immobile patient population across the region.

3.4.1.3 The added value of the Oxford AHSN

It was agreed following the November workshop that a light touch approach to assessing the added value of the Oxford AHSN in this area would be taken. This would involve a comparison of local and national utilisation rates and clinical outcomes, alongside any additional resource use associated with the running of the programme. The costs considered would be those related to implementation and adoption, over and above the cost of the IPC therapy. This will therefore take the form of a cost-effectiveness analysis, with results expressed as incremental cost per clinical outcome.

3.4.2 Methods

A cost-effectiveness model was developed to analyse the costs and benefits of the Oxford AHSN's IPC programme. This was a retrospective analysis using data from the beginning of the programme in April 2014 to the latest available data (September 2015)[42].

[42] Local data for the Oxford AHSN region is available up to December 2015, but national data is only available until September 2015, therefore we have had to limit the analysis to September.

3.4.2.1 Model overview

The model included all adult stroke inpatients in the Oxford AHSN region who were eligible for IPC therapy (eligibility required only that the patient was immobile) within the study period.

The analysis was conducted from an NHS perspective: the model included the direct costs of the programme to the Oxford AHSN (i.e. running costs, training costs), as well as the costs to the NHS of increased utilisation (more pumps, sleeves, nurse time required) and savings from reductions in VTE treatment costs.

The key benefit included in the model was the improvement in patient outcomes, including DVT (symptomatic or asymptomatic involving proximal or calf veins), PE (confirmed via imaging or autopsy), and death. Patient outcomes were calculated using the increase in utilisation rate seen in the Oxford AHSN region and the outcomes from the CLOTS3 trial.

Two strategies were compared:

- Strategy 1: The Oxford AHSN is not involved. We assume there is no cost of running the programme, and outcomes are in line with the average utilisation rate across all other (i.e. non-Oxford AHSN) units in England, Wales and Northern Ireland
- Strategy 2: The Oxford AHSN takes on the IPC project as part of its clinical innovation adoption programme. Strategy 2 represents the situation in reality.

The difference in costs and patient outcomes between the two strategies (Oxford AHSN project verses no Oxford AHSN project) is therefore driven by the changes in utilisation rates in the Oxford AHSN region compared to nationally.

The model was developed in Microsoft Excel 2013 v15.0.4719.1002.

3.4.2.2 Model inputs and calculations

Utilisation

IPC utilisation data for the Oxford AHSN region and nationally were obtained from the SSNAP database[43] (Royal College of Physicians, 2015). Data has also been presented in the Oxford AHSN's Final Audit Report (Oxford AHSN, 2016); the numbers in the audit report are similar but not exactly the same as those in the SSNAP database. Such differences are common when comparing national datasets to locally collected values, and staff at the Oxford AHSN indicated that in this case the differences are most likely due to a 'process issue', as there is some backdating of SSNAP data but not with the local data collection. We used the values from the SSNAP database in our main analysis (to ensure that the data would be comparable with the national values), but conducted an additional analysis with data collected by the Oxford AHSN to check whether this would have an impact on the results.

[43]The Sentinel Stroke National Audit Programme (SSNAP), Royal College of Physicians, collects information about the performance of stroke services in England, Wales and Northern Ireland. See https://www.strokeaudit.org/results.aspx.

When we refer to the "national" utilisation rates, this excludes the data for the Oxford AHSN region. The comparator is therefore all non-Oxford AHSN regions.

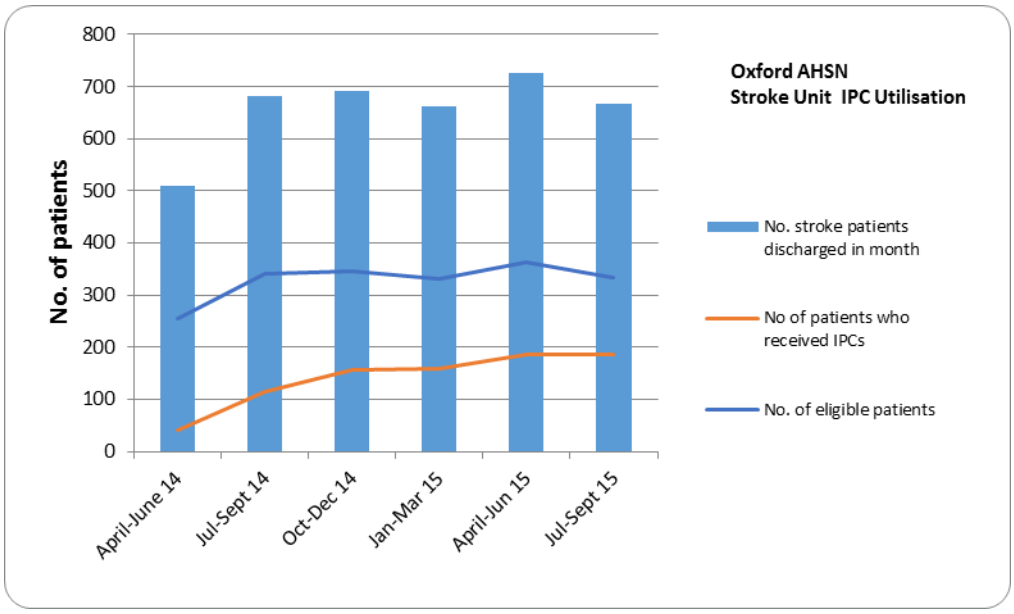
The Oxford AHSN records the utilisation rate as a % of eligible patients, whereas the SSNAP database records utilisation rates as a % of all stroke patients. In order for these to be commensurate, all figures from the SSNAP database have been doubled to show utilisation as a % of eligible patients[44].

All figures in the SSNAP database are reported quarterly; therefore we obtained data for April – June 2014, July – September 2014, October – December 2014, January – March 2015, April – June 2015, July – September 2015 and October – December 2014.

At the beginning of the project, in April 2014, only one stroke unit (John Radcliffe Hospital, Oxford University Hospitals NHS FT) was using IPC sleeves. Since then the remaining six sites have taken up use of IPC sleeves. Between project commencement in April 2014 and the latest data for September 2015, 842 patients in the Oxford AHSN region had received IPC.

Figure 10 shows the total number of stroke patients, the number of eligible patients (i.e. 50% of the total), and number of patients who received IPCs in the Oxford AHSN region between April 2014 and September 2015. The graph clearly shows the number of patients who received IPCs catching up with the number who are eligible over time. This is echoed in Figure 11 which shows the percentage utilisation over the same time period.

Figure 10: Utilisation of IPC sleeves in the Oxford AHSN region (April 2014 – December 2015)

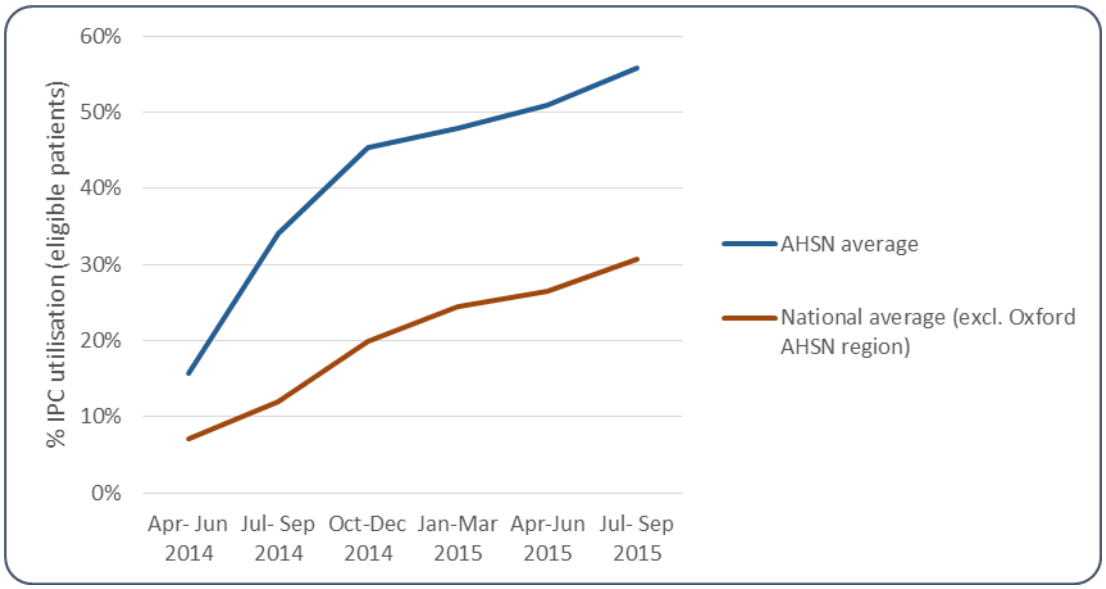


Source: Adapted from Oxford AHSN (2016) using SSNAP data

[44] Oxford AHSN estimate that 50% of all adult stroke patients are immobile (therefore eligible for IPC therapy) upon admission. Note that the Scottish Stroke Care Audit (SSCA) found that 47% (roughly half) of patients were found to be immobile on admission (data unpublished). We tested the effect of this approximation (i.e. 47% treated as half in the Oxford AHSN calculations) on the results of the analysis.

Figure 11 also reveals that the utilisation rate in the latest national data (July-Sept 2015) is 32%. During the same time period, the Oxford AHSN region achieved a much higher utilisation rate of 56%, increasing to 60% for the period October – December 2015 (national data unavailable). This suggests that the Oxford AHSN IPC programme resulted in a greater increase in uptake of IPC than that on a national level.

Figure 11: Local and national utilisation rates (April 2014 – September 2015)



Source: Adapted from Oxford AHSN (2016) using SSNAP data

Note that, whilst the Oxford AHSN region's performance is strong on average, there has been considerable variation in utilisation between sites. Based on conversations with staff at the Oxford AHSN, it seems that this is due to different clinical protocols, various levels of interest, and inevitable differences in routine care offered at the different sites. As the Oxford AHSN project has been applied uniformly across the sites, and we are interested in the added benefit of the Oxford AHSN as a whole, we use average utilisation rates in our analysis.

The utilisation data used in the model is shown in Table 23.

Table 23: Utilisation data used in the model

Month	IPC eligible stroke patients in Oxford AHSN region	Oxford AHSN utilisation rate	National utilisation rate
April-June 14	255	16%	7%
Jul-Sept 14	341	34%	12%
Oct-Dec 14	346	45%	20%
Jan-Mar 15	331	48%	25%
April-Jun 15	364	51%	27%
Jul-Sept 15	333	56%	31%

Source: SSNAP database
Note: The table appears to show that the Oxford AHSN started off with a higher utilisation rate than the national comparator. However, Oxford AHSN have clarified that in April 2014 their utilisation rate was 8%, which is very similar to the national value. The figure shown here is the average from the first three months of the IPC programme, and shows early success of the porgramme. Either way, our calculations account for these differences.

Clinical outcomes

Clinical outcomes are estimated using the utilisation rates and data from the CLOTS3 trial. Table 24 shows the relevant clinical outcomes from the CLOTS3 study.

Table 24: Deaths and VTE outcomes (CLOTS3) during 6 month follow up

	IPC (n=1438)	no IPC (n=1438)	Absolute risk difference	Odds ratio
Death			-2.9	0.85
n	320	361	(CI -6.0 to	(CI 0.70 to
%	22.3	25.1	0.3)	1.01)
Any DVT			–5.0	0.72
n	240	312	(CI –7.9 to –	(CI 0.60 to
%	16.7	21.7	2.1)	0.87)
Confirmed PE			–0.5	0.86
n	42	49	(CI –1.8 to	(CI 0.56 to
%	2.9	3.4	0.8)	1.30)

Source: Dennis et al., 2015
CI = 95% confidence interval; NR = not reported.

We assumed that if an event has not occurred within 6 months it will not occur (in effect we are adopting a 6 month model time horizon). This is a simplifying assumption and is conservative; it is likely to bias away from the more effective strategy, and therefore likely to understate the benefits of the Oxford AHSN.

The following calculations were used to estimate the number of DVT events during the study period:

First, Strategy 2: Let u_t^A represent the Oxford AHSN's IPC utilisation rate during period t (t = three month period, April 2014 – September 2015), and N_t represent the number of IPC eligible patients being discharged from the Oxford AHSN in period t. Then,

$$Patients\ \boldsymbol{receiving}\ IPC\ in\ \ AHSN\ region\ during\ period\ t = \ u_t^A . N_t = \ \boldsymbol{IPC_t^A}$$

And,

$$Eligible\ patients\ \boldsymbol{not\ receiving}\ IPC\ (receiving\ Routine\ Care\ only)\ in\ AHSN\ region\ during\ month\ t = \ (1 - \ u_t^A\ ). N_t = \ \boldsymbol{RC_t^A}$$

Now let DVT^{IPC} represent the percentage of patients who are receiving IPC that develop a DVT (taken from the CLOTS3 trial, reported in Table 2 above), and DVT^{RC} represent patients who are receiving routine care (no IPC) that develop a DVT (also Table 2). Then,

$$AHSN\ DVT\ events\ during\ period\ t = \ IPC_t^A . DVT^{IPC} + \ RC_t^A\ . DVT^{RC}$$

And,

$$Total\ AHSN\ DVT\ events\ during\ study\ duration = \sum_t (\ IPC_t^A . DVT^{IPC} + \ RC_t^A\ . DVT^{RC}) = DVT^{AALL}$$

Then, using a similar method, the number of events which would be expected had the Oxford AHSN had national utilisation rates was calculated (Strategy 1). Let u_{Nt} represent the national utilisation rate during period t. Then,

$$Patients\ \boldsymbol{receiving}\ IPC\ in\ \ AHSN\ region\ during\ period\ t\ = \ u_t^N . N_t = \ \boldsymbol{IPC_t^N}$$

And,

$$Eligible\ patients\ \boldsymbol{not\ receiving}\ IPC\ (receiving\ Routine\ Care\ only)\ in\ AHSN\ region\ during\ period\ t = \ (1 - \ u_t^N\ ). N_t = \ \boldsymbol{RC_t^N}$$

And,

$$AHSN\ DVT\ events\ during\ period\ t\ = \ IPC_t^N . DVT^{IPC} + \ RC_t^N\ . DVT^{RC}$$

And,

$$Total\ AHSN\ DVT\ events\ during\ study\ duration\ = \sum_t (\ IPC_t^N . DVT^{IPC} + \ RC_t^N\ . DVT^{RC}) = \ DVT^{NALL}$$

We can calculate the total number of DVT events avoided by the Oxford AHSN during the study period as:

$$Total\ DVTs\ avoided = \ DVT^{NALL} - \ DVT^{AALL}$$

The same method was used to estimate PE and death events. We also performed these calculations using an 80% utilisation rate (i.e. the initial Oxford AHSN target), and an 8% utilisation rate, which was the utilisation rate for the Oxford AHSN region at the beginning of the IPC implementation project (April 2014).

Quality of life

A recent systematic review of clinical outcome data (NICE, 2015) found that the CLOTS3 trial was the only study to report quality of life or utility data associated with the use of IPC in an immobile stroke patient population. This study used the EQ-5D. However, unfortunately, there were severe limitations associated with the collection of this data:

the quality of life questionnaire was only administered at 6 month follow up, and not at baseline. This was because the validity of asking patients to rate their quality of life shortly after admission to hospital with a stroke was deemed "questionable". The baseline scores were therefore estimated using a Bayesian Network analysis incorporating data from the other CLOTS studies and a proxy dichotomous indicator of functional status (based on the proportion of patients reporting 'severe disability requiring constant attention' at 6 months using the Oxford Handicap Scale). Based on this method, the mean baseline scores were -0.127 (Standard deviation (SD) 0.13) for IPC and - 0.130 (SD 0.13) for the no IPC arm. The mean EQ- 5D scores at 6 months were 0.222 (SD 0.39) for IPC and 0.217 (SD 0.37) for no IPC. This means that at 6 months, there were no statistically significant differences in patients' functional status or quality of life.

The NICE guideline development committee (NICE, 2015) commented that "*the statistical methods used to estimate quality of life at baseline was experimental and had not been independently verified*" and that "*the EQ-5D-3L is a generic quality of life measurement tool known to have limitations in detecting small improvements in severely disabled people"*. The economic analysis based on this quality of life data was thus assessed to have "*potentially serious methodological limitations*".

We therefore do not include this quality of life data in our analysis and do not calculate QALYs.

Costs to the Oxford AHSN

The costs to the Oxford AHSN are approximated based on the amount of Oxford AHSN staff input time which has been invested in this implementation strategy. The costs of staff time are proxied using the costs of wages and overheads; these costs are included to represent the opportunity cost of staff time.

The project manager at the Oxford AHSN estimated that one fifth of a full-time equivalent at NHS band 8c was used for 12 months. The total cost of this was estimated to be £24,574 (see Table 25).

Table 25: Oxford AHSN staff costs for IPC programme

Component	**Value**
Salary[±]	£64,429
Salary oncosts[1,†]	£14,269
Overheads[2,†]	£43,604
Capital overheads[3,†]	£4,370
Annual total (A)	**£126,672**
Non-London Multiplier (B)	0.97
Working time dedicated to IPC programme (C)	20%
Total staff cost to Oxford AHSN (A x B x C)	**£24,574**

Reference: Curtis and Burns, 2015

[1]Essential associated costs, for example the employer's national insurance contributions

[2]Management and other non-care staff overheads include administration and estates staff

[3]Includes costs for office, travel/transport and telephone, education and training, supplies and services (clinical and general), as well as utilities such as water, gas and electricity

[±]Mean annual basic pay per FTE by Agenda for Change band 8c
[†]Approximated by values for Band 8b scientific and professional staff

Costs to the NHS

The net cost to the NHS is made up of three components:

1 – **Direct medical costs**: the cost of the pumps, the sleeves, and the additional clinical staff time which is required to use IPC;

2 – **Non-medical costs**: The costs of time spent in training or undertaking audit activities;

3 – **Cost savings**: these arise from the reduction in VTE treatment.

The direct cost of using IPC was taken from the CLOTS 3 trial. They used the price of sleeves provided by the manufacturer (Covidien Ltd: £14 for a medium pair of standard sleeves and £26.00 - £31.50 for Comfort™ sleeves depending on size), yielding a total cost per patient of £64.10 per patient for the 30 days, once the cost of fitting and monitoring are accounted for. Pumps are provided on loan, for which there is no direct cost to the NHS.

The time that clinical staff spent in additional training and undertaking audit activities is small and assumed negligible.

The cost savings which arise from the reduction in DVT and PE were more difficult to estimate. Ideally, the estimate would be for treatment of DVT and PE in an immobile stroke inpatient population. However, no such estimates were identified through our thorough literature review. The CLOTS3 trial did not include these savings, and instead took an approach which only considered the impact of the IPC devices on length of stay.

Recent estimates of the cost of treating DVT, for example Wade et al. (2015) and Harnan et al. (2012), have been based on the NHS reference costs for a DVT treatment spell (note that these analyses do not focus specifically on stroke patients). This approach is not appropriate for use in this model, as the model considers patients who have already been admitted for stroke. The NHS reference cost system does not allow two codes to be applied to the same patient within the same treatment episode; if more than one code is potentially applicable, the code with the highest cost is recorded. In this case, these patients are likely to be coded as stroke patients. The system *does* allow for complications within a treatment episode, but the codes are not sufficiently granular to capture a single VTE occurrence during a stroke admission[45]. The NHS reference costs cannot, therefore, distinguish between an immobile stroke inpatient, and an immobile stroke inpatient with a single VTE event.

[45] Specifically, the NHS reference cost code for a stroke treatment episode in the 2014-15 schedule is AA35F. This code allows for complication (CC) scores 0-3; code AA35E applies to Stroke with CC Score 4-6; code AA35D applies to Stroke with CC Score 7-9. The CC scores are calculated by summing individual scores for different complications: immobility gets a score of 1, DVT gets a score of 1, and PE gets a score of 2. Only if a patient was immobile with a DVT and a PE (or had other comorbidities and complication), would their CC reach the threshold for code AA35E. The cost of a single VTE event is therefore not adequately captured by the NHS reference costs.

The most recent and applicable UK estimate of the cost of treating DVT and PE seem to be those which were compiled for the NICE VTE guideline (NICE, 2010). The estimate is based on resource use protocols for diagnosing and treating VTEs, in consultation with clinical experts from the VTE Guideline Development Group. Unit costs were taken from standard NHS sources: NHS Reference Costs, British National Formulary, NHS Electronic Drug Tariff, NHS Purchasing and Supplies Agency, and the Unit Costs of Health and Social Care. The cost of treating DVT was calculated to be £576, and the cost of symptomatic (non-fatal) pulmonary embolism was calculated to be £2,521 in 2006/07 prices. They assumed the cost of death is £0. They also assumed that the cost of treating VTE did not vary by population group (i.e. they do not distinguish between the cost of treating VTE amongst hip fracture, general surgery, and general medicine patients).

The costs have been updated to 2014/15 values using the hospital & community health services (HCHS) index (Curtis and Burns, 2015) for use within this model. The costs of treating a DVT and PE in an immobile stroke inpatient population were therefore **£676** and **£2,958** respectively.

The costs of the patients' stays in hospital were not included in the model for two reasons: firstly, the CLOTS3 trial did not demonstrate a significant difference in length of stay between the two treatment groups (IPC and no IPC). This means that the length of stay costs would be similar in both model arms, and as we are interested in the *incremental* costs between the two strategies, they can be excluded. Secondly, as the treatment costs of DVT and PE are being considered, there would be a risk of double counting if length of stay was also included in the model.

Total costs

The total costs of the two strategies were therefore calculated as follows:

As before, first we calculate the costs for Strategy 2:

$$Direct\ medical\ cost\ (Strategy\ 2) = cost\ of\ sleeves\ \times \sum_t IPC_t^A$$

And

$$Cost\ of\ DVT\ events = Cost\ of\ DVT\ \times\ DVT^{AALL}$$

$$Cost\ of\ PE\ events = Cost\ of\ PE\ \times\ PE^{AALL}$$

Then

$$Total\ cost\ (strategy\ 2\ ) = Direct\ medical\ cost\ (strategy\ 2) + cost\ of\ AHSN\ staff\ time + \ DVT^{AALL} + \ PE^{AALL}$$

Note that the cost of routine care does not need to be included as this is the same between the two strategies and is therefore redundant in an incremental analysis such as this one.

Similarly, to calculate the cost of Strategy 1:

$$Total\ cost\ (strategy\ 1\ ) = Direct\ medical\ cost\ (strategy\ 1) + DVT^{NALL} + PE^{NALL}$$

The incremental cost between the two strategies, and therefore the overall net cost of the IPC programme is calculated as:

$$Incremental\ cost = Total\ cost\ (strategy\ 2) - Total\ cost\ (strategy\ 1)$$

The incremental cost per additional IPC user is calculated as:

$$Incremental\ cost\ per\ additional\ IPC\ user = \frac{incremental\ cost}{\sum_t IPC_t^A - \sum_t IPC_t^N}$$

3.4.2.3 Model assumptions

The assumptions made in the model have been explained throughout the methods section, and are summarised here:

- We assume that there is no cost of running the project in Strategy 1. This is analogous to assuming that implementation increases spontaneously following the recent NICE recommendation, and not as a result of any specific project or any direct implementation activities. This is a conservative simplifying assumption, and if incorrect will bias against the Oxford AHSN. This means that we are more likely to underestimate the added benefit of the AHSN than overestimate it.
- We do not consider any clinical benefit post-September 2015 or into the future, and do not consider VTE or death events which happen after 6 months. Once again this is likely to bias against the Oxford AHSN as it does not include the improved clinical outcomes which are accrued after these cut offs. This assumption was necessary due to limited data availability.
- We assume immobile patients are 50% of total stroke patients. This assumption was based on information provided by Oxford AHSN, and was necessary to calculate the national utilisation rate of eligible patients[46]. Data from SSCA indicated that 47% of stroke patients were immobile on admission, meaning that the 50% estimate employed here could be an overestimate. This is likely to bias away from Strategy 2 (as there is a smaller eligible population in which the beneficial intervention can have an effect) and lead to an underestimate of the added value of the Oxford AHSN.
- We assume that clinical staff time spent in additional training for IPC and undertaking audit activities is very small and therefore negligible. This is a simplifying assumption based on conversations with staff at the Oxford AHSN who indicated that training would have been undertaken as part of other training activities and would not have significantly increased due to this project. In addition, training would likely be part of both strategies, and cancel out in an incremental analysis.
- We assume that the costs of treating VTE events in a general hospital population is representative of the cost of treating VTE events in an immobile stroke population; this assumption was inherited from the NICE VTE guideline (NICE, 2010) and has been necessary in the absence of any more specific estimates.

[46] As mentioned previously, we tested the effect of this assumption (varying it to 47% in line with the SSCA data) on the results. The impact was negligible (see Appendix 1).

3.4.3 Results

Results from the main analysis are shown here; results from the two additional analyses, 1) using the Oxford AHSN utilisation data and 2) using the alternative assumption of 47% of stroke patients being eligible for IPC, are shown in Appendix 1. Neither of these analyses had a notable impact on the results.

3.4.3.1 Utilisation

Between April 2014 and September 2015, an additional 434 patients in the Oxford AHSN region have received IPC sleeves than would have based on the national IPC utilisation rate[47]. An additional 687 patients have received IPC sleeves than would have if the utilisation rate remained at its pre-project level (8% in April 2014).

This indicates that the Oxford AHSN IPC project has been effective in increasing the IPC utilisation rate in the Oxford AHSN region.

3.4.3.2 Clinical outcomes

Twenty-two DVTs, two PEs and 12 deaths were avoided due to the increased utilisation of IPC sleeves in the Oxford AHSN region compared to nationally.

Fourty-three DVTs, three PEs and 20 deaths were avoided due to the increased utilisation of IPC sleeves in the Oxford AHSN region compared to the utilisation rate at the start of the project in April 2014.

If the target 80% were achieved, an additional 37 DVTs, four PEs and 21 deaths could have been avoided compared what has been achieved by the Oxford AHSN to date.

A summary of these results is shown in Table 26, with a more detailed breakdown available in Tables A-C, Appendix 2. As per the methods section above, all results are based on the number of immobile (and therefore IPC eligible) stroke patients in the Oxford AHSN region for the duration of the study (April 2014 – September 2015), with different utilisation rates applied.

Table 26: Estimated VTE and death events during study period

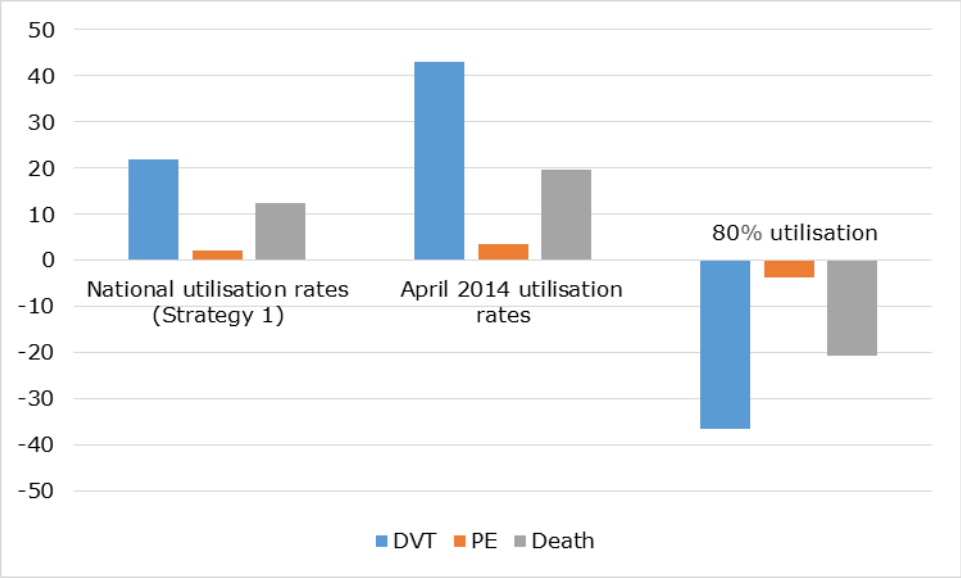
[47] Note that this number (434) is different that stated in the final Oxford AHSN audit report (Oxford AHSN, 2016) as different data sources were used.

	DVT	PE	Death
Absolute numbers			
AHSN utilisation rate (Strategy 2)	385	63	470
National utilisation rate (Strategy 1)	407	65	482
AHSN April 2014 utilisation rate	428	66	490
Target 80% utilisation rate	348	59	449
Events avoided due to AHSN IPC programme			
Compared to national utilisation	22	2	12
Compared to AHSN April 2014 utilisation	43	3	20
Compared to 80% target utilisation rate[1]	-37	-4	-21

[1]Negative values indicate that more events could have been avoided

Figure 12 shows the number of events avoided by the Oxford AHSN IPC implementation programme (Strategy 2) compared to: national utilisation rates (Strategy 1), the Oxford AHSN pre-IPC programme April 2014 utilisation rates, and the target 80% utilisation rate.

Figure 12: Events avoided compared to alternative utilisation rates



Source: OHE analysis, 2016.
Note: Negative values indicate that more events could have been avoided

3.4.3.3 Costs

The costs are shown in Table 27. The table illustrates how Strategy 2 has greater direct medical costs (due to the increase in utilisation of IPC sleeves) and also has the additional cost of the Oxford AHSN programme. However, Strategy 2 also has some

offsetting cost savings due to the reduction in VTE events. In total, over the study period, the Oxford AHSN IPC project increased total costs by £31,286.

Table 27: Aggregate costs components for all Oxford AHSN patients and results

	Strategy 1	Strategy 2	Incremental
Direct medical costs	£26,125	£53,972	£27,847
Oxford AHSN staff time	£0	£24,574	£24,574
DVT costs	£274,822	£260,112	-£14,710
PE costs	£191,897	£185,472	-£6,425
Total	£492,844	£524,130	**£31,286**
Total per additional IPC user			£72

3.4.3.4 Cost-effectiveness

The cost per DVT avoided was £1,437. The cost per VTE event avoided was £1,307, and the cost per death avoided was £2,526.

Without an estimate of the incremental cost per QALY gained, there is no conventional cost-effectiveness threshold that this can be compared to determine whether Strategy 2 is cost-effective by usual NHS standards. This said, given that the is NHS usually willing to pay between £20-30,000 for one additional QALY, the cost of less than £3,000 for one additional death avoided seems very low, indicating that the Oxford AHSN IPC implementation project would be considered good value for money.

3.4.4 Discussion

3.4.4.1 Limitations of this analysis

This analysis was subject to several limitations, most of which bias against Strategy 2, and therefore underestimate the added value of the Oxford AHSN. For example, there is a significant publication lag with the national data, and as such we were unable to include all of the most recent Oxford AHSN utilisation data. The local October – December 2015 data shows a marked increase in utilisation, which is unlikely to have been matched by the national average. As the utilisation rates are higher in the Oxford AHSN region than the average elsewhere, this means we are most likely underestimating the added value of the Oxford AHSN.

In addition, as mentioned previously, the model was based on several assumptions. For example, we do not include future benefits in our retrospective analysis. Assuming that utilisation rates do not immediately drop to match national averages as soon as the Oxford AHSN ceases to invest staff time, this means that we have underestimated the added value of the Oxford AHSN.

A methodological limitation of this analysis is that it did not calculate QALYs. This was not within the scope of this 'light touch' analysis, but based on our review of quality of life data it seems that this step would not have been feasible in any case. We also did not undertake discounting to allow for differential timing of costs and benefits; this was not considered necessary due to the short time horizon and retrospective nature of this analysis.

Further limitations are linked to data availability: the clinical outcomes data is based on only one study (albeit a large randomised controlled trial), and the clinical outcomes had to be inferred from utilisation data, as clinical outcomes are not monitored by the Oxford AHSN. The data to represent the costs of treating DVT and PE were also fairly old. Despite these limitations, the inputs used in the model were chosen as the most reliable available estimates, and were the most appropriate values to use within the context of this analysis.

Finally, exploration of uncertainty in the model parameters and assumptions through sensitivity analyses was not within the scope of this 'light touch' analysis. We did however conduct two such analyses, as 1) we considered that the approximation that 50% of stroke patients would be immobile was important, given that the only available data suggests that this should be 47%, and 2) we wished to explore the implications of using the national dataset rather than the data supplied by the Oxford AHSN. Neither of these changes made any notable impact on the results (results can be seen in Tables D and E, Appendix 2).

3.4.4.2 Added value of the Oxford AHSN

The results clearly show that the Oxford AHSN's IPC project increased IPC utilisation rates to a much greater extent than can be seen across the rest of the country. We estimate that the project prevented 22 DVTs, two PEs, and 12 deaths within an 18 month period, all for an additional total cost of £31,286. These results have also been supported by anecdotal evidence gathered by the Oxford AHSN through interviews with medical and nursing leads at each of the stroke units in the region (not including the Horton Hospital as they had not adopted IPC by this point). Key findings included:

- The increase in IPC utilisation appears to have reduced the number of VTE events;
- Units reported that Oxford AHSN management of the project enabled implementation at a more rapid pace than would have been achieved otherwise.

In addition, it is possible that the Oxford AHSN IPC implementation project has had further knock-on effects, or 'spillovers', which represent benefits not captured by our analysis. For example, staff from the Oxford AHSN suggest that the project may have increased awareness of VTE, including awareness of what the symptoms are, and also facilitated a greater focus on VTE prevention in stroke in general, even if IPC is not used.

The results of our analysis indicate that more VTE events and deaths could have been avoided had the Oxford AHSN region reached their 80% utilisation target. However, this local target was not linked to the national programme, and was not based on a formal assessment of local capacity. Commenting on the 'consider use of IPC' recommendation published by NICE, Oxford AHSN state: "*Because the NICE guidelines are not prescriptive around the use of IPC sleeves and place the decision with the clinician and patient/carer it makes it challenging to set a target for appropriate utilisation and therefore, having achieved 60% utilisation as a region, the AHSN will close the project from a monitoring perspective at the end of March 2016*" (Oxford AHSN, 2016). They also provide several recommendations for stroke units that wish to further increase their utilisation rates going forwards.

It is useful to consider whether any external factors which have not been included in this analysis (for example, demographics, case mix) could have also played a role. Whilst we cannot rule these out completely, we have controlled for the difference in baseline utilisation rates, and we can also see from the SSNAP data that the gender mix and average age of the stoke population in the Oxford AHSN region and the national average (full SSNAP dataset) are very similar (% female: 48% Oxford AHSN, 50% national; median age: 77 years Oxford AHSN, 77 years national).

Overall, compared to conventional thresholds at which healthcare interventions are typically considered cost-effective, this programme appears to have delivered good value for money. The cost per DVT avoided was £1,437. The cost per VTE event avoided was £1,307, and the cost per death avoided was £2,526.

Furthermore, the project is drawing to a close; Oxford AHSN staff time will cease to be invested, and therefore cease to incur costs. At the same time, it is hoped that the added benefit of the programme (in terms of improved utilisation and clinical outcomes) will continue into the future, in which case the added value of the Oxford AHSN in this clinical area would continue to increase.

The limitations of the study mainly relate to data availability. Conservative assumptions were made where possible, meaning that overall we are more likely to have underestimated rather than overestimated the added value of the AHSN.

4 THE ADDED VALUE OF THE OXFORD AHSN: CONCLUSIONS

Four case studies of Oxford AHSN project have been presented, three reveal improved clinical outcomes, achieved with moderate cost increases (or in at least one case cost savings), and demonstrate a tangible, positive, added value of the Oxford AHSN. The remaining case study indicated energy and carbon savings, as well as a high financial rate of return. In all cases the analyses were designed to assess the added value of the Oxford AHSN in relation to the case studies, and not to assess the 'cost-effectiveness' of the treatments being used.

The Oxford AHSN IAPT programme aimed to increase recovery rates in adult IAPT services by 5%. This has been achieved and surpassed. We estimate that the project has enabled an additional 3,199 patients to recovery compared to what would have been expected if the national recovery rate applied between January 2014 and November 2015. Further, we estimate that two years after the end of treatment, an additional 1,631 people are still in recovery in the Oxford AHSN region than would be had the national recovery rates applied. The project has led to an estimated £897,228 saving of NHS money due to reductions in physical healthcare costs. Even when taking into account the additional costs of clinical staff training and staff time at the Oxford AHSN, the savings still total around £750,000.

The second case study looked at Oxford AHSN's project to improve the referral pathway for premature babies. The changes to the referral pathway were termed the 'policy change'. The analysis found that the project had led to an improvement in the likelihood of survival after the policy change of 5.2% percentage points, rising from 40.7% prior to the policy change to 45.9% after the policy change. This translates into an increase of approximately 4 babies surviving per annum than would have been the case prior to the policy change (our most conservative estimate provided in the sensitivity analysis suggests a lower band increase of approximately 2 survivals). Set against modest cost increases, and, on some assumptions, cost savings, we suggest that the policy change (and Oxford AHSN's contribution to the policy change) does represent good value for money.

The third case study looked at Oxford AHSN's contribution to supporting the decision of five NHS hospital Trusts to work with partners to deliver investment in energy infrastructure and sustainability projects. Using data from a range of sources which were available to us, our study showed that there was a high degree of certainty about the value of these investments, in terms of energy and carbon savings, as well as a high financial rate of return. The analysis concluded that it was reasonable to predict an internal rate of return of 21.9% over a ten year period. This is well within what would be expected of low risk public sector investments in the UK. Assuming that the investment would not have gone ahead without Oxford AHSN's input, then set against the modest costs incurred by the Oxford AHSN, this project represents good value for money.

The final case study was of the Oxford AHSN's IPC implementation project. This project aimed to increase the utilisation of IPC therapy amongst adult stroke inpatients. The results of our analysis show that the project was successful, leading to utilisation rates that are higher than can be seen elsewhere in the country. We estimate that the project prevented 22 DVTs, two PEs, and 12 deaths within an 18 month period, all for an additional total cost of £31,286. Overall, compared to conventional thresholds at which

healthcare interventions are typically considered cost-effective, this programme appears to have delivered good value for money.

All three clinical case studies (the IAPT, maternity and IPC projects) demonstrate a positive added value of the Oxford AHSN from an NHS perspective. Given that patient outcomes improved in all three cases, it is likely there are additional, wider, benefits that have not been captured, such as patients recovery allowing them to return work (including informal and unpaid work), increased productivity in the work place (related to better health), and a reduction in the number claiming disability benefits. As such, it is likely that the analyses we have conducted have underestimate the added value of the Oxford AHSN from a societal perspective. We explored the possibility of including these in the analysis of the IAPT project, but severe data limitations meant that a complete analysis from the societal perspective was not feasible. Still, we were able to estimate that an additional 384 patients may have returned to work as a result of the Oxford AHSN's involvement in the IAPT services. This estimate is subject to a great deal of uncertainty as national data does not show a strong effect of IAPT therapy on employment status. These individuals will contribute to the economy, receive income, pay taxes, and will most likely come off disability benefits. Amongst those who recovered who are employed, there is also likely to be an increase in their productivity. Note that the carbon and energy savings indicated in the energy project case study are also of high value to society.

In addition, whilst conducting these case studies, we identified several areas where the Oxford AHSN is involved in research and data generation. Examples include monitoring and auditing activities in three case studies (IAPT, maternity and IPC projects), and additional studies (either planned or ongoing) to investigate the impact of recovery within the IAPT service on physical health care needs and patient employment status. Such knowledge generation represents an extremely important benefit of the Oxford AHSN that has not been captured in our analyses: information itself is valuable for improving care and reducing uncertainty, thereby ensuring efficient allocation of resources (Fenwick et al., 2008), and medical research can also produce 'spillovers' (HERD et al., 2008)[48].

Another area of added value to consider is the impact that the Oxford AHSN has had by enabling and facilitating large scale collaboration and implementation within the Oxford region. Arguably, the scale and network offered by the Oxford AHSN attracted CEF to offer its services at no cost (see Chapter 3.3); scale through developing clinical networks allowed rapid and wide scale change in managing premature babies (Chapter 3.4); and scale has also enabled common data collection, programme management and clinical leadership, all of which contributed to the success of the IAPT, Maternity and IPC case studies (Chapters 3.1, 3.2, and 3.4). Without the structure and network offered by the Oxford AHSN, these collaborations may have taken longer to develop or may not have happened at all.

[48] HERG et al. (2008) provide a detailed account on how medical research in general can provide wider economic gains – which are additional to the health gains. Indeed, investment in medical research by one organisation, public or private, may benefit not only that organisation but also other organisations in the medical sector, in other sectors, and also in other countries; i.e. there are what the economic literature refers to as 'spillovers'.

Finally, our results relate only to four cases studies; there are many more projects being undertaken by the Oxford AHSN, all of which are likely to incur costs, and have an impact on patients. What this report provides is evidence that the Oxford AHSN is capable of promoting high quality care and delivering projects which improve patient outcomes, at a cost that appears to represent good value for money. In some cases, projects have not only improved patient lives, but have also saved money for the NHS.

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APPENDIX 1

Figure A: Screen shot of Excel model

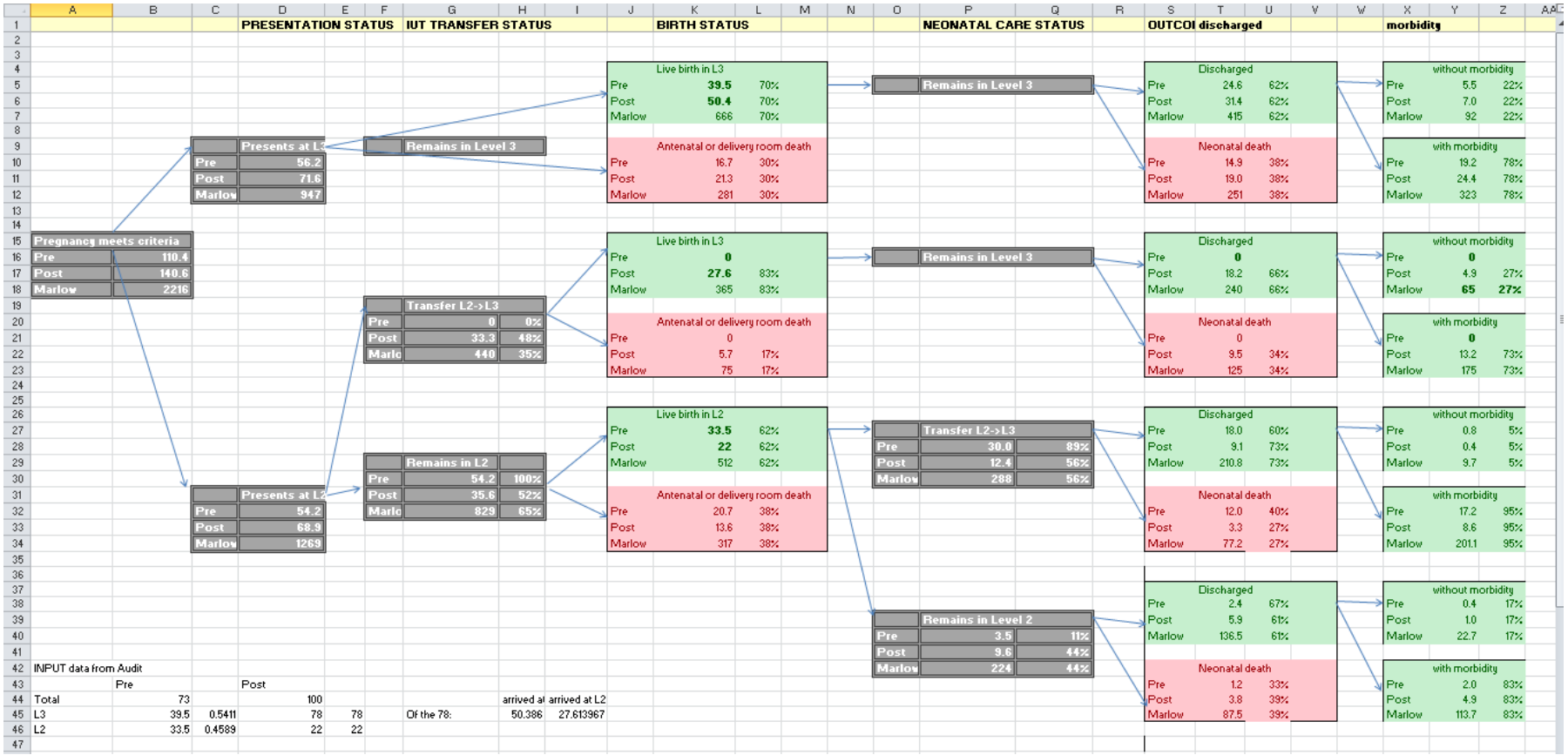


Table A: Probabilities used at decision and chance nodes in the decision model

Node See Figure 2 for details		**Iteration 1** **(using national-level data from Marlow et al.)** [1]	**Iteration 2** **('before')**[1]	**Iteration 3** **('after')**[1]
(1)	Admission to a level 3 unit	42.7%	50.9%	Assumed as 'Iteration 2'[2]
(2)	Live birth at a level 3 unit	70.3%	Assumed as 'Iteration 1'	Assumed as 'Iteration 1'
(3)	Discharged from a level 3 unit	62.3%	Assumed as 'Iteration 1'	Assumed as 'Iteration 1'
(4)	Discharged without morbidity	22.2%	Assumed as 'Iteration 1'	Assumed as 'Iteration 1'
(5)	Transfers from Level 2 to Level 3 unit	34.7%	0%	48.3%**
(6)	Live birth at a level 3 unit	83.0%	n/a	Assumed as 'Iteration 1'
(7)	Discharged from a level 3 unit	65.8%	n/a	Assumed as 'Iteration 1'
(8)	Discharged without morbidity from level 3 unit	27.1%	n/a	Assumed as 'Iteration 1'
(9)	Live birth at a level 2 unit	61.8%	Assumed as 'Iteration 1'	Assumed as 'Iteration 1'
(10)	Transfers from Level 2 to Level 3 unit	56.3%	89.5%	Assumed as 'Iteration 1'*
(11)	Discharged from a level 3 unit	73.2%	60.0%	Assumed as 'Iteration 1'*
(12)	Discharged without morbidity from level 3 unit	4.6%	Assumed as 'Iteration 1'	Assumed as 'Iteration 1'
(13)	Discharged from a level 2 unit	60.9%	66.7%	Assumed as 'Iteration 1'*
(14)	Discharged without morbidity from level 2 unit	16.7%	Assumed as 'Iteration 1'	Assumed as 'Iteration 1'

This table should be viewed in conjunction with Figure 2

[1] The reported probabilities are based on real data collected in the study except where stated that an assumption has been made.

[2] We would not expect fewer babies being admitted to a level 3 unit after the policy change, so we have assumed that the proportion admitted remains unchanged since 'before' the intervention, rather than using the data from Marlow et al. in this case.

* indicates that the assumption is changed to 'Iteration 2' in the sensitivity analysis

** indicates that the assumption is changed to 'Iteration 1' in the sensitivity analysis

Table B: Summary of key findings from the literature review: mortality and morbidity

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
Binder, S., et al. (2011) *Aim:* to test the hypothesis that the risk-adjusted predischarge morbidity and mortality of infants born at tertiary perinatal centres is less than those born at non-subspecialty perinatal centres *Setting:* all live births in the Cincinnati region (US) between January 1, 2003 and December 31, 2007. *Pop^{n}:* Between 499 and 1,500g born at less than 32 weeks gestation *Sample size:* 1,825	The odds of death for low birthweight babies (500 – 999 grams) before hospital discharge were significantly higher in a L2 unit compared to L3 unit: aOR 2.11 (95%CI 1.44, 3.10). Breaking down by birthweight there was a significant difference for extremely low birthweight babies (500- 999 grams) only: a) Extremely low birthweight (500 – 900g) aOR 2.41 (95%CI 1.49, 3.90) b) Low birthweight babies (1,000-1,499g) aOR 1.67 (95%CI 0.78, 3.56). After controlling for clinical risk index for babies, antenatal glucocorticoids		The odds of morbidity were higher in L2 units and, in general, the odds were higher for extremely low birthweight (500- 999 grams) babies. *Bronchopulmonary dysplasia or death:* a) All low birth weight: aOR 1.83 (95%CI 1.27, 2.65) b) Extremely low birthweight: aOR 2.93 (95%CI 1.66, 5.19) c) Low birthweight: aOR 1.28 (95%CI 0.72, 2.27) *Intracranial haemorrhage or death:* a) All low birth weight: aOR 3.51 (95%CI 2.42, 5.10) b) Extremely low birthweight: aOR 3.44 (95%CI 2.09, 5.68)	

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
	and antibiotics the odds of death was no longer significant: aOR 0.83 (95%CI 0.48, 1.43).		c) Low birthweight: aOR 4.30 (95%CI 2.39, 7.76) *Retinopathy of prematurity or death* a) All low birth weight: aOR 2.24 (95%CI 1.54, 3.26) b) Extremely low birthweight: aOR 2.56 (95%CI 1.55, 4.21) c) Low birthweight: aOR 2.08 (95%CI 1.08, 4.00) *Necrotizing enterocolitis or death* a) All low birth weight: aOR 2.14 (95%CI 1.49, 3.07) b) Extremely low birthweight: aOR 2.69 (95%CI 1.66, 4.37) c) Low birthweight: aOR 1.53 (95%CI 0.80, 2.90)	
Boland, R.A., et al. (2015) *Aim:* to compare infant mortality rates for very preterm babies born in	The odds of mortality by 1 year of age were higher for babies (<31 weeks) born in a non-tertiary than tertiary hospital: aOR 2.76 (9%CI CI 2.32, 3.27).			

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
tertiary hospitals compared with non-tertiary hospitals *Setting:* livebirths in Victoria (Australia) from 1990 to 2009 *Pop^{n}:* Between 22 and 31 weeks gestation *Sample size:*13,760	The odds of mortality decreased with increasing gestational age: a) <22-weeks: aOR 7.04 (95%CI 0.87, 56.8) b) 23 – 27 weeks: aOR 3.16 (95%CI 2.52, 3.96) c) 28 – 31 aOR 1.66 (95%CI 1.19, 2.31)			
Chung, J. H., et al. (2011) *Aim:* to evaluate the impact of these hospital-level factors on the outcome of death for very low birth weight infants using multilevel modelling. *Setting:* deliveries occurring in L2 units and upwards in the state of California (US) from January 1997 to December 2002 *Pop^{n}:* Between 500 to 1,499g	There was no significant difference in the odds of death within 24 hours of life or within the first year of life among infants were continually hospitalised from birth by place of birth. a) L2 vs. L3d: aOR 0.91 (95%CI 0.70, 1.19) b) L3a vs. L3d: aOR 0.81 (95%CI 0.65, 1.01) c) L3b vs. L3d: aOR 0.93 (95%CI 0.75, 1.14) d) L3c vs. L3d: aOR (0.90 (95%CI 0.76, 1.07)	The odds of death increased as the level of neonatal intensive care activity decreased. a) 1-10 births vs. >100: aOR 1.79 (95%CI 1.32, 2.42) b) 11-25 vs. >100: aOR 1.72 (95%CI 1.38, 2.13) c) 26-50 vs. >100: aOR 1.55 (95%CI 1.29, 1.87) d) 50-100 vs. >100: aOR 1.31 (95%CI 1.09, 1.59)		

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
Sample size: 25,755				
Gale, C., et al. (2012) *Aim:* to assess the impact of reorganisation of neonatal specialist care services in England after a UK Department of Health report in 2003 *Setting:* before 294 maternity and neonatal units in England, Wales, and Northern Ireland, 1 September 1998 to 31 August 2000; after 146 neonatal units in England, 1 January 2009 to 31 December 2010 *Pop^{n}:* between 27 and 28 weeks gestation, admitted to a neonatal unit within 28 days of birth. *Sample size:* 6,441 (before=3,522, after=2,919)	*Before vs. after reorganisation of services:* Survival at 28 days increased following reorganisation of services (aOR 1.93 [95%CI 1.61, 2.32]).			

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
Jensen, E. A. and S. A. Lorch (2015). *Aim:* To assess the independent effects of a birth hospital's annual volume of VLBW infant deliveries and NICU level on the risk of several neonatal morbidities and morbidity-mortality composite outcomes that are predictive of future neurocognitive development. *Setting:* all deliveries in all hospitals in California, Missouri, and Pennsylvania (US) between January 1, 1999, and December 31, 2009 *Pop^{n}:* Between 500 and 1,499g without severe congenital anomalies *Sample size:* 72,431	Higher proportion of deaths within 24 hours of life in a L1 unit compared to L3 b/c unit (66% vs. 48%, p=nr) a) L1 vs. L3b/c: OR 1.48 (95%CI 1.31, 1.67) b) L2a/b vs. L3b/c: OR 1.29 (95%CI 1.10, 1.51) c) L3a vs. L3b/c: OR 0.93 (0.81, 1.07) After controlling for both hospital activity no longer significant: a) L1 vs. L3b/c: aOR 1.08 (95%CI 0.90, 1.28) b) L2a/b vs. L3b/c: aOR 1.15 (95%CI 0.94, 1.41) c) L3a vs. L3b/c: aOR 0.89 (0.78, 1.01)	Higher proportion of deaths in first 24 hours of life in hospitals with 10 or fewer VLBW births per year compared to more than 50 (68% vs. less than 50%, p=nr) a) ≤10 vs. ≥50: OR 1.76 (95%CI 1.55, 2.00) b) 11-25 vs. ≥50: OR 1.31 (95%CI 1.16, 1.47) c) 26-50 vs. ≥50: OR 1.25 (95%CI 1.13, 1.39) Remained significant even after controlling for place of birth: a) ≤10 vs. ≥50: aOR 1.63 (95%CI 1.35, 1.96) b) 11-25 vs. ≥50: aOR 1.25 (95%CI 1.09, 1.44) c) 26-50 vs. ≥50: aOR 1.24 (95%CI 1.12, 1.38)	There was no significant difference for all four outcomes considered. Risk-adjusted probabilities for BPD, NEC, and ROP were lowest among infants born at hospitals with a level I NICU. *Bronchopulmonary dysplasia* a) L1 vs. L3b/c: OR 0.73 (95%CI 0.58, 0.92) b) L2a/b vs. L3 b/c: OR 1.14 (95%CI 0.85, 1.52) c) L3 a vs. L3 b/c: OR 1.19 (0.91, 1.56) *Severe intraventricular haemorrhage:* a) L1 vs. L3b/c: OR 1.04 (95%CI 0.88, 1.24) b) L2a/b vs. L3 b/c: OR 0.97 (95%CI 0.81, 1.16) c) L3 a vs. L3 b/c: OR 0.93 (95%CI 0.76, 1.14) *Necrotizing enterocolitis:* a) L1 vs. L3b/c: OR 0.61 (95%CI 0.52, 0.73)	The risk of risk-adjusted probabilities for BPD, NEC, and ROP were lowest among infants born at hospitals with 10 or less VLBW infant deliveries per year. *Bronchopulmonary dysplasia :* a) ≤10 vs. >50: OR 0.51 (95%CI 0.39, 0.67) b) 11-25 vs. >50: OR 0.69 (95%CI 0.53, 0.89) c) 26-50 vs. >50: OR 0.87 (95%CI 0.66, 1.15) *Severe intraventricular haemorrhage:* a) ≤10 vs. >50: OR 0.92 (95%CI 0.77, 1.10) b) 11-25 vs. >50: OR 1.08 (95%CI 0.91, 1.29) c) 26-50 vs. >50: OR 0.93 (95%CI 0.81, 1.07) *Necrotizing enterocolitis :* a) ≤10 vs. >50: OR 0.65 (95%CI 0.52, 0.82)

Reference	Mortality		Morbidity	
	Place of birth	Hospital activity	Place of birth	Hospital activity
			b) L2a/b vs. L3 b/c: OR 0.97 (95%CI 0.72, 1.30) c) L3 a vs. L3 b/c: OR 1.01 (95%CI 0.80, 1.27) *Retinopathy of prematurity :* a) L1 vs. L3b/c: OR 0.51 (95%CI 0.44, 0.60) b) L2a/b vs. L3 b/c: OR 0.76 (95%CI 0.61, 0.96) c) L3 a vs. L3 b/c: OR 0.63 (0.48, 0.83)	b) 11-25 vs. >50: OR 0.72 (95%CI 0.57, 0.89) c) 26-50 vs. >50: OR 0.91 (95%CI 0.74, 1.12) *Retinopathy of prematurity:* a) ≤10 vs. >50: OR 0.55 (95%CI 0.46, 0.66) b) 11-25 vs. >50: OR 0.67 (95%CI 0.55, 0.82) c) 26-50 vs. >50: OR 0.90 (95%CI 0.76, 1.06)
Lapcharoensap, W., et al. (2015) *Aim:* to identify independent risk factors for the development of BPD and the extent of hospital variation in BPD rates in a population-based cohort *Setting:* California Perinatal Quality of Care Collaborative, which collects more than 90% of VLBW			Bronchopulmonary dysplasia or mortality at 36 weeks postmenstrual age was significantly higher in a L2 hospital: a) L4 vs. L2: OR 1.23 (95%CI 1.02, 1.49) b) L4 vs. L3: OR 1.04 (95%CI 0.95, 1.14)	

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
infants receiving NICU care in California (US), from January 2007 to December 2011 *Pop^{n}:* Between 22 to 29 weeks gestation and between 400 and 1,500g. *Sample size:* 15,779				
Lasswell, S. M., et al. (2010) *Aim:* To evaluate published data on associations between hospital level at birth and neonatal or pre-discharge mortality for very low birth weight and very preterm infants. *Setting:* multi-country review from 1979 to 2008; 20 studies US, 15 from Canada, Ghana, Israel, Australia and Europe	Very low birth weight babies born outside of a L3 unit had an increased odds of pre-discharge mortality (OR 1.62 [95%CI 1.44, 1.83]) Restricted to only high quality studies: OR 1.60 (95%CI 1.33, 1.92). Restricted to extremely low birthweight (≤1,000 grams): OR 1.80 (95%CI 1.31, 2.46). Very pre-term babies born outside of a L3 unit had an increased odds of mortality (OR 1.21 [95%CI 1.21, 1.98])			

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
Pop[n]: Less than 1,500g and/or less than 32 weeks gestation *Sample size:* 41 studies; 104,944 very low birth weight infants (≤1,500 grams), 9,300 very pre-term babies (≤32 weeks gestation)	Restricted to high quality studies: OR 1.42 (95%CI 1.06, 1.88).			
Lorch, S.A, et al. (2012) *Aim:* impact on mortality of delivering at a high-volume, high-level NICU in comparison with other delivery hospitals in states with different systems of regionalisation and different patient populations *Setting:* all hospital based deliveries in Pennsylvania and California (US) between 1995 and 2005, and Missouri between 1995 and 2003	Delivering in a high-level NICU was associated with lower in-hospital mortality: Pennsylvania: 7.8 fewer deaths/1,000 deliveries (95%CI 4.1, 11.5); RR 0.35 (95%CI0.09, 0.61) California: 2.7 fewer deaths /1,000 deliveries (95%CI 0.9, 4.5); RR 0.82 (95%CI 0.70, 0.94) Missouri: 12.6 fewer deaths /1,000 deliveries (95%CI 2.6, 22.6); RR 0.50 (95%CI 0.26, 0.82)		Rates of complications were similar between hospitals. *Bronchopulmonary dysplasia* Pennsylvania: RR 1.02 (95%CI 0, 2.53) California: RR 1.21 (0.96, 1.53) Missouri: RR 0.05 (95%CI 0, 1.00) *Necrotizing enterocolitis:* Pennsylvania: n/r California: RR 1.98 (95%CI 1.46, 3.04) Missouri: RR 0.28 (95%CI 0, 1.20)	

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
Pop^{n}: Between 23 and 37 weeks gestation *Sample size:* 1,328,132			*Retinopathy of prematurity:* Pennsylvania: RR 0.38 (95%CI 0, 6.34) California: RR 2.52 (95%CI 1.52, 3.33) Missouri: RR 1.31 (0.60, 3.52)	
Marlow, N., et al. (2014). EPICure study *Aim:* to examine impact of the development of neonatal networks on outcomes for birth at extremely low gestational age *Setting:* all births in maternity hospitals in England during 2006 *Popn:* Between 22 and 26 weeks gestation. *Sample size:* 2,460	*Planned place of birth:* Babies of women booked into L3 had reduced mortality compared to women booked into L2 regardless of place of birth (aOR 0.79 [95%CI 0.63, 0.98]). *Place of birth:* Overall odds of mortality (up to 29 days post-birth) was significantly lower for births that occurred in L3 (includes those transferred from L2 to L3) compared to L2 (aOR 0.73 [95%CI 0.59, 0.90]) Odds of mortality in L2 compared to L3 (not	The odds of mortality were lower in higher activity units compared to medium activity units (aOR 0.68 [95%CI 0.52, 0.89]).	Morbidity was defined as having one or more of retinopathy of prematurity requiring retinal surgery, moderate or severe bronchopulmonary dysplasia, a severe brain injury or necrotising enterocolitis managed by laparotomy. *Place of birth:* No significant difference in odds of survival without neonatal morbidity by place of birth (aOR 1.27 [95%CI 0.93, 1.73]) *Transferred before birth:*	

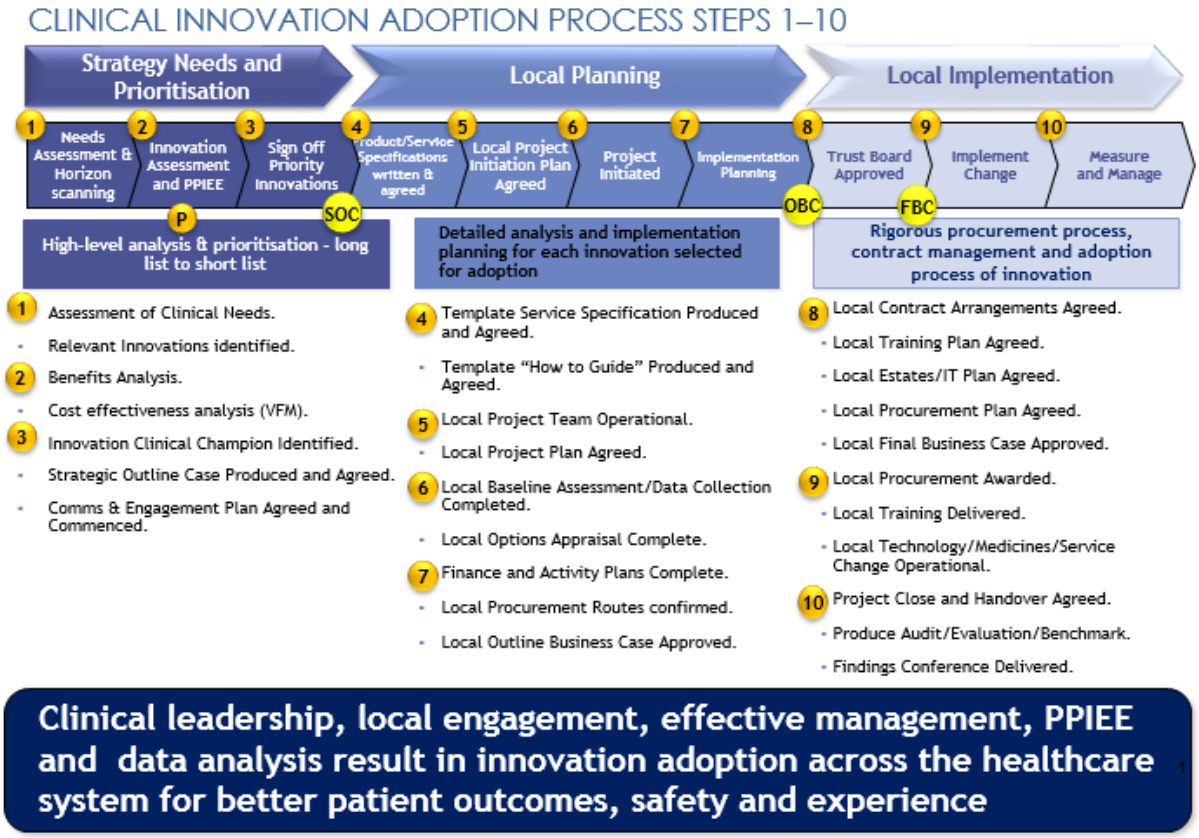
Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
	including women transferred to L3) were significantly higher during the delivery room (aOR 0.53 [95%CI 0.37, 0.77]) and neonatal period (up to 7 days) (aOR 0.69 [95%CI 0.51, 0.94]) only *Transferred before birth:* Lower odds of mortality for those transferred from L2 to L3 compared to those not transferred (stayed in L2) (aOR 1.44 [1.09, 1.90]). No difference in overall mortality between babies booked and born in L3 compared to those booked into L2 but transferred and born in L3 (aOR 1.08 [95%CI 0.83, 1.41]). *Transferred after birth:* No significant difference in overall mortality between babies born in L2 or L3 compared to neonatal		No significant difference in odds of survival without morbidity in those born in L3 compared to those transferred from L2 before birth (aOR 0.74 [95%CI 0.51, 1.06]). *Transferred after birth:* No significant difference between babies born in L2 compared to those transferred to L3 after birth (aOR 1.76 [95%CI 0.90, 3.46]) Significant increase in odds of survival without morbidity for babies born in L3 compared to those transferred to L3 post-birth (aOR 1.92 (95%CI 1.02, 3.60]). *Hospital activity:* No difference between high and medium activity	

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
	transfers to L3 (aOR 1.25 [95%CI 0.82, 1.89]; aOR 0.95 [95%CI 0.56, 1.58] respectively).		hospitals (aOR 0.79 [95%CI 0.55, 1.14])	
Watson, S.I., et al. (2014) *Aim:* to examine the effects of designation and volume of neonatal care at the hospital of birth on mortality and morbidity outcomes in very preterm infants in a managed clinical network setting. *Setting:* 165 National Health Service neonatal units in England contributing data to the National Neonatal Research Database at the Neonatal Data Analysis Unit and participating in the Neonatal Economic, Staffing and Clinical Outcomes Project, from 1 January 2009 to 31 December 2011	There was no difference in odds of neonatal (up to 28 days of age) or any in-hospital mortality for pre-term babies (<33 weeks gestation) born at a L3 unit compared to a L2 unit. Looking by gestational age time periods for neonatal mortality: a) <27 weeks; aOR 0.65 (95%CI 0.46, 0.91) b) 27- 33 weeks gestation; aOR 0.92 (95%CI 0.69, 1.22). There was no difference in odds of in-hospital mortality for either gestational age group.	There was a significant reduction in odds of neonatal mortality for babies born at <33 weeks in high- compared to low-volume hospitals (OR 0.73 [95% CI 0.56 to 0.95]). Looking at gestational age time periods separately there was a significant reduction for babies born at less than ≤27 weeks (OR 0.62, [95% CI 0.44, 0.87]), but no difference for babies born between 27 and 32 weeks. Reduction in in-hospital mortality for babies born between ≤27 weeks only (OR 0.71 [95% CI 0.52, 0.97]).	Four measures of morbidity were considered (bronchopulmonary dysplasia; necrotising enterocolitis ; retinopathy of prematurity) Babies born in L3 at ≤33 weeks had increased odds of BPD (OR 1.23 [95%CI 1.07, 1.40]). Looking at 27-33 weeks and <27 weeks separately; increased odds in babies born ≤27 weeks (OR 1.50 [95%CI 1.11, 2.01]), but no difference for babies born between 27 to 32 weeks. There were no other statistically significant differences observed for the morbidity outcomes.	Babies born ≤27 weeks in high volume hospitals had increased odds of BPD (OR 1.59 [95% CI 1.18, 2.14] and (aOR 1.78 [95%CI 1.12, 2.81]) There were no other statistically significant differences observed for the morbidity outcomes.

Reference	Mortality		Morbidity	
	Place of birth	**Hospital activity**	**Place of birth**	**Hospital activity**
Pop^{n}: Less than 33 weeks gestation *Sample size:* 20,554				
Zeitlin, J, et al. (2010) *Aim:* to assess evolution in care and health of very preterm babies between 1998 and 2003 after implementation of a regionalisation policy in France *Setting:* the Parisian region, France *Pop^{n}:* Between 24 and 31 weeks gestations *Sample size:* 1,068 (1997= 488, 2003=580)	Mortality declined from 19.1% to 14.8% (p=0.065). Being born in 2003 was associated with a reduced odds of mortality compared to 1997: aOR 0.66 (95%CI 0.46, 0.95). The greatest changes in mortality occurred between 25 and 28 weeks of gestation.		The incidence of grade III/IV intraventricular haemorrhage decreased from 11.3% to 4.1%: aOR 0.27 (95CI 0.15, 0.47). Cystic periventricular leucomalacia and bronchopulmonary dysplasia did not change.	

APPENDIX 2

Figure A: Oxford AHSN Clinical innovation adoption process



Source: Provided by Oxford AHSN.

Table A: Estimated number of VTE and death events within 6 months in the Oxford AHSN region (Oxford AHSN utilisation rates)

	Eligible patients receiving IPC			**Eligible patients not receiving IPC**			**Total**		
Month	DVT	PE	Death	DVT	PE	Death	DVT	PE	Death
April-June 14	7	1	9	47	7	54	53	8	63
Jul-Sept 14	19	3	26	49	8	56	68	11	82
Oct-Dec 14	26	5	35	41	6	47	67	11	82
Jan-Mar 15	26	5	35	37	6	43	64	10	78
April-Jun 15	31	5	41	39	6	45	70	11	86
Jul-Sept 15	31	5	41	32	5	37	63	10	78
Total	**141**	**24**	**187**	**244**	**38**	**283**	**385**	**63**	**470**

Source: OHE analysis, 2016.
Note: Numbers in the columns may not appear to add up to the total due to rounding.

Table B: Estimated number of VTE and death events within 6 months in the Oxford AHSN region (national utilisation rates)

	Eligible patients receiving IPC			**Eligible patients not receiving IPC**			**Total**		
Month	DVT	PE	Death	DVT	PE	Death	DVT	PE	Death
April-June 14	3	1	4	51	8	59	54	9	63
Jul-Sept 14	7	1	9	65	10	75	72	11	84
Oct-Dec 14	12	2	15	60	9	69	72	11	85
Jan-Mar 15	14	2	18	54	8	63	68	11	81
April-Jun 15	16	3	21	58	9	67	74	12	89
Jul-Sept 15	17	3	23	50	8	58	67	11	81
Total	**68**	**12**	**91**	**339**	**53**	**392**	**407**	**65**	**482**

Source: OHE analysis, 2016.
Note: Numbers in the columns may not appear to add up to the total due to rounding.

Table C: Estimated number of VTE and death events within 6 months in the Oxford AHSN region (Oxford AHSN April 2014 utilisation rates)

	Eligible patients receiving IPC			**Eligible patients not receiving IPC**			**Total**		
Month	DVT	PE	Death	DVT	PE	Death	DVT	PE	Death
April-June 14	5	1	5	51	8	59	55	9	63
Jul-Sept 14	6	1	6	68	11	79	74	11	85
Oct-Dec 14	6	1	6	69	11	80	75	12	86
Jan-Mar 15	6	1	6	66	10	76	72	11	82
April-Jun 15	6	1	6	73	11	84	79	12	90
Jul-Sept 15	6	1	6	66	10	77	72	11	83
Total	**35**	**5**	**35**	**393**	**62**	**455**	**428**	**66**	**490**

Source: OHE analysis, 2016.
Note: Numbers in the columns may not appear to add up to the total due to rounding.

Table D: Results of analysis when 47% (rather than 50%) of stroke patients are immobile and eligible for IPC

	Strategy 1	**Strategy 2**	**Incremental**
Events			
DVT	381	359	22
PE	61	59	2
Death	453	440	12
Total costs	**£463,651**	**£494,937**	**£31,286**
Total per additional IPC user			£72

Source: OHE analysis, 2016

Table E: Results using utilisation data supplied by Oxford AHSN (strategy 2 only)

	Strategy 1	**Strategy 2**	**Incremental**
Events			
DVT	407	387	20
PE	65	63	2
Death	482	470	12
Total costs	**£492,844**	**£521,380**	**£28,536**
Total per additional IPC user			£77

Source: OHE analysis, 2016
Note: This analysis was conducted using monthly data.