Eastern AHSN

Kent Surrey Sussex Academic Health Science Network

Evaluation report of the Little Journey mobile application

COMMISSIONED BY EASTERN AHSN

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Executive Summary

Introduction

Little Journey is an interactive, virtual reality (VR) mobile app designed to prepare children aged 3 to 12 years for day-case surgery and created by the company Little Sparks Hospital (LSH). It has been co-designed by patients, members of public and the hospital multi-disciplinary team. It enables children to 'visit' the day case ward, anaesthetic and recovery rooms and interact with staff and equipment they'll see on the day of their operation – all in the comfort of their home through virtual reality.

Every year, over 500,000 children undergo elective surgery in the UK (Sury, et al., 2014). Nearly 80% of these are day case, also called day surgery (Appleby, 2015). Day surgery is the planned admission of a surgical patient for an elective or semi-elective procedure where the patient is admitted, undergoes surgery and is discharged on the same calendar day.

Preoperative anxiety is an important issue in paediatric surgery, affecting more than 50% of children undergoing surgical procedures (Kain, et al., 1996). Children often report intense anxiety and significant distress, especially in the preoperative holding area and during induction of anaesthesia (Kain, et al., 2006). Intense anxiety is emotionally traumatic for children and parents, and is manifest in various ways, such as agitation, crying, shivering, fighting and escape behaviour (Litke, et al., 2012). Additionally, preoperative anxiety has been associated with adverse clinical, behavioural and psychological effects in children, such as delirium, increased postoperative pain and new-onset maladaptive behavioural changes, including nightmares, nocturnal enuresis and separation anxiety (Kain, et al., 2004).

The Little Journey product was designed by Dr Chris Evans, anaesthetic trainee and PhD student at University College London Hospitals (UCLH), to create a more appropriate and engaging way to convey healthcare information. The existing leaflets can be hard to read, too abstract and are ill-adapted for patients between the age of 3 and 12 years old.

Data was first collected for the acceptability, usability and feasibility study at UCLH between July 10th, 2017 and March 19th, 2018 with children undergoing dental surgery. It consists of a cardboard virtual reality headset alongside a smartphone with the downloaded Little Journey app and enables young patients:

- To see a 360-degree view of the ward, anaesthetic rooms and recovery rooms that they will visit on the day of their surgery.
- To understand each step of the surgery through the explanations of animated characters of staff.
- To better remember the key information thanks to the interactive programme and the games that can be triggered by the patients.

Used in the weeks leading up to their surgery – either in 2D or 3D alongside a VR cardboard headset - it allows children time to process the information provided and reduce the fear linked to their hospital appointment.

Following the success of the pilot, the project won multiple awards including the Innovation in Anaesthesia, Critical Care and pain award in 2018.

A multi-centre randomised controlled trial assessing the effectiveness of the Little Journey app at reducing peri-operative anxiety compared to standard care is underway, the first patient was recruited in September 2019 and the data collection is expected to last for 19 months. It was funded by the National Institute for Health Research (NIHR) Research for Patient benefit scheme.

The Little Journey app has been tailored to 44 hospitals and is currently used in 38 different hospitals across the United Kingdom and the Republic of Ireland. It is also been downloaded in 36 countries around the world (91% of the users are UK-based).

Purpose of report

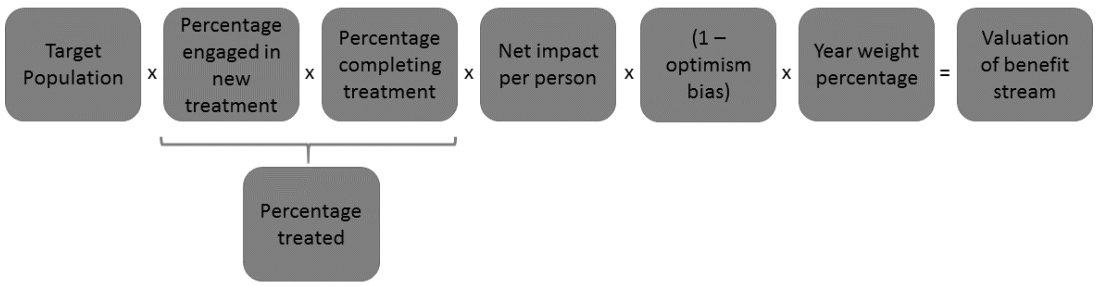
With the ever-increasing pressures placed upon health and social care systems, any interventions made ideally need to improve outcomes, increase safety and/or provide better value. This report has been conducted to understand the value impact achieved through the Little Journey app to understand the return on investment and opportunity for wider rollout. It may also help focus decision-making on the scale and which elements of the programme are most suitable for replication.

Methodology

This study produces a current and an ex-post appraisal of the impact of Little Journey app. It estimates the impact of the value produced using the best available evidence from the pilot, the current implementation and other literature. This assessment is in line with the HM Treasury 'Green Book: Central Government Guidance on Appraisal and Evaluation (2018)

The following core process is applied to the estimation of these benefits:

Figure 1 Calculation of net present benefits



This process takes a standard approach of working out the number receiving the treatment, multiplied by the net benefit or impact per person, multiplied by a factor to remove an optimism bias, and a second factor which accounts for phasing of delivery, with lower weights placed on roll-out years and a weight of 1 placed on full implementation years, to give a total net benefit of the benefit stream, over and above the counterfactual, for whom the percentage engaged in the new treatment, and the percentage completing treatment (the percentage treated) will be zero.

The counterfactual is the way patients would have received information regarding their surgery in the absence of the Little Journey app. Depending on the Trust, the counterfactual can be a

Pre-Assessment Clinic appointment, a surgery invitation letter, a leaflet or a combination of these. In addition to the existing pathway, parents and patients are advised to use the mobile app prior and on the day of the surgery once Trusts are using the Little Journey app. The counterfactual is captured in each benefit stream and through patient and staff questionnaires.

The report takes a five-year view of the programme. While further time horizons are possible, there is a consequent increase of uncertainly in the results going forward. The 'year-weight' accounts for the fact that benefits are likely to diminish over the five-year period as the workforce changes and the momentum of the Little Journey app dwindles.

Currently 38 hospitals are actively using the Little Journey app across the United Kingdom and the Republic of Ireland. Out of these, five agreed to collect the data feeding into this evaluation. The data collection included a baseline of some pre and postoperative key indicators (induction technique and time, premedication, unplanned admission, etc.), a post implementation of these indicators, a workforce impact questionnaire and a patient questionnaire.

Scenario 1 assesses the financial and social impact of Little Journey in the 5 hospitals which submitted a complete set of data, scenario 2 evaluates the impact of the app in all the Trusts currently using the app i.e. 29 sites once the private providers and the sites situated outside of England are excluded. Scenario 3 models the outcomes should Little Journey be introduced in all Trusts that perform paediatric surgeries, i.e. 145 sites across England.

The costing structure is described in more details in section 3.4, 4.4 and 5.4 for scenarios 1, 2 and 3 respectively. For the scenarios 1 and 2, the 'year-weight' factor is valued at 1 for the 2 first years and a fade out prudently assumed from year 3. For scenario 3 the 'year-weight' is 0.5 for the year 1 to account for a progressive two-year roll-out across all sites, 1 for years 2 and 3 and faded out for years 4 and 5.

Results

Headline results

Table 1 lays out the headline findings for the five years to financial year 2019/2023, modelled using a combination of actual results, recorded by the Little Sparks team and academic studies conducted into relevant research areas. This table shows the costs and benefits at the 5 sites taking part in the data collection, whilst table 2 shows the results of modelling of all Trusts currently using the mobile app. Tables 3 shows an indicative cost benefit analysis, was the product to be rolled out across England Kingdom in the same manner as previously.

Table 1 Base-case headline results by year – Little Journey in 5 Trusts - scenario 1 (£,000, net present value – 2019 prices)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
NHS cash releasing savings	£ 0.92	£ 0.94	£ 0.87	£ 0.80	£ 0.72	£ 4.25
NHS non-cash releasing savings	£ 56.8	£ 56.1	£ 49.8	£ 43.7	£ 37.8	£ 244.2
Societal benefits	£ 101.3	£ 98.0	£ 85.2	£ 73.2	£ 62.0	£ 419.8
Total Benefits	**£ 159.1**	**£ 155.0**	**£ 135.9**	**£ 117.7**	**£ 100.4**	**£ 668.2**
Total costs	**£ 3.0**	**£ 14.0**	**£ 17.7**	**£ 21.6**	**£25.7**	**£ 82.0**
Net present value (benefits – costs)	**£ 156.1**	**£ 141.0**	**£ 118.2**	**£ 96.2**	**£ 74.7**	**£ 586.2**
Benefit to cost ratio	**53.6**	**11.1**	**7.7**	**5.5**	**3.9**	**8.2**

Table 2 Base-case headline results by year – Little Journey in 29 hospitals - scenario 2 (£,000, net present value – 2019 prices)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
NHS cash releasing savings	£ 6.4	£ 6.6	£ 6.0	£ 5.5	£ 4.9	£ 29.5
NHS non-cash releasing savings	£ 420.2	£ 429.3	£ 394.8	£ 358.3	£ 320.2	£ 1,922.7
Societal benefits	£ 752.4	£ 757.7	£ 686.6	£ 614.5	£ 541.4	£ 3,352.6
Total Benefits	**£ 1,179.0**	**£ 1,193.6**	**£ 1,087.4**	**£ 978.2**	**£ 866.6**	**£ 5,304.8**
Total costs	**£ 22.5**	**£ 94.6**	**£ 120.1**	**£ 146.7**	**£ 174.5**	**£ 558.5**
Net present value (benefits – costs)	**£ 1,156.5**	**£ 1,099.0**	**£ 967.3**	**£ 831.5**	**£ 692.1**	**£ 4,746.3**
Benefit to cost ratio	**52.36**	**12.62**	**9.05**	**6.67**	**4.97**	**9.50**

Table 3 Base-case headline results by year – Little Journey across England (145 sites) - scenario 3 (£,000, net present value – 2019 prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
NHS cash releasing savings	£ 2.6	£ 5.3	£ 5.4	£ 4.9	£ 4.5	**£ 22.6**
NHS non-cash releasing savings	£ 590.8	£1 ,204.2	£ 1,227.4	£ 1,125.1	£ 1,018.9	**£5,166.3**
Societal benefits	£ 1,057.9	£ 2,125.5	£ 2,134.7	£ 1,929.5	£ 1,722.9	**£ 8,970.5**
Total Benefits	**£ 1,651.2**	**£ 3,334.9**	**£ 3,367.5**	**£ 3,059.5**	**£ 2,746.3**	**£14,159.4**
Total costs	**£ 201.6**	**£ 404.6**	**£ 498.8**	**£ 597.4**	**£ 699.9**	**£2,402.3**
Net present value (benefits – costs)	**£ 1,449.7**	**£ 2,930.3**	**£2,868.7**	**£ 2,462.1**	**£ 2,046.4**	**£11,757.1**
Benefit to cost ratio	**8.19**	**8.24**	**6.75**	**5.12**	**3.92**	**5.89**

Sensitivity testing

Figure 2 presents the probability distribution for total net present benefits calculated using the Monte Carlo method to predict sensitivity of the outcome to variation in underlying assumptions as explained in section 1. This graph shows the costs and benefits for the scenario 1, whilst figure 3 shows the probability distribution results of modelling of the current implementation and figures 4 does the same for the national roll-out.

Figure 2 Probability of total net present value (NPV) – Scenario 1

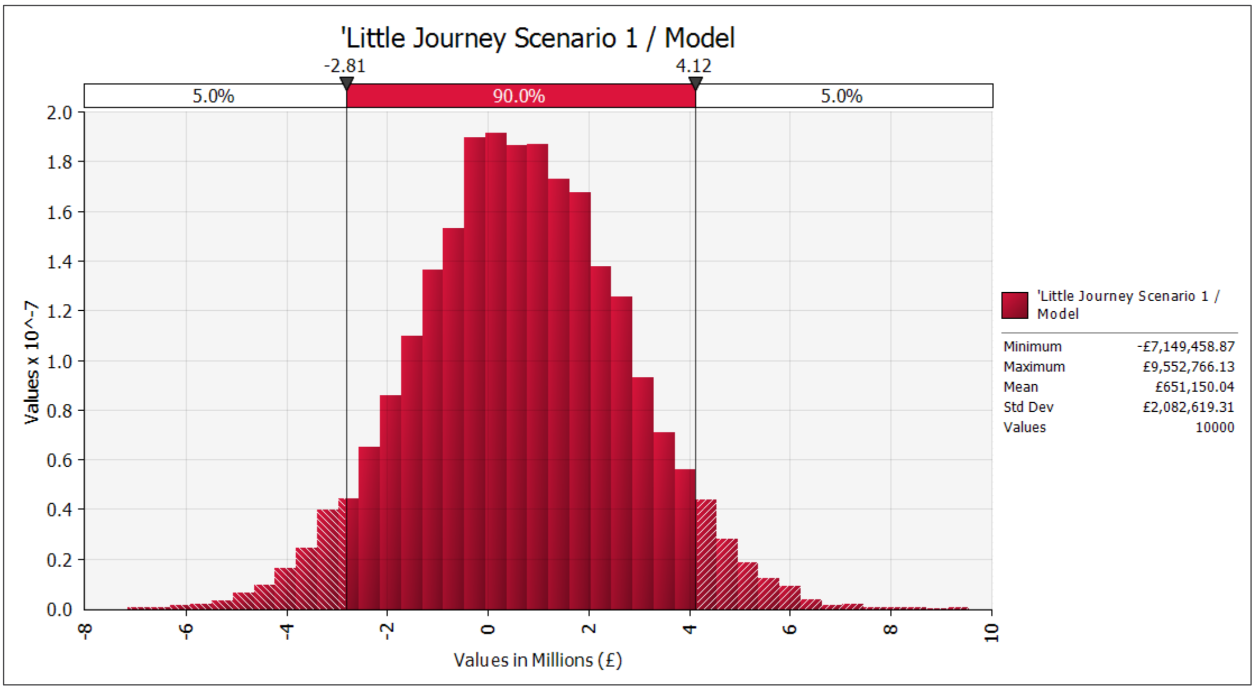


Figure 3 Probability of total net present value (NPV) – Scenario 2

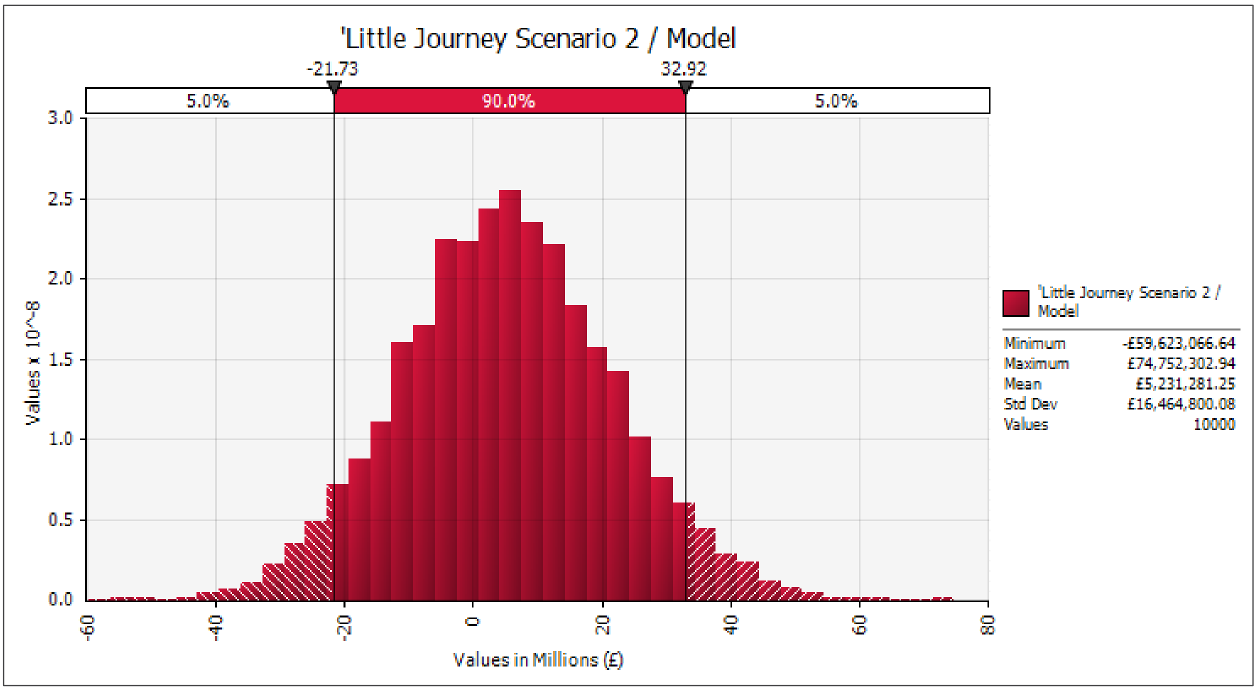
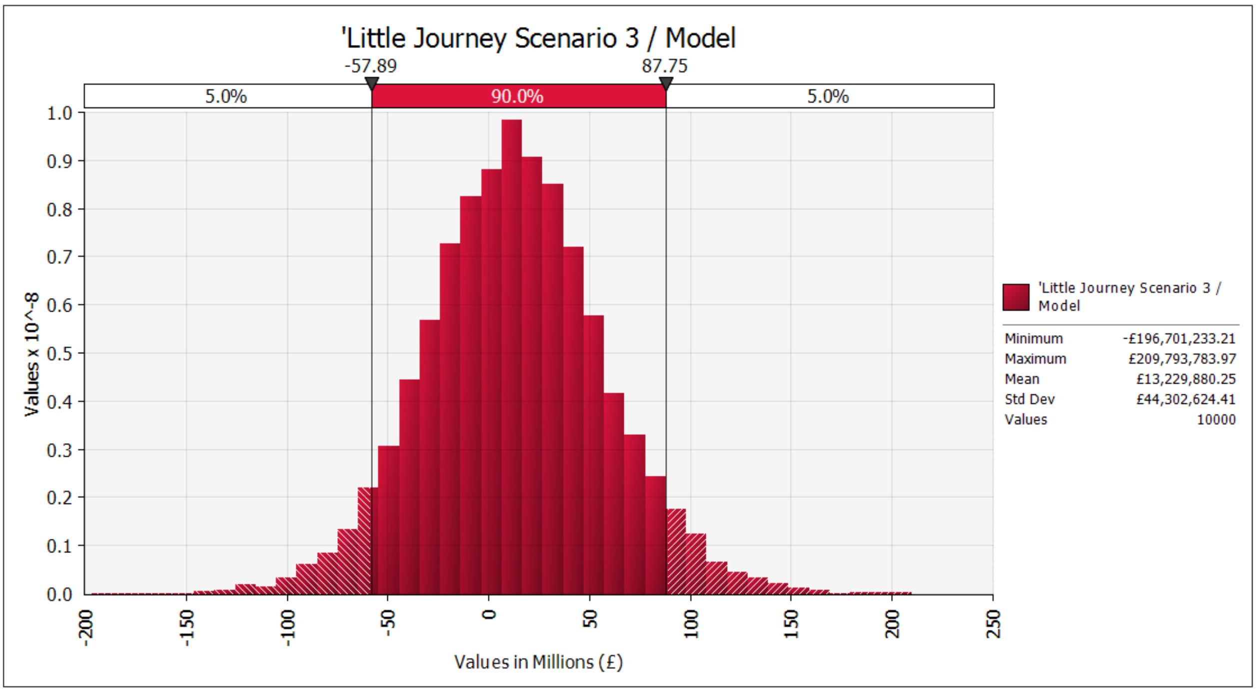


Figure 4 Probability of total net present value (NPV) – Scenario 3



Conclusions

This study's purpose is to understand the impact the Little Journey mobile app is having, based on the costs it has generated. The economic analysis that has been conducted was designed to answer one primary question; could robust estimates of the total health and social economic benefits that Little Journey is contributing be generated via a desk-based study, augmented by standardised data and published sources.

Ability to deliver robust results

This study's primary findings are:

- It is possible for a desk-based study to generate estimates of the value produced that are sufficiently robust to be useful for policy-making, but there are areas where we have applied some caution in the application of the results in terms of estimating an overall net present value of the programme;
- Several of the benefit streams identified have information gathered from older research studies. As such there is little means to verify that benefits identified within these studies remain applicable to the present-day value attributed. To guard against overestimating on this basis, prudent application of a variable optimism bias attempts to control for this effect.
- The study has been compelled to use a number of assumptions in the absence of project data:
- As a result of the absence of some data, whilst it is possible to identify potential benefit streams, it is not necessarily the case that we can quantify these. Data is not necessarily available, or there is insufficient evidence that in practical terms all the streams come to fruition. Where this is the case, the potential benefit has been explained, but has not been assigned an economic value.

Results of the study

The conclusions of this study, which has looked to identify the costs and benefits of the Little Journey mobile application:

- **Little Journey is estimated to deliver tangible value of £3.03 and £3.50 of benefit within the health care system (cash and non-cash releasing) for every £1 invested in the project for the scenario 1 and the current implementation (scenario 2) respectively.** This is based on cautious and prudent adjustments for optimism bias applied to both the benefits and the costs.
- **A further £5.12 and £6.00 are identified in social benefits for every £1 invested (respectively for the pilot and the current project).**
- **Should Little Journey be rolled out** nation-wide it is estimated to deliver an overall average gross benefit of £5.89 for every £1 invested. However, the sensitivity analysis that in more than a third of possible outcomes, returns will be negative.

External validation of model

The model and this report have been subject to external validation by Richard Heys, a professional economist. Richard has degrees in economics from the University of Oxford and UCL. He has worked as a professional economist, both for government and in the private sector for eighteen years. He has worked in partnership with the KSS AHSN for three years, validating economic analyses of health projects.

I have reviewed this analysis and am satisfied it is an accurate assessment of the potential costs and benefits of this project. However, whilst the core scenarios show a positive net present value, users should note the sensitivity analyses in figures 2-4 which reveal that, accepting certain assumptions could vary, and using realistic ranges for these, that in slightly more than a third of possible outcomes the net return would be negative. Another way of putting this is that if this exercise was carried out ten times, around seven would deliver benefits greater than costs and around three would deliver benefits less than costs. This is an important uncertainty which should be carefully explored before rolling this programme out. Specifically, are there cost items which can be controlled to reduce this range of potential outcomes.

Richard Heys, September 2019

1 Introduction

Effective pre-operative care is fundamental to safe and effective day and short stay surgery. Pre-operative preparation has three essential components:

- To educate patients and carers about the surgery pathways
- To inform patients about planned procedures and post-operative care, providing important information in writing, to help patients make informed decisions
- To identify medical risk factors, promote health and optimise the patient's condition. (Verma, et al., 2011)

The Royal College of Nursing encourages giving the opportunity to paediatric patients and their relatives to familiarise themselves with the environment and the staff who will provide their peri-operative care (Royal College of Nursing, 2013). They highlight it may relieve anxiety and answer questions about both the anaesthetic and surgical processes.

The medium used to share and explain information before the surgery varies widely between hospitals. It ranges from face-to-face conversations in pre-assessment clinics, child-friendly tools tailored to the patient age group such as videos or illustrated book, to leaflet included in the invitation letter or phone consultation with the parents only. The section 2 explores the existing preoperative pathways and how they are viewed by the member of staff taking part in its implementation.

The majority of information materials and preparatory interventions are designed by adults for children. There has been minimal work focusing on how children wish to receive health information when they are having procedures, what this information should contain and the role of information on children's experiences (Gordon et al., 2011; Lambert et al., 2013; Smith and Callery, 2005). The interviews conducted by Bray et al. (2019) revealed that many of the children don't see or access any information before coming to the hospital for their procedure and they reliant on their parents for access to information before their hospital visit. They expressed their desire to receive clear and honest information presented in an engaging and accessible format.

If not performed adequately, pre-operative care can result in adverse consequences such as delayed recovery (Kerimoglu, et al., 2013) as well as increased anxiety (Carmichael, et al., 2015) and failing to attend follow-up appointments (Shahnavaz, et al., 2015). Preoperative anxiety is an important issue in paediatric surgery, affecting more than 50% of children undergoing surgical procedures (Kain, et al., 1996). Children often report intense anxiety and significant distress, especially in the preoperative holding area and during induction of anaesthesia (Kain, et al., 2006). Intense anxiety is emotionally traumatic for children and parents, and is manifest in various ways, such as agitation, crying, shivering, fighting and escape behaviour (Litke, et al., 2012). Additionally, preoperative anxiety has been associated with adverse clinical, behavioural and psychological effects in children, such as delirium, increased postoperative pain and new-onset maladaptive behavioural changes, including nightmares, nocturnal enuresis and separation anxiety (Kain, et al., 2004).

Little Journey is a computer-generated three-dimensional environment with which a user can interact designed to prepare children aged 3 to 12 years old for day case surgery. It is built on the following principles:

- **Child-centred product:** animated characters of hospital staff has been developed with two versions tailored to the 3-7 age group and the 8-12 age group respectively. The app also includes age-appropriate games that familiarise the patients further with the hospital environment and create positive associations. Child narrated relaxation animations are also featured to aid coping with anxiety

- **Realistic and informative experience:** the preparatory tool follows a pre-set storyline reflecting what will happen on the day of surgery - users visit the day case ward, anaesthetic and recovery rooms - and takes approximately 10-15 minutes to complete.
- **Designed to inform parents:** the app also features a parent menu which enables them to access information about the day case but also to remind them of crucial elements via push notifications at different stages before the procedure. The menu includes:
  - Checklists of what to bring on the day of the procedure
  - Telephone links displayed to call the hospitals directly to reschedule operations
- **Product easily available:** Little Journey can be downloaded from the Play Store or the App Store and used with a phone, a hand-held tablet and in complement a Google cardboard compatible headset for an interactive immersive 360-degree experience.

2 Qualitative analysis

2.1 Workforce impact questionnaire

The hospitals taking part in the implementation of the Little Journey app were contacted and asked to complete the questionnaires detailed in table 4. The aim of this anonymous questionnaire was to assess the preoperative communication practices, the Little Journey pathway, their impact on paediatric patients' wellbeing and how they are perceived by the members of staff. Ten sites completed the questionnaires.

Table 4 Workforce impact questionnaire

	Question	Answer type
1.	Before using the Little Journey app, how was information regarding paediatric surgeries given to patients and parents:	Free text answer
1.a.	Do you have a Pre-assessment clinic?	Free text answer
	Percentage of patients seen in total:	
	Percentage of patients seen face-to-face versus telephone consultation:	
	Who do they see: Pre-assessment nurse, anaesthetist, health play specialist, other?	
	Average length of time between PAC and surgery (in days):	

	Any risk stratification according to anxiety/surgical severity/ ASA grade:	
1.b.	Do you provide any other resources to patients?	- Leaflet: APAGBI versus bespoke - Bespoke video - Webpage - Other
2.	Does the health play specialist see all patients before surgery?	- Yes - No, only those deemed at high risk of anxiety - Other
3.	The previous pathway was satisfactory and well-adapted to paediatric patients:	- I strongly agree - I agree - I neither agree nor disagree - I disagree - I strongly disagree
4.	In my opinion, children with preoperative anxiety benefit most from (please rank the following answer with 1=most beneficial, 5=least beneficial):	- Open and clear communication regarding the benefits, risks and preoperative requirements (e.g. dietary restrictions/ fasting) of a surgical operation - Interdisciplinary collaboration to reduce the lapse of time between a patient admission and the induction - Making the patients and their parent familiar with the surgical pathway and the hospital settings - Administering preoperative medication to the patient - Other
5.	The Little Journey concept is not easy to present and explain to both parents and children:	- I strongly agree - I agree

		- I neither agree nor disagree - I disagree - I strongly disagree
6.	Introducing the Little Journey app in the preoperative pathway was a complicated process:	- I strongly agree - I agree - I neither agree nor disagree - I disagree - I strongly disagree
7.	Integrating the Little Journey app in the preoperative pathway improved the patient experience:	- I strongly agree - I agree - I neither agree nor disagree - I disagree - I strongly disagree
8.	Using the Little Journey (select all statements that apply):	- Produces a calm state in paediatric patients - Sometimes makes the patients dizzy/sick/unwell because of the headsets - Reduces patients' anxiety and fear - Doesn't impact positively on the patients' behaviour or well-being - Makes the separation from parents easier - Has no added-value for the parents - Improves cooperation and manageability of patients for staff members - Other
9.	Other comments:	Free text answer

The majority of respondents was anaesthetists although a variety of professions were represented (consultant paediatric anaesthetist, theatre manager, preoperative lead nurse). They were leading on the implementation of Little Journey and the main point of contact with the LSH team.

Preoperative communication practices

Information related to day case surgery was delivered using various channels in the 10 sites surveyed. All declared sharing some paper resources with the patient and the patient's relatives via leaflets, letters or booklets. Only 3 sites benefited from face-to-face pre-operative assessment and discussion and 2 declared performing all the pre-operative consultation over the phone. In other cases, the project leads declared it varied depending on the specialty, if the patient was a regular attender or on the complexity of the surgical procedure.

One site used a photobook to illustrate and prepare the patients to the procedure, whilst another gave out booklets tailored to different age groups. Additionally, online resource was available for patients and family to consult before the surgery, but the respondents fear it was not often used by patients.

What constitutes good care/ best practices?

When asked what was the most beneficial for children with preoperative anxiety, all project leads ranked first or second having an "open and clear communication regarding the benefits, risks and preoperative requirements (e.g. dietary restrictions/fasting) of a surgical operation" and "making the patients and their parent familiar with the surgical pathway and the hospital settings". On the other hand, "administering preoperative medication to the patient" was ranked least beneficial for 9 of the staff members.

Impact of Little Journey

Questions 5 to 8 were assessed the perceptions of Little Journey. It was found that no project lead found the app difficult to present or explain to parents and children. This shows the adaptability of the Little Journey app, given that the Trusts all had varied pathways with regards to paediatrics surgery. Similarly, 8 out of 10 sites strongly disagreed or disagreed with the statement that introducing the app in the preoperative pathway is a complicated process.

Six leads thought integrating Little Journey in the preoperative pathway improved the patient experience, whilst the four others neither agree nor disagree as they have just started using the app. Likewise, 7/10 respondents shared that the app "Produces a calm state in paediatric patients" and "Reduces patients' anxiety and fear". Others could not attribute an improvement in behaviours or a reduction of anxiety to Little Journey alone but recognised that it was part of the methods they used and therefore beneficial for both parents and children.

3 General Methodology

3.1 Standard Framework

This study produces an ex-post appraisal of the Little Journey current implementation and an ex-ante appraisal of the prospective impact of the initiative, estimated using the best available evidence from emerging project data and academic research. The project is assessed in line with the standard HM Treasury guidance. This guidance, 'The Green Book' (HM Treasury, 2018) applies throughout the public sector to ensure consistent estimation of costs and benefits in cost-benefit appraisals. In recent years this has been supplemented by a number of Departmental or sectorial 'supplementary guidance' documents. This study attempts to retain consistency with this landscape, except where the supplementary guidance documents contradict each other. In these cases, the study takes a 'first principles' approach to identifying an appropriate methodology based on economic fundamentals.

The supplementary guidance documents of most relevance are:

- Policy appraisal and Health (DoH, 2013)
- Public Service Transformation (HM Treasury 2014)
- Risk (HM Treasury, 2013)
- Technology Appraisal in Health (NICE, 2017)

In addition to this supplementary guidance, there is also relevant technical research we have drawn upon, specifically in relation to the value of a preventable fatality, where we refer to Deloitte (2009) and Woolf & Orr (2009).

It is worth noting that the assessment is a socio-economic assessment of the costs and benefits of the Little Journey app to the UK as a whole. It therefore captures costs and benefits that accrue outside the health and social care sectors and so is consistent with the 'Green Book'. Consequently, it is not produced purely to align with NICE guidance (NICE, 2017). The key difference between this study and the NICE approach are:

- **Costs:** NICE is only concerned with those costs which fall on the NHS and personal social services (PSS). For example, this study also captures the private costs of social care and costs falling on volunteers.
- **Outcomes:** NICE is only concerned with 'all direct health effects, whether for patients or, when relevant, carers.' Whilst the study has not identified any non-health effects (taking the human costs of illness, including lost earnings as a 'health effect'), the study is not restricted from doing so.
- **Productivity:** NHS-NICE (2017) states that 'productivity costs are not included in either the reference-case or non-reference case'. In general, if the study identifies an impact on productivity, the analysis will attempt to capture it.

3.2 Standardised data sources

In addition to the framework described above, HM Government has also looked to enable quicker and more efficient delivery of cost benefit appraisals, particularly by local government, through the funding and development of three sets of standardised unit cost databases, from which we will look to draw data as standard. These are:

- Department for Transport's **WebTAG** data book
- **PSSRU's** 'Unit Costs of Health and Social Care 2018' and

- **New Economy 'Unit Cost Database'** (2015) which divides costs into financial costs and economic costs. These terms broadly equate to 'public sector delivery costs' and 'all other socio-economic costs'.

These sources present an efficient but effective mechanism for identifying values for many costs and outcome benefits. They are broadly consistent with one another but where they are not, we will look to identify the original source data where possible to identify the most relevant source.

Optimism bias

It has previously been reported that commissioners and practitioners are often overly optimistic about the outcomes that will be achieved by the project or programme and the amount of money that will be needed to deliver these outcomes (New Economy, 2015). It seems reasonable to assume that the degree of over optimism will be greater when the data and evidence upon which the cost effectiveness model is based are uneven, old or incomplete. Therefore, the model applies optimism bias correction factors in response to the level of uncertainty in the data or assumptions used. The optimism bias approach used is based on the confidence grade definitions shown in table 5.

Table 5 Optimism bias correction grading

Confidence grade	Colour coding in model	Data Source	Age of data	Known data error	Optimism bias correction
1		Formal service delivery contract costs Figures derived from local stats / RCT trials	1-2 years old	+/- 5%	5%
2		Practitioner monitored costs Figures based on national analysis in similar areas	2-3 years old	+/- 10%	10%
3		Costs developed from ready reckoners Figures based on generic national analysis	3-4 years old	+/- 15	15%
4		Costs from similar interventions elsewhere Figures based on international analysis	4-5 years old	+/-20%	25%
5		Cost from uncorroborated expert judgement Benefit from uncorroborated expert judgement	>5 years old	+-25%	40%

The confidence grade which the CBA model applies to the data is determined by the lowest assessment in any of the descriptive columns. The optimism bias correction factor for the data is then determined based on the lowest confidence grade found in relation to each individual outcome and costs are increased by the corresponding percentage factor (shown in the table above). Data in the spreadsheet are colour-coded to enable a quick visual assessment of the quality of the cost data inputs.

3.3 Methodological process

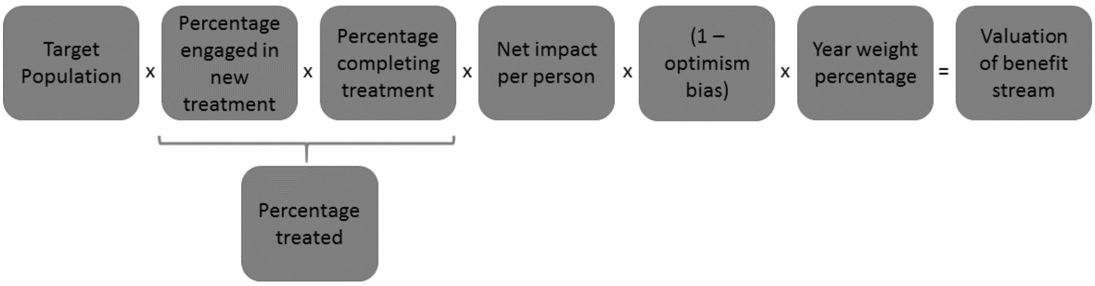
This study deploys a tried and tested approach to estimate the impact of the Little Journey programme. The approach has the following major stages:

For each outcome, data are needed to determine inputs for the model. The input data required are the:

- total population in the project area e.g. the number of paediatric patients undergoing surgery in a hospital;
- population at risk in this study the total population is also the population at risk as the population is derived from the number of current paediatric day case surgeries;
- level of engagement with the target population (e.g. the percentage of patients downloading the app as well as the percentage of patients frequently engaging with the app);
- scale of impact in changing the outcome (percentage success at achieving the desired outcomes - e.g. avoiding a hospital admission).

This process takes a standard approach of working out the number receiving the treatment, multiplied by the net benefit or impact per person, multiplied by a factor to remove the optimism bias, to give a total net benefit of the benefit stream, over and above the counterfactual.

Figure 1 Calculation of net present benefits



Gathering evidence from existing sources using a targeted literature review to populate the indicative formula outlined in Figure 6, sourcing materials through interviews with subject matter experts and more general literature review techniques to identify the best evidence and mechanism for estimating benefits. Key sources will be:

- **Evaluations of similar delivery models** to identify effectiveness rates and the best ways of measuring these.
- **Indirect benefit estimation methods** – using alternative methods to assess benefit streams if direct estimation methods are not applicable. Examples may be, 'willingness to pay' surveys of consumers of a service to identify what they would be willing to pay to receive this service.
- **Limited estimation methods** – in some cases there may not be sufficient data to capture the full range of benefits from an intervention. In these cases, we will look to identify all benefit streams and quantify those where we can. In particular we have discovered it is normally possible to identify avoided costs, which whilst they may fail to capture the wider social benefits provides a starting point for an assessment.

Applying a discount to future costs and benefits. In order to determine the present value of the costs and benefits for use in calculations of cost benefit ratios, the values of future costs and benefits are discounted to current prices. The discount rate is used to convert all costs and benefits to 'present values', so that they can be compared. The model uses a standard discount factor of 3.5%, following HM Treasury (2018) guidance. The discount calculation can be expressed mathematically as: $D_n = \frac{1}{(1+r)^n}$

For example, a payment of £150 at the middle of year 5 has a present value at the middle of year 0 of £141.33, with the following working:

$$£\,150 * \frac{1}{1.035^5} = £\,150 * 0.9422 = £\,141.33$$

Applying the existing estimates of effectiveness to data on the size of the treatment groups in the area modelled, including any steps in roll-out.

The following chapters take each benefit stream in turn and describe the methodology used to estimate the value of the project for the scenario. Later chapters look at changes to the assumptions for other scenarios and the resultant benefits and costs.

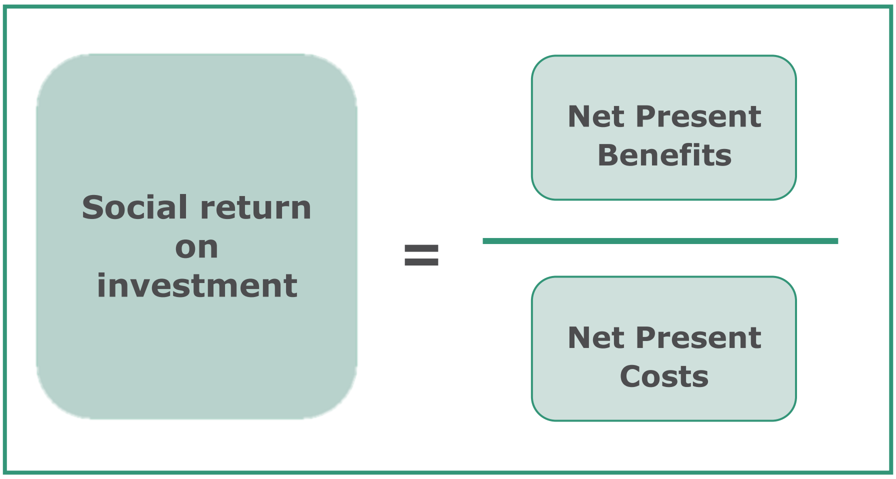
Net present value

The net present value (NPV) is a measure of the additional value created by implementing the project. To provide a consistent measure of costs and benefits now and into the future, future costs and benefits are discounted to produce present values. These present values are then used in the NPV calculation as follows: Net present value = Present value of the benefits – Present value of the costs

Cost benefit ratio

The financial return on investment. This is calculated by dividing the present value of the budgetary savings by the upfront budgetary cost of the intervention as shown in figure 4.

Figure 2 Cost benefit ratio calculation



Monetisation

To turn outcomes from the programme into a financial benefit, each outcome needs to be monetised. There are two overall benefit categories, one of which is further divided to allow a prudent understanding of how the benefit can be realised:

Efficiency Savings, either to the health care sector or others. How these benefits are realised depends of the "cashability" of the saving. "Cashability" refers to the extent to which a change in an outcome will result in a reduction in fiscal expenditure. The ability to cash depends on the type of benefit, scale, timing and the leadership in place to realise the savings. This report takes a prudent approach to identify benefits where the fiscal saving can be easily realised by dividing the fiscal savings into the following benefit streams:

- **NHS related cash releasing benefits:** These benefits produce immediate cashable savings to the provider. An example of this benefit would be a reduction in premedication usage, following intervention by the LSH team.
- **NHS related non-cash releasing benefits:** These benefits are important to reducing demand and strain on services, but a fiscal value cannot be realised without decommissioning of services, which is often difficult due to factors of scale (e.g. shutting one bed on a ward has a small impact on spending, whereas shutting a whole ward allows for fixed costs to be saved). Benefits which can be described as non-cash releasing include reduced hospital length of stay and reduced re-admissions where the scale of the effect on any one institution is unlikely to release savings of a magnitude which can result in a change in behaviour by the institution.

Social value – The overall benefit to the public, including, but not limited to, employment related benefits, such as fewer sick days and improved health and wellbeing. A key element of understanding these benefits is the approach the model takes in calculating quality of life changes. Quality of life related benefits use a Quality Adjusted Life Year (QALY) calculation. The basic construction of a QALY valuation for a particular health state is the number of years of life spent in that state multiplied by a health state utility-based weighting (cf. Williams, 1985). So, for example, a health state which lasts 10 years and is valued at 0.9 in terms of health state utility would give 9 QALYs. The QALY provides a single index allowing a measurement of the effects of health interventions on mortality and morbidity.

This QALY is then given a financial value using the willingness to pay threshold value used by NICE on behalf of the NHS. NICE methods guides refer to a threshold of £20 000-£30 000 per QALY. A sensitivity range is used to reflect the range within which this threshold is applied, with the lower value (£20,000) taken as the modal value.

Other benefits – Although this report is primarily concerned with the fiscal benefits associated with the Little Journey, it is important to acknowledge the other benefits for which there is evidence, for which an accurate value cannot be attributed. These benefits include reputational value and staff confidence and satisfaction levels.

3.4 Sensitivity analysis

Monte Carlo analysis is a modelling technique which simulates the impact of the expected variance in key variables on the output of interest, in this case the net present value. The approach is best described using an example.

Step One: Allocation of ranges*:*

Variables whose impact is of interest are given base-case values (or mean estimates), and an expected range. In the example below, we look at quality of life adjustment factor and expected life expectancy:

Step Two: example

Table 6 Presentation of the example used

Variable	Lower range estimate	Base-case / mean estimate	Upper range estimate
Quality of life adjustment factor	0.420	0.565	0.710
Life expectancy (years)	4.73	6.30	7.88

Step Three: Allocation of a distribution shape

All data has a shape to its distribution. If there is equal likelihood of any value within a range being drawn, then a rectangular distribution can be used (so called because a graph of the probability of any specific value being drawn would appear to be a rectangle). If there is a lower likelihood of a value at the extreme ends of the range being drawn, then a triangular distribution could be used.

If there is reason to believe the distribution meets the statistical qualities required to be defined as normal, Poisson, etc, then these can be applied. In this study, we have generally applied triangular distributions as this best reflects the ranges used and diminishing probabilities of more extreme ends. Where a different distribution has been used, it is expressly noted in the text.

Step Four: Random selection of values within the range

The model selects at random a value for each variable from within the range between the upper and lower estimate and calculates the outcome from each draw, considering the distribution shape selected and therefore the probability of any value being drawn.

Step Five: Repetition

Table 7 Five first draws of the repetition step

Variable	Draw 1	Draw 2	Draw 3	Draw 4	Draw 5
Quality of life adjustment factor	0.45	0.50	0.55	0.60	0.75
Life expectancy (years)	4.5	5.0	5.5	6.0	7.5
Quality of Life Year monetary value	£47.000	£47.000	£47.000	£47.000	£47.000
Benefit (lives saved x value of lives saved)	£95,175	£117,500	£142,150	£169,200	£264,375

Five draws are given above, using a rectangular distribution. These deliver estimates lying between £95,195 and £264,375.[1] The draw is repeated thousands of times. In this study, we use 10,000 runs as standard.

Creating 10,000 estimates allows the creation of a distribution of possible outcomes from the draws made. From this distribution, we can then compute the range within which we expect 90% of the observations from the draws to fall. This is called the 90% confidence interval.

3.5 Modelled scenarios

The data available has been deployed to measure the impact of three scenarios; current stage of the project in 5 hospitals; current implementation with all the NHS providers located in England and rollout across England.

Scenario 1 covers the impact of the Little Journey app in 5 sites currently using the product: South Tees Hospital NHS Foundation Trust, Royal Berkshire Hospital, Stoke Mandeville Hospital, Wexham Park Hospital and Cambridge University Hospital NHS Foundation Trust. The five sites have agreed to collect data before and after the intervention.

Scenario 2 covers all sites currently using Little Journey, e.g. 29 hospitals once private providers and sites located outside of England are excluded.

The scenario 3 simulates the roll out of Little Journey across all paediatric hospitals in England. Given the point at which this analysis is being conducted, roll out across the country has not been completed and data to allow the impact of the project to be evaluated is not currently

[1] In this particular study, these range from positive to negative values.

available. To control for this uncertainty, where the data used for the assumptions comes from the results of the current implementation, or is based on academic evidence, an additional optimism bias is applied to model the variability of implementation at scale.

3.6 Quantitative analysis - methods

The data collection was based on the 5 sites covered by the scenario 1. For each hospital, the project lead collected metrics on the surgery time and the medication given before and after the surgery. This data was collected as baseline and three months after the introduction of Little Journey and the target was to audit 20 patient notes in each site. The target was met for the baseline collection (100 patient records audited), and the sample size for the Little Journey period is 81.

This data enabled the study to perform statistical analysis, focusing on statistical significance, power and effect size. The Excel toolkit Analysis was used to run the statistical tests, with t-test two samples assuming equal variances and t-test two samples assuming unequal variances were used in the study as the sample size of the 2 time periods are different. As a rule of thumb, if one variance is up to 4 times the other, the equal variance assumption gives good results and the corresponding t-test is then used. Hedges' g formula was used to measure effect size. Effect size tells how much one group differ from another – usually a difference between an experimental group and control group. The following rules (Glen, 2016) were used to interpret the results:

- Small effect (cannot be discerned by the naked eye): 0.2
- Medium effect: 0.5
- Large effect (can be seen by the naked eye): 0.8

It is suggested to remain cautious when using these rules, the terms "small" and "large" effects can mean different things in different areas. For example, a "small" reduction in mortality rate is invaluable, where a "small" weight loss may be meaningless. When possible, this study referred to prior studies to see how the results fit into the bigger picture as advised by Durlak (2019)

4 Scenario 1 – Current programme in 5 sites

4.1 Scenario description

This scenario aims to present the impact of the current implementation in 5 hospitals in England who have agreed to collect surgery indicators prior to and after the implementation of the Little Journey app for 20 patients per site for both time period. South Tees Hospital NHS Foundation Trust, Royal Berkshire Hospital, Stoke Mandeville Hospital, Wexham Park Hospital and Cambridge University Hospital NHS Foundation Trustare the sites this scenario focuses on. They also consented for their project lead to fill a staff questionnaire focusing on the changes in the pathway and the staff perceptions.

The surgery KPI questionnaire is presented in the Appendix 2, it captures numerous parameters such as the patient age, weight, their fasting times, the premedication given, the induction technique, and post-operative medication. A breakdown of surgery-related times is also collected:

- **Time to induction:** time (in minutes) from entry to the anaesthetic room to the induction of anaesthesia (placement of endotracheal tube/ laryngeal mask airway).
- **Time to recovery readiness**: time from arrival in the recovery room to recovery room staff identification of readiness to be discharged to the ward.
- **Time to discharge:** time from arrival on the ward following surgery to discharge home.
- **Total time in hospital**: time from arrival in hospital on the morning of surgery to discharge home.

The model also utilised the data collected from the app users, the data is stored and analysed via Firebase, a feature of Google Analytics.

4.2 Key assumptions

The results of the individual benefit streams detail where the data regarding impact and cost information is sourced from. Where local data is not available, the following data, in order of preference, will be; regional or national specific data, with market forces factors applied; UK-focussed academic research; international academic research. Where academic research is used, preference is given to the most recent or relevant study evidence available. The base year in the model - e.g. the reference year for constructing an index (enabling to make comparison from this point) – is 2019 as it is the reference year for scenario 1. Any historical costing data used will be uplifted to current estimates using an inflation rate derived from the Gross Domestic Product (GDP) deflator produced by the Treasury from data provided by the Office for National Statistics (ONS) and the Office for Budget Responsibility (OBR).

Population for scenario 1:

This study uses the Hospital Episode Statistics (HES), a data warehouse containing details of all admissions, outpatient appointments and A&E attendances at NHS hospitals in England. It looks at the number of surgical day cases for paediatric patients (e.g. 133 HRG codes) for in the 5 Trusts involved in the data collection for the last 3 years (July 2016 to June 2017, July 2017 to June 2018 and July 2018 to June 2019) and forecasts the population from 2020 to 2023 using the relative growth during these 3 years.

Two ratios are applied to most benefits to exclude the patients who did not interact with the mobile app to benefit from its advantages.

- **Patient activation rate:** 71% of patients downloaded Little Journey. It is calculated based on the number of app users from South Tees (632) divided by the number of day cases booked during the evaluation period (e.g. 896).
- **Patient engagement:** 79% of patients have a total session time higher than 3 minutes or who created more than 3 sessions. It is calculated using the in-app data.

Both rates rely on the in-app data to evaluate the level of engagement of the users. However, the app does not collect any data for the users who did not consent to data collection when downloading the app or for those who didn't use the app for 3 minutes at a single session. Therefore, it is reasonable to assume that the rates are higher than the ones used in the modelling.

4.3 Overall benefits

In total, 11 significant monetised benefits of the programme are identified, across the six benefit streams. Identified benefits are based on the programme being funded by the 5 hospitals for the period analysed by the model.

Table 8 Scenario One: Overall benefits expected (£,000, net present value, 2019 prices)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
Population	11,151	10,154.00	10,653	11,175	11,724	**54,857**
NHS cash releasing savings	£ 0.92	£ 0.94	£ 0.87	£ 0.80	£ 0.72	**£ 4.25**
NHS non-cash releasing savings	£ 56.8	£ 56.1	£ 49.8	£ 43.7	£ 37.8	**£ 244.2**
Societal benefits	£ 101.3	£ 98.0	£ 85.2	£ 73.2	£ 62.0	**£ 419.8**
Total	**£ 159.1**	**£ 155.0**	**£ 135.9**	**£ 117.7**	**£ 100.4**	**£ 668.2**

4.4 Overall costs

The costs included within the model are a combination of initial costs and project costs. The initial costs are the cost of the staff time receiving training and taking the pictures and the cost posting the VR camera provided by theLSH team.

On a yearly basis, the Trusts support the costs of the service agreement, of the cardboard VR headsets, of the personalised cards (each Trust has a unique QR code that takes the patient directly to its surgery pathway) and of the staff time dedicated to implement and maintain the use Little Journey.

The intervention is currently largely subsidised by local charities: they support the cost of the consumables provided to the Trusts (cardboard headsets and patient cards). While, the charity funding does not influence the costs calculation of the model, it gives a more complete view of how the project was implemented and supported by the local stakeholders.

Besides, as an incentive for the Trusts to take part in the data collection, LSH waivered the service agreement fee for the first year for South Tees Hospital NHS Foundation Trust, Royal Berkshire Hospital, Stoke Mandeville Hospital, Wexham Park Hospital and Cambridge University Hospital NHS Foundation Trust. It was reflected in the model in scenarios 1 and 2. South Tees hospital have paid an annual agreement of £240 (inclusive of VAT). The service agreement fee was included for all sites in scenario 3 as a prudent assumption.

For every year of the project, the study assumes 6 hours, shared between a hospital-based nurse band 5 and a consultant anaesthetist, were dedicated in each site for training and various administrative tasks. The 'Unit Costs of Health and Social Care 2018' was used to get the hourly rate of these two health care professionals (respectively £37 and £108 per hour at 2019's prices).

Table 9 Scenario One: Overall costs expected (£,000, net present value, 2019 prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Service agreement cost	£ 0.3	£ 1.4	£ 1.3	£ 1.3	£ 1.3	**£ 5.5**
Consumables	£ 0.0	£ 10.1	£ 13.9	£ 17.8	£ 22.0	**£ 63.7**
Camera postage cost	£ 0.07	£ 0.0	£ 0.0	£ 0.0	£ 0.0	**£ 0.07**
Staff time cost	£ 2.6	£ 2.6	£ 2.5	£ 2.5	£ 2.4	**£ 12.6**
Total	**£ 3.0**	**£ 14.0**	**£ 17.7**	**£ 21.6**	**£25.7**	**£ 82.0**

Consumables: cardboard VR headsets and card

The cardboard headsets are provided by a third-party company and LSH can send them to the Trusts. South Tees hospital was given 40 headsets for free (unit cost: £2.80) and Addenbrooke's received 140 headsets for free, 70 were the new version at £2.80 per headset and 70 were the older version at £1.30 each.

The model reflects that in 2019 the VR sets were given for free to the 5 sites, for the following years it projects a progressive uptake of 30% of the patient population in 2020, 40% in 2021, 50% in 2022 and 60% in 2023. One could argue that the hospitals keen on paying for the cardboard headsets are likely to get enough to offer them to all their patients, whilst other hospitals would not get them and recommend to their patients to use the 2D version of the mobile app. However, deducting the behaviour of the different sites towards cardboard headsets would require making more assumptions based on the hospital size, its spending habits, etc. which can also be questioned. Therefore, using a progressive uptake to model the sites paying for the VR headsets is a reasonable approximation.

Business cards with printed QR codes has also being developed by LSH to give out to the patients at the pre-operative assessment clinics or to include in the surgery invitation letter. Each site was given about 100 business cards for free, the cost for the company was £23.95 for 1000 business cards.

The model reflects that in 2019 the personalised cards were given for free to the 5 sites, in the future LSH will send the design of the cards to the hospitals which will then print them in-house. Therefore, the personalised cards have not been included as an additional cost in the model.

Table 10 Scenario One: Overall costs for consumables (£,000, net present value, 2019 prices)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Number of VR cardboard sets	180	3,196	4,470	5,862	7,380
Cost for VR sets	**£ 0.0**	**£ 10.1**	**£ 13.9**	**£ 17.8**	**£ 22.0**

4.5 Overall scenario results

Taking the costs and benefits specified above into account, the following return on overall investment can be seen:

Table 11 Scenario One: Overall return on investment (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
Total Benefits	£ 159.1	£ 155.0	£ 135.9	£ 117.7	£ 100.4	£ 668.2
Total costs	£ 3.0	£ 14.0	£ 17.7	£ 21.6	£25.7	£ 82.0
Net present value (benefits – costs)	£ 156.1	£ 141.0	£ 118.2	£ 96.2	£ 74.7	£ 586.2
Benefit to cost ratio	53.6	11.1	7.7	5.5	3.9	8.2

We also provide a sensitivity analysis to investigate the net present value (NPV) which this analysis presents. This shows that overall NPV could vary between -£2.81m and £4.12m at the 90% confidence level. Although, the NPV is negative at the lower end of the range, the sections 4.1 to 4.10 explain the different benefits and why some of them are weighting negatively on the overall sensitivity analysis of the NPV. The limited data and small sample size are the main elements explaining why some negative benefits are witnessed. The benefits presented in the table above, however, are the most likely scenario.

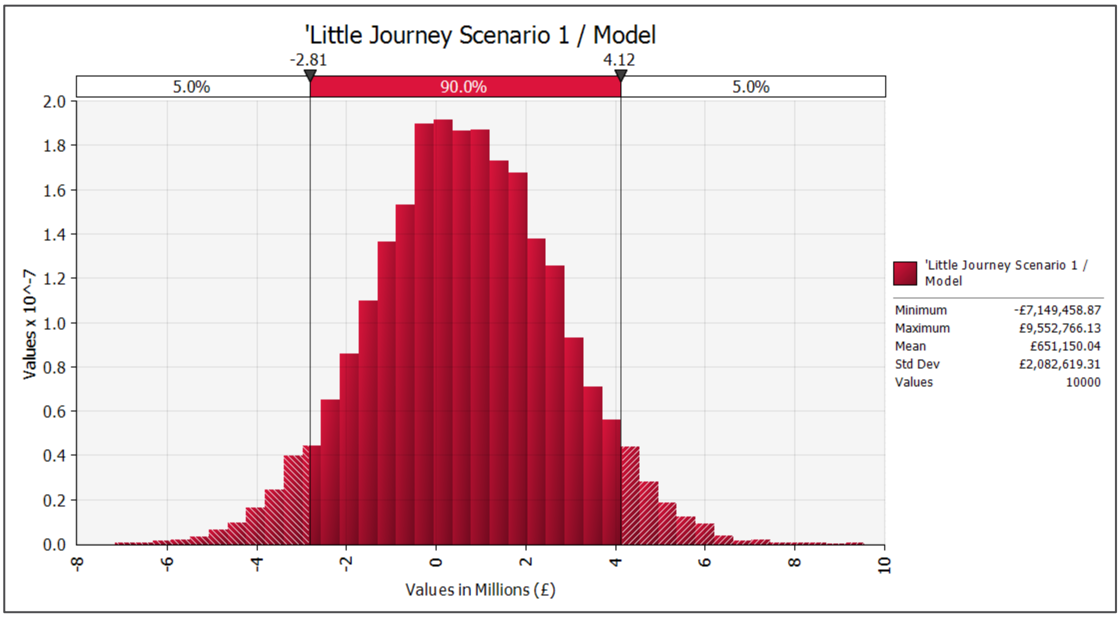


Figure 3 Probability of total net present value (NPV) – Little Journey scenario 1

On-the-day cancellations

Introduction

Elective surgical case cancellations are a persistent problem. Last minute cancellations cause additional anxiety, frustration and anger for patients going through the surgical pathways. Moreover, operating theatres rely on a constant flow to function efficiently and to fill capacity. Late cancellations interrupt patient flow and decrease the throughput of the theatres resulting in wasted resources.

According to the Foundation Trust Network, the participants of the Benchmarking Operations Theatre 2013 project had a median of 7.5 cancellations per 100 procedures and last-minute procedure cancellations by patients (both adult and paediatric patients) accounted for 39% of all last-minute procedure cancellations.

To tackle last minute cancellations, effective assessment and communication with patients prior to the day of surgery is key. While most Trusts have a process in place to remind patients of upcoming procedure dates, the format and implementation of this service varied between trusts.

Discussions identified the importance of tailoring the method and process to the patient group; for example, texting reminders to elderly patients may not be the most effective way of communicating, while for working patients negotiating the date of procedure reduces the chance of a DNA (did not attend).

The Little Journey app has a parent menu dedicated to checking if their child is fit for surgery and that they are able to travel to the hospital. That includes asking if they have been unwell recently (scanning for URTI – upper respiratory tract infection) or if any change in the condition was noticed since last seen by the surgeon (risk of deterioration) but also a reminder of the fasting guidelines based on the child's age and surgical procedure. Moreover, the app now proposes to the user to call the hospital to reschedule the procedure if they declare their child unfit for surgery.

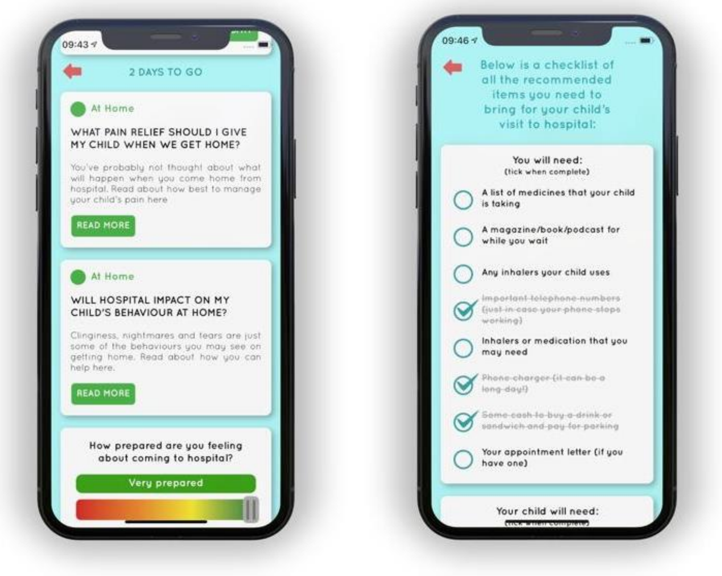


Figure 4 Parent menu of the Little Journey application

According to the in-app data, 49 users have phoned their hospitals, after being prompted by the app to reschedule the surgery if their child was not deemed fit for surgery according to the app check list between May and July 2019.

This figure was used in the model for the scenario 1 as the population for the benefits related to on-the-day cancellations. For scenarios 2 and 3, the percentage of patients rescheduling their surgery through the app was calculating using the figure used for scenario 1 divided by the total number of users for the same time period. This percentage is 0.009% after application of the optimism bias.

The evaluation also had access to the on-the-day cancellation rate of South Tees Hospital prior to the intervention, 6.2% between April 2018 and March 2019, and during the project period, 4.8% between May 2019 and July 2019. This suggests a 1.4% reduction during the Little Journey period. It is very encouraging however there is no indication these cancellations have been triggered by the use of Little Journey; therefore, the model is using the in-app data.

Benefit calculations

Accorded to Turunen and colleagues (2018), the cost of a paediatric cancellation is 1,511€ (Finland, 2016 prices) e.g. £1,206 once adjusted with the 2016 exchange rate.

The benefit calculation takes the difference of cancellation rate between the baseline and the one assumed after the intervention, that difference is then multiplied by the cost of a paediatric cancellation.

Besides the financial burden represented by on-the-day cancellations, postponing a surgery also means that the patient remains in pain whilst waiting for the surgery and lead to higher incidence of complications, thus affecting the children's well-being (Rabbitts, et al., 2015).

Health-related quality of life (HRQOL) is a widely reported patient-centered outcome and an important marker of recovery for children undergoing surgical procedures. Using age-appropriate versions of the 23-item Pediatric Quality of Life Inventory 4.0 Generic Core Scales (PedsQL)' Rabbitts et al. (2015) found a baseline HRQOL value of 81.9 compared to a value of 84.8 one month after hospital discharge.

This improvement in quality of life cannot be witnessed if the surgery is cancelled, therefore paediatric patients lose the difference of HRQOL while they wait for a new surgery.

The average number of days a paediatric patient has to wait after an on-the-day cancellation widely varies depending on the relative urgency of performing the procedure, the Trust capacity and the waiting list system implemented. Therefore to account for the waiting time, this study uses the 28-day standard as a proxy measure. The NHS consitution (NHS, 2018) states that if the hospital cancels your operation at the last minute for non-clinical reasons, they should offer you a new date within 28 days of the date your operation was originally booked for.

These difference to health related related quality of life are used to calculate a QALY figure to which can be applied a value based on the NICE willingness to pay threshold. The model uses a methodology described in Brennan (2006) to achieve this, resulting in a 1.74% difference in the quality of a patient's life, once optimism bias is removed. This is multiplied by the fraction of a year that patients on average can expect to wait for their surgery, 28 days based on the NHS constitution. Multiplying this value by the NICE willingness to pay threshold value gives a realistic estimation of the NHS specific economic cost of reduced quality of life.

Finally, cancellations of paediatric outpatient surgery also have economic implications for the patient's families. Tait et al. (1997) reported that 38.5% of mothers and 50.0% fathers missed a day of work due to an on-the-day cancellations. Although a factor of children have both their parents present on the day of surgery, this study assumes that one family member/carer accompanies the patient.

A missed day of work represents a lack of earning for the population, the Annual Survey of Hours and Earnings (ASHE) estimates the median gross weekly earnings in 2017 at £448.5 (for all employees – full time, part time and independent contract). This value was used to calculate the social benefits resulting a reduction of missed days of work.

Applied to the population, the model suggests the following benefits from the programme.

Table 12 Scenario 1: breakdown for reduced on-the-day cancellation (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Cash releasing benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Non-cash releasing benefit	**£ 49.9**	**£ 49.0**	**£ 43.2**	**£ 37.7**	**£ 32.3**
Social benefit	**£ 101.3**	**£ 98.0**	**£ 85.2**	**£ 73.2**	**£ 62.0**
Total benefits	**£ 151.3**	**£ 147.0**	**£ 128.5**	**£ 110.9**	**£ 94.3**

4.6 Induction time

The conduct of paediatric anaesthesia presents many unique challenges. One of the most striking is the variability of behaviour and responses of children and their parents at induction. Behavioural problems, the need for restraint, difficult intravenous (IV) access and co-morbidities add complexity and can make the art of maintaining a calm and smooth induction incredibly difficult (Kelly, et al., 2017).

There are several methods of anaesthetic induction: Gaseous induction, breathing a mixture of volatile anaesthetic agents until loss of consciousness is achieved; Intravenous induction, where an anaesthetic drug is injected intravenously in a dose sufficient to produce unconsciousness; Other, where an induction agent is given by a non-intravenous route, generally orally, rectally or intramuscularly, to produce loss of consciousness. In this study, we are considering gas and intravenous inductions only.

Gas induction

Traditionally, the gas induction method is thought to be less harmful for children (Hamer Hodges, 1960; Hamilton, 1995; Lerman & Johr, 2009). In many textbooks of pediatric anesthesia, the potential fear of needle among pediatric patients is stressed.

However, mask can trigger as much resistance as a needle. Moreover, volatile agents have an unfamiliar and often pungent smell causing even the most well-prepared child to lose composure when the concentration of anesthetic gas is increased.

Sevoflurane is a commonly used induction agent, it is not associated with a pungent odor, airway irritation or hemodynamic instability, and thus is widely accepted by not only patients but also anesthesia providers. The limitation of using sevoflurane is the associated cost, especially when used in high concentrations and at high fresh gas flows, as in paediatric inhalation induction (Singh, et al., 2014).

To monetise the impact of a shorter induction time when gas induction is used, this study relies on the findings of Singh et al. (2014), i.e. that 3.09mL of sevoflurane used per min for an incremental induction. According to the National Institute for Health and Care Excellence (NICE) – British National Formulary, the cost for hospital of sevoflurane volatile liquid is £123 per 250mL, therefore an incremental sevoflurane induction is estimated at £1.52 per min for the benefit calculations.

The baseline induction time was of 8.77 minutes (8 minutes and 46 seconds) and of 7.90 minutes (7 minutes and 54 seconds) after the introduction of Little Journey. No statistical difference was found when performing the analysis (P>0.05 for a t-test).

Intravenous induction

Intravenous induction agents have the potential to produce a more stable anaesthesia, can be used in more complex scenarios (e.g. upper airway surgery), do not rely on alveolar ventilation to take effect and are relatively easy to monitor and adjust during the procedure, without producing operating room pollution (Eyres, 2004). While gaseous induction often bolts from avoiding the use of needles during waking periods, the use of mask may also be associated with anxiety and stress in the child (Zielinska, et al., 2011), especially when placed onto the child and held there against their will.

Besides, the pungency of some inhalation agents is such that they can be upsetting to the child and may irritate the respiratory tract to some degree (Brown, 2013). Other advantages of intravenous induction are seen in the rapid induction produced compared with gaseous induction, which is particularly important in emergency anaesthesia situations (FRCA, 2014). Furthermore, a child with a full stomach or with a notable degree of gastro-oesophageal reflux may pose a relative contraindication to gaseous induction.

Propofol in particular is commonly used in children and is able to produce anaesthesia as rapidly as gaseous agents, although distribution throughout the bodily compartments is more extensive (Zielinska, et al., 2011). The propofol infusion rate recommendations in children aged 3 to 11-year-old used in this study is given by Gaynor & Ansermino (2016) at 0.25 mg/kg/min (i.e. 0.025 mL/kg/min). The NHS hospital price is £20.16 for 5 ampoules of 20mL (active agents: propofol 10mg per 1mL) according to NICE – British National Formulary.

The baseline induction time was of 7.33 minutes (7 minutes 20 secondes) and of 7.86 minutes (7 minutes 51 secondes) after the introduction of Little Journey. No statistical difference was found when performing the analysis (P>0.05 for a t-test).

To understand the change in intravenous induction time, this study looks at the mean value per hospital before and after the implementation of Little Journey as well as the average of absolute deviations of data points from their mean. A significant difference in the value of the average of absolute deviations for baseline and post Little Journey indicate the presence of more outliers in one of the datasets.

The results of the analysis are presented in table 13.

Table 13 Intravenous induction time for the 5 sites of the scenario 1

	Addenbrookes	South Tees	Stoke Mandeville	Wexham Park	Royal Berkshire
Mean value pre	**6.44 min**	**7.69 min**	**9.11 min**	**13.42 min**	**2.29 min**
Sample size (pre)	**9**	**12**	**9**	**12**	**17**
Variance (pre)	**20.02**	**7.51**	**8.99**	**44.41**	**1.03**
Mean value post	**7 min**	**6.76 min**	**11.7 min**	**12.2 min**	**5.14 min**
Sample size (post)	**1**	**21**	**6**	**9**	**16**
Variance (post)	**0**	**6.28**	**33.89**	**29.28**	**10.98**

For Cambridge University Hospital NHS Foundation Trust, the induction time increased from 6.44min to 7min however there was only one data point for the post period therefore no conclusion can be drawn for this site. In South Tees Hospital and Wexham Park Hospital, there was respectively a 56-second and a 1 minute and 13 seconds decrease in the induction time after the introduction of Little Journey. The values of the variances are also of similar order.

However, there was an increase in the induction time for both Stoke Mandeville Hospital and Royal Berkshire Hospital and in both cases the variance values post Little Journey are four to ten times higher than the variance at the baseline. The variance gives a measure of the scatter of the data set, thus, this difference in spread of the data points limits the relevance of comparing induction times between the two time periods.

This study would recommend a larger scale data collection to better determine the impact of the Little Journey app on intravenous induction time. However for the purpose of this evaluation, the overall increase of 31 seconds (1 minute 18 seconds after application of the optimism bias) has been used for the modelling of the benefits.

Staff time cost

Another cost to include when working on the induction process is the cost of the staff time. Indeed, at least a consultant anaesthetist and an Operating Department Practitioner (ODP) are present in the induction room. Thus, a reduced induction time can free up some capacity for the staff present. The Unit Costs of Health and Social care (2018) estimate the hourly rate of consultant anaesthetist and of an ODP at respectively £108 and £37. The increase in the induction time) was used to calculate the impact of the introduction of Little Journey.

Change of induction method

Changing the scheduled induction technique from intravenous to gas on the day of the surgery is not only time consuming but also represents a loss of materials, indeed, the IV cannulae is one-use-only. According to the NHS supply chain price ranking sheets, the price is £0.78 per cannulae (for a safety cannulae ported with wings blue 22G x 25mm PUR).

The baseline percentage of change of induction technique of 12% and of 11.3% after the introduction of Little Journey was used to calculate this benefit stream.

Results of benefit

Taken as a whole, these benefits contribute the following economic results to the programme:

Table 14 Scenario One: Benefits breakdown for induction time changes (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Cash releasing benefit	**- £ 0.02**	**- £ 0.02**	**- £ 0.02**	**- £ 0.02**	**- £ 0.02**
Non-cash releasing benefit	**- £ 1.2**	**- £ 1.3**	**- £ 1.2**	**- £ 1.1**	**- £ 1.0**
Social benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Total benefits	**- £ 1.3**	**- £ 1.3**	**- £ 1.2**	**- £ 1.1**	**-£ 1.0**

The Table 14 presents the economic impact of the change in induction time. The increase in induction time generates a negative value for the benefit of £5,783.2 over the 5 years modelled. The section "intravenous induction" explains the limitations of the data, and the recommendations to repeat and expand the data collection as the change is not statistically significant and the difference in variance makes the comparing the two time periods delicate.

4.7 Perioperative medication

Introduction

Induction of anaesthesia may be a stressful experience for children and their parents. If the child resists intervention, unnecessary distress may occur. As well as being undesirable in itself, this may also influence the child's attitude to medical care in the future (Bray, et al., 2019).

Sedative premedication of children reduces the frequency of crying and the need for restraint at induction of anaesthesia even when the child is accompanied by a parent and has a topical anaesthetic applied before intravenous induction (Page & Morgan-Hughes, 1990). Sedative premedication makes post hospital behavioural disturbances less likely even after day surgery (McCluskey & Meakin, 1994). One well researched sedative premedicant for children is oral midazolam 0.5–0.75 mg/kg, administered 30–60 min before induction. It can be used in day case anaesthesia. And was the one premedication reported in this study.

Despite its common use, attitudes towards the practice of routine paediatric premedication vary considerably amongst health professionals. Rosenbaum & Kain (2009) highlight the key points arguing against the routine use of premedication in children:

- With modern anaesthetics, the need for premedication is drastically reduced
- Parental presence reduces the need for routine pharmacologic premedication
- The specific effect of midazolam to block explicit memory while preserving implicit memory is a serious problem in children
- Implementation of a multimodal information package is a valid alternative to premedication in a large number of cases

Little Journey, with its child-centred and age-specific content, allows both carer and child to have a better understand of what will happened, what the operative environment is looks like, and insights into the risks involved. It can therefore limit the need for premedication.

An additional detriment of premedication is the increase in pain experienced. The evidence in paediatric practice that relief of post-operative pain is cost-effective or beneficial to organ function is lacking. Nonetheless pain relief is a basic humanitarian requirement, which in the hospital environment is entrusted to healthcare professionals (Department of Health, 2003). It is essential that this responsibility is discharged safely and effectively.

In the data provided by the 5 sites, the 3 most commonly used premedication used were paracetamol, ibuprofen and midazolam. In the baseline, 24% of patients received premedication (out of 101 patients), against 2.5% during the Little Journey project period (out of 80 patients). The difference between the two periods was statistically significant ($P<0.001$ when performing a t-test).

Paracetamol, ibuprofen, dihydrocodeine and ondansetron were the most common drugs given post-surgery in the study. In the baseline, 36% of patients received postoperative medication (out of 101 patients), against 58% during the Little Journey project period (out of 80 patients). The difference between the two periods was statistically significant ($P= 0.002$ when performing a t-test).

A dose of 10mg of oral midazolam was used in the benefit calculation, in accordance with the data source. The table 15 presents the unit cost of midazolam, as well as other commonly used drugs for premedication and post-operative medication.

Benefits calculation

The difference in medication given to patients was used to calculate the benefit stream. The British National Formulary for Children (NICE, 2019) gives the drug tariff price for the drugs given to our population and the unit cost was calculated by taking into account the dosage for the different medications.

The table below details the drug tariff price (at 2019's price), the number of units per box, the dosage (according to the data source) and the unit cost.

Table 15 National drug tariff prices (£, net present value, 2019 values)

	Drug tariff price	Number of units	Dosage	Unit price
Paracetamol	£ 0.98	12	500mg tablet	**£ 0.08**
Ibuprofen	£ 1.18	16	200mg tablet	**£ 0.07**
Midazolam	£ 91.50	4	10mg oral syringe	**£ 22.88**
Dihydrocodeine	£ 0.87	28	30mg tablet	**£ 0.03**
Ondansetron	£ 18.00	10	4mg tablet	**£ 1.80**

Table 16 Scenario One: Benefits breakdown for reduction of perioperative medication (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Cash releasing benefit	**£ 0.9**	**£ 1.0**	**£ 0.9**	**£ 0.8**	**£ 0.7**
Non-cash releasing benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Social benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Total benefits	**£ 0.9**	**£ 1.0**	**£ 0.9**	**£ 0.8**	**£ 0.7**

4.8 Recovery readiness and discharge times

Introduction

The definition of day surgery in the UK and Ireland is clear: the patient must be admitted and discharge on the same day, with day surgery as the intended management. Thus, discharge time is a capital outcome to ensure the good standard of paediatric surgeries. The British Association of Day Surgery recognises that nurse-led discharge is fundamental to safe and effective day and short stay surgery (The Association of Anaesthetists of Great Britain and Ireland & The British Association of Day Surgery, 2011).

Recovery from anaesthesia and surgery can be divided into three phases:

- **Recovery readiness or first stage recovery** lasts until the patient is awake, protective reflexes have returned and pain is controlled. This is undertaken in a recovery area with one member of staff per patient present. Use of modern drugs and techniques may allow early recovery to be complete by the time the patient leaves the operating theatre, allowing some patients to bypass the first stage recovery area (Lubarsky, 1996). Most patients who undergo surgery with a local anaesthetic block can be fast-tracked in this manner.
- **Discharge or second stage recovery** ends when the patient is ready for discharge from hospital. This should ideally be in an area adjacent to the day surgery theatre. It is equipped and staffed to deal with common postoperative problems (PONV, pain) as well as emergencies (haemorrhage, cardiovascular events). Some of the traditional discharge criteria such as tolerating fluids and passing urine are no longer enforced. Mandatory oral intake is not necessary and may nausea and vomiting and delay discharge. Protocols may be adapted to allow low-risk patients to be discharged without fulfilling traditional criteria. Patients and their carers are provided with written information that includes warning signs of possible complications and where to seek help.
- **Late recovery** ends when the patient has made a full physiological and psychological recovery from the procedure. This may take several weeks or months and is beyond the scope of this document.

Initiatives aiming to reduce anxiety and improve children understand of the surgical procedure have proven to reduce the recovery and discharge time. Indeed, a randomised controlled trial the demonstrated that the presence of medical clowns shortens the overall time in the hospital (Kocherov, et al., 2016).

Additionally, a South Korean research team underlined the efficacy of an immersive virtual reality (VR) tour of the operating theatre in children to reduce anxiety (Ryu, et al., 2017). Children in the VR group had a significantly lower score on the modified Yale Preoperative Anxiety Scale (m-YPAS) than those in the control group (median 31.7 (interquartile range 23.3–37.9) and 51.7 (28.3-63.3) respectively; P <0.001). Thus, the immersive preoperative tour was effective in alleviating preoperative anxiety in children.

Recovery readiness time were measured in the 5 hospitals, the average value pre-intervention and post-intervention respectively are 35.73 minutes and 31.32 minutes (e.g. respectively 35 minutes 44 seconds and 31 minutes 19 seconds). No statistical difference was found when performing the analysis (P>0.05 for a t-test).

Similarly, discharge time was measured during the baseline, it was on average 3 hours and 12 minutes, and during the Little Journey implementation, it was on average of 4 hours and 25 minutes. To understand this significant difference this study looked at the average value at pre and post intervention for each site. The table below summarises the analysis.

Table 17 Discharge time breakdown per hospital (based on respectively 100 and 80 patients for the pre and post intervention)

	Baseline mean (h)	Baseline median (h)	Little Journey mean (h)	Little Journey median (h)
Cambridge University Hospital NHS Foundation Trust	04:34:44	04:00:00	03:30:00	04:00:00
South Tees Hospital	02:27:43	02:04:40	03:11:07	02:40:00
Stoke Mandeville Hospital	04:38:25	02:00:00	03:30:00	04:00:00
Wexham Park Hospital	03:23:15	02:45:00	03:20:00	02:45:00
Royal Berkshire Hospital	00:59:51	00:35:00	09:48:00	02:27:00

The table 17 highlights the discrepancy in Royal Berkshire Hospital discharge times: its baseline discharge time is 59 minutes when the other sites range between 2h27 and 4h38. Similarly, its post-intervention discharge time is over 9h when the other sites discharge time ranges between 3h10 and 3h30. Another element to consider is the median value, a baseline median value of 35 minutes, close to the mean value, suggests that the data points were uniformly lower across the 20 patients. On the contrary in the post intervention period, the median discharge time is 2h27 which suggests that the average is skewed upward by outlier values.

Out of the 20 patients notes audited for the baseline data capture, the hospital indicated that 14 were community dental short surgeries and 4 were oral surgeries which can explain the significant difference in discharge time.

The project lead also indicated that the post-intervention data collection was captured more complex ENT/ophthalmology surgeries, the outliers discharge times in this time period could be due to this difference in complexity of surgery

Because of the clear difference of patient cohorts both between the pre and post intervention period but also when comparing Royal Berkshire Hospital to the other sites, it was decided to exclude Royal Berkshire Hopsital of the average discharge time.

After exclusion of this site, the baseline discharge time was measured on average 5 hours and 8 minutes, and the Little Journey discharge was on average of 2 hours and 58 minutes. No statistical difference was found when performing the analysis (P>0.05 for a t-test).

Benefits calculation

The difference in recovery readiness time before and after the introduction of Little Journey was used for the benefit calculation. During the first stage recovery, each paediatric patient has a one-on-one with a staff member (ODP or nurse) until they are recovery ready. Reducing the length of the first stage recovery would free capacity, allowing the health professional to attend to other patients, and generate a non-cash releasing benefit. The hourly rate of a hospital-based nurse (band 5) is £37 according to the Unit Costs of Health and Social Care (2018). The total population, the percentage of patients actively using the app, the difference in recovery readiness time and the hourly rate for a band 5 nurse were multiplied to calculate this financial benefit.

Table 18 Scenario One: Benefits breakdown for reduction in recovery readiness time (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Cash releasing benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Non-cash releasing benefit	**£ 0.4**	**£ 0.4**	**£ 0.4**	**£ 0.4**	**£ 0.3**
Social benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Total benefits	**£ 0.4**	**£ 0.4**	**£ 0.4**	**£ 0.4**	**£ 0.3**

Similarly, the difference in discharge time was utilised to calculate the financial consequence of the Little Journey app. To monetise the impact of a difference in discharge time, this study uses the cost of a day case, e.g. £1,579.6 ('2017/18 and 2018/19 National Tariff: currencies and prices' for 141 selected HRG codes), considering that cost is spread across 12 hours (in our dataset more than 90% of discharge times were under 12 hours), which equates to a cost of £131.63 per hour.

Table 19 Scenario one: Benefits breakdown for reduction in discharge time (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Cash releasing benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Non-cash releasing benefit	**£ 6.6**	**£ 6.8**	**£ 6.3**	**£ 5.7**	**£ 5.2**
Social benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Total benefits	**£ 6.6**	**£ 6.8**	**£ 6.3**	**£ 5.7**	**£ 5.2**

4.9 Unplanned admissions after surgery

Unplanned overnight admission to hospital is stressful and a major inconvenience for children and their families. For healthcare providers it has adverse organisational and financial consequences. Unplanned admission increases the pressure on acute beds and hospitals are obliged to absorb the increased costs of inpatient care. High unplanned admission rates may be due to inadequacies in one or more aspects of the care pathway; patient selection, pre-assessment, peri-operative management, staff experience, as well as the day care facilities, geographical factors and case mix (Royal College of Aneasthetists, 2012).

The Royal College of Anaesthetists and the Royal College of Surgeons of England have recognised unplanned admission rates as an important quality indicator of children's day case surgery in recent reports (Royal College of Aneasthetists, 2009). According to the same authority, an unplanned admission rate of <2% from day surgery units with a mixed adult and paediatric practice is suggested as an appropriate benchmark.

The Little Journey app, with its highly immersive tour of the operating theatre and real-time interactions, meets the challenge of providing informative yet recreational content. It sets out to reduce patient anxiety which in turns positively affects the whole of the periopearive pathways: from improving patient attendance to avoiding unplanned admissions.

In the sites included in scenario 1, the average rate was of 0.18% for the baseline (for 100 patients) and of 0.15% after the intervention (out of 85 patients). The data collection was performed retrospectively for the baseline audit and between May and July 2019 for the post intervention audit.

Benefits calculation

Using the difference in admission rates pre and post intervention and the cost of an unplanned admission and after applying the appropriate optimism bias, this study is able to evaluable this financial benefit.

The '2017/18 and 2018/19 National Tariff: currencies and prices' was used to calculate the cost of an unplanned admission. The average non-elective spell tariff for paediatric procedures is £1,906 (based on 141 HRG codes, 25 codes were expensive outliner codes and therefore excluded).

Table 20 Benefits breakdown for avoided hospital admission (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Cash releasing benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Non-cash releasing benefit	**£ 1.1**	**£ 1.2**	**£ 1.1**	**£ 1.0**	**£ 1.0**
Social benefit	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**	**£ 0.0**
Total benefits	**£ 1.1**	**£ 1.2**	**£ 1.1**	**£ 1.0**	**£ 1.0**

4.10 Other benefits

In addition to the economic and patient quality of life benefits described above, other benefits relate to the Little Journey mobile which can be seen to accrue over time. It is not prudent to attempt to attach an economic value to these benefits, due either to insufficient evidence, or no realistic way to monetise the benefit.

These benefits have been grouped under the type of benefit that they fall under.

Fasting times guidelines

Pre-operative fasting, which is defined as the restriction of food and fluid intake for few hours before general anaesthesia or sedation, is one of the cornerstones of perioperative patient safety. Induction of anaesthesia or sedation results in a depression of the gag, cough and swallow reflexes that normally protect the airway, placing patients at risk of pulmonary aspiration, pneumonia and even death should regurgitation or vomiting of gastric contents occur (Hamid, 2014). The guidelines for preoperative fasting recommend intervals of 6, 4, and 2 hours (6-4-2) of fasting for solids, breast milk, and clear fluids, respectively (Frykholm, et al., 2018).

Subjects are fasted before surgery in order to allow gastric emptying, thus reducing the risk of pulmonary aspiration (Royal College of Nursing, 2013). However prolonged periods of fasting can cause hypoglycaemia, metabolic acidosis, dehydration, cardiovascular instability, discomfort, hunger, and grumpiness, especially in toddlers and infants (Frykholm, et al., 2018).

Recent research has brought forward new insights concerning preoperative fasting in children. Firstly, children are often fasted for unnecessarily long intervals despite the implementation of current guidelines, Thomas, et al. (2018)'s research suggested a clear fluids fasting duration of on average 6-7 hours and up to 15 hours for several studies. Secondly, that prolonged fasting could have detrimental metabolic and behavioural effects in small children, it increases thirst and irritability for instance (Agegnehu, et al., 2016). Thirdly, that the rationale for 6-4-2 h limits in current guidelines may be questioned, indeed in 2018, the traditional 2-hour clear fluid fasting time was updated. The Association of Paediatric Anaesthetists of Great Britain and Ireland, the European Society for Paediatric Anaesthesiology, and L'Association Des Anesthesistes-Réanimateurs Pédiatriques d'Expression Francaise agreed that clear fluid fasting times for elective general anaesthesia and sedation can be reduced to 1 hour, unless clinically contraindicated (Thomas, et al., 2018).

In our study, solid and liquid fasting times were measured at baseline and after the introduction of Little Journey. There was a significant difference between the average solid fasting times during the baseline and Little Journey period with respectively 13h23min and 11h42min (P= 0.0014 for the t-test). The Hedges' g statistic test was also used in the study and showed an effect size of 0.49. Effect size gives an indication of how much one group differs from another (Walker, 2008) – in our case the difference between the baseline and the Little Journey group. With 0.5 being considered as a medium effect, our result shows the difference of fasting times between the two time periods is not only statistically significant but also meaningful (as opposed to trivial).

Although a significant reduction was observed, the average value was almost twice as high as the recommended 6h. Excessive fasting times were also found by Buller & Sims (2016) with 30% of patients audited fasting for more than 12 hours. Their study also revealed that children on morning lists fasted longer than children on afternoon lists.

The baseline liquid fasting time was of 315.89 minutes (5 hours and 16 minutes) and of 261.88 minutes (4 hours and 22 minutes) after the introduction of Little Journey. No statistical difference was found when performing the analysis (P>0.05 for the t-test) and the Hedges' g test revealed a small effect size (g=0.198). Similarly, Buller & Sims found that 62% of children fasted longer than 4h for clear fluids.

These findings highlight that Little Journey, with its interactive parent menu which reminds them of the recommended guidelines, has a positive impact on the patient fasting times. Applying the appropriate fasting times can prevent distress and discomfort for the patient as well as catabolic state, hypoglycaemia, reduced intravascular volume and difficult intravenous access if prolonged. Despite the reduction in fasting times observed, the study shows there is a significant potential for improvement for the sites audited.

While other studies have investigated how early postoperative oral fluid intake influences the need for opioids and the incidence of vomiting (Chauvin, et al., 2017) no research to our knowledge establishes a quantified causality link between excessive fasting times and medical outcomes. Indeed, it is linked with adverse effects for the patients, but it cannot be quantified in terms of material or human resources used. Therefore, this benefit stream was not monetised.

Hospital reputation

Patient’s relatives are often very conscious of the care received, with parents having great expectations from the healthcare professionals when their child is undergoing day case surgery. A tool introduced to mitigate the distress and anxiety generated by a surgical procedure and better share information ahead of the hospital visit would be viewed in positive light both by the patient’s relatives and member of staff involved in the paediatric surgical procedure.

Hospitals adopting Little Journey can improve the patient and patient’s family experience as well as improving the knowledge on child-centred communication channel, adding to the body of research available.

5 Scenario 2 – Current implementation

5.1 Scenario description

The scenario 2 assessed follows the implementation of the Little Journey initiative within 29 hospitals located in England. The project started in September 2017 and funding was obtained to run the project for 3 years. Modelling this provides evidence of the possible impact of the project as it is currently envisioned at a realistic level.

The benefit streams identified remain the same as for scenario 1, although estimated values change in line with the changes to the treated population and the phasing of the roll-out.

5.2 Key assumptions

The model uses the same assumptions as within scenario 1.

In this scenario, the population reflects the larger number of hospitals involved in the current implementation. The year weighting is identical to the scenario 1's year weighting as they are both looking at the same time period.

5.3 Overall benefits

As with scenario 1, 11 significant monetised benefits of the programme are identified, across the three benefit streams of cash releasing and non-cash releasing healthcare system savings and societal benefits.

Table 21 Overall benefits for scenario 2 (£,000, net present value, 2019 values)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
Population	78,771	72,733	75,752	78,896	82,171	**388,323**
NHS cash releasing savings	£ 6.4	£ 6.6	£ 6.0	£ 5.5	£ 4.9	**£29.5**
NHS non-cash releasing savings	£ 420.2	£ 429.3	£ 394.8	£ 358.3	£ 320.2	**£1,922.7**
Societal benefits	£ 752.4	£ 757.7	£ 686.6	£ 614.5	£ 541.4	**£3,352.6**
Total	**£ 1,179.0**	**£ 1,193.6**	**£ 1,087.4**	**£ 978.2**	**£ 866.6**	**£5,304.8**

5.4 Overall costs

Similarly to the scenario 1, the costs included in the table 22 combine:

- Cost of staff time
- Service agreement fee
- Camera postage costs
- Optional cardboard headsets and cards

Besides, as an incentive for the Trusts to take part in the data collection and to secure some data for this study, LSH waivered the service agreement fee for the first year for 4 of the 29 hospitals.

For every year of the project, the study assumes 6 hours, shared between a hospital-based nurse band 5 and a consultant anaesthetist, were dedicated in each site for training and various administrative tasks. The 'Unit Costs of Health and Social Care 2018' was used to get the hourly rate of these two health care professionals (respectively £37 and £108 per hour at 2019's prices).

The scenario reflects that in 2019 the VR sets were given for free, for the following years it projects a progressive uptake of 30% of the patient population in 2020, 40% in 2021, 50% in 2022 and 60% in 2023.

Overall costs for the scenario 2 (£,000, net present value, 2019 prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Service agreement cost	£ 6.9	£ 7.9	£7.7	£ 7.6	£ 7.4	**£ 37.4**
Consumables	£ 0.0	£ 71.8	£97.8	£ 124.8	£ 153.0	**£ 447.4**
Camera postage cost	£ 0.4	£ 0.0	£ 0.0	£ 0.0	£ 0.0	**£ 0.4**
Staff time cost	£ 15.2	£ 14.9	£14.7	£ 14.4	£ 14.1	**£ 73.3**
Total	**£ 22.5**	**£ 94.6**	**£ 120.2**	**£ 146.7**	**£ 174.5**	**£ 558.5**

Table 22 Overall costs for consumables (£,000, net present value, 2019 prices)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Number of VR cardboard sets	180	22,726	31,559	41,086	51,349
Cost for VR sets	**£ 0.0**	**£ 71.8**	**£97.8**	**£ 124.8**	**£ 153.0**

5.5 Overall scenario results

Taking the costs and benefits specified above into account, return on overall investment is as follows:

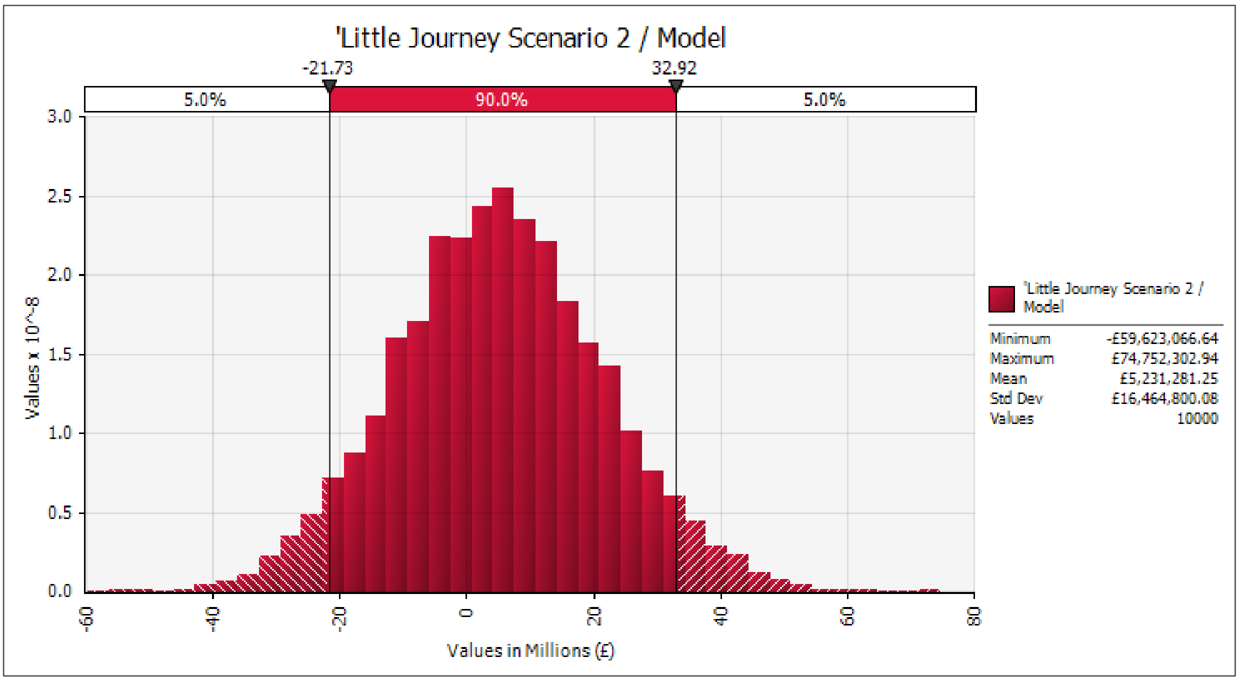
Table 23 Overall return on investment (£,000, net present value, 2019 prices.)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
Total Benefits	**£ 1,179.0**	**£ 1,193.6**	**£ 1,087.4**	**£ 978.2**	**£ 866.6**	**£ 5,304.8**
Total costs	**£ 22.5**	**£ 94.6**	**£ 120.1**	**£ 146.7**	**£ 174.5**	**£ 558.5**
Net present value (benefits – costs)	**£ 1,156.5**	**£ 1,099.0**	**£ 967.3**	**£ 831.5**	**£ 692.1**	**£ 4,746.3**
Benefit to cost ratio	**52.36**	**12.62**	**9.05**	**6.67**	**4.97**	**9.50**

The sensitivity analysis shows that the net present value could vary between

-£21.63m and £32.66m at the 90% confidence level. The benefits presented in the table above, however, are the most likely scenario.

Figure 5 Probability of total net present value (NPV) – Little Journey current implementation (scenario 2)



6 Scenario 3 – Implementation of Little Journey across England

6.1 Scenario description

The scenario 3 modelled is to assess the potential benefits that might accrue, together with costs, were the Little Journey mobile application to be extended across all hospitals performing paediatric surgery in England e.g. 145 sites in total. Modelling this scenario provides evidence-based estimates of the possible impact of the project, were it to be adopted to a widest extent.

The benefit streams remain the same as for those identified within scenario 1.

6.2 Key assumptions

Given that this is an indicative scenario showing the potential benefits and costs were the programme to be rolled out further, rather than reflecting any actual programme results, this scenario builds on the assumptions made within scenario 1, adjusting the inputs where necessary to reflect the much larger populations and spread of the programme.

There are two key changes to the inputs to the model made within this scenario, compared to scenario 1 and 2; population and optimism bias control. With the involvement of all paediatric hospitals across England the population reflects the much larger cohort of potential patients. The study assumes half of the sites would be set up in year 1 and the other half in year 2.

Further to the controls discussed in the previous chapters regarding scenario 2, when considering a potential roll out across England an additional uncertainty needs to be considered and mitigated. For scenarios 1 and 2 the current activities of Little Journey are well known, and the counterfactual, the different options patients have when it comes to pre-surgery information is understood. This makes calculation of the marginal difference of the programme more straightforward.

When rolling out across England, the current paediatric pathways and the attention they give to patient anxiety at the various hospitals is a lesser known variable and may differ considerably amongst the cohort. To control for this uncertainly and ensure the estimation of benefits and costs is a prudent one, an additional 15% is applied to the benefit calculations, over and above the optimism bias correction used in scenario 2 to duplicate intervention bias correction. Intervention bias refers to how the researcher, or other factors, intervene with the test subjects.

Finally, given that there are no current plans for rollout across England, the year markers have been removed, replacing with Years 1 through 5 and with a staged roll out included. Although this is almost certainly a much faster roll out than would be achieved in reality, it is felt that it is important to give an indication of costs and benefits that can be achieved at full implementation.

In the model, 2019 is chosen as the start year to respect the base year and discounting approach taking in the other scenarios.

When monetising the benefits, values are updated to reflect the different costings where applicable. This has been weighted to account for differing trust size.

6.3 Overall benefits

As with scenario 1, 11 significant monetised benefits of the programme are identified, across the three benefit streams of cash releasing and non-cash releasing healthcare system savings and societal benefits.

Table 24 Overall benefits (£,000, net present value, 2019 prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Population	259,357	240,622	249,990	259,722	269,833	**1,279,523**
NHS cash releasing savings	£ 2.6	£ 5.3	£ 5.4	£ 4.9	£ 4.5	**£22.6**
NHS non-cash releasing savings	£ 590.8	£1 ,204.2	£ 1,227.4	£ 1,125.1	£ 1,018.9	**£5,166.3**
Societal benefits	£ 1,057.9	£ 2,125.5	£ 2,134.7	£ 1,929.5	£ 1,722.9	**£8,970.5**
Total	**£ 1,651.2**	**£ 3,334.9**	**£ 3,367.5**	**£ 3,059.5**	**£ 2,746.3**	**£14,159.4**

6.4 Overall costs

The costs included in this scenario are the same as those described in scenarios 1 and 2.

Table 25 Overall costs (£,000, net present value, 2014 prices)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Service agreement cost	£ 23.0	£ 45.2	£ 44.3	£ 43.4	£ 42.6	**£198.5**
Consumables	£ 133.7	£ 272.4	£ 370,2	£ 471.4	£ 576.3	**£1,823.9**
Camera postage cost	£ 1.1	£ 1.1	£ 0.0	£ 0.0	£ 0.0	**£2.2**
Staff time cost	£ 43.8	£ 85.9	£ 84.3	£ 82.6	£ 81.0	**£377.7**
Total	**£ 201.6**	**£ 404.6**	**£ 498.8**	**£ 597.4**	**£ 699.9**	**£2,402.3**

Table 26 Overall costs for consumables (£,000, net present value, 2019 prices)

	Year 1	Year 2	Year 3	Year 4	Year 5
Number of VR cardboard sets	36,093	74,997	103,889	134,916	168,202
Cost for VR sets	**£ 133.7**	**£ 272.4**	**£ 370,2**	**£ 471.4**	**£576.3**

6.5 Overall scenario results

Taking the costs and benefits specified above into account, the following return on overall investment is as follows:

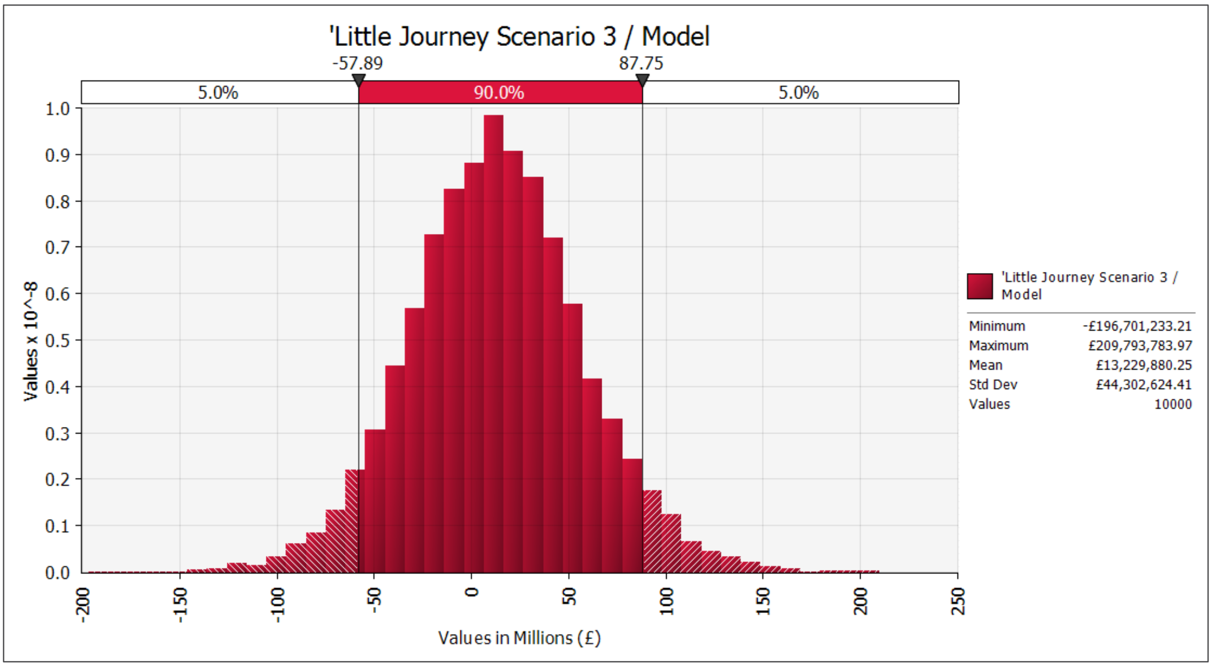
Table 27 Overall return on investment ££,000, net present value, 2019 prices)

	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023	Total
Total Benefits	£ 1,651.2	£ 3,334.9	£ 3,367.5	£ 3,059.5	£ 2,746.3	£14,159.4
Total costs	£ 201.6	£ 404.6	£ 498.8	£ 597.4	£ 699.9	£2,402.3
Net present value (benefits – costs)	£ 1,449.7	£ 2,930.3	£2,868.7	£ 2,462.1	£ 2,046.4	£11,757.1
Benefit to cost ratio	8.19	8.24	6.75	5.12	3.92	5.89

The sensitivity analysis shows that the net present value could vary between

-£57.89m and £87.75m at the 90% confidence level. The benefits presented in the table above, however, are the most likely scenario.

Figure 6 Probability of total net present value (NPV) – Little Journey (scenario 3)



7 Discussion

This report was commissioned to analyse the impact of the Little Journey mobile application for the current implementation and prospectively for a roll-out across England.

Through robust research of the costs and benefits arising from the project and appropriate application of these results within a model, we can show that the programme makes a significant positive impact on the health economy and patient quality of life.

The conclusions of this study, which has looked to identify the costs and benefits of the Little Journey application show that:

- **Little Journey is estimated to deliver tangible value of £3.03 and £3.50 of benefit within the health care system for every £1 invested in the project for the scenario 1 and the current implementation (scenario 2) respectively.** This is based on cautious and prudent adjustments for optimism bias applied to both the benefits and the costs.
- **A further £5.12 and £6.00 are identified in social benefits for every £1 invested (respectively for the pilot and the current project).**
- **Should Little Journey be rolled out** nation-wide it is estimated to deliver an overall gross benefit of £5.89 for every £1 invested.

The future benefits rely on Little Journey being implemented, in scope, scale and speed, in line with current plans, to keep the momentum going in each site. Without continued focus, the benefits gained in future years can be expected to 'fade out' as the app is not presented to the patients.

To address having to rely on the member of staff introducing Little Journey to their patients and recommending they use it, the LSH team wants to automate the process and bypass the human factor to make sure no patient is left behind. As soon as a patient is scheduled for surgery, they would automatically receive an email or a phone notification to prompt them to download and start using the Little Journey app. This measure has the potential to improve the patient activation rate as well as the engagement rate if the system is able to send reminders, thus improving the percentage of patients harvesting the benefits of Little Journey which would translate into increasing economic benefits.

The authors encountered several limitations. The need to rely on academic sources for some of the benefits often resulted in the need to apply higher optimism bias correction, reducing the benefit within the model. Should the data collection performed in the scenario 1 be continued and extended to more patients, localised data could be used in future roll-out. As well as reflecting better the implementation of this intervention, with reduced need for higher optimism bias correction, the benefits may well be higher. Utilising an informatics partner (such as the KSS AHSN) to assist in the definition, collection and analysis of data to monitor and evaluate the project as it is rolled out further would significantly improve uncertainty associated with less evidence-based assumptions. Additionally, the data collected by the randomised control trial could also be used by future evaluations to monetise the societal benefits of reducing patients' anxiety.

Economic modelling is not an exact science and its outputs should be seen as a guide to decision-making and not a substitute for experienced local knowledge. There will always be some need for assumptions or reliance on secondary data, which limits the ability to generalise and draw broad policy lessons from an individual project or programme review. All outputs from the model are subjected to a range of risk and sensitivity tests to understand more about the degree of confidence with which the outputs from our model should be treated. As further evidence is made available, particularly from the current implementation or a regional roll-out, the model should be reviewed and amended accordingly. This will act to further enhance the accuracy of the model and the ability to draw wider conclusions.

Secondly, when partners commission and evaluate interventions they should be advised to consider more than just the benefit-cost ratio of the project. They should consider interventions from a range of perspectives, including the qualitative analysis, strategic contribution and capacity to deliver, alongside the Net Present Value or Cost Benefit Ratio, and the range of potential results revealed through the sensitivity risk, which demonstrates negative return on slightly more than a third of the draws of the sensitivity analysis.

Extending the data collection in time and sample size would enable to confirm the changes in preoperative metrics and therefore the economic impact of these changes (positive and well as negative). With better quality data, some of the assumptions used could be associated with lower optimism bias thus increasing the economic impact of the intervention.

The study highlights the opportunity to better address the needs of the paediatric patients undergoing surgery. An intervention such as Little Journey appears potentially financially viable, profitable and effective in real-life settings.

Furthermore, whilst this study uncovers and discusses how some communication channels are not fit to inform and help children to prepare for day case surgery, it is likely that the hospitals taking part are keen on innovation initiatives and educated to the effectiveness of audio-visual materials to share information with patients. There are potentially bigger needs in sites that have not sought out and implemented Little Journey. They may be less tech-savvy, not benefitting from the presence of a health play specialist or specialist paediatric nurse to make the hospital stay of anxious patients more comfortable. Therefore, they may have worse medical outcomes, such as higher rate of premedication, longer time needed for induction and recovery, more frequent POV and thus the introduction of Little Journey would generate more benefits than described in the current model.

An additional challenge for health care providers is to ensure that safe, effective, easy to implement at low cost initiatives can reach every child. In 2018, only 77% of adults in Great Britain reported accessing internet “on the go” – referring to accessing the internet away from home or work, for example via a smartphone or tablet (Office for National Statistics, 2019). Therefore, hospitals must be careful not to reinforce digital exclusion and create alternative options for patients’ families who do not own a smartphone. This could be making a tablet available at the hospital for patients to come and use it, or by signposting to their patients’ other solutions such as libraries equipped with tablets available for their consumers or schools.

Despite these limitations, this report has demonstrated a significant average return on investment, in addition to the clear patient care benefits provided by the Little Journey mobile application. The principles driving the LSH team are in harmony with the NHS Long Term Plan (NHS England, 2019). By promoting proactive patients’ behaviours and be having a child-centred design, Little Journey is aligned with the pledges that “people will get more control over their own health” and supports “a strong start in life for children and young people”. It also embodies the pledge that “digitally-enabled primary and outpatient care will go mainstream across the NHS” and helps boost out-of-hospital care.

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The discussion underlined how capital rigorous data capture is to conduct an evaluation. This study is no exception and heavily relied on the dedication and the time commitment of clinical teams in the 5 sites of the scenario 1. They invested time and resources to introduce the app to their patients and other staff members and collected the data which evidenced the impact of the Little Journey app. Furthermore we would like to acknowledge with much appreciation the crucial role of Dr Joel Chin, Stephanie Fairbain, Georgina Forman, Emma Lally, Dr Kate Bush (Cambridge University Hospital NHS Foundation Trust); Dr Linden Baxter, Claire Tucker (Wexham Park Hospital); Dr Claire Seeley, Dr Dawn Wilkinson, Dr Warren Fisher, Claire Lord (Royal Berkshire Hospital); Dr Amy Norrington, Dr Sophie (South Tees Hospital NHS Foundation Trust) and Dr Katharine Francis (Stoke Mandeville Hospital).

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Appendix A - Benefits breakdown by stream

The following tables provide nominal benefits identified for the programme detailed in the report by scenario. Benefits listed in these tables are 3-year sum totals, following the year weighting and roll out profile as detailed in the relevant scenario section.

Scenario 1 – Little Journey (after optimism bias, £ nominal)

Benefit stream	Benefit value
On the day cancellations – direct cost	£212,171.69
On the day cancellations – parents' days off cost	£4,162.53
On the day cancellations – Quality of life benefits	£415,603.16
Induction time reduction – cost of anaesthetic (gas)	£51.42
Induction time reduction – cost of anaesthetic (IV)	-£150.36
Induction time reduction – cost of staff time	-£5,764.50
Induction time reduction – cost of change of technique	-£9.72
Recovery readiness – cost of staff time	£1,960.09
Reduction of perioperative medication	£4,363.49
Discharge time cost of a bed day	£30,494.77
Reduction of unplanned admissions	£5,322.67

Scenario 2 – Current implementation of Little Journey (after optimism bias, £ nominal)

Benefit stream	Benefit value
On the day cancellations – direct cost	£1,696,496.96
On the day cancellations – parents' days off cost	£33,283.07
On the day cancellations – Quality of life benefits	£3,319,351.61
Induction time reduction – cost of anaesthetic (gas)	£363.34
Induction time reduction – cost of anaesthetic (IV)	-£1,062.51
Induction time reduction – cost of staff time	-£40,735.64
Induction time reduction – cost of change of technique	-£68.66
Recovery readiness – cost of staff time	£13,851.21
Reduction of perioperative medication	£30,220.22
Discharge time cost of a bed day	£215,495.46
Reduction of unplanned admissions	£37,613.41

Scenario 3 – Implementation of Little Journey across England (after optimism bias, £ nominal)

Benefit stream	Benefit value
On the day cancellations – direct cost	£4,558,444.44
On the day cancellations – parents' days off cost	£89,430.78
On the day cancellations – Quality of life benefits	£8,881,043.25
Induction time reduction – cost of anaesthetic (gas)	£976.28
Induction time reduction – cost of anaesthetic (IV)	-£2,854.93
Induction time reduction – cost of staff time	-£109,455.63
Induction time reduction – cost of change of technique	-£184.50
Recovery readiness – cost of staff time	£37,217.86
Reduction of perioperative medication	£24,675.95
Discharge time cost of a bed day	£579,030.85
Reduction of unplanned admissions	£101,066.28