Understanding the potential cost-effectiveness of an online education course: Gateway-C

Commissioned by Greater Manchester Cancer Vanguard Innovation Programme

Produced by Cheryl Jones and Katherine Payne

Manchester Centre for Health Economics,
4th Floor, Jean McFarlane Building,
Division of Population Health, Health Services Research and Primary Care
The University of Manchester
Oxford Road
Manchester M13 9PL

Date: 12th December 2018

1.0 Introduction

Over 300,000 individuals were diagnosed with cancer in England in 2016 (ONS 2016). Almost half of these individuals tend to be diagnosed in the late stages of cancer (stage 3 or 4) (Farrington 2014). There is evidence to suggest that survival rates in England are lower than the European average; however, if England were to match the European average 5,000 to 10,000 deaths could be avoided per year (Abdel-Rahman et al. 2009). Observed survival from cancer could be increased through improvements in diagnosing cancer in its earlier stages and avoiding 'late diagnosis' (Independent Cancer Taskforce 2015). Late diagnosis may potentially be caused by: delays in people presenting to the healthcare service with symptom (presentation); delays in people being seen in primary care; delays in people between referred from primary to secondary care; delays in treatment in secondary care (Rubin, McPhail, and Elliott 2011). People presenting at the late stages of cancer are three times more likely to die compared with those people presenting at the early stage of diagnosis (GM Report 2017). Late stage diagnoses patients require more intense treatment compared with early stage diagnoses which translates to greater resource use and a greater reduction in quality of life (QoL) (GM Report 2017). Early diagnosis of cancer has been recognised as key factor towards obtaining better cancer outcomes (Independent Cancer Taskforce 2015) and Greater Manchester (GM) has the second highest level of late diagnosis in England; a key factor contributing towards high mortality figures is the number of people who are diagnosed late (GM Report 2017).

The majority of cancer diagnoses come via referrals from primary care by General Practitioners (GPs). From 2006 to 2008, around 26% of people were referred using the two-week urgent referral pathway and 21% of people were referred on the non-urgent referral pathway (Elliss-Brookes et al. 2012). A major challenge for GPs is to be able to contrast between significant and non-significant symptoms of cancer and make an appropriate referral to specialist secondary care (Rubin et al. 2015). Many people present to their GP with symptoms consistent with lower-risk features making it difficult for GPs to differentiate potential patients with cancer or another type of illness with similar symptoms (Hamilton 2010). Cognisant of these challenges, a team of experts in cancer conceptualised the need for, and developed, an online education resource called 'Gateway-C' to provide GPs with training and easy access to information about cancer to improve the appropriate referral of patients to secondary care. Gateway-C was developed in Greater Manchester by members of the

Strategic Clinical Networks, the Greater Manchester Cancer pathways boards, commissioning groups, specialist cancer GPs, service users, Cancer Research UK and Macmillan as part of the Greater Manchester Cancer Vanguard Innovation Programme.

2.0 Study aim

The aim of this study was to understand the potential costs and consequences of an education e-learning platform (Gateway-C) designed to improve GPs ability to identify significant and non-significant symptoms of cancer and appropriately refer patients to secondary care for further investigation and/or treatment of cancer. This study is an early analysis of Gateway-C using currently available data. The study also aimed to describe which data would be required to inform a definitive analysis of Gateway-C.

3.0 Methods

A decision-analytic model-based cost-effectiveness (CEA) was used to address the aim of this study and answer the decision problem presented in Table 1. This CEA is reported in line with published criteria (Husereau et al. 2013).

Table 1 Key design criteria for the stated decision problem

Decision Problem	To what extent must an online education course influence GP referral behaviour for colorectal cancer and non-small cell lung cancer to be an effective use of the healthcare budget?
Intervention	Gateway-C is an online education course designed to improve the ability of GPs in primary care to identify significant and non-significant symptoms of cancer and appropriately refer patients to secondary care for further investigations and treatment.
Comparator	Current referral pathway used by GPs in primary care prior to the introduction of Gateway-C.
Model Type	Decision tree and Markov model
Population	Patients with suspected symptoms of cancer for (a) suspected colorectal or (b) suspected non-small cell lung cancer (NSCLC)
Setting	Primary and secondary care within the National Health Service in England
Perspective	The National Health Service in England
Time Horizon	Two time horizons were used in this study (i) short-term capturing the time to referral to secondary care and (ii) long-term that captured the impact of Gateway-C across a lifetime
Costs	National currency (£) at 2016 prices
Consequences	Three relevant consequences were defined for this study: (i) The percentage improvement in appropriate referrals made by the GP to secondary care where appropriate is defined as the number of people subsequently diagnosed with cancer (colorectal or NSCLC) (ii) The number of GP attendances before being referred (iii) Quality Adjusted Life Years (QALYs)
Discounting	3.5% for both costs and consequences
Cost-effectiveness threshold	NICE recommended threshold of £20,000 per QALY gained

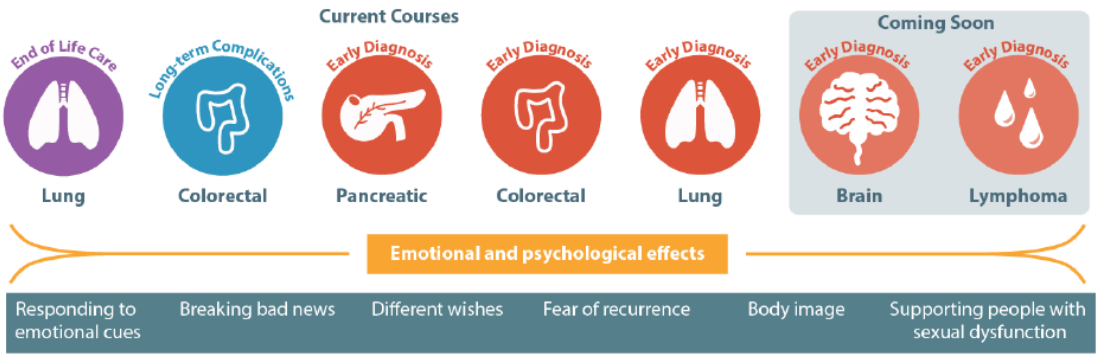
3.1 Study Population

Two relevant populations were defined for this decision-analytic model-based economic evaluation (a) adults suspected colorectal (CRC) or (b) adults suspected non-small cell lung cancer (NSCLC). The analysis presented in this study reports the impact of Gateway-C on CRC and NSCLC, which were selected as two examples because they are the most commonly diagnosed cancers in the UK (ONS 2016).

3.2 The Intervention

Gateway-C is an online interactive e-learning platform designed to improve recognition of cancer symptoms in patients. Once enrolled onto the online course, GPs are presented with a selection of modules; see Figure one. The modules follow a patient through key events, from early diagnosis to end-of-life care, on the cancer pathway for each included type of cancer. The early diagnosis module is the focus for this analysis. The early diagnosis module trains GPs using pre-recorded interviews with a wide range of experts to provide their insight of dealing with patients with cancer. The course also provides quizzes where the GP is asked to decide the appropriate method of referral or care; the consequences of their decision are then shown. Reflective pieces and journal articles from experts are also available on the online course. GPs are able to login and out of the course as many times as they need and may complete the course at their own pace. Each module on the course takes on average two hours to complete. Gateway-C also contributes towards GPs Continuing Professional Development (CPD) certification. The costs of producing this intervention are included in this analysis, including the time taken for GPs to complete the additional training.

Figure 1 Modules included in Gateway-C



3.3 Comparator

The relevant comparator defined for this study was the existing approach GPs take to refer patients with symptoms of CRC or NSCLC before Gateway-C was introduced. In primary care, a GP may refer a patient for further diagnostics in secondary care using the two-week wait (2WW) route, where patients must be seen by a consultant within two weeks (NICE 2017), or routine referral (Elliss-Brookes et al. 2012).

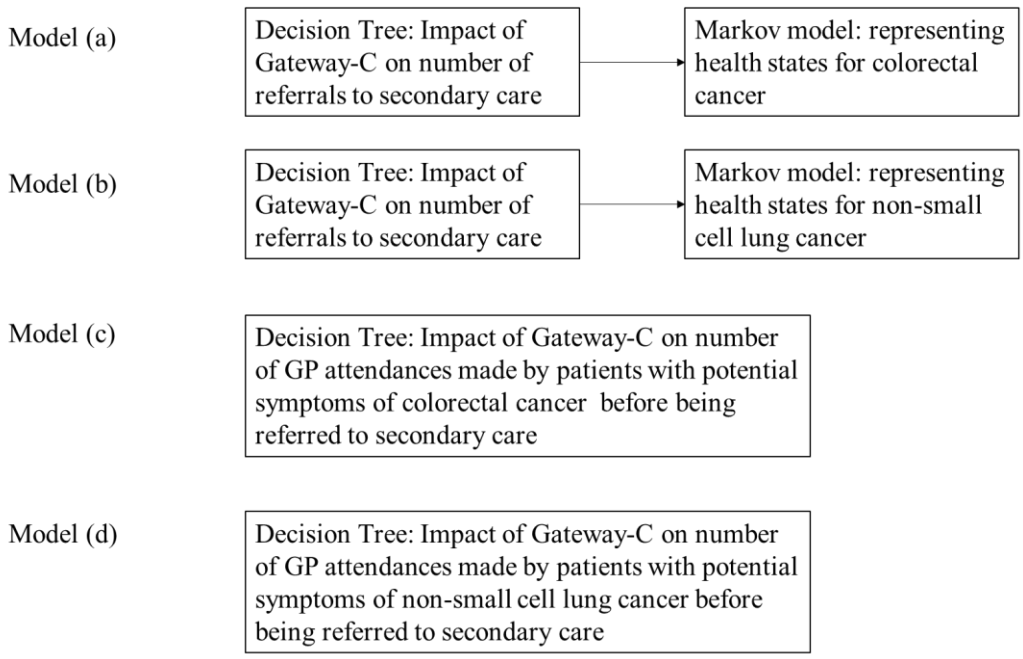
3.4 Model conceptualisation

The model conceptualisation process followed published recommendations by Roberts et al. (2012). Roberts et al. (2012) describes the process of model conceptualisation which initially involves understanding the decision problem that needs to be addressed. A model structure is then formulated matching the attributes and characteristics of a particular modelling type to the needs of the decision problem. The decision problem was defined so that the focus of this analysis would address how Gateway-C may influence GP referral behaviour for CRC and NSCLC. Gateway-C may impact costs and outcomes in primary care and secondary care, over short-term and long-term time horizons. Two sub-model structures were required to model the impact of Gateway-C; a de novo decision tree was designed to model the short-term impact on primary care and a Markov model was used to simulate the long-term impact on secondary care.

3.5 Model structure

Figure 2 provides an overview of the model structures.

Figure 2: Overview of the model structures



Two decision trees were designed to capture the impact of the costs and consequences of Gateway-C at the primary care level when compared with current practice. One decision tree

was designed to capture the impact of Gateway-C on referrals to secondary care (Figure 3). A second decision tree was designed to capture the impact of Gateway-C on the number of fewer repeated GP attendances made by patients with potential symptoms of cancer before being referred to secondary care (Figure 4). Two separate Markov models were then structured for CRC and NSCLC. The models were based on those conceptualised and developed by Westwood et al. (2017) and Hinde et al. (2015) for CRC and NSCLC, respectively. Westwood et al. (2017) conducted a Heath Technology Assessment (HTA) of faecal immunochemical tests used to triage patients with lower abdominal symptoms for suspected CRC referrals in primary care. This HTA included a systematic review and a cost-effectiveness analysis of the faecal immunochemical tests. The study by Hinde et al. (2015) modelled the cost-effectiveness of a public awareness campaign for the early detection of non-small-cell lung cancer (NSCLC) in the UK.

3.5.1 Primary Care: Decision tree model

Figures Three and Four present a schematic of the two decision trees designed to capture the costs and consequences of Gateway-C when compared with current practice. The square in the decision trees represents the decision problem; should the healthcare sector (NHS) invest in Gateway-C. The circles represent an event that happens by chance (Briggs, Sculpher, and Claxton 2006). One set of end nodes of each decision tree show the number of patients referred secondary care, which then fed into the relevant Markov model and are marked "MM" on the relevant decision tree. An defined set of nodes show when patients are discharged from the NHS because they do not have symptoms consistent with cancer (CRC or NSCLC).

Both decision trees illustrate the referral process with and without Gateway-C. Figure 3 represents the impact on referrals made by the GP to secondary care. First, the patient presents to their GP with symptoms that may indicate they have CRC or NSCLC. The GP then decides whether the patient should be referred to secondary care for diagnostic tests or discharged back into the community. If the GP decides to refer the patient, the GP may refer using the using a two-week-wait (2WW) or routine (non-urgent) referral pathway. The 2WW referral pathway specifies that a specialist cancer consultant must see the patient within two weeks from when the referral is received by the hospital (NICE 2017). The final outcome of the decision tree describes the number of patients that receive a definitive diagnosis for CRC

or NSCLC, the number of patients who do not have cancer, and the number of patients not referred to secondary care.

Figure 3: Decision tree capturing the impact on referral to secondary care[1]

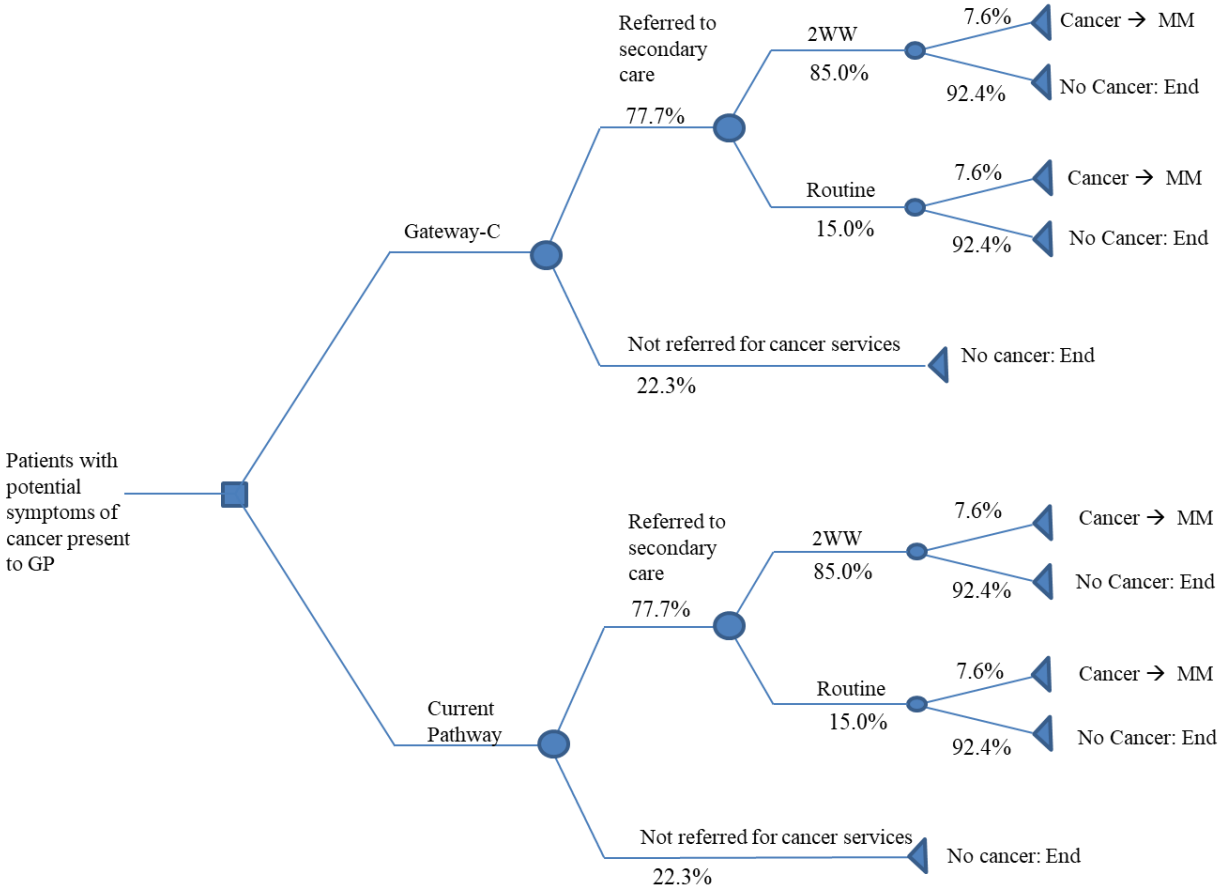
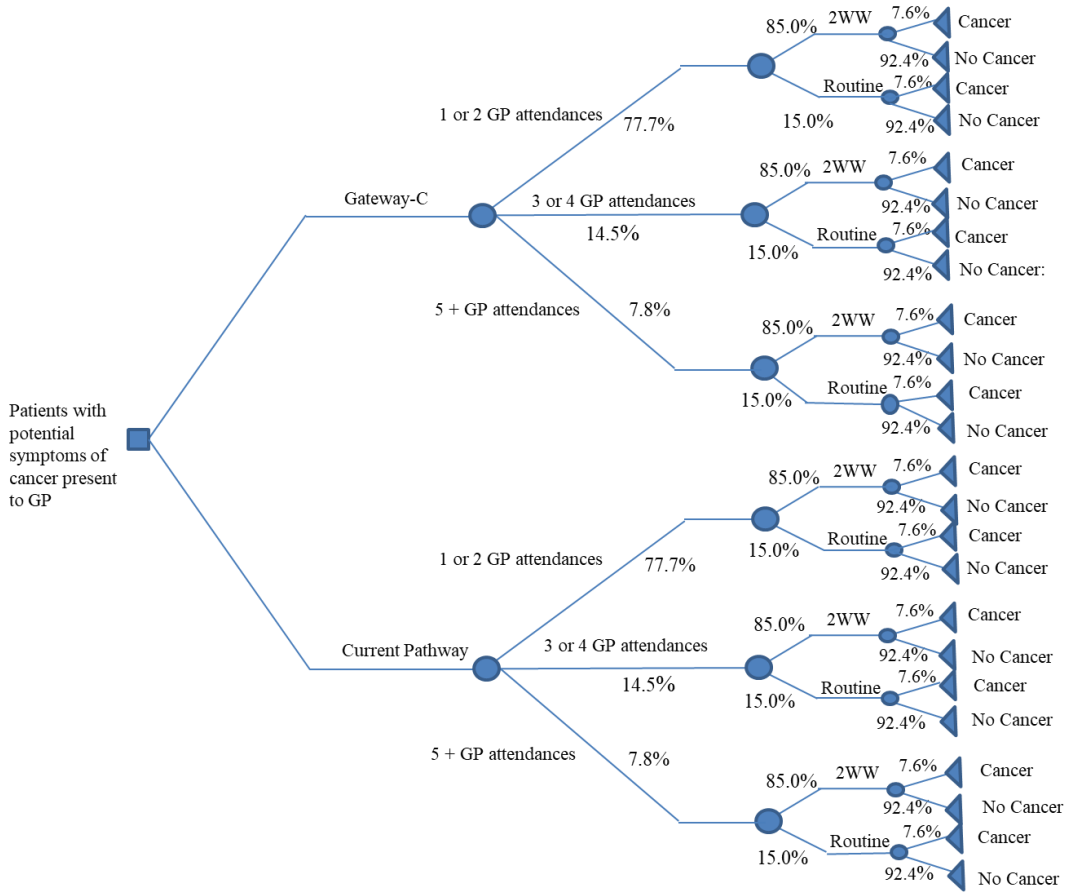


Figure 4 represents the impact of Gateway-C on the number of GP attendances made by patients with potential symptoms of cancer before being referred to secondary care. The decision tree has three branches which define the number of times a patient visits the GP before being referred to secondary care. This decision tree was not linked to a Markov model.

[1] Abbreviations: 2WW = two week wait; MM = Markov model

Figure 4: Decision tree capturing the impact on number of attendances in primary care[2]



3.5.2 Secondary Care: Markov model

Referrals for cancer made by the GP at the primary care level will subsequently have an impact on the costs and consequences in secondary cancer care. Once patients are referred to secondary care by their GP it was assumed that all patients undergo diagnostic tests and treatment. Two separate Markov models were designed to simulate the expected potential costs and consequences for a cohort of patients diagnosed and treated for CRC and NSCLC.

Markov models simulate a series of mutually exclusive health states that reflect the journey of a cohort of patients through a disease pathway (Briggs et al. 2006). Markov models are able to handle complex healthcare pathways by modelling transitions from one health state to another over discrete time periods (cycles) (Briggs et al. 2006). Each health state will then have specific costs and consequences attached for each cycle of the model. The total expected

[2] 2WW = Two week wait

values of the cost and consequences are then calculated by summing the individual costs and consequences for each state weighted by the time a patient spends in that health state.

3.5.2.1 Markov Model: CRC

The structure of the Markov model used for CRC is presented in Figure 5. A lifetime horizon was adopted and each cycle length was set to one year. Patients enter the model from the decision tree having received a definitive and staged diagnosis for CRC, see the decision tree in Figure 3. The stages of CRC were defined using Duke's grading system for CRC (Table 2), which was the same system used in Westwood et al. (2017) (NCIN 2010). Patients diagnosed with CRC may stay in the health state they first entered (Duke's A, B, C or D), progress to a worse health state (Duke's B, C or D), die from CRC, or die from all other causes.

Figure 5: Markov Model for Colorectal Cancer

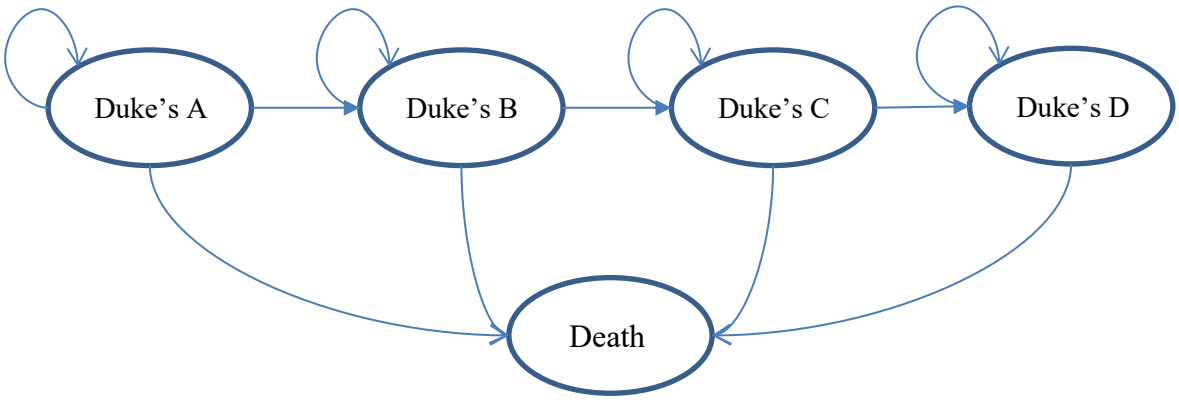


Table 2 Duke's staging for CRC

Duke's Staging for Colorectal Cancer	Definition
Duke's A	Cancer is in the innermost lining of the bowel or slightly growing into the muscle layer
Duke's B	Cancer has grown through the muscle layer
Duke's C	Cancer has spread to at least one lymph node in the area clost to the bowel
Duke'D	Cancer has spread to somewhere else in the body

Source: NCIN (2010)

The total costs and consequences were estimated over the a lifetime horizon. All costs and QALYs were discounted at a rate of 3.5% recommended by NICE (NICE 2013). Lifetime costs per stage of treated CRC were applied which included the cost of diagnostic testing, treatment, follow-up, and palliative care (Westwood et al. 2017). Lifetime consequences were

valued using quality adjusted life years (QALYs). QALYs were estimated by multiplying the length of life by the utility value (quality of life preference weighting) per stage of CRC. The costs and utility values to produce QALYs, along with data sources, are reported in sections 3.5.3 and 3.5.4.

3.5.2.1 Markov Model: NSCLC

The structure of the Markov model used for NSCLC is presented in Figure 6. The staging system applied for NSCLC was based on a previously published Markov model for NSCLC (Hinde et al 2015). An aggregated form of the TNM staging was applied to represent the three key stages of NSCLC: stage I and II; stage IIIa, and stage IIIb and IV (Table 3). Patients enter the model from the decision tree in one of three health states (stage I & II, stage IIIa, or stage IIIb & 4), and may remain in the same health state, progress to a worse health state, die from NSCLC, or die from all other causes.

Figure 6: Markov Model for Lung Cancer

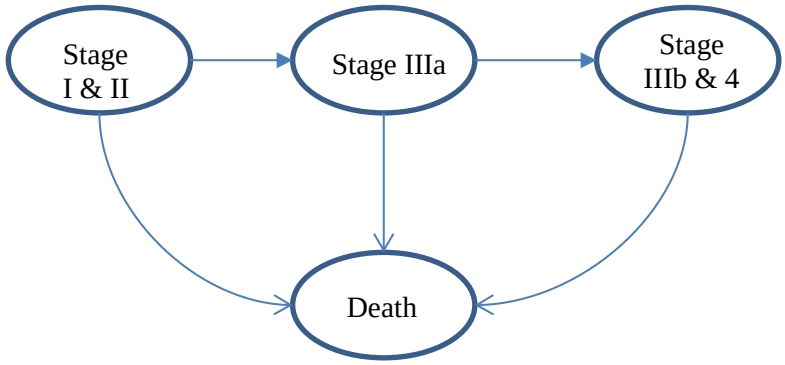


Table 3 Staging for NSCLC

NSCLC Staging Groups	Definition	Description of worst stage NSCLC per group
Stage I and II	Limited disease	Cancer is up to 5cm in size and has spread to the lymph nodes or cancer is up to 7cm and there are no cancer cells in any lymph nodes
Stage IIIa	Advanced disease	Cancer is up to 5cm in size and has spread to the lymph nodes in the centre of the chest on the same side as the tumour
Stage IIIb and IV	Extensive	Cancer is present in both lungs or cancer has spread beyond the chest to a lymph node or organ such as the liver or bone or cancer has spread to several areas in one or more organs

Source: Hinde et al (2015); Cancer Research UK (2017)

3.5.3 Decision Tree: Model inputs

Four main model inputs were required for the decision tree: probabilities; the number of patients with susptected CRC or NSCLC that enter the model; costs and consequences (measured in QALYs). These are now described.

Probabilities

The probabilities of referral (Table 4) via the 2WW and routine pathway were taken from an audit of referrals of individuals who have received a diagnosis of cancer (Swann et al. 2017). These data were used to populate the decision trees capturing the impact on referral to secondary care (Figure 3) for CRC and lung respectively.

Table 4 Type of GP referral for cancer to secondary care

Type of Cancer	2WW (%)	Routine (%)	Total GP referrals (%)
Colorectal (Colon and Rectal)	917 (85%)	166 (15%)	1083
Lung	976 (92%)	89 (8%)	1065

Source: Swann et al. (2017)

The number of GP attendances from patients with cancer was taken from a published source. The National Cancer Patient Experience Survey (2016) reported 77.7% of individuals with a cancer diagnosis visited a GP once or twice, 15.5% saw a GP three to four times, and 7.9% saw a GP five or more times before being referred to secondary care. These data were used to populate the decision trees capturing the impact on the number of primary care visits (Figure 4) for CRC and lung respectively. For the decision tree presented in Figure 3 it was assumed that 77.7% of patients were referred to secondary care and 22.3% were discharged back into the community.

The number of patients with suspected CRC or NSCLC

The number of patients with suspected CRC or NSCLC in England was estimated using statistics from Public Health England (PHE) and NHS Digital. PHE listed the proportion of patients with suspected CRC as the number of patients per 100,000 with lower gastrointestinal cancer. The statistics used in the model to estimate the number of patients with suspected CRC or NSCLC are reported in Table 5.

Table 5 Number of patients with suspected cancer

Year: 2016/17	England	Source
2WW suspected CRC cancer*	511 per 100,000	Cancer Services, Public Health England (2018)
2WW suspected NSCLC	109 per 100,000	Cancer Services, Public Health England (2018)
Number of patients registered with a GP	58,606,772	NHS Digital (2017)

*Reported as lower Gastrointestinal (GI) on PHE website

The total number of patients with suspected CRC or NSCLC in England was estimated based on the probability of being referred to secondary care the first time (77.7%) or not referred (23.3%) and the probability of being referred via the two-week-wait (85.0%) or non-urgent pathway (15.0%). Table 6 presents the estimated number of patients with suspected CRC or NSCLC who visited their GP in England.

Table 6 Number of patients with suspected CRC or NSCLC that visited the GP

	Total number of patients
Suspected CRC	453,449
Suspected NSCLC	89,365

Costs

The cost for providing the intervention (Gateway-C) included all the funds used to develop and deliver Gateway-C in its first year. Gateway C was designed by a team of experts in 2015 and piloted from February 2016 to April 2016. This study considers the cost of producing Gateway-C as a set of eight existing modules. The cost of producing Gateway included the staff time, IT infrastructure and consumables required which amounted to £614,896.86. In addition, the cost of each GP accessing and completing the training modules was included. These two elements of the cost of Gateway-C were then included in the analysis as a total cost per consultation with a GP who had undergone additional training from Gateway-C. The method to calculate the additional cost per consultation with a GP who had undergone the Gateway-C training was based on methods used by the PSSRU (2017) (see Appendix 1). Using this approach, the additional cost per consultation with a Gateway-C trained GP was estimated to be £0.26. The Personal Social Services Research Unit (PSSRU) report the standard cost of a single GP consultation, lasting 9.22 minutes, to be £36. The cost of a single

consultation with a GP trained by Gateway-C was estimated to cost £36.26 per 9.22 minute visit.

Consequences

The outcome required for the decision trees was initally the number of patients appropriately referred by the GP to secondary care. The definition of an appropriate referral is defined as an a referral that meets NICE guidelines meaning that the patient does not necessarily have to be diagnosed with cancer for the referral to be deemed appropriate (NICE 2017; personal communication with Dr. Sarah Taylor). However, data that describes the number of appropriate referrals made by GPs to secondary cancer care was not available. An expert elicitation study was designed to generate an estimate of appropriate referrals with and without Gateway-C; however, the experts asked to complete the elicitation exercise felt that they were unable to provide estimations stating that they would be purely be making a guess. Therefore, due to the lack of data available to describe appropriate referrals made by the GP, the percentage probability of patients referred by the GP, via the 2WW route, and had received a definitive diagnosis for cancer was used in the model. Public Health England (PHE, 2018) reports the percentage number of patients referred, via the 2WW route, by the GP and had received a definitive diagnosis for cancer was 7.6% for 2016/17 (PHE, 2018).

In the absence of data that could be used to describe the impact of Gateway-C on referrals of patients with suspected CRC or NSLCL, the basecase analysis assumed Gateway-C had no impact on referrals made by GPs to secondary cancer care. Therefore, to inform a scenario where Gateway-C does have an impact, a 'what-if' analysis was run to identify the percentage number of patients referred, via the 2WW route, by the GP and had received a definitive diagnosis for cancer where Gateway-C becomes cost-neutral at the primary care level. Further information about this analysis is presented in section 3.6.

3.5.4 Markov Model Inputs: CRC and NSCLC

Three types of model inputs were required for the Markov models: probabilities; costs and consequences. These are now described.

Probability of Diagnosis

The distribution of patients that enter each CRC stage (Duke's A to D) was determined by the probability of being diagnosed per stage. The probability of being diagnosed for each stage of CRC (see Table 7) and NSCLC (see Table 8) was taken from the National Cancer

Registrations and Analysis Service for 2016 for the Greater Manchester area (NCRAS, 2018). The number of cases recorded with each diagnosed stage of CRC and NSCLC also included the number of cases diagnosed but the stage was unknown. The percentage of unknown diagnoses for CRC ranged from 3% to 17% and for NSCLC ranged from 4 to 9%. The unknown cases of CRC and NSCLC were redistributed across the stages using the percentage of cases diagnosed per stage. Tables 7 and 8 show the probability of being diagnosed per stage for CRC and NSCLC, respectively, that were inputted into the model.

Table 7 Cases of diagnosis of CRC in England 2016

	Stage 1	**%**	**Stage 2**	**%**	**Stage 3**	**%**	**Stage 4**	**%**	**Total**
CRC	6590	19	8967	26	10,435	30	8,961	26	34,952

Source: NCRAS (2018)

Table 8 Cases of diagnosis of NSCLC in England, 2016

	Stage I and II	**%**	**Stage IIIa**	**%**	**Stage IIIb and IV**	**%**	**Total**
NSCLC	10,603	**28**	7,825	**20**	19,935	**52**	38,363

Source: NCRAS (2018)

Probability of Death

The probability of death was estimated by taking into account the probability of death caused by CRC, NSCLC and all cause mortality. The probability of death caused by CRC was informed using 15 year predicted survival data from the NG12 study, see Table 9. (NG12, 2015). After 15 years, the probability of death from CRC was assumed to remain constant.

Table 9 Predicted 15 year CRC survival probability by Duke's stage

Year	Duke's A	Duke's B	Duke's C	Duke's D
0	100	100	100	100
1	97.211	92.233	82.357	38.112
2	95.541	85.403	65.111	17.669
3	94.577	81.644	56.749	11.27
4	93.9	79.078	51.476	8.192
5	93.377	77.144	47.725	6.396
6	92.953	75.598	44.865	5.225
7	92.595	74.316	42.581	4.404
8	92.286	73.222	40.696	3.798
9	92.015	72.271	39.103	3.333
10	91.773	71.431	37.731	2.965
11	91.555	70.679	36.532	2.668
12	91.356	70	35.47	2.422
13	91.173	69.381	34.52	2.217
14	91.004	68.812	33.664	2.042
15	90.848	68.287	32.886	1.891

Source: NG12 study

The probability of death caused by NSCLC was estimated using survival of NSCLC statistics for adults in England with NSCLC and followed up in 2015 collected by ONS (ONS, 2016). Predicted survival probabilities for subsequent years were not available for NSCLC. ONS collected survival data for each of the four stages of cancer. The probability of survival for stage 1 and 2 was averaged to reflect stage I and II in the model. Stage 3 survival statistics from ONS were used for stage IIIa and stage 4 for stage IIIb and IV see Table 10.

Table 10 Survival rates for NSCLC by stage for adults in England 2016

	Stage 1 & 2	Stage 3a	Stage 3b&4
Men	0.74	0.42	0.15
Women	0.77	0.46	0.19
Average	0.75	0.44	0.17

*Source:*ONS, 2016

The probability of all cause mortality was taken from age-and gender specific mortality rates per 1,000 population for England and Wales using statistics reported by the Office for National Statistics in 2016 (ONS, 2016).

Transition Probabilities

Transition probabilities describe the probability of a patient progressing from one stage of cancer to another, for example moving from stage one to stage two within the specified Markov model. The CRC transition probabilities used in this model were those reported by

Tappenden et al. (2007) and subsquently used in Westwood et al. (2017). Transition probabilities for NSCLC were taken from Hinde et al. (2015). Tables 11 and 12 reports the transition probabilities for CRC and NSCLC, repectively.

Table 11 Transition Probabilities for CRC

Duke's Staging	Transition Probability
A to B	0.58
B to C	0.66
C to D	0.87

Source: Tappenden et al, 2007

Table 12 Transition probabilities for NSCLC

Stage	Transition Probability
Stage I and II	0.009
Stage IIIa	0.44
Stage IIIb and IV	0.007

*Source:*Hinde et al, 2015

Costs

All costs were estimated over the model lifetime horizon. The lifetime costs are reported for each CRC stage and were discounted at 3.5% per year (NICE recommendation) (NICE 2013). The study took a healthcare perspective and therefore only those costs directly attributable to the National Health Service (NHS) in England were taken into account. Lifetime costs, per patient, were taken from a study by Tappenden et al., (2007) and inflated to 2016 prices using the inflation rates reported by Hospital and Community Health Services index (PSSRU, 2017). The lifetime costs of CRC per patient (Table 13) included the cost of diagnosis, treatment (chemotherapy, surgery and radiotherapy), and follow-up care.

Table 13 Lifetime costs of CRC (£; 2016)

Cancer Stage	Mean cost
Duke's A	£10,969.39
Duke's B	£18,497.30
Duke's C	£29,925.75
Duke's D	£19,914.56

Source: Tappenden et al, 2007

Gateway-C was designed to help reduce the number of incorrect CRC cancer referrals to secondary care. In theory, a reduction in incorrect CRC referrals would mean fewer

diagnostic tests need to be carried out, therefore potentially saving money for the NHS. Tappenden et al. (2004) reported the cost of diagnosing CRC per stage (see Table 14). The cost per diagnosis were adjusted to 2016 prices using the Hospital and Community Health Services Index (PSSRU, 2017) and averaged to produce an average cost per diagnosis for patients without cancer.

Table 14 Average cost (£) of diagnosing CRC

Duke's CRC Stage	Diagnosis Cost 2004 prices	Diagnosis Cost 2016 prices
A	£1010.86	£1,777.49
B	£956.33	£1,681.60
C	£993.30	£1,746.61
D	£931.12	£1,637.28
Average Cost	£972.90	£1,710.75

Source: Tappenden et al. 2014; PSSRU, 2017

The lifetime costs for NSCLC were collected and estimated from two sources. Hinde et al., (2015) reported costs of being diagnosed and treated per stage of cancer (I and II, IIIa, and IIIB & IV). The costs were taken from a previous study by Fleming et al. (2008). Hinde et al., acknowledged that the costs were likely to represent a significant underestimate of the total cost to the National Health Service (NHS) in England. Follow-up costs for NSCLC were taken from a costing document by Cancer Research UK 'Saving Lives, Averting Costs' (CRUK, 2014). Total follow-up costs consisted of follow-up care and palliative care. Total follow-up costs were reported in 2014 prices and were inflated to 2016 using the HCHS inflation index from the Unit Costs of Health and Social Care (PSSRU, 2016). The costs were reported per stage 1, 2, 3 and 3 NSCLC and therefore to reflect the structure of the model stage 1 and 2 costs were combined and stage 3 was used to represent stage IIIA and stage 4 used to represent stage IIIB and IV. Table 15 reports the estimated lifetime costs of NSCLC.

Table 15 Lifetime Costs (£; 2016) of NSCLC

NSCLC Stage	Diagnosis & treatment	Follow-up	Total Lifetime, mean, £
Stage 1&2	£9,782.67	£2,614.16	£12,396.83
Stage 3a	£8,843.50	£2,436.138	£11,279.64
Stage3b&4	£6,175.40	£941.24	£7,116.63

Source: Hinde et al, 2015; Flemming et al, 2008

The process of diagnosing patients who do not have cancer also has a cost attached. The cost of diagnosing NSCLC was taken from Hinde et al (2015). Hinde et al. (2015) reported the cost of diagnosis per stage in 2012 sterling. The cost of diagnostic, per stage, was adjusted to

2016 sterling, totalled and divided by three to give the average cost per diagnosis, per patient (see Table 16). The cost per diagnosis of NSCLC was estimated at £1,065.05.

Table 16: Cost (£) of diagnosing NSCLC

NSCLC Stage	Diagnosis Cost 2012 prices	Diagnosis Cost 2016 prices
I & II	£1,035	£1,134.59
IIIa	£1,046	£1,101.36
IIIB & IV	£911	£959.21
Average Cost	£997.33	£1,065.05

Source: Hinde et al, 2015; Flemming et al, 2008; PSSRU, 2017

Consequences

The life-time horizon aimed to capture the consequences using QALYs. QALYs capture changes in both health-related quality (morbidity) and quantity (mortality) of life. The quantity of health is measured using a count of the number of life-years that remain. The quality of health is measured using generic preference weighted health-related quality of life measures; typically, in the United Kingdom, quality is measured using the EuroQol Five Dimensions (EQ5D) (EuroQol Group 1990). Preference weights are used to indicate the value of a health state where perfect health is equal to one and death is equal to zero. More preferable health states are given greater weighting (Drummond et al. 2015).

QALYs were estimated by multiplying the number of life years (LY) by the utility values associated with that health state. QALYs were discounted at a rate of 3.5% per year, as recommended by NICE (NICE, 2013). A systematic review, conducted in 2016, identified studies that had derived health state utility values for CRC suitable for use in economic evaluations (Jeong and Cairns 2016). The review identified five studies that explicitly valued utilities for the four stages of CRC. One study measured health-related quality (HRQoL) of life of colon and rectal cancer, separately, using various health surveys including the EuroQol Five Dimensions (EQ5D) (Wilson, Alexander, and Kind 2006). HRQoL of colon and rectal cancer was measured using a patient populations from the United Kingdom. The authors estimated the EQ5D index scores for patients with Duke's stage A and B at 0.786 and Duke's stage C and D at 0.806. The utility values identified by this study are questionable because it would be expected that patients with more severe CRC to have lower HRQoL utility values as measured by the EQ5D. An earlier study by Ness et al., (1999) measured utilities (standard gamble method) per stage of CRC from a patient population from the USA who had

undergone removal of the colorectal adeoma using bespoke interviews (Ness et al, 1999) and the standard gamble method (Drummond et al. 2015). Whilst the health utilities were measured using a US population, the most recent HTA for CRC applied these values per stage of CRC (Westwood et al., 2017). It was decided, based on previous studies, that the utility values measured by Ness et al. (1999) were the most appropriate for use in this model for CRC. Table 17 presents the utility values per Duke's stage of CRC.

Table 17 Utilities for CRC per stage

Stage CRC	Utility Value
Duke's A	0.74
Duke's B	0.70
Duke's C	0.50
Duke's D	0.25

Source: Ness et al., (1999)

The utilities used for the Markov model for NSCLC were taken from a meta-analysis of pooled utility values (Sturza 2010); these are reported in Table 18. The utilities were pooled from studies using a variety of elicitation techniques including standard gamble, EQ5D, and seperate time tradeoff experiments.

Table 18 Utilities for NSCLC per stage

NSCLC Stage	Utility Value
Stage I and II	0.825
Stage 3a	0.772
Stage 3b and 4	0.573

*Source:*Hinde et al., (2015) adapted from Sturza (2010)

3.6 Analysis

The base-case analysis consisted of two parts: 1) the decision tree; and 2) the Markov model. The results from the decision tree (Figure 3) was used to estimate the cost per patient that received a definitive diagnosis of CRC or NSCLC that were referred by the GP with and without Gateway-C. The model was then used to estimate the number of of additional referrals of patients with cancer to secondary care needed for Gateway-C to be cost-neutral. The number of patients that received a definitive diagnosis of cancer was selected as the main outcome because the percentage number of patients referred to secondary care that are defined as approprite by NICE was not available (see section 3.5.3 *consequences*). The

decision tree was also used to estimate number of patients that were referred to secondary care but did not receive a diagnosis for cancer.

The results from the Markov model informed the potential cost per QALY of the entire cancer care pathway (primary and secondary care) with and without Gateway-C for both CRC and NSCLC over a lifetime horizon. However, due to a complete lack of relevant data it was not possible to estimate the likely impact of Gateway-C on GP referral behaviour of patients with symptoms potentially indicative of cancer. The basecase analysis assumed Gateway-C had no impact on the number of patients, with symptoms potentially indicative of CRC or NSCLC, referred by the GP to secondary care and received a definitive diagnosis for cancer. A sensitivity analysis was used to understand the potential impact of Gateway-C.

3.6.1 Sensitivity Analysis

Due to the lack of data describing the number of patients, with symptoms potentially indicative of cancer, referred by the GP to secondary care and received a definitive diagnosis of cancer, a best-case scenario was developed to identify the threshold percentage value where Gateway-C becomes cost-neutral. The identification of the percentage number of patients that receive a definitive diagnosis for cancer after a GP referral was completed using 'what-if' analyses using the decision tree in Figure 3. The identified threshold percentage was used to estimate the number of people that enter the Markov model on the Gateway-C care pathway in order to estimate the expected costs and QALYs of GPs referring more accurately to secondary care as a result of Gateway-C. The same cost-neutral threshold percentage was also used to identify the number of fewer patients referred to secondary care and found to not have cancer. This informed the potenial diagnostic cost savings in secondary care of testing fewer patients who do not have cancer.

Gateway-C's ability to be cost-neutral was also dependent on the number of GPs that complete the training. The more GPs that complete the training, the lower the cost per GP consult. The decision tree (Figure 3) was used to identify the minimum number of GPs needed, under the assumption that Gateway-C achieves its cost-neutral referral rate of patients with cancer to secondary care, for Gateway-C to be cost-neutral.

The decision tree presented in Figure 4 was used to identify the number of fewer GP attendances patients with suspected CRC or NSCLC attend before receiving a referral to secondary care for Gateway-C to be cost-neutral. The model assumed that Gateway-C had no impact in terms of the percentage number of patients referred to secondary care and receive a definitive diagnosis for cancer; this was held at 7.6% for the care pathways with and without Gateway-C.

A probabalistic sensitivity analyses (PSA) is typically performed to explore the degree of uncertainty surrounding the cost-effectiveness of an intervention (Briggs et al. 2006). A PSA allows all inputs to vary simultaneously providing a more accurate representation of uncertainty around the results. However, due to the lack of data for the percentage number of patients referred to secondary care who also receive a definitive diagnosis for cancer, a probabilistic senstivity analysis (PSA) could not be run. The reason for this is because the percentage number of patients referred who also receive a definitive diagnosis for cancer was not available. This is the key variable that drives the economic model, meaning that without a plausible estimate the PSA results would not be reliable.

The results section also reports key data that would need to be collected in order to more fully evaluate the impact of Gateway-C on GP referrals of patients presenting with symptoms indicative of cancer.

4.0 Results

To understand the impact of Gateway-C on referrals made by the GP to secondary care for patients with symptoms of CRC or NSCLC, a decision tree was used to estimate: 1) the cost per patient referred to secondary care and received a definitive diagnosis of cancer; 2) the percentage referral rate by GPs and the patient receiving a definitive diagnosis for cancer at which Gateway-C becomes cost-neutral at the primary care level; and 3) the cost-savings associated with reducing the number patients without cancer referred to secondary care for diagnostic testing. The results of the analyses are reported here.

4.0.1 Cost per patient referred to secondary care and received a definitive diagnosis of cancer

Table 19 reports the the cost per patient referred, with symptoms indicative of CRC or NSCLC, to secondary care and had received a definitive diagnosis of cancer. The basecase

model assumed Gateway-C had no impact on referrals made by GPs. The care pathway for Gateway-C is more costly compared to current care.

Table 19 Cost (£; 2016) per referred patient to secondary care and received a definitive diagnosis

Basecase (7.6%)	**Colorectal Cancer**		**Lung Cancer**	
	Current Care	Gateway-C	Current Care	Gateway-C
Cost of primary care	£16,324,176	£16,444,144	£3,217,125	£3,240,768
Number of cancer patients identified	26,777	26,777	5,277	5,277
Cost per identified cancer patient	£609.63	£614.11	£609.63	£614.11

4.02 Cost per QALY: Markov Model

Table 20 presents the expected costs and QALYs assuming Gateway-C had no impact on referrals made by GPs. Given these assumptions, necessary due to a lack of data, Gateway-C, for CRC and NSCLC, was slightly more costly compared with current care with no difference in QALYs gained.

Table 20 Cost (£; 2016) per QALY Gateway-C CRC and NSCLC

Basecase (7.6%)	**Colorectal Cancer**		**Lung Cancer**	
	Current Care	Gateway-C	Current Care	Gateway-C
Cost of correct refer	£22,350	£22,458	£14,646	£14,651
QALYs	0.75	0.75	1.58	1.58

4.1 What-if Analysis on impact of Gateway-C on referral rate

Given the lack of available data, a 'what-if' analysis was conducted to identify the threshold referral rate of patients that receive a definitive diagnosis at which Gateway-C becomes cost-neutral. The percentage number of patients needed to be referred and diagnosed with CRC or NSCLC was 7.68% (rather than the assumed current practice referral rate of 7.6%), equating to the identification and correct referral of an additional 282 patients (of 453,449) with CRC and 56 (of 89,365) patients with NSCLC, see Table 21.

Table 21 Cost (£; 2016)-neutral referral rate for Gateway-C

Cost-Neutral	CRC		NSCLC	
	Current Care	Gateway-C	Current Care	Gateway-C
Total cost of primary care	£16,324,176	£16,444,144	£3,217,125	£3,274,868
Number of patients correctly referred	26,777	27,059	5,277	5,333
% referral rate	7.6%	7.68%	7.6%	7.68%

4.1.1 Estimated number of GPs needed to complete Gateway-C training

Due to the fixed costs involved for the development of Gateway-C, the greater number of GPs that complete the training will lower the cost per GP consult. The analysis estimates the minimum number of GPs needed to complete Gateway-C for it to be cost-neutral at 1000. The minimum number of GPs needed to complete Gateway-C was estimated based on the assumption that Gateway-C was able to achieve a referral rate of patients with cancer to secondary care at 7.68%

4.1.2 Estimated cost-savings from avoided referrals of patients without cancer

The total cost of diagnostic testing for CRC and NSCLC is reported in table 22. The total cost of diagnostic testing was estimated by multiplying the number of people referred to secondary care and diagnosed as not having cancer by the cost per diagnostic test, reported in Tables 14 and 16. The difference in the number of people not referred to secondary care under Gateway-C was assumed to be the number of people not referred to secondary care who do not have CRC or NSCLC.

Table 22 Cost (£; 2016) of cancer diagnostic testing assuming a referral rate of 7.68%

	CRC		**NSCLC**	
	Number of patients referred to secondary care	**Total cost of diagnosis**	**Number of patients referred to secondary care**	**Total cost of diagnosis**
Current Care	325,553	£556,938,188	64,159	£68,332,871
Gateway-C	325,271	£556,456,049	64,104	£68,273,708

4.1.3 Lifetime Results on impact of Gateway-C on referral rate

Tables 23 reports the lifetime costs and QALYs under the assumption that Gateway-C is able to achieve a 7.68% referral rate of patients with CRC or NSCLC to secondary care. This

shows that if Gateway-C achieves this referral rate then it becomes less expensive than current care in terms of the lifetime costs but the QALYs are not affected.

Table 23: Lifetime impact of Gateway-C on referral rate for CRC

	CRC Current Care	CRC Gateway-C	NSCLC Current Care	NSCLC Gateway-C
Total Cost	£22,350	£22,096	£14,646	£14,504
Total QALYs	0.75	0.75	1.58	1.58

4.1.4 Impact of Gateway-C on Number of GP attendances

Figure 5 was used to estimate the required impact of Gateway-C on the number of fewer GP attendances for people with CRC or NSCLC before being referred to secondary care for the intervention to become cost-neutral (Table 25). The basecase analysis for CRC assumed 352,330 people (equating to 77.7%) would require one or two visits to the GP before referral to secondary care, 65,750 people (equating to 14.5%) would require three to four visits and 35,369 people (equating to 7.8%) would require five visits or more. The total cost of attendances was estimated by mutlipying the total number of attendances by the cost of a GP appointment with and without Gateway-C. The total number of GP attendances made by patients with symptoms indicative of CRC was estimated at 726,425. Based on the difference in the total cost of all GP attendances, with (£36 per attendance) and without Gateway-C (£36.26 per attendance), it was estimated that Gateway-C must reduce the number of attendances by 5,209 (equating to 0.72%) to become cost-neutral for CRC.

The basecase analysis for NSCLC assumed 69,436 people (equating to 77.7%) would requires one to two visits to a GP before referral to secondary care, 12,958 people (equating to 14.5%) would require three to four and 6,970 people (equating to 7.8%) would require five visits or more. The total number of GP attendances made by patients with symptoms indicative of NSCLC was 153,126. Based on the difference in the total cost of all GP attendances with and without Gateway-C, it was estimated that Gateway-C for NSCLC must reduce the number of attendances by 1,475 (equating to 0.96%) to become cost-neutral.

4.2 Key data to be collected for future evaluation of Gateway-C

The results for this early decision-analytic model-based economic evaluation of Gateway-C relies on available data extracted from published sources. This resulted in high levels of uncertainty in the expected costs and consequences for Gateway-C compared with current

practice. Table 25 list the types of data that would need to be collected to address the key evidence gaps in the current literature to show the potential added value of Gateway-C.

Table 25 Key data required for economic evaluation of Gateway-C

Data Item	Description
Number of patients presenting with potential symptoms of cancer	Number of patients that have presented to the GP with symptoms that may be indicative of cancer. The GP should record a patient as such if the GP thinks there is the slightest chance the patient has cancer
Number of attendances of patients presenting with potential symptoms of cancer to the GP before being referred to secondary care	Number of attendances patients have presented to the GP with symptoms that may be indicative of cancer before being referred to secondary care
Number of patients who are referred to secondary care via: 2WW, non-ugent	Number of patients who have presented with symptoms indicative of cancer and record the type of referral given (or not). Patients who have not been referred should have this recorded to track patients who may present again in the future.
Diagnostic test results: cancer (yes or no), type of cancer (lung, etc.), and the stage of the cancer.	Cancer present or not and the type and stage of cancer the patient was diagnosed with. Record when the diagnosis was received by the GP and the patient.
Number of patients not referred	Number of patients who present with symptoms indicative of cancer but not referred by the GP
Mortality	Number of patients with cancer and subsequently die because of cancer. This needs to be linked to the initial diagnosis (type of cancer diagnosed and stage)
Progression of cancer	Number of people who progress or regress between stages of cancer
Healthy post cancer treatment	Number of patients who are considered to have made a "full recovery" (in remission)
Relapse	Number of patients who relapse and are diagnosed with cancer for a second (third, etc) time.
Patient Characteristics	Record all relevant characteristics of each patient including age, gender, ethnicity, and so on
Cost of setting up intervention	How much did it actually cost the NHS to develop the intervention? Fixed Costs: How much did it cost to create the intervention? (Gateway-C, how much did each module cost to create? This is separate to the cost of creating the Gateway-C platform) Who developed the intervention, how much of their time did they dedicate to it, what salary are they paid? Plus, all set-up costs including Information Techonologies used, etc. This is NOT the same as the forecast costs of developing the intervention. Variable Costs: How much does it cost per year to maintain?

5.0 Discussion

The analysis presented in this study reports an early decision-analytic model based economic evaluation of the potential impact of Gateway-C on GP referrals of patients with suspected CRC or NSCLC to secondary care. Due to a lack of data, the base-case analysis assumed that Gateway-C had no impact on GP referrals of patients with symptoms potentially indicative of CRC or NSCLC to secondary care. Under this assumption, Gateway-C was found to cost more than current practice. For Gateway-C to become cost-netural, the results suggest that GPs must improve their referrals (patients referred to cancer that receive a definitive diagnosis) to secondary care to 7.68%, compared with 7.6%. Also, the analysis identified that the minimum number of GPs needed to complete Gateway-C training was 1000 given a referral improvement of 7.68%. The analysis also reports the reduction in the number of visits to the GP for Gateway-C to become cost-neutral. The results suggest that Gateway-C would need to reduce repeated GP visits by 0.72% for CRC and 0.96% for NSCLC. Inferences about the impact on health status, as a result of Gateway-C, cannot be made because the data were not available.

Strengths

This study is one of a limited number that have focussed on the economic evaluation of online education courses. Existing economic evaluations of interventions designed to improve GP performance have focused on evaluating non-online training programmes. For example, a study by Devine et al. (2012) evaluated the cost-effectiveness of an identification and referral programme to improve safety (IRIS) to help GPs identify women who are suffering domestic abuse. IRIS intervention consisted of a multi-disciplinary team that provided face-to-face training session with a clinical team under the conditions of a RCT. To our knowledge, limited, if any, economic evalautions used to assess the cost-effectiveness of online courses in cancer currently exist.

This study has conceptualised and developed a decision tree that reflects the key stages of a patient's journey through a cancer pathway from primary care to secondary care. The Markov models for CRC and NSCLC were largely based on previous models developed for CRC and NSCLC populations in England. The structure of the two models presented in this study can be used, modified and improved upon in future studies evaluating the economic impact of an on-line education package for improving the referral of people with cancer.

A key contribution of this study is the methodology used to estimate the additional cost of Gateway-C per GP consult. Methods used by the PSSRU to estimate the cost of hospital services were closely followed to arrive at an estimated additional cost of Gateway-C per GP consult. The method is useful to reflect the opportunity cost of the GPs time spent completing courses and understanding the extra cost of that training per GP consult.

Limitations

The most significant limitation of the study was the lack of data that described the impact of Gateway-C on referrals by the GP of patients with symptoms indicative of CRC or NSCLC to secondary care. An expert elicitation exercise was designed to generate an estimate of the impact of Gateway-C on GP referrals of patients with CRC or NSCLC; however, the experts expressed that they were unable to provide estimates. This parameter is likely to drive the relative cost-effectiveness of Gateway-C and be the key variable Gateway-C was developed to have an impact on. As a consequence, the results of this study are indicative, at best, and a future definitive study when more data are available is required to establish the expected impact of Gateway-C.

The percentage number of patients referred and who subsequently receive a definitive diagnosis for cancer used in the model was taken from a source published by Public Health England. This percentage described the number of patients referred to secondary care and diagnosed with all types of cancer. Ideally, specific percentage referral and diagnosis rates for CRC and NSCLC would need to be applied to be able to more compare the impact Gateway-C would need to have on GP referrals for CRC and NSCLC.

Importantly, the full cost of providing Gateway-C was not fully represented in this study. The total cost of developing and delivering Gateway-C is reported in this study; however, the cost of maintaining and updating Gateway-C was not included. It is expected that cost of maintaining and updating Gateway-C is unlikely to be signifcantly costly; however, it is good practice to include all costs, current and future costs, that fall on the healthcare sector. Cost data for maintaining and updating Gateway-C were not available.

The Markov model was designed to represent different stages of cancer to death. The Markov model assumed that patients could not go into remission; patients could only progress or stay

in the stage of in which they were diagnosed. The assumption made here is a conservative one because patients can go into remission and become cancer free. Existing Markov models (Westwood et al. 2017; Tappenden et al. 2007; Hinde et al. 2015) also do not model remission and for simplicity and pragmatic reasons remission was not explicitly modelled.

Future studies that involve the evaluation of the relative cost-effectiveness of training interventions, such as Gateway-C, need to consider the types of data that need to be collected before the intervention is piloted or tested. It is important to have discussions with health economists about data collection before a study is designed. In response to the limited data collected, a table of key data variables that are required for a subsequent economic evaluation of Gateway-C was produced. This list of key data requirements will aid the design and development of potential future economic evalautions of Gateway-C should it be further evaluated in the future.

6.0 Conclusion

Due to the lack of data, the study presented here present indicative results of the potential impact of Gateway-C on referrals of patients with symptoms suggestive of CRC or NSCLC. The base-case analyses were based on the assumption that Gateway-C had no impact on GP referral behaviour. The results, under this assumption, suggest Gateway-C was more costly compared with current practice. The results of this study are not definitive due to the substantial lack of available data. As a result, a list of key data required to evaluate an intervention, such as Gateway-C, is reported with the aim of aiding any potential future evaluations of Gateway-C.

References

Abdel-Rahman, M., D. Stockton, B. Rachet, T. Hakulinen, and M. P. Coleman. 2009. 'What If Cancer Survival in Britain Were the Same as in Europe: How Many Deaths Are Avoidable?'. *British Journal of Cancer* 101 Suppl 2 (December): S115–24. https://doi.org/10.1038/sj.bjc.6605401

Briggs, Andrew, Mark Sculpher, and Karl Claxton. 2006. *Decision Modelling for Health Economic Evaluation*. 1 edition. Oxford: Oxford University Press, USA

Cancer Research UK. 2017. Lung Cancer - Stages, types and grades. Accessed [online] https://www.cancerresearchuk.org/about-cancer/lung-cancer/stages-types-grades

Cancer Research UK. 2014. Saving lives, averting costs. Report.

Devine, Angela, Anne Spencer, Sandra Eldridge, Richard Norman, and Gene Feder. 2012. 'Cost-Effectiveness of Identification and Referral to Improve Safety (IRIS), a Domestic Violence Training and Support Programme for Primary Care: A Modelling Study Based on a Randomised Controlled Trial'. *BMJ Open* 2 (3). https://doi.org/10.1136/bmjopen-2012-001008

Drummond, Michael F., Mark J. Sculpher, Karl Claxton, Greg L. Stoddart, and George W. Torrance. 2015. *Methods for the Economic Evaluation of Health Care Programmes*. Oxford University Press

Elliss-Brookes, L., S. McPhail, A. Ives, M. Greenslade, J. Shelton, S. Hiom, and M. Richards. 2012. 'Routes to Diagnosis for Cancer - Determining the Patient Journey Using Multiple Routine Data Sets'. *British Journal of Cancer* 107 (8): 1220–26. https://doi.org/10.1038/bjc.2012.408

EuroQol Group. 1990. 'EuroQol--a New Facility for the Measurement of Health-Related Quality of Life'. *Health Policy (Amsterdam, Netherlands)* 16 (3): 199–208.

Farrington, Jo. 2014. 'Early Detection of Cancer in Greater Manchester: Report on Data and Intelligence (NHS Report)'

Fleming, Ian, Pauline Monaghan, Anna Gavin, and Ciaran O'Neill. 2008. 'Factors Influencing Hospital Costs of Lung Cancer Patients in Northern Ireland'. *The European Journal of Health Economics: HEPAC: Health Economics in Prevention and Care* 9 (1): 79–86. https://doi.org/10.1007/s10198-007-0047-4

Hamilton, William. 2010. 'Cancer Diagnosis in Primary Care'. *Br J Gen Pract* 60 (571): 121–28. https://doi.org/10.3399/bjgp10X483175

GM Report. Greater Manchester Cancer Vanguard Report. 2017. Cancer Vanguard Evaluation Report Project 5 - Creating an online platform of cancer education and information for primary care

Hinde, S., C. McKenna, S. Whyte, M. D. Peake, M. E. J. Callister, T. Rogers, and M. Sculpher. 2015. 'Modelling the Cost-Effectiveness of Public Awareness Campaigns for the Early Detection of Non-Small-Cell Lung Cancer'. *British Journal of Cancer* 113 (1): 135–41. https://doi.org/10.1038/bjc.2015.167

Husereau, Don, Michael Drummond, Stavros Petrou, Chris Carswell, David Moher, Dan Greenberg, Federico Augustovski, Andrew H. Briggs, Josephine Mauskopf, and Elizabeth Loder. 2013. 'Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Statement'. *BMJ* 346 (March): f1049. https://doi.org/10.1136/bmj.f1049

Independent Cancer Taskforce. 2015. 'Achieving World-Class Cancer Outcomes: A Strategy for England'.

Jeong, Kim, and John Cairns. 2016. 'Systematic Review of Health State Utility Values for Economic Evaluation of Colorectal Cancer'. *Health Economics Review* 6 (August). https://doi.org/10.1186/s13561-016-0115-5

Manchester CCG. Central Manchester Clinical Commissioning Group (CCG). Annual Report 2016/17. Number of people registered GP in Manchester CCG and number of GP practices.

National Cancer Patient Experience Survey. 2016. Accessed [online] http://www.ncpes.co.uk/index.php

Ness, R. M., A. M. Holmes, R. Klein, and R. Dittus. 1999. 'Utility Valuations for Outcome States of Colorectal Cancer'. *The American Journal of Gastroenterology* 94 (6): 1650–57. https://doi.org/10.1111/j.1572-0241.1999.01157.x

NCIN (National Cancer Intelligence Network). 2010. Colorectal Cancer Survival by Stage - NCIN Data Briefing. Accessed[online]http://www.ncin.org.uk/publications/ data_briefings/ colorectal_cancer_survival_by_stage

NCRAS (National Cancer Registration and Analysis Service). 2018. The National Cancer Registration and Analysis Service. Accessed [online] http://www.ncin.org.uk/home

NG12. 2015. National Collaborating Centre for Cancer (NCC-C). Suspected Cancer: Recognition and Management of Suspected Cancer in Children, Young People and Adults. Clinical guideline. Appendices A–E. London: NCC-C; 2015. Accessed [online] URL:www.nice.org.uk/guidance/ng12/evidence/appendices-ae-74333342

NHS Digital (National Health Service). 2017. Number of patients registered with GP in England. Accessed [online] https://digital.nhs.uk/data-and-information/publications/statistical/patients-registered-at-a-gp-practice/september-2017 - number of patients registered with GP in England

NICE (The National Institute for Health and Care Excellence). 2013. 'Guide to the Methods of Technology Appraisal 2013 | 1-Introduction | Guidance and Guidelines | NICE'. 2013. http://www.nice.org.uk/article/pmg9/chapter/1-introduction

NICE (The National Institute for Health and Care Excellence). 2017. 'Suspected Cancer: Recognition and Referral: Guidance and Guidelines'. 2017. https://www.nice.org.uk/guidance/ng12/chapter/1-recommendations-organised-by-site-of-cancer

ONS (Office for National Statistics). 2016. 'Cancer Registration Statistics, England: 2016'. Accessed [online]https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/cancerregistrationstatisticsenglandfinal2016.

PSSRU (Personal Social Services Research Unit). 2017. Unit Costs of Health and Social Care. L. Curtis and A. Burns.

Public Health England (PHE). 2018. Cancer services. Accessed [online] https://fingertips.phe.org.uk/profile/cancerservices/data#page/0/gid/1938132830/pat/46/par/E39000037/ati/152/are/E38000016/iid/91349/age/1/sex/4

Roberts, Mark, Louise B. Russell, A. David Paltiel, Michael Chambers, Phil McEwan, and Murray Krahn. 2012. 'Conceptualizing a Model: A Report of the ISPOR-SMDM Modeling Good Research Practices Task Force–2'. *Medical Decision Making* 32 (5): 678–89. https://doi.org/10.1177/0272989X12454941.

Rubin, G P, C L Saunders, G A Abel, S McPhail, G Lyratzopoulos, and R D Neal. 2015. 'Impact of Investigations in General Practice on Timeliness of Referral for Patients Subsequently Diagnosed with Cancer: Analysis of National Primary Care Audit Data'. *British Journal of Cancer* 112 (4): 676–87. https://doi.org/10.1038/bjc.2014.634.

Rubin, Greg, Sean McPhail, and Kathy Elliott. 2011. 'National Audit of Cancer Diagnosis in Primary Care'. Royal College of General Practitioners.

Rubin, Greg, Fiona Walter, Jon Emery, Richard Neal, Willie Hamilton, and Jane Wardle. 2014. 'Research into Practice: Prompt Diagnosis of Cancer in Primary Care'. *The British Journal of General Practice* 64 (625): 428–30. https://doi.org/10.3399/bjgp14X681205.

Sturza, Julie. 2010. 'A Review and Meta-Analysis of Utility Values for Lung Cancer'. *Medical Decision Making: An International Journal of the Society for Medical Decision Making* 30 (6): 685–93. https://doi.org/10.1177/0272989X10369004.

Swann, Ruth, Sean McPhail, Jana Witt, Brian Shand, Gary A. Abel, Sara Hiom, Jem Rashbass, Georgios Lyratzopoulos, Greg Rubin, and The National Cancer Diagnosis Audit Steering Group. 2017. 'Diagnosing Cancer in Primary Care: Results from the National Cancer Diagnosis Audit'. *Br J Gen Pract*, December, bjgp17X694169. https://doi.org/10.3399/bjgp17X694169

Tappenden, Paul, James Chilcott, Simon Eggington, Julietta Patnick, Hannah Sakai, and Jonathon Karnon. 2007. 'Option Appraisal of Population-Based Colorectal Cancer Screening Programmes in England'. *Gut* 56 (5): 677–84. https://doi.org/10.1136/gut.2006.095109.

Wigan CCG. Wigan Borough Clinical Commissioning Group (CCG). Annual Report 2016/17. https://www.wiganboroughccg.nhs.uk/.../1-governing-body?...wbccg-annual-report- nunber of patients registered and number of GP practices

Westwood, Marie, Isaac Corro Ramos, Shona Lang, Marianne Luyendijk, Remziye Zaim, Lisa Stirk, Maiwenn Al, Nigel Armstrong, and Jos Kleijnen. 2017. 'Faecal Immunochemical Tests to Triage Patients with Lower Abdominal Symptoms for Suspected Colorectal Cancer Referrals in Primary Care: A Systematic Review and Cost-Effectiveness Analysis'. *Health Technology Assessment (Winchester, England)* 21 (33): 1–234. https://doi.org/10.3310/hta21330.

Wilson, Timothy R. B. Sc, David J. M. B. B. S. Alexander, and P. M. Phil Kind. 2006. 'Measurement of Health-Related Quality of Life in the Early Follow-Up of Colon and Rectal Cancer'. *Diseases of the Colon & Rectum* 49 (11): 1692–1702. https://doi.org/10.1007/s10350-006-0709-9.

Appendix 1: Method used to calculate the additional cost per GP consultation when Gateway-C is used

The additional cost per GP consult, lasting 9.22 minutes (PSSRU, 2017) was based on the cost of Gateway-C for the first year, the working lifetime of a GP and the number of years a GP worked post-qualifications, see Table 1. working lifetime of a GP was 26 years and reported by PSSRU (2017), and the number of years the GP was assumed to be using their qualification for. The assumption made was that GPs complete Gateway-C training at the beginning of their career.

Table 1 Inputs to calculate the additional cost of Gateway-C per GP consult

Item	Data	Source
Cost Gateway-C for year 1	£614,896.86	GM cancer vanguard (2017)
Expected working life (years) (EWL)	26	PSSRU (2017)
Work years post-qualifications (W)	44	PSSRU (2017)

The GPs working life was annuitised using an annual discount rate of 3.5%, as recommended by H.M. Treasury. The discount factor was calculated using the following formula:

$$Vn = 1/1(1+r)^n \qquad (1)$$

Where V is the discount factor per year, r is the discount rate (3.5%) and n is the number of years bthe cost is delayed after the base year. The discount factor for all 44 years were summed to derive an annuitised discount factor (ADF) of 22.283 for the 44 years. The equivalent annual cost (EAC) of Gateway-C was estimated using formula two:

$$EAC = Cost\ of\ Gateway - C / \left(\frac{EWL}{W}\right) * ADF^r \qquad (2)$$

Where EWL is the expected working life of the GP, the number of work years post-qualification and ADF is the annitised discount factor. Table 2 reports the cost per GP of Gateway-C. The number of GPs registered in England in 2016 was 34,495 (NHS Digital 2017).

Table 2 Total cost of Gateway-C per GP in first year

Item	
Time taken for GP to train per module (hours)	2
Per hour patient contact (cost)	£236
Total	£472
EAC per GP	£35.85
Number of GPs	34495*
Cost of G/C per GP	£17.83
Total G/C per GP (in first year)	**£53.67**

*Source: (NHS Digital 2017)

The additional cost per GP consult was estimated and the results are reported in table 3.

Table 3 Additional cost of GP consult

Cost Item	**Gateway-C**
Annual (excluding travel)	£252,697*
Cost of G/C (1 year)	£53.67
Total	£252,750.67
Per hour patient contact	£236.00*
(number of hours of contact)	1071
Per minute patient contact	£3.93*
(number of mins per hour)	60
Per surgery consultation 9.22 mins	**£36.26**

*Reported by PSSRU (2016)