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Rapid cancer diagnosis for patients with vague symptoms:

a cost-effectiveness study

Abstract

Background

A pilot rapid diagnosis centre (RDC) allows GPs within targeted clusters to refer adults with vague and/or non-specific symptoms suspicious of cancer, who do not meet criteria for referral under an urgent suspected cancer (USC) pathway, to a multidisciplinary RDC clinic where they are seen within 1 week.

Aim

To explore the cost-effectiveness of the RDC compared with standard clinical practice.

Design and setting

Cost-effectiveness modelling using routine data from Neath Port Talbot Hospital, Wales.

Method

Discrete-event simulation modelled a cohort of 1000 patients from referral to radiological diagnosis based on routine RDC and hospital data. Control patients were those referred to a USC pathway but then downgraded. Published sources provided estimates of patient quality of life (QoL) and pre-diagnosis anxiety. The model calculates time to diagnosis, costs, and quality-adjusted life years (QALYs), and estimates the probability of the RDC being a cost-effective strategy.

Results

The RDC reduces mean time to diagnosis from 84.2 days in usual care to 5.9 days if a diagnosis is made at clinic, or 40.8 days if further investigations are booked during RDC. RDC provision is the superior strategy (that is, less costly and more effective) compared with standard clinical practice when run near or at full capacity. However, it is not cost-effective if capacity utilisation drops below 80%.

Conclusion

An RDC for patients presenting with vague or non-specific symptoms suspicious of cancer in primary care reduces time to diagnosis and provides excellent value for money if run at $\geq 80\%$ capacity.

Keywords

cancer diagnosis; cost-effectiveness; early detection of cancer; general practice; non-specific symptoms; rapid diagnosis centre.

INTRODUCTION

A cancer diagnosis at an advanced stage worsens survival, quality of life, and patient experience.¹ Furthermore, it increases healthcare costs due to more expensive treatments, higher toxicity, and symptom burden,² and imposes a high financial burden on patients and society. Expediting cancer diagnosis and treatment initiation by improving patient navigation through complex diagnostic pathways is therefore central to recent national strategies.³ The National Institute for Health and Care Excellence (NICE) revised its guidelines to achieve timely cancer diagnosis and treatment based on 'risk thresholds' or 'red flags'.⁴ If the risk of symptoms being caused by cancer is above a positive predictive value of 3%, referral to the urgent suspected cancer pathway (USC) is warranted. However, 50% of patients with cancer in UK general practice do not present with the red flags required for referral to a site-specific suspected cancer pathway.⁵ These patients with vague and/or non-specific symptoms wait a median of 34 days longer to diagnosis compared with patients presenting with alarm symptoms.⁵

Recognising that existing guidelines and pathways underserve this patient population, the Danish 'three-legged model'⁶ was adapted

to provide fast access to multidisciplinary diagnostic centres for patients with non-specific and/or vague symptoms that could be due to cancer.⁷ In Wales, two health boards are piloting rapid diagnosis centres (RDCs), coordinated through the Welsh Cancer Network, to evaluate the feasibility, acceptability, effectiveness, and cost-effectiveness of these services through referral from primary care. The Swansea Bay University Health Board (SBUHB) pilot RDC opened in June 2017 and runs two half-day clinics a week with five available clinic slots. The current multidisciplinary team (MDT) consists of a consultant physician, a radiologist, a clinical nurse specialist (CNS), and a healthcare support worker (HCSW). Management and clinical guidance are provided by the RDC coordination manager and GP project lead. GPs can refer adults with vague and/or non-specific symptoms that could be due to cancer but do not meet criteria for referral under a USC pathway to the RDC. Appointments are usually confirmed within 48 hours of referral and chest X-ray and blood tests are initiated by the GP prior to the RDC appointment. Patients are seen at the RDC within a week and leave the clinic with either a diagnosis and management plan or further investigations booked.

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How this fits in

Patients presenting in general practice with vague or non-specific symptoms suspicious of cancer are currently underserved. Rapid diagnosis centres (RDCs) seek to address the unmet needs of patients who do not meet referral criteria to an urgent suspected cancer pathway. However, no evaluations of the cost-effectiveness of these novel services exist. This evaluation found that a pilot RDC reduced time to diagnosis and provided excellent value for money at >80% capacity utilisation compared with standard clinical practice.

Although the RDC addresses an important unmet need, the additional resources and costs required may displace other interventions and services for patients with cancer. This evaluation is therefore aimed at exploring the cost-effectiveness of the RDC in its first year of operation compared with standard clinical practice, to ensure that the RDC is doing more good than harm.

METHOD

Patient-level discrete-event simulation (DES)⁸ and decision analytic modelling were used to estimate the time from referral to diagnosis and the cost-effectiveness of the RDC compared with standard clinical practice.

DES models a sequence of events, following patients as they move through the cancer pathway. It allows resource costs and health outcomes to be modelled and is utilised widely in healthcare settings to tackle issues relating to capacity⁹ and pathway redesign.^{8,10}

The model was implemented in Microsoft Excel (2016), Visual Basic for Applications (version 7.01), and SIMUL8 Professional. Deterministic and probabilistic sensitivity analyses (PSA) explored the impact of assumptions and uncertainties.

The RDC clinicians validated the modelled patient pathways and all assumptions. The evaluation followed the NICE reference case¹¹ and adhered to Consolidated Health Economic Evaluation Reporting Standards (CHEERS).¹² An NHS and Personal Social Services perspective was adopted, following patients from referral to radiological diagnosis. The model ran over 1 year and findings were expressed as costs (in GBP at 2017 exchange rates) and quality-adjusted life years (QALYs). No discounting was applied as the time horizon did not exceed 12 months. The time horizon of 1 year was chosen to reflect the length of the available pilot data of the RDC.

Study population

Adults aged ≥ 18 years in the pilot area who were referred by their GP to the RDC at Neath Port Talbot Hospital (NPTH) for further investigation of non-specific and/or vague symptoms that could be due to cancer between June 2017 and May 2018 were included in the evaluation.

A cohort of 1000 patients was simulated based on real-life data of the NPTH RDC (for the intervention group) and routinely collected records of outcome-matched patients within SBUHB, who were referred to the USC pathway by their GP but then downgraded to the non-urgent pathway because of the absence of red-flag symptoms (for the control group). This sample size of simulated patients was chosen because it was sufficiently large to account for the variability inherent in the data, yet not so large that the model run-time became excessive. The number was validated by comparing the key modelling summary statistics for varying patient numbers (a facility that is available on SIMUL8). Data received for analysis were fully anonymised with all patient identifiers removed. Relevant permissions were in place before data release and data matching for the control group was performed by SBUHB.

Modelled patient pathways

On referral by their GP, patients attended the next available RDC clinic slot (Figure 1). Clinics began with an MDT meeting where current and available historical patient notes were discussed. Thereafter, patients saw the physician/CNS/HCSW for consultation and physical examination followed by a computed tomography (CT) scan. Alternatively, patients could start with a CT scan, followed by their physician/CNS/HCSW appointment. At the second MDT meeting all patient findings were discussed and the patients were placed into one of four categories:

- cancer diagnosis with referral to specialist;
- non-cancer diagnosis;
- no serious pathology found with discharge to GP; and
- no diagnosis; continue investigations.

Patients with suspected cancer were seen again by the CNS for a 20-minute appointment to discuss their diagnosis and begin a holistic needs assessment. Patients with non-cancer diagnoses or those who required further investigations were referred to relevant hospital departments. Patients with no serious pathology were reassured and discharged to their GP.

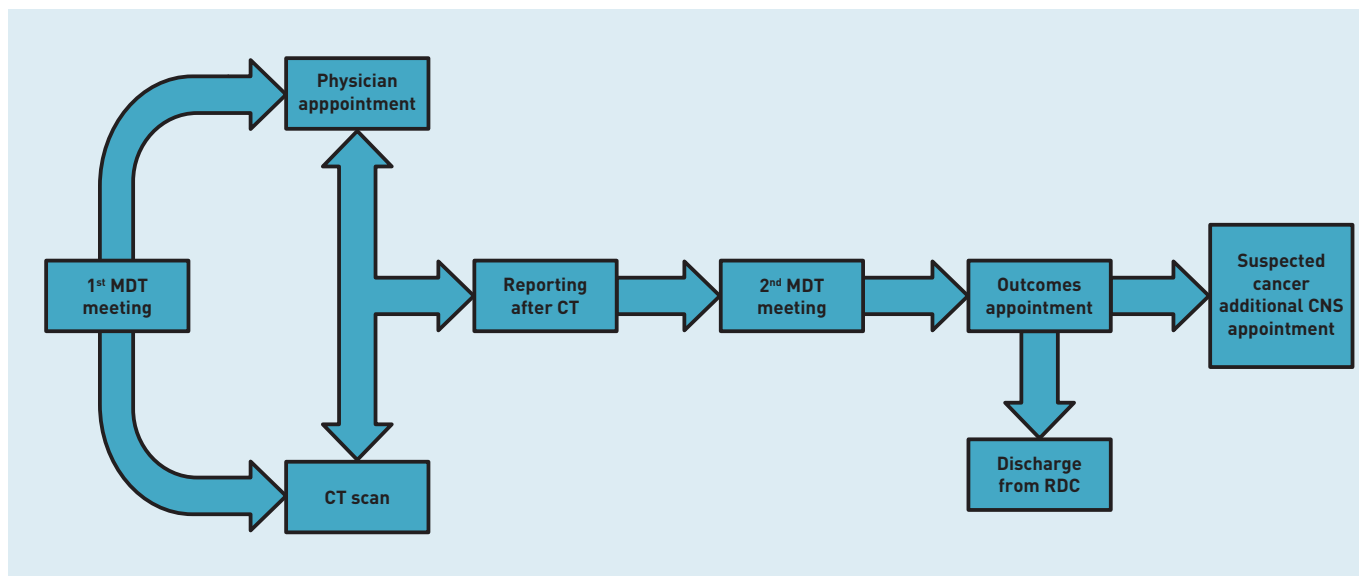


Figure 1. Schematic of the patient pathway through the rapid diagnosis centre (RDC) in the model intervention group. CNS = cancer nurse specialist. CT = computed tomography. MDT = multidisciplinary team.

Input parameters and data sources

Routinely collected, fully anonymised service data from the RDC provided model data inputs. The probability of a patient receiving a given diagnosis (for both RDC and control groups) was obtained from individually analysed RDC data. Expert opinion and clinical judgement were used where necessary to accurately interpret the diagnostic codes. Number of days between referral (to either RDC or USC) and diagnosis was obtained from RDC and hospital records. Distributions were fitted to the available data to allow sampling for each simulated individual in the model. Healthcare resource use was collected routinely for RDC patients and NPTH records were manually searched for control patients. RDC implementation costs included staff costs and overheads, and access to endoscopy, stationary, postage, consumables, and other non-pay items provided by the NPTH Finance Department. The number of CT scans (including the number of body areas scanned for each patient) and other investigative tests were recorded routinely and costed using published unit costs.¹³ Hospital records were searched for patients who required further investigations to identify secondary care resource use between RDC attendance and diagnosis. Similarly, control patient healthcare resource use was obtained from hospital records. Secondary care resource use was then micro-costed for each patient individually using standard unit costs.¹³ Primary care resource use for both model groups was established by examining the GP-reported mean frequency of GP visits in the 6 months prior to RDC referral, costed using standard unit costs.¹⁴ No utility data were recorded during the RDC. Therefore,

a rapid literature review was conducted and MEDLINE, PubMed, and NHS Economic Evaluation Database were searched following a systematic review framework. Search terms included 'suspected cancer diagnosis', 'quality of life pre-diagnosis and post-diagnosis', 'anxiety', and 'vague symptoms' (the complete list of search terms (or search strategy) can be obtained from the authors on request).

The initial search yielded 2438 results, of which 2426 were not relevant for patients with vague symptoms, based on a scan of the abstracts. Of the remaining 12 papers, three were applicable to the evaluation in question and reported data on QoL that could be used to extrapolate utility values.¹⁵⁻¹⁷ However, none of these papers reported utilities based on responses to the EQ-5D questionnaire, which is the preferred patient-reported outcome measure used to calculate utilities required for health economic evaluation.¹¹

Because of this lack of EQ-5D results in the published literature, utilities were extrapolated from the general population¹⁸ with pre-diagnosis anxiety-related decrements applied based on relative literature values.¹⁵⁻¹⁷ Further information and a detailed list of input parameters and data sources are available from the authors on request.

Analyses

A model-based cost-utility analysis (CUA) of the actual RDC provision between June 2017 and May 2018 assessed the incremental costs per QALY gained as a result of the introduction of the RDC compared with standard clinical practice. QALYs incorporate quantity of life and quality of life in one measure. The

Table 1. Total healthcare cost between referral and diagnosis

Outcome category	Mean cost per RDC patient, £ (SD), n = 189	Cost per control patient, £ (SD), n = 85	Difference, £
1 patient per clinic			
Cancer diagnosis	2758	2397 (2107)	361
Other diagnosis	2758	871 (688)	1887
No serious pathology found (discharge)	2758	515 (139)	2243
No diagnosis (further investigations)	3148 (214)	953 (381)	2195
2 patients per clinic			
Cancer diagnosis	1438	2397 (2107)	-959
Other diagnosis	1438	871 (688)	567
No serious pathology found (discharge)	1438	515 (139)	923
No diagnosis (further investigations)	1828 (214)	953 (381)	875
2.78 patients per clinic^a			
Cancer diagnosis	1068	2397 (2107)	-1329
Other diagnosis	1068	871 (688)	197
No serious pathology found (discharge)	1068	515 (139)	553
No diagnosis (further investigations)	1458 (214)	953 (381)	505
3 patients per clinic			
Cancer diagnosis	998	2397 (2107)	-1399
Other diagnosis	998	871 (688)	127
No serious pathology found (discharge)	998	515 (139)	483
No diagnosis (further investigations)	1388 (214)	953 (381)	435
4 patients per clinic			
Cancer diagnosis	778	2397 (2107)	-1619
Other diagnosis	778	871 (688)	-93
No serious pathology found (discharge)	778	515 (139)	263
No diagnosis (further investigations)	1168 (214)	953 (381)	215
5 patients per clinic			
Cancer diagnosis	646	2397 (2107)	-1751
Other diagnosis	646	871 (688)	-225
No serious pathology found (discharge)	646	515 (139)	131
No diagnosis (further investigations)	1036 (214)	953 (381)	83

^aActual mean number of patients seen between June 2017 and May 2018 per clinic. RDC = rapid diagnosis centre. SD = standard deviation.

Table 2. Summary of the results of the cost-utility analysis for a model cohort of patients, N = 1000

	No RDC	RDC	Difference (95% CI)
2.78 patients per clinic			
Cost	£934 156	£1 207 651	£273 494 [-£445 641 to £747 343]
QALY	1416	1425	9.20 [-204 to 201]
ICER (cost per QALY gained)	£29 732		
4 patients per clinic			
Cost	£934 156	£917 826	-£16 330 [-£713 924 to £448 358]
QALY	1416	1425	9.20 [-204 to 201]
ICER (cost per QALY gained)	-£1775 (outperforms)		
5 patients per clinic			
Cost	£934 156	£785 836	-£148 320 [-£839 771 to £312 218]
QALY	1416	1425	9.20 [-204 to 201]
ICER (cost per QALY gained)	-£16 124 (outperforms)		

ICER = incremental cost-effectiveness ratio. QALY = quality-adjusted life year. RDC = rapid diagnosis centre.

incremental cost-effectiveness ratio (ICER) resulting from the CUA was compared with the willingness-to-pay threshold of £20 000 per QALY gained as standardised by NICE.¹¹ A series of deterministic one-way sensitivity analyses investigated the impact of changes in RDC costs, number of patients per clinic, healthcare costs, and alternative utility assumptions on the results. PSA calculated the probability of the intervention being cost-effective at different willingness-to-pay thresholds based on 1000 bootstrapping iterations drawn from distributions around the mean base case values, and these probabilities were presented as a cost-effectiveness acceptability curve.

RESULTS

Between June 2017 and May 2018, 189 patients attended the RDC. Of these patients, 46% were male and the mean age was 70 years [standard deviation (SD) = 12.9 years; minimum = 26; maximum = 95]. Most patients presented with unexplained weight loss, pain, fatigue, and shortness of breath. The final outcomes were categorised into four groups: cancer diagnosis with referral to specialist (n = 23, 12%), non-cancer diagnosis (n = 30, 16%), no serious pathology found with discharge to GP (n = 68, 36%), and no diagnosis; continue investigations (n = 68, 36%).

Time to diagnosis

Mean time to diagnosis was 5.9 days (SD = 3.4; minimum = 1.0; maximum = 15.0) for RDC patients who had a cancer diagnosis, other diagnosis, or were discharged. For patients requiring further investigations, the mean time to diagnosis was 40.8 days (SD = 28.0; minimum = 0.0; maximum = 132.0). If outliers were removed (that is, 3-month delays for four patients needing specialised services), this decreased to 33.9 days. Control patients waited 84.2 days (SD = 65.3; minimum = 0.0; maximum = 657.0) for diagnosis.

Costs between referral and diagnosis

Total staff costs per half-day clinic were calculated as £2640 with CT scan and other test costs amounting to £118.21 per patient. Healthcare costs accumulated between RDC referral or USC downgrade and radiological diagnosis were estimated for all outcome categories in both model groups. Patients diagnosed with cancer or other conditions and discharged to their GP with no serious pathology found were assumed to only incur RDC costs. Any further investigations and all control pathways were costed individually. Costs are displayed in Table 1 for different

Table 3. Summary of one-way sensitivity analyses conducted and optimal strategy based on WTP of £20 000

Parameter	Change	Optimal strategy
Cost of RDC	Change number of patients per day from 2.78 to 5	RDC (outperforms)
Cost of RDC	Change number of patients per day from 2.78 to 4	RDC (outperforms)
Cost of RDC	Change number of patients per day from 2.78 to 3	No RDC (ICER = £22 140)
Cost of RDC	Change number of patients per day from 2.78 to 2	No RDC (ICER = £69 969)
Cost of RDC	Change number of patients per day from 2.78 to 1	No RDC (ICER = £213 459)
All costs	Add 20% to all costs	No RDC (ICER = £35 678)
All costs	Subtract 20% from all costs	No RDC (ICER = £23 786)
All costs	Add 50% to all costs	No RDC (ICER = £44 598)
All costs	Subtract 50% from all costs	RDC (ICER = £14 866)
Adjusted OR for control group cancer patients	After 2 months increase cancer QALY OR from 0.69 to 0.95	No RDC (ICER = £34 848)
Cancer diagnosis utility	Utility decreases by 3% to 0.602	No RDC (ICER = £62 637)
Utility	Keep all utilities 0.664 rather than 0.62 for all patients until diagnosis	No RDC (ICER = £245 102)
Utility	Keep all utilities 0.664 rather than 0.62 for all patients until diagnosis with number of patients 5 per day	RDC (outperforms)
Utility	Keep all utilities 0.664 rather than 0.62 for all patients until diagnosis with number of patients 4 per day	RDC (outperforms)
Utility	Keep all utilities 0.664 rather than 0.62 for all patients until diagnosis with number of patients 3 per day	No RDC (£182 514)
Utility	Keep all utilities 0.664 rather than 0.62 for all patients until diagnosis with number of patients 2 per day	No RDC (ICER = £576 811)
Utility	Keep all utilities 0.664 rather than 0.62 for all patients until diagnosis with number of patients 1 per day	No RDC (ICER = £1 759 700)

ICER = incremental cost-effectiveness ratio. OR = odds ratio. QALY = quality-adjusted life year. RDC = rapid diagnosis centre. WTP = willingness-to-pay.

Cost-effectiveness

The model base case used actual outcome data and costs of the RDC between June 2017 and May 2018 with a mean number of 2.78 patients per clinic. During this service start-up phase, the RDC was more costly and more effective compared with referral to USC pathway followed by downgrade with an ICER of £29 732 (Table 2). Since July 2018, the RDC has run near or at full capacity, consistently seeing between four and five patients per clinic, with a mean number of 4.65 patients (93% use of capacity) per clinic over the last year, thus outperforming usual care (that is, being less costly and more effective).

During deterministic sensitivity analysis (Table 3), findings were robust to changes in utility values and the assumption that the pre-diagnosis stage is associated with increased anxiety. Findings are sensitive to changes in costs and the number of patients attending each clinic. As such, due to economies of scale, the RDC outperforms standard clinical practice with four or five patients per clinic, but is not cost-effective when only one, two, or three patients are seen.

PSA based on the observed 2.78 patients per clinic in the RDC start-up phase produced a probability of being cost-effective of 48.5% at a willingness-to-pay threshold of £20 000 (Figure 2). At maximum capacity of five patients per clinic, RDC outperforms standard clinical practice with a 56.0% probability of being cost-effective.

DISCUSSION

Summary

A pilot RDC for patients with vague and/or non-specific symptoms suspicious of cancer is cost-effective compared with standard clinical practice available in Wales (that is, referral to USC pathway and subsequent downgrade due to the absence of red-flag symptoms) when run near or at full capacity.

patient numbers per clinic to illustrate the effect of capacity on RDC per-patient costs.

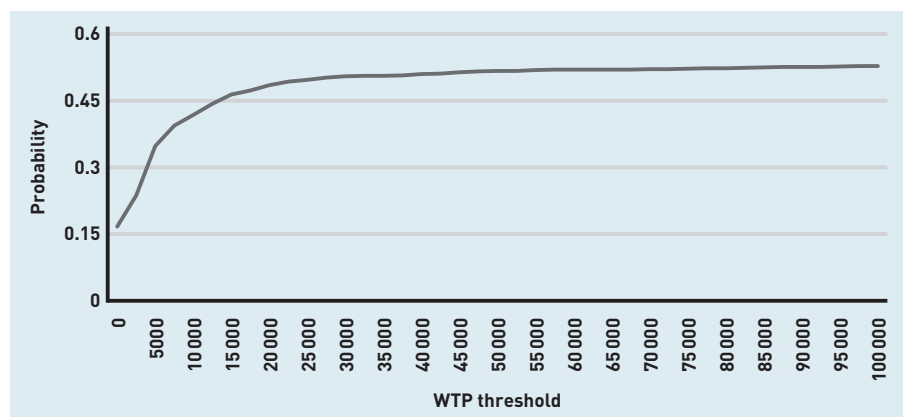


Figure 2. Cost-effectiveness acceptability curve summarising results of probabilistic sensitivity analysis across 1000 runs assuming 2.78 patients per clinic at different WTP thresholds. WTP = willingness-to-pay.

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Ethical approval

This modelling study using retrospective service data was supported by Swansea Bay University Health Board (formerly Abertawe Bro Morgannwg University Health Board) R&D Department. The study was classed as service development, rather than research, and, as such, did not require full research evaluation and ethical approval.

Provenance

Freely submitted; externally peer reviewed.

Competing interests

The authors have declared no competing interests.

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At between 80% and 100% capacity, the RDC produces more QALYs and is less costly, and thus outperforms standard clinical practice. Below 80% capacity, the RDC is not cost-effective at a £20 000 willingness-to-pay threshold. Mean time to diagnosis was 84.2 days (SD = 65.3) in the control group. This was reduced to 5.9 days (SD = 3.4) in patients who were diagnosed directly at the RDC clinic and to 40.8 days (SD = 30.0) if further investigations following RDC were warranted.

Strengths and limitations

This analysis is the first to consider the cost-effectiveness of an RDC for patients with vague and/or non-specific symptoms suspicious of cancer in the UK, using a relevant control, routine data, and DES. DES has proven valid and useful in various healthcare settings to model the impact of patient pathway changes,⁸ redesign,¹⁰ and capacity changes.⁹ However, the complexity of the service, patient population, and case mix required simplifications and assumptions to be made. These were verified by RDC key team members. The analysis assumes that all RDC staff are present throughout, even if the clinic is not at full capacity. As this may not accurately reflect routine practice, it could overestimate RDC implementation cost and underestimate cost-effectiveness at lower capacities. Detailed information was available for the patient pathway after RDC attendance. However, it was impossible to track patients in the control group who required further investigations after their first outpatient appointment for which no further patient notes were accessible. Therefore, the time to diagnosis was assumed to be the time to first outpatient appointment, which may underestimate time to diagnosis in a few cases. Although the impact of this omission is likely small, these results may still represent a conservative estimate of the cost-effectiveness of the RDC.

Furthermore, QoL data were not collected routinely as part of the RDC process. Utilities had to be extrapolated from the general population¹⁸ with decrements applied based on relative literature values.¹⁵⁻¹⁷ Although this was deemed the best available approach, this amount of data manipulation may have introduced bias. However, removing the effect of anxiety on patient QoL in sensitivity analysis showed that the effect of this uncertainty was small and did not change the direction of results.

Data used to populate the model were taken from the first year of the RDC pilot operation. These immature data did not

allow extrapolation of the longer-term impact of the RDC on healthcare resource use, patient outcomes, or survival. Considering the potential positive effect of earlier diagnosis on prognosis, this omission will underestimate the cost-effectiveness of the RDC. It is therefore planned to extend the model to a longer-term time horizon as soon as more mature data become available.

Comparison with existing literature

Although evaluations of rapid and multidisciplinary diagnosis centres are currently underway,¹⁹ this is the first robust and complete analysis of the cost-effectiveness of the RDC as part of routine care in the UK. Also, to the best of the authors' knowledge, no economic evaluations of the Danish cancer patient pathway for patients presenting with non-specific symptoms and signs of cancer (NSSC-CPP), on which the UK model of this service is based, exist.

Considering clinical outcomes, the cancer diagnosis rate of 12% in the RDC was comparable with conversion rates in many site-specific cancer pathways. Urgent suspected cancer pathway conversion rates were reported to be between a median of 8.0% and 17.0%,²⁰ and to have a mean of 11.8%,²¹ depending on the use of urgent pathways, referral rates, and cancer type. Also, a recent systematic review and meta-analysis of fast-track diagnosis of colorectal cancer found a cancer detection rate of 7.7% (confidence interval = 6.9% to 8.5%).²² Furthermore, the current study's results are similar to data from Danish NSSC-CPP patients ($n = 23\ 934$), which suggest a mean cancer diagnosis rate in an RDC setting of 11% (with values between 9% and 12%).²³

Implications for research and practice

Referral to rapid diagnosis services from primary care for patients with vague and/or non-specific symptoms suspicious of cancer addresses an important unmet need and provides value for money when run near or at full capacity. Furthermore, it reduces time to diagnosis and has the potential to improve patient outcomes. Development of a minimum dataset or registry, including collection of patient QoL data, should be considered to aid any future evaluations of the clinical and cost-effectiveness of the RDC. Harmonisation of key data items of RDC models across the UK and consensus on a suitable control in local and national contexts will be crucial in any comparisons. Using this first model as a template will enable further investigation as data mature.

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