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Original Article

Research or reality: Within the context of UK radiotherapy and cancer services, where should research and investment be focused to best improve UK treatment outcomes?

O.F.D. O'Connell

Department of Radiotherapy, Cookridge Hospital, Leeds LS16 6QB, UK

Abstract

Purpose: It is now six years since the publication of the NHS Cancer Plan. During this time, there has been considerable investment and research within UK cancer services. Some progress has been made towards improving treatment outcomes, but obstacles persist. This article explores some recent advances in cancer treatment and considers whether UK cancer treatment outcomes will best improve through the clinical advances being made in cancer research or whether improvement now needs to be more explicitly driven via a strategic approach. *Methodology*: The article explores this question from two differing perspectives. First, from a research perspective, it reviews briefly the evidence for a selection of clinical advancements in cancer therapy that have all been cited as providing breakthroughs in treatment outcomes. Second, it considers the investment in cancer research within a more strategic context, focusing on the reality of managing an improvement programme in UK cancer services. Here, some of the practical obstacles to improving treatment outcomes are highlighted. *Findings*: Significant progress has been made over the past six years towards improving UK treatment outcomes. Much of this is a direct result of international advances in clinical research. Further progress, however, is required. This article argues that progress will best be achieved by focusing resources and research investment on tackling some of the endemic strategic obstacles, highlighted in this article, that are the present reality within UK cancer services.

INTRODUCTION

Each year approximately 200,000 people are diagnosed with cancer in England, and 120,000 die of the disease. These rates were cited as among the worst in Europe, and, consequently, improving UK treatment outcomes became a key NHS priority.[1] Current predictions suggest the incidence of cancer is set to increase, with cancer overtaking cardiovascular disease as the biggest killer in the Western world.[2]

Research investment in the area of cancer is considerable. The UK National Cancer Research Institute estimates its total annual spend on cancer research to be £257 million. Of this, approximately £15 million is directly spent on radiotherapy and radiobiology research.[3] Of course, this ignores the further considerable international research investment.

With these levels of research investment, expectations of what is feasible will always exceed available budgets. Consequently, implementation of emerging research needs to be both clinically proven and cost effective.[4]

This article aims to explore some specialized techniques and advances in cancer therapy and to consider, in the context of UK radiotherapy

Correspondence to: Department of Radiotherapy, Cookridge Hospital, Leeds LS16 6QB, UK. Email: Owen.O'Connell@leedsth.nhs.uk

services, where best this research effort and investment should now be focused.

The article will examine these advances from two different perspectives. First, from the research perspective, a selection of emerging technological advances will be briefly examined. All these have been cited as providing breakthroughs in cancer treatment. The second, more strategic perspective, considers the reality within UK cancer therapy and examines some critical challenges facing implementation of the Cancer Plan targets.[1]

This article will explore an argument as to whether academic and commercial interests are perhaps, being allowed too much to drive and shape the debate on future advances in cancer therapy. It will conclude that, although it is important to acknowledge and support research, investment should focus on addressing some of the endemic strategic challenges present within UK cancer therapy if treatment outcomes are to continue to improve.

SOME EMERGING TECHNOLOGIES: THE RESEARCH

Evaluating current and future research investment in the area of UK cancer therapy first requires some consideration of the key areas of emerging technology. Clearly, this in itself is potentially a vast subject and thus will be only briefly considered here. From the specialized techniques and advances currently being researched, a number of emerging technologies have been selected:

- Positron emission tomography–computed tomography (PET–CT) functional imaging;
- Intensity-modulated radiation therapy (IMRT) and tomotherapy;
- Hadron therapy;
- Pharmaceutical research and pharmacogenomics.

These have been highlighted for analysis because all have been cited as providing possible future breakthroughs in cancer treatment.

PET–CT functional imaging

Diagnostic imaging has witnessed enormous changes in the past twenty years. Notably, the introduction of CT scanners and virtual simulation have supported the development of 3D conformal radiotherapy (3DCRT) and fundamentally changed radiotherapy practice.[5]

Despite these advances, Carey argues that there is still no reliable imaging method to distinguish those cancers that are 'biologically aggressive from those that may have a more indolent clinical course'.[6] This, surely, remains the challenge for imaging technology.

For the detection of metabolic as well as morphological changes, magnetic resonance spectroscopy (MRS) has been suggested.[7,8]

Internationally, however, it is the emergence of PET–CT that is significantly advancing functional imaging. The UK National Cancer Research Institute believes its future contribution will influence treatment management and advance our understanding of cancer mechanisms.[9]

PET–CT's contribution is, perhaps, most notable in the diagnosis and treatment of lung cancers. Erdi[10] argued that the incorporation of PET–CT fused images improved tumour definition, reduced geographical misses and improved local control. Ruysscher[11] supports these findings, arguing that the use of combined PET–CT enables significant dose escalation while preserving normal-tissue complications. NICE[12] recommends that all lung patients eligible for radical radiotherapy should have a PET–CT scan.

It is not just in lung cancer where PET–CT is making an impact. Heron[13] reviews PET–CT's use across a variety of tumour sites. Some key findings are summarized in Table 1. Heron[13] argues that these developments within PET–CT functional imaging, combined with advances in molecular and genetic science, will enable image-guided radiotherapy to advance.

The impact of PET–CT in the UK is less advanced. Postcode lotteries remain. At present, there are only approximately 15 PET–CT scanners in the UK, mostly located around London.

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Table 1. PET–CT: a review of the current evidence[13]

Tumour site	Research findings
Head and neck	Schwartz et al.[64] in a study of pre-radiotherapy staging found PET–CT superior to CT alone. PET–CT correctly identified 2 patients (in a study of 20 patients) with nodal disease that CT had diagnosed as node negative
Lung cancer	Tinteren et al.[65] reported that patients who underwent PET–CT scans had a relative reduction of 51% in the number of thoracotomies needed, with consequent savings in both patient morbidity and health care costs
	Holloway et al.[66] used PET–CT to define treatment volumes, enabling dose to be increased to 84 Gray before dose-limiting toxicity halted the study
	Ruysscher et al.[11] increased the dose to 69 Gray while maintaining the same level of toxicity to the lung, oesophagus and spinal cord when using PET–CT versus 3D planning with CT alone
Gynaecological cancer	Grigsby et al., [67] in a study of cervical cancer, found PET–CT to be superior to CT alone in detecting the presence of lymph node metastases
	Cohn et al., [68] in a study of vulval cancer, found PET–CT to be more accurate at detecting extra-nodal metastatic disease confined to the groin
Gastrointestinal cancer	Westreenen et al.[69] demonstrated that PET–CT could reduce surgical intervention by up to 50% owing to better detection of more extensive disease
	Duong et al.[70] reported that PET–CT for the staging of oesophageal cancer facilitated better selection of patients for tailored treatment planning, leading to improved disease survival.
Brain tumours	Popperl et al., [71] in a study of 63 patients with a suspected recurrent glioma, reported that they were able to successfully to distinguish between clinical recurrence and post-therapeutic benign lesions using PET–CT.

Access to PET–CT imaging technology is hampered both by capital costs, estimated at approximately £1.5 million per scanner,[14] and geographical access to a cyclotron, owing to the rapid half-life of the FDG-18 isotope.[15,16]

IMRT and tomotherapy

The development of increasingly conformal treatments has seen the emergence of IMRT. These precise treatment techniques are being assisted by more robust planning algorithms, such as the Monte Carlo algorithm.[17]

Inverse-planning systems are being developed, supporting IMRT implementation, optimizing treatment accuracy and integrating volumetric imaging into on-line validation of treatments.[18]

Beavis[19] describes the emergence of helical tomotherapy, arguing that this represents the future of IMRT. Kupelian[20] believes developments within tomotherapy and serial megavoltage CT imaging will enable PTVs to be monitored during treatment and to be further reduced through tumour shrinkage. Suit[21] concurs, describing a fourth-dimensional planning stage, namely time, whereby tumour motion and shrinkage are corrected on-line during treatment and updated throughout the patient's course of radiotherapy.

Concerns, however, have been raised with integral dose levels. Hall and Wuu[22] warn of the risk in secondary radiation-induced carcinomas as a result of increased integral doses from the multiple field arrangements used with IMRT treatment techniques. Similarly, Mutic[23] reports an increase in whole-body dose equivalent using tomotherapy treatments, with consequent possible increases in radiation-induced fatalities.

Access to tomotherapy units within the UK remains very limited. Interestingly, though, the Cromwell Hospital in London has recently announced its intention to migrate entirely to this technology, with a second tomotherapy unit having been commissioned in Summer 2006.[24]

Hadron therapy

Hadron therapy, using protons, neutrons and light ions to treat complex and advanced tumours, is attracting increasing interest. Charged hadrons have a much more defined distribution of dose at depth, characterized by their Bragg Peak, which is high and narrow because of their monoenergic release of the highest dose towards the end of their energy range.[25]

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In a keynote lecture on the future of radiotherapy in the twenty-first century, Suit[21] argued that proton beams are likely to replace photon beams in the next 20–30 years owing to their superior physical characteristics. Certainly, several reports demonstrate much higher levels of conformality and avoidance of normal tissue than is possible using even the most sophisticated IMRT techniques.[21,25,26]

Worldwide, there are relatively few hadron facilities operational. To date, clinical studies have been limited to phase-I and phase-II trials.[26] Clinical results do appear impressive, as demonstrated in Table 2. However, some of these studies remain unpublished. Lennox[27] is perhaps more cautious than Suit,[21] arguing that there is not yet enough long-term experience, derived properly through randomized clinical trials, to demonstrate the superiority of hadron treatment.

Any belief that protons will replace the photon plays down the practical obstacles to their implementation – notably, the costs associated with commissioning such centres. Suit[21] argues that history demonstrates that 'perceived efficacy and not the cost primarily determine the fate of new technology'. As I argue later, such a view is unlikely to find favour within the context of current NHS funding constraints.

The costs of commissioning a hadron facility are considerable. Goitein and Jermann[28] estimate them to be 2.4 times the costs of photon treatments, but argue that they will reduce over the next 10 years. Costs could be reduced further if treatments were offered over longer hours, or over shorter fractionation regimes.[28]

There are other, indirect practicalities to be considered. A hadron facility requires a significant amount of space, precluding building within many current hospital sites. Moreover, as these accelerators are served from a single energy source, if the cyclotron develops problems, this will halt all treatments within the facility.[28]

Jones and Burnet[26] argue strongly for the presence of a hadron facility within the UK. It is noteworthy that their demands are being considered as part of the current 'radiotherapy stock-take' exercise.[29]

Pharmaceutical research and the emergence of pharmacogenomics

Systemic treatment has developed during the past 20 years as an integral element of cancer management. With lung cancer, for example, chemotherapy advances have been cited as improving response rates, although these have since largely plateaued.[30] Similarly, with breast cancer, the use of both chemotherapy drugs and hormone treatments, such as tamoxifen, are now recommended for early-stage treatment.[31] However, progress has been slow, steady and very costly, with clinical outcomes rarely achieving those purported by their manufacturers.

Table 2. *Advantages of hadron therapy: a review of the current evidence*[21]

Tumour site	Research findings
Skull-based sarcoma	Debus et al.[72] report 10-year local control rates of 95% for proton therapy versus 45% with photon therapy
Uveal melanoma	The Massachusetts Eye and Ear Infirmary, in association with the Harvard Cyclotron, report 15-year local control rates of 95% for proton therapy; however, this study, reported by Suit,[21] remains unpublished
	Egger et al.[73] substantiate the findings of the previous study, reporting a 10-year local control rate of 95%
Paranasal sinus carcinoma	Thornton, having treated 86 patients with advanced disease (T3 and T4), reports 4-year local control rates of 83% for proton therapy;[74] again, it is notable that this study is reported by Suit [21] from unpublished data
Hepatocellular carcinoma	Tokuuye et al., [75] in a study of 236 patients with a very high dose rate of approximately 4.5 Gray per fraction, reports 3-year local control rates of 93% for proton therapy

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Current pharmaceutical research is focusing on developing new strategies within genetic and biological oncology. Pharmacogenomics is emerging to develop drugs that are 'personalized' to a specific patient's genetic profile.[32] For many cancers, critical proteins affecting tumour growth are now being targeted using monoclonal antibodies.

Such developments, of course, bring added cost pressures. The annual NHS drugs bill is estimated at £7 billion, with the UK pharmaceutical industry being cited as the third most profitable economic activity.[33] However, conflicts exist between the interests of the NHS, patients and the pharmaceutical industry.

Recent reports regarding the benefits and funding of the monoclonal antibody Herceptin (trastuzumab) provide an interesting illustration of this conflict.

Two studies demonstrated benefits from Herceptin for early-stage breast cancer.[34,35] An editorial, commenting on these studies, described their results as 'simply stunning ... and revolutionary', suggesting 'maybe even a cure'.[36]

Unsurprisingly, this editorial sparked media attention, with international demands for Herceptin. Within the UK, NICE and the Department of Health both experienced pressure to license and fund the drug.

The *Lancet* highlighted several flaws in the research, notably merged clinical trial data, a lack of overall and disease-free survival data and no analysis of cardiotoxicity.[37] The *Lancet* concluded that the evidence for Herceptin in early-stage breast cancer remained unclear and argued that bodies such as NICE should be allowed to consider their decisions properly on the basis of clinical evidence. Moss[38] concurred, arguing that the evidence presented suggested only modest improvements for a minority of early-stage patients. Interestingly, Moss also highlighted a potential conflict of interest, with Dr. Hortobagyi also being a paid consultant for the leading US distributor of this drug.[38]

Consequently, within the UK, in addition to recommending increased funding for NICE to enable more timely analysis of new drugs, the Health Committee also recommends that professional bodies declare their members' interests through a public register.[33]

ARE WE BEING SEDUCED BY THE RESEARCH? BACK TO REALITY

The previous section provides some insights into potential developments in cancer therapy. However, some caution is required. It is perhaps too easy to be seduced by all this research and technology and to miss the wider picture concerning treatment outcomes.

Bentzen[39] poses an interesting question regarding whether limits need to be established on demands for ever-increasing technological accuracy within oncology, and asks whether demands for greater accuracy will further improve outcomes. Bentzen concludes that further technological refinement needs to be more closely allied with those patient subgroups most likely to benefit.[39] Certainly, this accords with an emerging theme within much current research, as illustrated, for example, within pharmacogenomics.

Research advances in cancer therapy need to be considered against their likely contribution to improving UK treatment outcomes. Here, a distinction may be drawn between two, sometimes opposing, perspectives.

The first, and perhaps more popular, perspective operates at the micro-level. Here, individual research studies abound, each exploring and, sometimes, claiming advances in cancer outcomes. Many of the studies cited above fit such a paradigm. This perspective lends itself more to the scientific method and also to international commercial interests, many of which, support this research.

The second perspective operates at a more macro-level. Here, arguments to advance cancer therapy focus on the reality of service

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Table 3. Additional NHS investment in UK cancer services (£millions)[76]

Financial year	
2001 – 2002	199
2002 – 2003	406
2003 – 2004	639
Breakdown of the main areas of investment:	
Extra staff (975 consultant posts):	£230 million
Cancer drugs (representing 45% of the additional revenue spend):	£192 million
New equipment:	£113 million
Staff training, modernizing services and palliative care:	£104 million

provision and those strategic solutions that can best improve outcomes. This perspective applies more within a national socio-political arena than the former. It does have practical influence over cancer advances and, in consequence, will have a greater, more immediate, impact on improving UK treatment outcomes.

Having explored the micro-level perspective, this article now considers the macro-level perspective.

Within the context of the NHS Cancer Plan,[1] some critical strategic constraints affecting improvements in UK cancer outcomes persist. Despite the very real progress made towards improving treatment outcomes as a result of its published targets, a number of critical obstacles remain. These have been either ignored or dismissed in favour of the more micro-level solutions discussed above.

To further improve UK treatment outcomes, there is now a need to adhere more rigidly to a strategic perspective:

- First, there needs to be a proper and more explicit health care rationing debate to achieve an affordable NHS in the twenty-first century;
- Second, continued progress is required to reduce waiting times for cancer treatment;
- Third, equipment replacement and manpower planning in radiotherapy services need to be more robust in the context of predicted increases in workload;
- Fourth, there needs to be speedier progress in agreeing clinical protocols to consolidate fractionation regimes based on the current evidence.

Health care rationing: what can the NHS afford to buy?

The NHS Cancer Plan established a 10-year strategy to improve cancer care and treatment outcomes in the UK.[1] Since then, significant additional investment has been directed towards cancer services, as highlighted in Table 3.

A review of progress indicated that mortality rate predictions for the under 75's are slightly ahead of schedule to meet the 20% reduction target by 2010.[40] The National Audit Office further supported this analysis in its report on progress against the Cancer Plan targets.[41] Both these reports have received criticism for too optimistic an analysis.

Sikora argues that the UK still lags behind most other countries in Europe and the USA in its cancer services, believing the answer is to introduce a more pluralist solution, with the private sector competing with the NHS to deliver cancer services.[42] Although this view is seen by some as controversial, there is speculation that such options may be supported as part of the current National Radiotherapy Advisory Group's (NRAG's) 'radiotherapy stock-take'.[43]

Such funding debates do highlight wider health economics questions concerning what NHS services the UK can now afford to provide. The twenty-first century NHS is a vastly different institution from that envisaged back at its inception in 1948. The pace of medical advances since then means we do need to revisit properly the notion of a health care service free at the point of delivery for all. Not all scientific advances can be afforded and, consequently, choices will have to be made.

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Against a backdrop of significant government investment, and in the absence of such an explicit debate, there has been much media attention to the latest NHS funding crisis and redundancies. Some radiography departments have already experienced redundancies, and included amongst these have been reductions in therapy radiographer establishments.[44,45]

Health care funding pressures are not unique to the UK. Schueren argues they are common across most Western countries, and that, as a consequence, explicit health economics choices now need to be made.[46]

Future investment and advances in cancer therapy, therefore, need to be considered in the context of this more explicit health care rationing debate. Without such a debate, there is a very real danger that many of the current capital investment programmes under way within cancer services across the UK will instead be attacked in media headlines, alluded to by critics such as Sikora, citing wastage of taxpayers' money owing to a failure to invest properly in the revenue, as well as the capital, consequences of such developments.[42]

The need to reduce waiting times for cancer treatment

In addition to these economic pressures, increasing waiting times represent challenges to improving treatment outcomes.

The Cancer Plan established two specific targets to be met by December 2005.[1] Nationally, neither target has been achieved (Table 4). Meeting these targets has been described as 'an enormous challenge'. Failure to achieve waiting times is largely attributable to the national shortage of therapy radiographers, which, despite investment, will take time to resolve.[40]

A UK audit of radiotherapy centres, however, suggests waiting times have risen. Reasons cited are a combination of increased patient numbers, insufficient equipment and increasingly complex treatments.[47]

A number of studies have directly cited radiotherapy delays as having an adverse impact on treatment outcomes. O'Rourke and Edwards demonstrated that delays, in both referral and treatment, resulted in patients initially eligible for radical treatment having to be treated palliatively.[48]

It would be wrong to presume that this is just a UK problem. International studies demonstrate similar problems.[49,50] Both these studies cite similar reasons to those given by Ash[47] for these delays and demonstrate that such delays have an adverse impact on tumour control and treatment outcomes.[49,50] Similarly, Huang et al. reported a three-fold increase in local recurrence for head and neck tumours when waiting times rose above six weeks.[51]

In response to calls for a UK hadron facility,[26] Dodwell and Crellin caution that such investment will merely divert scarce resources from tackling this larger problem of increased waiting times, thereby further adversely affecting outcomes. They argue that these strategic issues need to be addressed first.[52]

Equipment replacement and proper manpower planning

Despite the significant investment highlighted in Table 3, the Royal College of Radiologists argues that the benefits of much replacement equipment are being countered by the deteriorating age profile of existing stock. This also, through machine breakdown and unplanned treatment interruptions, affects treatment

Table 4. *Progress towards the 2005 waiting time targets*[40]

2005 waiting time targets	Progress
Maximum two-month (62 days') wait from urgent GP referral to first treatment for all cancers by December 2005	78 % of all urgently referred patients with cancer treated within 62 days (based on published data for April–June 2004)
Maximum one-month (31 days') wait from diagnosis to first treatment for all cancers by December 2005	89.9 % of all patients diagnosed with cancer treated within 31 days (based on published data for April–June 2004)

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Table 5. Investment in UK cancer equipment[40]

Equipment purchased	Replacement equipment	New equipment	Total
Computed tomography scanners	168 (75%)	55 (25%)	223
Magnetic resonance imaging scanners	56 (50%)	57 (50%)	113
Linear accelerators	76 (73%)	28 (27%)	104

outcomes.[53] Table 5 highlights the relative proportion of new and replacement equipment.[40]

Furthermore, many departments are operating with significant vacancy levels such that they are unable to staff their normal working sessions at full capacity.[53] A UK audit of head and neck radiotherapy provision concurs. James et al. cite both ongoing shortages of radiotherapy and medical-physics staff and the need for further investment in equipment.[54] More recently, Dodwell and Crellin have argued that, despite investments, staff shortages mean many radiotherapy centres are unable to cope with increasing workloads.[52]

Meanwhile, Sikora depicts an image of new linear accelerators 'lying around in boxes' within the NHS owing to the inability properly to fund the staff for their use.[42] Certainly, it has proved easier to secure capital investment, through programmes such as the New Opportunity Funds, than the revenue investment required to staff and run such machines on a ongoing basis.

Proper manpower planning for key staff groups within cancer services remains critical to future improvements in treatment outcomes. The attempt to address recruitment shortages with the introduction of the four-tier service has been one response. Initial reports, however, describe its implementation as haphazard and lacking uniformity.[55]

Expansion of radiotherapy training places offers a further solution. These are reported to have doubled since 2000, and attrition rates have also reduced.[41] Beardmore, however, reports concerns that overall attrition rates remain at nearly one-third.[29] Surprisingly, attrition rate analyses seem to focus purely on student radiotherapists, with little research or comment made on attrition rates of experienced staff within the profession generally.

All the manpower planning effort towards expanding the number of therapy radiographers is, however, being countered by the present NHS implementation of the 'Agenda for Change' (AfC). It had been envisaged that this would establish a uniform national pay and conditions programme across the NHS for all staff groups. It fails, however, to recognize and accommodate those key staff groups where there are national shortages. Indeed, its implementation has meant that salaries for therapy radiographers and medical dosimetrists have fallen across all grades of staff nationally. This has happened despite the national shortage. In consequence, many UK radiotherapy centres' expansion programmes are now being thwarted by high vacancy levels and inadequate staffing establishments.[56]

AfC has, in addition, been criticized for being locally interpreted, such that pay disparities persist across different grades of staff and between different radiotherapy centres. Consequently, some of those (foundation) hospitals that are able to, have chosen to drop the AfC pay and conditions structure in favour of pre-existing agreements.[57]

AfC is not conducive to attracting and retaining key staff in therapy radiography and medical dosimetry. For progress to be made towards the achievement of the NHS Cancer Plan targets, the national implementation of AfC among these staff groups needs urgent reconsideration.

Meeting increased capacity demands means continued investment in equipment and staffing. The Royal College of Radiologists argues

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for the need to plan accounting for future capacity requirements and not just for present-day requirements.[53]

The Society of Radiographers published two position papers recently in an attempt to influence future workforce planning: one to establish initial baseline establishment requirements;[58] the other to define better the future role of the therapy radiographer.[59]

There is much that the UK could learn from the approach taken in Australia in radiotherapy utilization modelling. Delaney et al.[60] suggest a much more scientifically robust model to develop an evidence-based benchmark to measure the use of radiotherapy for specific cancers. Involving the country's leading clinical oncologists and epidemiologists, an expert committee reviewed the evidence for specific cancers and compared the optimum rate of radiotherapy use with current radiotherapy utilization.

Delaney's utilization model has now been used to map more than 23 of Australia's major cancer sites, reviewing the evidence from more than 1,400 scientific papers in the process to advise the Australian government on demand for radiotherapy. With such a robust model, and the active involvement of the country's leading clinicians, the Australian government could not ignore such advice and has already implemented most of the recommendations.[56] Although it falls short of making specific recommendations on manpower planning, such a methodology could be extended to define more conclusively the current and future manpower requirements in cancer services.

Significantly, the NRAG has been established to undertake a 'radiotherapy stock-take' considering all aspects of planning and delivery of radiotherapy services, including equipment requirements, service delivery, workforce requirements and future developments.[29] These recommendations, expected to be published in 2007, are likely to have a major influence on the future strategic development of UK cancer therapy.

The impact of differing fractionation regimes

Increasingly complex treatments have already been cited here as contributory causes of rising waiting times.[47,49,50] In addition, combined equipment and staffing pressures, compounded by financial pressures, suggest that additional capacity must be identified to improve treatment outcomes. Within these increasingly complex treatments, the impact of the fractionation regimes adopted needs to be considered.

Ash reported a reduction in the number of fractions prescribed for palliative treatment, but this was offset by an increased fractionation for radical treatments.[47] Kirkbride believes these changes represent qualitative changes in radiotherapy practice that ultimately will improve outcomes.[61] However, Kirkbride also argues that urgent consensus is required on fractionation regimes, highlighting that 85 different palliative fractionation regimes were reported as part of the audit undertaken by Ash.[47,61]

Ongoing clinical trials, notably START, are investigating the optimum fractionation regime for breast treatments. Breast irradiation represents approximately 40% of the workload of UK radiotherapy departments.[62] Given this, reductions in fractionation here as a result of such research could have a major impact on waiting times and, in consequence, treatment outcomes.[63]

Bentzen argues that fractionation also needs to be considered from this more pragmatic, rather than radiobiological, viewpoint when looking at its impact on treatment outcomes.[39]

To date, progress by the Royal College of Radiologists in agreeing clinical protocols to consolidate the number of different fractionation regimes has been slow. This slow progress may well also be hindering improvements in clinical outcomes. It is notable, therefore, that NRAG has also highlighted fractionation as one aspect to focus on in their future strategic recommendations.[29]

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CONCLUSION

Improving treatment outcomes for cancer, in the context of rising epidemiological incidence, presents considerable challenges. Improvements have been demonstrated since the NHS Cancer Plan[1] was first published. Although the UK still does not lead Europe in terms of its treatment outcomes, its position is improving such that it no longer falls at the bottom of the performance tables, and there is evidence that UK mortality rates have fallen.[41]

The considerable investment in research and technology has been instrumental in achieving these improvements. Continued research is vital if further advances are to be made. Equally, this research needs to be supported by sustained investment to exploit those findings that best improve outcomes.

Research and investment, however, occurs in an international arena. Emerging technologies are the product of both commercial and scientific interests and commercial, and parochial, interests still arise. Examples cited here, such as the research on Herceptin and academic lobbying for a UK hadron facility, illustrate this.

There is a dilemma here, and some conflict, as to whether such research interests should lead future advances in cancer treatment or whether research should be more centrally directed towards achieving the targets established in the Cancer Plan.[1]

To an extent, there is tacit acceptance that individual research will pursue its own agenda, regardless of national considerations. That said, this article has highlighted the strategic constraints that have a significant impact on treatment outcomes. Most notable, perhaps, are the indications that emerging technology must demonstrate both clinical and economic effectiveness and that capital investment in equipment and technology alone will not secure improvements in treatment outcomes. Revenue investment also needs proper consideration to expand and retain key staff groups within radiotherapy services, thereby ensuring that the service improvements currently under way across the NHS are properly realized.

The NHS Cancer Plan[1] has been described as 'well constructed, well regarded' and as 'provid[ing] a good foundation for further refinements'.[41] This article concludes that although it is important to acknowledge and support research into emerging technologies, the need to remain properly focused on addressing the endemic strategic challenges facing UK cancer services remains paramount if treatment outcomes are to continue to improve.

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