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VISION FOR RADIOOTHERAPY

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Every year around 300,000 people are diagnosed with cancer in the UK and more than 150,000 people die from cancer. Cancer Research UK is the world's leading cancer charity dedicated to saving lives through research. Together with our partners and supporters, our vision is to bring forward the day when all cancers are cured. We support research into all aspects of cancer through the work of over 4,000 scientists, doctors and nurses. In 2012/13, we spent £351 million on research in institutes, hospitals and universities across the UK. The charity's pioneering work has been at the heart of the progress that has already seen survival rates in the UK double in the last forty years. We receive no government funding for our research. www.cancerresearchuk.org

NHS ENGLAND

NHS England is from April 2013 the sole commissioner for radiotherapy for all cancer treatments in England. A national team defines the service specification and national clinical access policies and 10 area teams contract with providers. In building a 5-year strategy this joint report with Cancer Research UK is key in defining the focus on radiotherapy for the next few years. NHS England is supported by a national Clinical Reference Group for Radiotherapy and Stereotactic Radiosurgery to provide clinical and public advice. <http://www.england.nhs.uk/>

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This report was written by Emlyn Samuel and Jennifer Boon (Cancer Research UK) with input from an expert Steering Group. For more information, please contact Jennifer Boon, jennifer.boon@cancer.org.uk, 020 3469 5374.

We would like to thank the Steering Group, contributors and panelists at our expert meeting as well as all those who submitted written evidence. Please see Appendix 1 for a full list of contributors.

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VISION FOR RADIO THERAPY

Radiotherapy can cure cancer, is cutting-edge and is cost effective. It is second only to surgery in its effectiveness in treating cancer, and experts suggest around four in ten patients whose cancer is cured receive radiotherapy.² Around 50 per cent of cancer patients should receive radiotherapy as part of their treatment.

Radiotherapy has become significantly more sophisticated in the last decade. Advanced radiotherapy treatments target tumours more accurately and reduce the irradiation of healthy tissue, improving patient outcomes and reducing side effects. But while technical advances are being made, historically the NHS has not adopted innovations into clinical practice in a consistent and equitable way in radiotherapy centres across England. NHS England now commissions radiotherapy for the whole of England, offering a real opportunity to drive improvements consistently across the NHS.

This report sets out NHS England's and Cancer Research UK's shared vision for the future of innovation in radiotherapy. It will inform NHS England's 5 year strategy for radiotherapy services, which will be developed as part of the specialised services strategy planning taking place in early 2014. A clear vision will provide the NHS with a framework to build an effective strategy to meet the Prime Minister's commitment, that from April 2013 onwards, patients will be guaranteed access to innovative radiotherapy where clinically appropriate and cost-effective. We hope that health departments in the devolved nations will also find this document useful, potentially taking forward relevant elements within their countries.

This report defines advanced and innovative radiotherapy and sets out the radiotherapy that should be available to patients in the future. Our vision for patients requiring radiotherapy in the NHS in England is that:

All patients will receive advanced and innovative radiotherapy that has been shown to be clinically and cost effective. Radiotherapy will provide patients with substantially improved outcomes, higher cure rates, and fewer side effects from their treatment.

Innovation in radiotherapy will enable:

- Stratification of patients who will benefit from radiotherapy.
- Personalisation of radiotherapy treatment based on physical and biological characteristics of the patient and their disease.

² Department of Health (2012). *Radiotherapy services in England 2012*.
<https://www.gov.uk/government/publications/radiotherapy-services-in-england-2012>

- Treatment to be adapted to the patient during the course of treatment, reacting to physical and biological changes, for example, due to innovations in real time imaging and the use of biomarkers.

NHS England will need to ensure that all radiotherapy centres meet national standards through the application of robust service specifications and the quality dashboard. This will include the right equipment, workforce capacity and capability to deliver optimal, high quality treatment to all patients in a timely manner, wherever they live.

NHS England, working in partnership with Cancer Research UK, the professional bodies, radiotherapy service leaders and manufacturers, will define a national strategy for the implementation of the vision. This will align with NHS England's commissioning intentions to ensure that services develop to meet these aspirations.

This will require focus on the following key elements:

1. Strong leadership at national and local levels

Effective leadership in NHS England and radiotherapy centres is vital to meet the challenges to innovation in radiotherapy, and particularly in encouraging strong partnership working between centres. Robust commissioning levers and incentives at the national level will be necessary to drive innovation and efficiency in radiotherapy and remove outdated practice.

2. Standardised treatment protocols

A consistent approach to the treatment of patients with radiotherapy using nationally agreed protocols to ensure patients have the same standard of treatment regardless of where they live. Waiting times for treatment will be further reduced as appropriate for each type of cancer or condition to avoid unnecessary delays.

3. Evaluating and quickly adopting innovation

The timely formation of national clinical policies to support the rapid adoption of affordable new technologies, including treatment devices, imaging techniques and treatment planning software, across the NHS is needed, where evaluation has shown clinical effectiveness and cost effectiveness.

4. Realising the full potential of advances in treatment imaging

Some of the greatest foreseeable improvements in radiotherapy will be driven by advances in imaging, with advances being made across the radiotherapy pathway. Real-time, multi-modality imaging and the identification and validation of predictive biomarkers will drive personalisation of treatment, and the ability to assess patient responses during treatment.

5. Optimising the highly skilled workforce

Taking full advantage of advances and innovations in radiotherapy will require highly skilled staff, effective team working, training and sufficient capacity in the workforce. New models of working will be crucial to deliver advanced treatments and supportive care across radiotherapy pathways.

6. Harnessing the power of data

Data generated from radiotherapy planning and treatment, for example the Radiotherapy Dataset, has the potential to provide powerful insights into the delivery of radiotherapy. It can also inform research and innovation. Data must be used to its full potential, including linking with outcome data to inform new treatment pathways and support personalisation. Each radiotherapy centre must generate their own local outcome data to inform discussions with patients about treatment options.

7. Embedding research activity into the radiotherapy service

Ensuring radiotherapy practice is at the forefront of innovation will require a dedicated focus to ensure research becomes an integral part of radiotherapy services. This will drive more clinical trial opportunities as well as service level innovations. All cancer areas should equitably benefit from further research, in particular brachytherapy and molecular radiotherapy.

8. A continued drive for cost efficiency

As well as improving patient outcomes, adoption of new radiotherapy techniques, clinical practices, and approaches is needed in order to streamline pathways, drive cost effectiveness, and release the resources for further investment.

9. Better public awareness of radiotherapy

With greater emphasis on increasing public awareness and understanding of the benefits of radiotherapy, more patients should have the opportunity to choose radiotherapy as a preferred treatment option.

INTRODUCTION

Radiotherapy is a highly effective treatment for cancer. Around four in ten people whose cancer is cured receive radiotherapy and 16 per cent of all cancer cures can be attributed entirely to radiotherapy. It is second only to surgery in terms of its effectiveness in treating cancer. Radiotherapy is also considered a highly cost effective treatment, accounting for just 5 per cent of the national spend on cancer treatments.³

Radiotherapy is currently provided by 50 NHS Trusts in England. The radiotherapy services provided by NHS Trusts are referred to as 'radiotherapy centres' throughout this report. The way radiotherapy services are managed within Trusts may differ depending on local agreements. For example, many NHS Trusts manage the radiotherapy service within their own hospital setting, while others manage associated local satellite services to provide treatment at multiple sites.

Radiotherapy treatments have become significantly more sophisticated in the last decade, with the increasing role of Intensity Modulated Radiotherapy (IMRT), Image Guided Radiotherapy (IGRT), Stereotactic Ablative Radiotherapy (SABR), Stereotactic Radiosurgery (SRS), 4D adaptive radiotherapy, proton beam therapy and brachytherapy. Radiotherapy is continuously evolving. Research is constantly finding ways to refine current treatments as well as discovering new techniques that can improve patient outcomes.

However, while advances are being made, the pace at which innovations have been adopted across the NHS has been inconsistent, leading to inequitable access to these services for patients. As new and improved, evidence based treatments become available, it is essential that NHS England clinical access policies are developed to make them routinely accessible to patients. An effective mechanism to reduce variation and ensure outdated practice is discontinued is also needed.

The National Radiotherapy Advisory Group recommendations, published in 2007, highlighted that an ageing population would increase demand on radiotherapy services over time. When the Department of Health National Radiotherapy Implementation Group (NRIG) published Radiotherapy Services in England 2012, the report revealed that there was more work to be done to ensure enough capacity, both in equipment and workforce, to meet demand and deliver appropriate access to radiotherapy.⁴ The landscape of radiotherapy

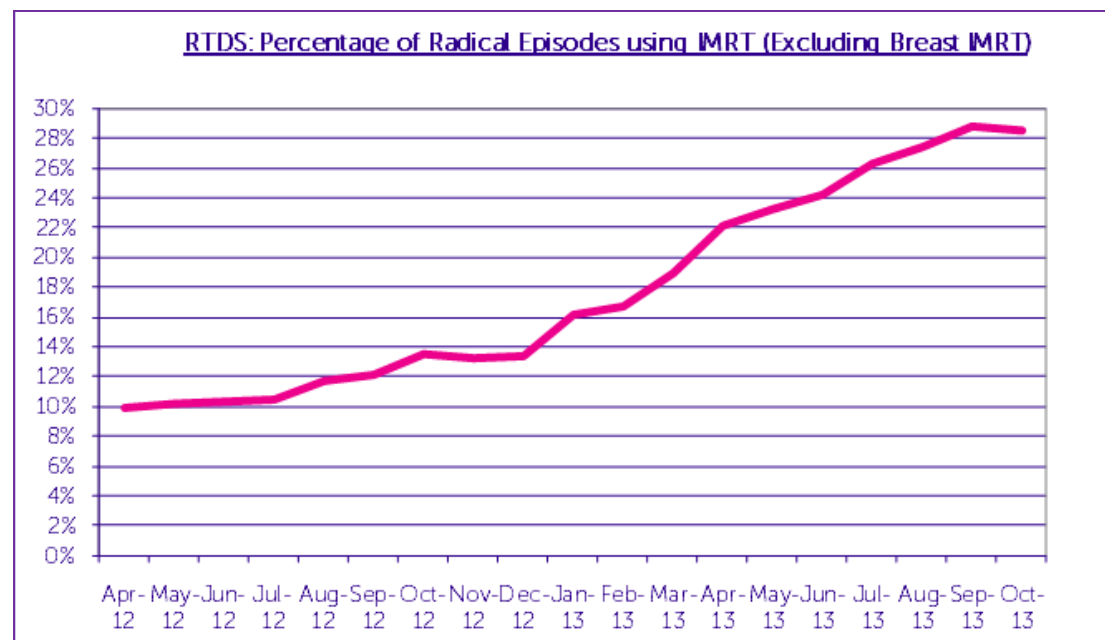
³ Department of Health (2012). *Radiotherapy services in England 2012*.
<https://www.gov.uk/government/publications/radiotherapy-services-in-england-2012>

⁴ Department of Health (2012). *Radiotherapy services in England 2012*.
<https://www.gov.uk/government/publications/radiotherapy-services-in-england-2012>

is changing. Innovation, shorter courses of treatment and faster treatment times means that a review of the future capacity requirements to meet demand is needed.

In October 2012 the Prime Minister announced a new guarantee to patients in England, stating that from April 2013 onwards, patients will be guaranteed access to innovative radiotherapy where clinically appropriate and cost effective.⁵

Along with this announcement, the Government launched the Radiotherapy Innovation Fund, a £23 million fund to support the roll out of advanced radiotherapy treatment in England. As demonstrated in the graph below, this Fund provided a real boost to radiotherapy services, and is having a substantial impact on increasing the number of patients receiving IMRT in England.⁶



Subsequently, the Department of Health and NHS Supply Chain secured a financial agreement with radiotherapy manufacturers for the block purchase of 20 new linear accelerators (linacs) for services in England, enabling NHS Trusts to purchase linacs (either replacement or additional) for their radiotherapy service at a highly competitive rate.

⁵ Department of Health press release (2012). <https://www.gov.uk/government/news/eight-thousand-patients-to-benefit-from-advanced-cancer-treatment>

⁶ Cancer Research UK et al. (2013). *The Radiotherapy Innovation Fund: An Evaluation of the Prime Minister's £23 million Fund*. http://www.cancerresearchuk.org/prod_consump/groups/cr_common/@nre/@pol/document/s/generalcontent/rifevalreport.pdf

As of April 2013, radiotherapy is commissioned by NHS England as a specialised service, covering the whole of England. This oversight at national level provides a real opportunity to make substantial improvements whilst continuing to focus on delivering the existing commitment to increase levels of inverse planned IMRT for patients. Alongside NHS England, Monitor will develop the pricing structure so that it becomes more detailed to reflect the varying complexity of radiotherapy treatments.

It is recognised that more needs to be done to achieve the guarantee set out by the Prime Minister to deliver innovative radiotherapy treatments. As a way forward, this report sets out a vision for patients requiring radiotherapy, to ensure services are fit for the future, both in terms of adopting new evidence based technologies, and planning and delivery of services. This will provide NHS England with the framework to develop a strong national strategy to aid adoption of these innovations. It will be important for NHS England to work in partnership with the professional bodies, manufacturers and service providers to understand upcoming innovations and facilitate their adoption. Health departments in the devolved nations may also find this vision useful in continuing to develop their radiotherapy services.

This report was produced collaboratively by Cancer Research UK and NHS England. A meeting was held on 8th and 9th October 2013 at which manufacturers of radiotherapy devices and software presented a panel of experts with their upcoming innovations in radiotherapy over the next ten years. Subsequently, a call for evidence was issued allowing all organisations, manufacturers and individuals to contribute to the development of this vision. A list of contributors can be seen in Appendix 1.

DEFINITIONS

Radiotherapy is evolving, with new terms arising to describe new techniques, treatments and pathways. This complex language can be challenging when trying to lay out a clear vision for the future. Therefore, the following definitions of what these techniques involve have been established to give consistency and clarity to the language used in this vision. Brand names are not referred to, only generalised treatment types or descriptive technologies. Patients must be given advice regarding the most appropriate treatment for them, as some techniques are more suitable to certain cancers and conditions than others.

External beam radiotherapy is usually given using a linear accelerator machine (linac). These machines use electricity to create the radiotherapy beams (x-rays) to target tumours. Other types of machine are also emerging, such as those that produce proton beams. Other techniques such as brachytherapy and molecular radiotherapy deliver radiation internally where it is needed.

For the purposes of this report, **advanced radiotherapy** is defined as techniques which are already in clinical use in England, but may, in some cases, benefit from further uptake or development within the NHS.

- **4D Adaptive Radiotherapy** is the ability to take account of the tumour shape in the three physical dimensions plus the fourth dimension of change with time. It can work well for tumours in areas of the body that may move during treatment, for example due to breathing.
- **Arc therapy** using three-dimensional volume imaging is a type of IMRT involving shorter treatment times, meaning less scope for patient movement as well as higher throughput and efficiency.
- **Brachytherapy** is the delivery of radiation using sealed sources which are placed close to the site that is to be treated. Isotopes used in brachytherapy can be applied directly to the tumour by surface applicators, inserted into body cavities and tubular organs via specially designed delivery systems (intracavitary and intraluminal therapy) or inserted directly into a tumour (interstitial therapy).
- **Chemoradiation** is when chemotherapy and radiotherapy are given together. Chemotherapy may be given intravenously via a pump or orally during part of the radiotherapy course. Radiotherapy and chemotherapy treatments may also be alternated between each other.
- **Image guided radiotherapy (IGRT)** is any imaging at pre-treatment and delivery, the result of which is acted upon, that improves or verifies the accuracy of radiotherapy. IGRT encompasses the whole range of imaging,

from simple to more complex imaging, that allows direct visualisation of the tumour and surrounding tissue. Using scanning during treatment enables verification of tumour position in relation to adjacent soft tissue organs.

- **Intra-operative radiotherapy (IORT)** is applying therapeutic levels of radiation to a target area while the area is exposed during surgery.
- **Intensity modulated radiotherapy (IMRT)** is a high precision form of radiotherapy. It moulds (conforms) the shape and dose of the radiation precisely to the volume of tumour tissue that needs to be treated, reducing exposure to healthy surrounding tissue. Doses can also be varied to different areas at variable risk of harbouring tumour deposits.
- **Molecular radiotherapy (MRT)** is the treatment of disease with radiopharmaceuticals. As with external beam radiotherapy, MRT offers the advantage of delivering high radiation doses to a specific target and sparing healthy organs from serious side effects; however in common with chemotherapy the treatment is generally delivered systemically with systemic side effects.
- **Proton beam therapy** uses a different type of radiation beam called a proton beam. Protons differ from conventional radiotherapy because the beam stops at a certain depth within the body. This can be used to minimise the dose to the tissues of the body outside the tumour target area. This is only available in the UK to treat cancer of the eye. The NHS England Proton Overseas Programme does send some highly selected patients overseas for treatment.⁷ The aim is to expand this programme prior to opening the UK proton beam service in early 2018.
- **Stereotactic ablative radiotherapy (SABR)** refers to the precise irradiation of an image defined extra cranial lesion (not in the brain) and is associated with the use of a high radiation dose delivered in a small number of fractions. The technique requires specialist positioning equipment and imaging to confirm correct targeting. It allows sparing of the surrounding healthy normal tissues. SABR is currently supported by a national clinical policy for non-small cell lung cancer⁸. Other indications are being evaluated.
- **Stereotactic radiosurgery (SRS)** refers to the precise irradiation of an image defined lesion, similar to SABR, but given as a single fraction. It has become the standard treatment for a number of cranial (in the brain)

⁷ <http://www.england.nhs.uk/ourwork/d-com/spec-serv/bpt/>

⁸ <http://www.england.nhs.uk/wp-content/uploads/2013/08/b01-p-a.pdf>

treatments. National clinical policies are in place for a variety of conditions including cranial schwannoma, meningioma, metastases, glomus tumours, arteriovenous malformations and the treatment of trigeminal neuralgia.⁹

Innovative radiotherapy is defined as approaches (including planning, software, training and delivery) and treatments with the potential to deliver significant patient benefit which are not currently in mainstream clinical use in England, but have the potential to become available in the next several years. An example is using hypofractionation techniques, which are being tested in clinical trials for certain cancers such as breast¹⁰ and prostate¹¹.

- **Hypofractionation** involves giving patients larger doses of radiotherapy, but fewer times, reducing the number of visits to hospital for treatment. In addition, the total dose of radiotherapy over the course of treatment is usually lower.

⁹ <http://www.england.nhs.uk/resources/spec-comm-resources/npc-crg/group-d/d05/>

¹⁰ The START trial in breast cancer has recently reported that hypofractionation is as safe and effective as the standard international dose. <http://www.cancerresearchuk.org/cancer-help/trials/start-standardisation-of-breast-radiotherapy>

¹¹ The CHHIP trial is looking at treating radiotherapy for prostate cancer in fewer, higher doses. <http://www.cancerresearchuk.org/cancer-help/trials/a-trial-comparing-different-ways-of-giving-radiotherapy-for-prostate-cancer>

RADIOTHERAPY IN THE CONTEXT OF FINANCIAL CONSTRAINT

Radiotherapy is already cost effective. However, the adoption of advanced and innovative techniques has the potential to drive further efficiencies and cost effectiveness. For example, shorter treatment times are now possible with the use of arc therapy.

As radiotherapy becomes more sophisticated, there is a need for greater support and investment in equipment, software, research and training. New technology platforms may require greater investment than a standard linac. But advances in radiotherapy seek to provide better outcomes and fewer side effects, leading to less financial impact on the NHS in the long term.

High quality radiotherapy services will enable the NHS to make savings across the whole of health and social care. Efficient pathways and much shorter treatment times will lead to a larger number of patients being treated per machine. Fewer high technology machines might be needed, but care could be delivered close to patients' homes using telemedicine to link expert staff.

There are a number of elements of radiotherapy treatment and planning which will become more efficient despite the increasing complexity of treatments. Innovations in software and imaging technology will allow for upgrades to linacs to keep pace with new technologies as much as possible.

Quality assurance (QA), required to ensure the safety of treatment, can currently involve taking linacs out of clinical treatment for several hours each month. Innovative QA tools can increase machine availability and reduce staff requirements for QA procedures. In general, increased automation has the potential to provide efficiency savings, or at least offset the increased demands placed on staff by the increasing complexity of their roles. Automated planning systems may increase efficiency with better processes and smoother pathways.

Hypofractionation is viewed as extremely promising in terms of efficiency gains, potential improved outcomes and improved patient experience. This is an important area for current and future research, to build the evidence base. Increased use of hypofractionation is likely to release capacity in existing radiotherapy centres.

The potential for extended working hours and seven day working may lead to improvements in patient experience, but may also improve efficient use of existing machine capacity, making better use of assets. Working seven days routinely could offer opportunities to run trials of different treatment models, as all current treatment regimens are based on five day treatments with a two

day break. However, the benefits of seven day working will need to be set against affordability in terms of staffing costs and the need for additional workforce capacity.

A better planned and aggregated procurement process will put the NHS in a stronger position to secure equipment at a competitive rate, to get the best possible value for money when investing in equipment and software. This could be achieved by working closely with NHS Supply Chain.

More advanced and consultant non-medical, therapeutic radiographer roles may be required to carry out the more complex tasks. This is likely to be a cost efficient investment.

However, it may not make economic sense for all radiotherapy centres to evaluate and adopt novel treatments. Thought will be needed regarding how rapid adoption of these will be achieved. While patients must have equal access to the most appropriate techniques, regional centres may have a role to play in piloting new innovations and delivering more specialised techniques.

CHALLENGES

There are a number of challenges that radiotherapy services need to overcome to achieve this vision.

Capacity

Radiotherapy services need flexibility to allow for adoption of new techniques as well as to cope with variation in demand. This flexibility not only requires sufficient up-to-date equipment, but also appropriately trained and qualified staff to run the service effectively and implement changes.

Workforce

Deficiencies in numbers of staff in crucial positions, such as physicists, therapeutic radiographers and clinical oncologists, is a constraint. There is limited access to funded training programmes to enable effective implementation of advanced radiotherapy techniques in their centres.

An appropriate skills mix, with effective team working and strong leadership, is required to effectively run a radiotherapy service. But there remains a shortfall in radiotherapy workforce capacity across the service, impinging on the ability to deliver advanced techniques and innovate.^{12,13} Recruitment into the service, as well as retention of highly skilled staff, is problematic. It is thought that there is a lack of specific career pathways for radiographers and physicists in particular, as well as a perception of being undervalued and underpaid.

Insufficient workforce capacity inevitably puts a strain on the service to meet demand with existing technologies and hinders the adoption of advanced, more complex techniques within current working models. A survey by the Royal College of Radiologists has highlighted the new challenges that clinical oncologists in particular face, including the need to recognise that more time must be put aside to plan complex treatments, and that this time should be recognised in job plans.¹⁴

Existing staff need to be trained to deliver new and advanced techniques through well co-ordinated multiprofessional programmes at post-registration level. Opportunities for funding these programmes should be sought so that there is confidence that new equipment is not under-utilised due to lack of

¹²Society and College of Radiographers and the Institute of Physics in Engineering and Medicine (2012). *Report on the census of radiotherapy workforce in the UK 2012*.
www.sor.org/learning/document-library/report-census-radiotherapy-workforce-uk-2012

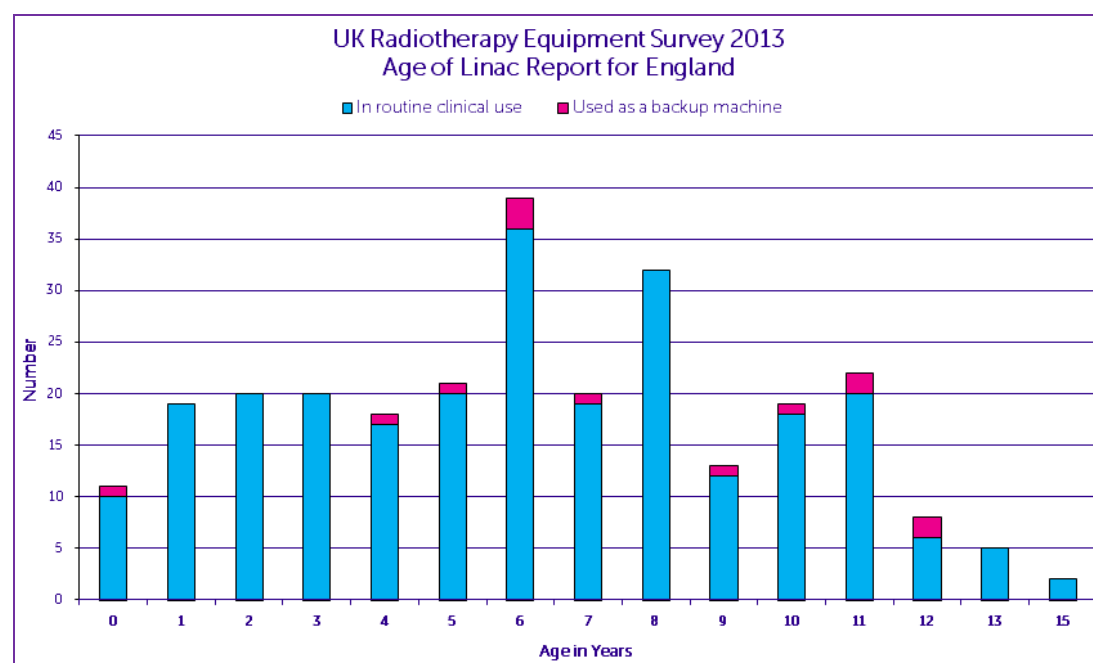
¹³Royal College of Radiologists (2012). *Clinical Oncology workforce report 2012*.
[www.rcr.ac.uk/docs/oncology/pdf/BFCO\(13\)4_census.pdf](http://www.rcr.ac.uk/docs/oncology/pdf/BFCO(13)4_census.pdf)

¹⁴Royal College of Radiologists (2011). *Oncology registrars' forum: trainee survey*.
www.rcr.ac.uk/docs/oncology/pdf/ORF%20Survey%202011%20Oct%202011%20FINAL%2027%2010%2011.pdf

staff education and training in delivering new techniques. Also, staff must be engaged with innovation and supported to understand the benefits involved so that they are advocates rather than opponents of change.

Equipment replacement

It is acknowledged that the initial expense of linacs in particular is a considerable capital cost to NHS Trusts. This cost should be balanced against the high numbers of patients who are treated over the life span of the linac. As seen in the graph below, a considerable number of linacs currently in use in the NHS are coming to, or have surpassed, their life span.



Ageing equipment prevents centres from keeping pace with innovation and provide advanced techniques to agreed levels of good practice. It is therefore important in the short term that equipment is replaced to ensure advanced techniques are available to patients who need it. NHS Trusts should have appropriate replacement plans for these machines to ensure they continue to meet national service standards.¹⁵ It is also important that the equipment purchased now is of high specification so that it remains up to date, or has the ability to be upgraded, for its lifetime.

Leadership and collaboration

Prior to April 2013, the National Radiotherapy Implementation Group (NRIG), supported by the National Cancer Action Team (NCAT), was responsible for implementing recommendations to improve the radiotherapy service in

¹⁵ NHS England Radiotherapy Clinical Reference Group (2013). *Radiotherapy service specification*. <http://www.england.nhs.uk/wp-content/uploads/2013/06/b01-radiotherapy.pdf>

England. These functions have now been replaced by the Radiotherapy Clinical Reference Group and the Cancer and Blood National Programme of Care as part of NHS England specialised commissioning structures.

National clinical leaders include the Clinical Director for Specialised Services, the National Clinical Director for Cancer and the Chairs of the Radiotherapy and Stereotactic Radiosurgery Clinical Reference Groups. In addition the Cancer Peer Review team has moved into NHS England Specialised Services from January 2014. The Strategic Clinical Networks, Academic Health Science Networks, and the Radiotherapy Board¹⁶ will also play a key role in delivering strategic change.

Contributors to this report were concerned that momentum was lost during the transition resulting from the NHS reforms in England. It is important that now these new structures are in place, national leadership takes forward the required services developments.

Local leadership is variable, with some radiotherapy centres making big improvements where others have not. In addition, a lack of infrastructure to share information across centres hinders collaboration and sharing of best practice.

Research and innovation

Radiotherapy centres undertaking research are more likely to implement new techniques and technologies faster for both trial and non-trial patients.¹⁷ There is a need to link research and development with clinical service; centres with world leading radiotherapy treatment facilities usually undertake academic research. It is hoped that the newly formed Academic Health Science Networks will aid the collaboration between centres, particularly important to effectively and equitably implement new treatment technologies and pathways.

A major barrier to uptake of advanced techniques and the ability to innovate is thought to be the current funding mechanisms. Current payment mechanisms do not incentivise centres to undertake research, such as clinical trials using hypofractionation, as they will lose money for treating patients fewer times. Innovations such as this are likely to produce more cost-effective radiotherapy as well as the patient benefits discussed previously.

¹⁶ A structure established in April 2013 jointly by the Society and College of Radiographers, the Institute of Physics and Engineering in Medicine, and the Royal College of Radiologists, to support the continuing development of radiotherapy.

¹⁷ Venables et al. (2012). *Clinical Oncology. Does Participation in Clinical Trials Influence the Implementation of New Techniques? A Look at Changing Techniques in Breast Radiotherapy in the UK.*

Workforce capacity issues also impinge on the ability to undertake research, due to the lack of staff time needed to perform research studies.

The ability to change practice in radiotherapy mainly relies on conducting full randomised controlled trials, which take a long time. While these are the gold standard for research and innovation in the NHS, they are not always suitable in radiotherapy. Some alternative approaches, such as Commissioning through Evaluation, allow appropriate services and treatments to be funded within defined parameters, in a small number of participating centres, and within an explicit evaluation programme. This allows patients, who are deemed clinically suitable, to access a treatment which shows significant promise in terms of improving quality of life or potentially survival, but is not accessible through a formal research trial.

In addition, the routine collection of patient tumour (imaging and biomarker) and treatment related data can provide a wealth of data on outcomes that could influence treatment decisions. This could also potentially eliminate the need for some clinical trials in the future. This is known as theragnostics and is highlighted in more detail in sections on data (page 31) and research (page 35).

Awareness

Another challenge is a lack of public awareness of the benefits of radiotherapy. The profile of radiotherapy within the NHS is not as good as it could be. Although strides had been made with the support of NRIG, through the National Radiotherapy Awareness Initiative, this support no longer exists. Endeavours to raise the public profile of radiotherapy should continue. Radiotherapy should be seen as a cutting edge treatment that is a preferred choice of cancer patients where appropriate.

ENSURING ACCESS TO INNOVATIVE RADIOTHERAPY

To achieve this vision it is recognised that a radical review of the way radiotherapy services are configured will be needed. It will be important to find alternative ways of working to sustain the range of services available to patients.

The opportunities that developments in innovation provide must be embraced, including the potential to create partnerships between radiotherapy centres to form an integrated radiotherapy team. This approach could serve a wider population base, potentially with multiple delivery points. It could also provide resilience at all times in all centres regardless of size, and would ensure that:

- Recruitment challenges for smaller centres becomes a thing of the past and that highly skilled individuals are available to support the whole service.
- Innovative technology and IT infrastructure support the specialist medical physicist workforce to work across a number of centres while being based at one.
- Clinical oncologists can work as part of a larger integrated team so that specialist teams work across multiple centres.
- Minimum numbers of patients with rarer cancers are managed by an integrated team to avoid single handed practice.
- Every patient pathway has a sufficient level of staffing and expertise regardless of where the patient is treated.
- National standards and protocols are adhered to, ensuring that all patients receive the same level of treatment and avoid unnecessary or inappropriate treatments.

National strategy

A national strategy being devised for specialised services should use this vision as a framework. It should include promoting investment in programmes that support the uptake of innovation, such as Commissioning through Evaluation. This will allow planned and coordinated evaluation of emerging technologies and will ensure consistency of standards. To effectively deliver innovative radiotherapy in an evaluative framework it is likely that further ring fenced funding will be required.

The strategy should promote regular revisions of service specifications, the quality dashboard and national pricing structures or tariffs so these continue to reflect the most up to date practice and encourage innovation. This will ensure that NHS England is in a position to routinely commission these improvements. National protocols should be standardised to ensure that all patients receive the same level of treatment no matter which centre they are

treated in. The strategy should also clearly set out the responsibilities of NHS Trusts in delivering improvements at the local level, for example having appropriate replacement plans in place.

Radiotherapy research should be promoted at a national level. More clinical trials in radiotherapy will ensure that innovation is an ongoing and embedded process within the service. The strategy should consider how and where research and innovation is undertaken, for example whether 'centres of excellence' are established to innovate and spread best practice.

The national strategy should also identify how to increase public awareness of radiotherapy. Public confidence in radiotherapy in general, and radiotherapy research in particular, needs raising in order to increase trial participation and willingness to choose radiotherapy as a preferred treatment option where appropriate.

Workforce

Services must have sufficient workforce capacity to enable the adoption of advanced and innovative techniques. This includes the need to recruit and retain more highly skilled staff, and ensure services have enough flexibility to cope with variations in demand and have dedicated time for research and QA. See section on staffing and workforce (page 28) for more detail.

Ways of working

The service should adapt to extended working hours and seven day working. A recent national survey has reported that a proportion of patients would be willing to attend radiotherapy out of normal hours.¹⁸ The Radiotherapy Board is currently developing guidance on this, due for publication in 2014. The benefits would be to maximise the use of expensive equipment and enhance patient choice. However, the service would need sufficient support, additional workforce and incentives to achieve this.

Waiting times need to be improved, particularly for tumours that may grow significantly during the waiting time period, requiring more urgent treatment. Waiting time targets should be made more cancer site specific to recognise this variation in urgency.

Information Technology (IT) systems

Service delivery needs to be streamlined through the optimisation of IT to support processes. There is a need for increased automation in the planning process and for compatible planning and delivery systems. Peer review of patient outlining and treatment plans in particular could significantly improve outcomes if adopted, by making sure improvements are shared and

¹⁸ NHS England (in press). *Radiotherapy Access Survey 2012 National Report*

communicated. A good IT infrastructure and a national database of plans to promote the sharing of best practice would facilitate this.

Technology, such as cloud based systems, now supports virtual planning so that it can be undertaken from any location. Opportunities should be explored to take advantage of these benefits, for example to allow for flexible home based working for some aspects of this work. However, local planning is still needed. Keeping this practice in radiotherapy centres and close to patients and clinicians is important, especially as clinicians who have seen and assessed the patient should be directly involved in the planning process.

Multi-centre collaboration

Opportunities for partnership working across radiotherapy centres should be explored to ensure that a focus on evaluating more highly specialist treatments is co-ordinated across England. Larger centres can act as 'treatment facilitators' to optimise work flows, support delivery of treatment where there is patient demand, and develop best practice.

More complex planning and treatment of rarer or harder to treat cancers should be done by integrated multi-centre teams. A model could be to develop equal partnerships between centres, which could be a way of ensuring equitable access across larger populations by having a single team and multiple delivery points. Centres providing radiotherapy at multiple sites (satellites) also provide an effective compromise between local access and specialisation.

DEVICES, IMAGING AND SOFTWARE

TREATMENT DEVICES

Innovative treatment devices will play a crucial role in the future of radiotherapy. As and when these innovations arise, there is a clear need for evaluation mechanisms to assess their efficacy. Assessing innovations within radiotherapy centres is currently challenging and better mechanisms are needed to support this.

Innovation in radiotherapy will enable the stratification of patients, the ability to provide truly personalised treatment based on physical and biological characteristics, and improved ways of adapting radiotherapy during treatment.

The major new innovation in treatment devices is likely to be incorporation of real time imaging and tracking of tumours. For example, this could be integrating an MRI and linac into one device or placing a scanner on rails within the treatment room. This development will allow for enhanced adaptive radiotherapy - the ability to revise plans during treatment. In general, dedicated scanners (PET-CT and, in the longer term, MRI) will be used for radiotherapy planning.

It is likely that smaller, cheaper versions of existing devices, for example smaller proton beam therapy systems and more compact linacs will emerge. In addition, the introduction of devices that produce a variety of types of beam with different energies will allow greater flexibility as to the type and dose of treatment given by individual devices (e.g. IMRT or IGRT or SABR). Laser technology may be employed to produce proton beams in linacs. Developments are also expected in radiation source technology and there is the potential for new radioisotopes to be used.

Mobile or temporary radiotherapy installations will become increasingly important for access in remote areas, and will also help radiotherapy centres maintain capacity during upgrades or replacements.

The couches that patients lie on when they are being treated are also expected to become more sophisticated, allowing dynamic repositioning during treatment and more accurate targeting.

The use of intraoperative radiotherapy involving intra- and peri-operative implants, markers and transponders, including spacer devices, is also likely to increase. Advances in approaches to gating, immobilisation and motion management, for example by use of electromagnetic transponders, is expected.

Quality assurance will continue to be crucial. Improved technology to verify 3D and 4D dose distributions to quality assure IMRT planning is expected.

NHS Trusts must have good asset replacement plans to ensure that new devices can be planned for and ensure that existing devices do not become outdated. Innovative equipment is likely to be more expensive at the outset than traditional linacs. It is important to find a way to encourage service development, despite the high capital cost of some equipment.

IMAGING

The greatest improvements in radiotherapy over the next ten years will likely be driven by advances in imaging technologies. Images already play a crucial role in diagnosis of cancer and planning of radiotherapy treatment. However, increased use of real time and multi-modality imaging will provide highly personalised and adaptable treatment. Tumours that may move during treatment will also be easier to track and target properly, particularly crucial in cancers in parts of the body such as the lungs or bowel.

Increased use of automation across the pathway, such as automated contouring and outlining, and deformable image registration software, are expected to have significant beneficial impacts on outcomes and free up resource at the initial planning stages. Comparison of pre- and post-treatment imaging will be used to assess tumour recurrence.

Many innovations are likely to be seen over the next ten years, which the NHS should be in a place to adopt if evidence of cost effectiveness can be demonstrated. These include:

- Increased use of MRI in treatment planning, either through an integrated MRI/linac or by incorporating MRI into treatment rooms.
- Higher quality cone beam CT scanning.
- Increased use of functional imaging (PET, MRI) during treatment to assess the response of the tumour and surrounding tissue to radiation.
- The use of novel biomarkers or tracers to improve specificity – allowing better targeting and characterisation of cancer cells which are more sensitive to radiotherapy.
- Integration of ultrasound technology into treatment delivery, both in brachytherapy and external beam radiotherapy.
- More accurate image registration and deformation to optimise treatment planning.
- Greater integration between imaging, planning and dosimetry and the fusion of multi-modality imaging.
- Non-invasive methods to verify the radiation given to the patient at the time of treatment.

- Photoacoustic imaging – an extension of ultrasound technology that provides functional information about tissues, for example on tissue oxygenation.

SOFTWARE

Cloud computing and improved data sharing will have an important role to play in the future of the radiotherapy service. They will be used to promote consistency, by sharing best practice and allowing timely analysis of the quality of service being delivered. Web based interfaces also have the potential to allow data sharing across different platforms, allowing services to benchmark against each other.

Computing advances are likely to speed up processing times, increase automation and progress towards a paper free service. This is a fast developing area and continual investment will be required, with equipment and software refreshes every 2-3 years. With more sophisticated computing, the time taken to plan treatment, acquire images and deliver treatment is expected to decrease. Higher performance computers will also facilitate adaptative radiotherapy in real time, in line with advances in devices and imaging discussed above.

Planning systems will develop significantly over the next ten years, with treatment plans being generated more quickly and more accurately. The use of image based biomarkers, anatomical atlas libraries, and dose painting are all expected to become increasingly developed within radiotherapy software. Replanning during the course of treatment will also become faster and easier. Remote planning is expected to become much more widely used and robust planning methods for proton beam therapy will emerge.

Increasingly sophisticated software will be able to automate some aspects of the planning process, helping to raise standards and improve efficiency in radiotherapy treatment. This will also allow for the storing and sharing of plans and the ability to link plans with outcomes data. This will lead to knowledge based planning, where plans can be generated based on best practice and then adapted to suit the patient. The storing and sharing of plans also supports quality assessment and peer review.

Personalised plans based on tumour heterogeneity will emerge based on gene sequencing and associated biomarkers to predict tumour (and normal tissue) response.

Many of these innovations are in the process of being developed or are already available. They will become more prevalent over the next ten years. However, these developments may be expensive and there is a need to invest to ensure

that this potential is fully realised. Although software does not have a defined lifetime in the same way as hardware, it is still vital that centres find a way to invest continually. Similarly, new standards must be adopted uniformly across centres to ensure practice variation is minimised.

TECHNIQUES

EXTERNAL BEAM RADIOTHERAPY

Many of the upcoming innovations in the field of external beam radiotherapy are intrinsically linked to advances in imaging to provide more accurate treatment, as highlighted in the imaging section (page 23).

In addition to this, the use of novel agents, chemo-radiotherapy techniques and radiation sensitisation are likely to become more widely adopted in the future. Dose escalation can be achieved by adding sensitising agents which make tumour tissue more sensitive to radiation, or by individualising treatments using prognostic factors for outcomes. Also, hypoxia modification is not currently common practice despite evidence of benefit in some cancers.¹⁹

Hypofractionation has the potential to deliver good outcomes while also being efficient and improving patient experience. This needs to be further substantiated through research and adopted more widely in the future.

A number of other innovations in external beam radiotherapy are likely to be introduced over the next ten years:

- Advances in proton beam therapy – e.g. more compact, cheaper technologies - and further research on application of proton beam for more indications.
- Wider use of SABR, with image guidance.
- The increased use of biological agents or radiosensitisers in combination with external beam treatment.
- Sub-volume boosting, which is the ability to apply higher doses to specific volumes of tissue.
- Improved gating, which would increase the accuracy of the radiotherapy beam.

Although radiotherapy can be curative, it also has an important role in palliative care. This is an area in which access and outcomes should be improved in the future. Radiotherapy is also used to treat benign disease, with current accepted indications in the UK including benign intracranial and ocular disease, and musculoskeletal inflammatory and degenerative conditions. This may become an area of growing significance for the radiotherapy service over the next ten years.

¹⁹ Overgaard J. (2011). Radiotherapy Oncology. *Hypoxic modification of radiotherapy in squamous cell carcinoma of the head and neck-a systematic review and meta-analysis.*

BRACHYTHERAPY

In the future, centres providing brachytherapy should offer improved imaging, for example MRI use in pelvic treatment planning, to support greater personalisation and stratification of treatment. Improved image guidance will also allow for better modelling, simulation and dose calculation based on tissue characteristics.

Intraoperative imaging will become more prevalent, allowing adaptive brachytherapy to be carried out. Deformable imaging will also be important to support this.

Brachytherapy should become more widely available and may also be extended to more cancers, including anal and rectal cancer and non-melanoma skin cancer. This type of treatment should be undertaken in larger and more specialised radiotherapy centres to allow minimum treatment numbers, promote reasonable throughput and maintain skills in a cost effective way.

A number of further innovations in brachytherapy include:

- Improved integration between brachytherapy and external beam therapy, so that brachytherapy treatment plans are optimised to account for the external beam dose.
- More innovative approaches to the workforce in brachytherapy with increasing roles for radiographers, physicists and specialist nurses, and the appointment of consultant radiographers.
- Miniature electronic brachytherapy devices which do not require a radioactive source.
- The use of nanoparticles, such as gold, which when targeted into the tumour act as radiosensitisers to potentially allow dose reduction or make treatment more effective.
- Novel fractionation schedules and the further development of focal and focused brachytherapy and dominant lesion boosting.
- Robotics prototypes and the use of novel isotopes in brachytherapy may be developed within the next ten years.

Ongoing collaboration with industry to take part in large scale studies and trials is essential to promote ongoing innovation in this field.

STAFFING AND WORKFORCE

To deliver innovations it is vital that the NHS has a high quality and highly motivated workforce working well in multi disciplinary teams. As technology becomes more sophisticated and techniques more diverse, the demands placed on staff will increase and it is critical to consider how best to support and develop them accordingly.

The radiotherapy workforce needs “future proofing”, for example by developing capacity around proton beam therapy and other advanced and innovative techniques. Addressing deficiencies in staffing numbers and enhancing skills of all staff to be able to deliver advanced and innovative techniques should be a priority. As imaging becomes increasingly significant in radiotherapy, it is especially important that staff are upskilled in imaging and image interpretation. As treatment planning is becoming more sophisticated, this is another area in which more training may be required.

In addition, enabling non-medical staff to take on more advanced and consultant practioner roles would have significant benefits on the ability to undertake innovative service development. An example is the positive impact of the advanced and consultant radiographer practitioner role focused on site specific or technical delivery pathways.²⁰

Leaders within centres need to review treatment pathways on a regular basis and agree the appropriate workforce configurations. Workforce configurations should be considered alongside the need to evaluate and implement new innovations. If evaluation takes place in a small number of centres, post-registration training and professional development needs can be identified from those centres, and education and training programmes established to meet the service need across the system.

Re-evaluation of radiotherapy patient pathways may enable tasks, traditionally undertaken by one professional group, to be completed by others. This could enhance and streamline pathways as technologies become more sophisticated. Development of this kind would also allow career progression for radiographers, and enable clinical oncologists to focus more on complex cases. Project management and leadership training is also essential for radiotherapy teams.

²⁰ www.sor.org/learning/document-library/implementing-career-framework-radiotherapy-policy-practice

Recognition

Job satisfaction among radiographers is considered to be relatively low.²¹ Attrition rates from pre-registration therapeutic radiographer programmes are too high and this needs to be addressed.²² To combat these issues, it is crucial to improve staff recognition, implement recognised career progression pathways, and promote the radiotherapy service within NHS trusts and the public.²³

It is also important that the challenges of a career in radiotherapy are acknowledged and staff have realistic workloads. Good leadership and strategic planning is critical to this, and education and development can also be used to increase resilience and guard against staff burnout in what can be a challenging emotional environment.

Innovation and research

Staff at all levels must be actively engaged in innovation and supported to continually develop services for patient benefit. Encouraging partnerships and joint working between centres when piloting new innovations is an important way of ensuring consistent and high quality implementation. Specific training on research techniques is needed, but developing collaborative working and an ethos of research are also key to ensuring that innovation is promoted among the radiotherapy workforce.

Workforce skills need to be seen as a key part of rolling out a new innovation. It may be that some innovations are best piloted initially in dedicated centres, allowing evaluation of the workforce skills needed for wider adoption.

Data and IT

Given the increasing use and complexity of the IT surrounding radiotherapy, radiotherapy centres will need to ensure they have dedicated IT infrastructure and personnel. In addition, data collection and sharing should become a core activity for centres. To do this effectively, centres will need to ensure that they fully understand the technology and data that is collected. This is a potential skills gap.

Skills mix

It is important to get the skills mix and team working within centres right, given the multidisciplinary nature of radiotherapy. The benefit of national leadership

²¹ Radiography (2013). *How was it for you? What factors influence job satisfaction for band 5 and 6 therapeutic radiographers.*

²² www.sor.org/learning/document-library/improving-retention-radiotherapy-workforce-role-practice-placements-student-attrition-pre-8

²³ For example, the Society and College of Radiographers Education and Career Framework for the Radiography workforce (2013). www.sor.org/learning/document-library/education-and-career-framework-radiography-workforce

in the form of NRIIG was the promotion of multidisciplinary working, which cascaded down to centres. This type of leadership at the national level must not be lost.

The right numbers of appropriately trained individuals must be available in each profession, with skills to match service needs and leadership to ensure effective team working. Multi-disciplinary workforce planning should take place in all centres. There needs to be an appropriate balance between services being delivered in smaller centres and smaller centres becoming affiliated with larger ones to allow them to tap into a larger skills base.

Education and training

It is important that the educational curricula for physicists, radiographers and oncologists keeps pace with emerging techniques. Good dialogue between the educators and professional bodies is therefore needed to ensure that curricula are developed to reflect changes within the service.

A collaborative approach to skills enhancement is essential. Manufacturers are in a strong position to support staff training on their devices and software. At the local level, closer links between radiotherapy centres and Higher Education Institutions should be pursued and clinical professionals from the radiotherapy service should be involved further in the delivery of pre-and post registration education programmes. Health Education England and the Local Education and Training Boards have a key role in supporting commissioning of the right numbers of professionals. Professional bodies have an important part to play in dissemination of knowledge and identification of learning outcomes to support changing service need. Centrally agreed best practice guidance should also be provided to radiotherapy centres. The Radiotherapy Board has a key part to play in delivering this guidance.

Training on specific equipment and systems is, of course, important, but there is also a need for training to encompass core techniques more generally and how they complement each other. Some areas of practice, such as brachytherapy, require the development of post-registration education and training to support very specific service needs.

Radiotherapy centres should be encouraged to work in partnership. It is also important that staff attend and present at conferences and professional meetings to share learning and that evidence is published. The NHS should support attendance of multi-disciplinary delivery teams to attend radiotherapy meetings, to balance the support given by pharmaceutical companies for this activity.

THE ROLE OF DATA

The collection and analysis of the vast amount of data generated by the radiotherapy services in England has significant potential to add to our understanding of the service and how to best improve it. In particular, data could be valuable in two areas: firstly, better understanding and improving radiotherapy treatments themselves and, secondly allowing effective planning and evaluation of the radiotherapy service. To underpin these developments, it is crucial to focus on standardised data entry, data archiving and data transparency.

The value of the Radiotherapy Dataset (RtDS) is widely acknowledged and its use should be expanded; for example patient reported outcome data could also be routinely collected. Data collection should be a core activity for radiotherapy centres and this is an area which would benefit from further investment. Linkage between the RtDS and cancer registries is valuable both for research and for strategic planning of service provision.

Utilising data effectively will place the service in an increasingly strong position to plan for the future, enhance patient choice and access, and evaluate future innovations.

Understanding and improving radiotherapy

Better collection and analysis of outcome data, for example linked with staging and treatment type, will allow assessment of impact of advanced and innovative radiotherapy approaches.

The type of data collected and when it is collected needs to be standardised and mandated, so that it can provide valuable comparisons between centres. Real time decisions will be informed by tracking patient care data through treatment pathways. Data can be used to help identify biomarkers which, alongside pre-treatment functional imaging information, will provide the foundations of personalised radiotherapy. Although software manufacturers can design clinical support programmes, they require data, such as toxicity, quality of life and survival, to underpin them and make them effective.

Randomised control trials can be challenging in radiotherapy, but lessons can be learned from day to day treatment. By effectively linking and analysing data generated from treatment, there is the potential to predict the outcome of radiotherapy dose and fractionation. By linking outcomes data with other datasets including comorbidity profiling and diagnostic data, it is possible to analyse the effectiveness of radiotherapy treatments over time, and in particular identify key parameters associated with improved outcomes (this is known as theragnostics). To do this, there is an urgent need to systemise the collection of relevant treatment plan and outcome data.

Large scale studies will also allow the comparison of different types of treatment, meaning that assessments can be made about efficacy and what should be adopted more widely. In the future, data should be published so that patients can see what outcomes they can expect.

Planning and evaluating the service

Data is critical to effective national, strategic planning. It can provide an overview of equipment and staff resource, allowing NHS England to plan for service reconfigurations as well as targeted recruitment and training. Given the concerns around age of linacs, data on asset replacement is particularly significant. Robust evidence is essential to the effective procurement policy which is needed to overcome any asset shortages. More generally, population level data could be used to build predictive models and inform reconfiguration of services and planning.

Datasets have an important role in identifying variations in the service and benchmarking performance. Underfunded or underutilised resource could be revealed, as could geographic variation in access to advanced and innovative radiotherapy. Outcome data is key to long term quality improvement with the potential for it to be used to establish key performance indicators with which to assess performance and monitor adherence to national guidelines. As mentioned, collection of agreed and standardised outcomes data needs to be improved in order to allow this.

Data sharing could be valuable in peer support and allowing centres to learn from one another. By benchmarking performance, data sets could also inform selection and choice by patients, thereby incentivising improvement.

PATIENT OUTCOMES AND EXPERIENCE

Fundamental to this vision is improved survival and better patient experience, with fewer long term side effects. Over the next ten years, with advances in the early diagnosis of cancer and more precise radiotherapy treatments available, survival rates in England should equal the best survival rates in Europe and the world. Availability of advanced and innovative radiotherapy techniques that are more accurate at targeting tumours should lead to better patient survival. In addition, if we also achieve better detection of early stage cancers this will lead to more patients being treated with curative intent.

Reducing both the short and long term side effects of radiotherapy is also crucial. More precise techniques will mean that the volume of normal, healthy tissues around the cancer exposed to radiation is minimised during treatment. Patients should therefore expect to experience better quality of life during and after treatment, regardless of whether treatment intent is to cure cancer, cure a non-malignant tumour or control pain at the end of life.

A number of aims have been identified that, if achieved, could ultimately contribute to achieving the vision:

- All patients have access to the advanced radiotherapy techniques that they need, as well as timely access to innovative techniques as they arise;
- Patients have more choice in the type of radiotherapy treatment they receive;
- Treatment is shorter (delivered with fewer visits to the hospital) with the increased use of hypofractionation techniques where appropriate;
- Treatments are better tailored to the individual, with the use of biomarkers, radiosensitizers and imaging;
- Patient pathways are more streamlined and waiting times from diagnosis to first treatment reduced;
- Patients are more satisfied with the treatment they receive;
- More patients are aware of the benefits of radiotherapy and therefore more choose radiotherapy as their preferred treatment;
- Increased patient participation in clinical trials.

Patient experience

The radiotherapy patient experience survey shows that patients already have a good experience of care, with 94 per cent of patients rating their overall care excellent or very good.²⁴ This survey is a valuable tool for assessing

²⁴ Quality Health (2013). *Radiotherapy Patient Experience Survey*. <http://www.quality-health.co.uk/resources/surveys/national-cancer-experience-survey/2013-national-cancer-patient-experience-survey-reports/493-radiotherapy-patient-experience-survey-2013-national-report>

performance and driving improvements, and should continue to be carried out regularly.

Aims around service improvement, as outlined above, should lead to patients having an even better experience of care. Access to more advanced and innovative treatments that are more targeted and reduce side effects would have the greatest impact on patient experience of radiotherapy. The potential for these treatments to effectively treat cancer, while allowing patients to continue their normal lives during and after treatment due to reduced side effects, is of immense value.

Patients being treated faster and with fewer visits to radiotherapy centres would have a positive impact on satisfaction. New treatment regimens using hypofractionation would mean fewer appointments, while having similar or better patient outcomes. In addition, more streamlined patient pathways and reduced waiting times between diagnosis and treatment, would likely reduce patient anxiety.

Reducing travel times to radiotherapy centres and extending working hours could provide improvements in patient experience as well as potentially reducing NHS capital costs. Training staff to be able to effectively support patients emotionally is an important part of improving patient experience.

Les Banks was treated with radiotherapy for Hodgkin's Lymphoma. He shared his vision for the future of radiotherapy:

- Radiotherapy has always suffered from being seen as a second class treatment compared with chemotherapy and I hope this will have changed in the future.
- Most patients have at least a basic understanding of how chemotherapy works but very few understand how radiotherapy works, this need to be improved in the future.
- Radiotherapy units can seem very bleak and scary when you're being treated; they need to be made warm, colourful and inviting.
- One of the biggest problems for patients is the use of the word "radiation": more information and better education is needed for patients and their families to help reduce the stress involved with this form of treatment.
- More information should be given to patients regarding the possible long term side effects of radiotherapy.
- Patients need to understand that radiotherapy treatment has changed dramatically over the years and will continue to improve in the future.

RESEARCH

Research and innovation must be acknowledged as a critical part of the radiotherapy service. World leading radiotherapy centres deliver research and innovation as well as treatment. High quality research must be incentivised and recognised and the NHS must work to foster a proactive culture of research and innovation. There is also work to do to instil more confidence in the public about radiotherapy research and encourage them to take part. There is an increasing level of enthusiasm for research within the service that must be capitalised on to deliver the best possible outcomes in the future.

Collaboration is fundamental to radiotherapy research; radiotherapy centres should work together on research initiatives and also look to partner with manufacturer and academia led initiatives.

As mentioned in the previous section on data, high quality datasets have a vital role to play in research with data mining and population based research being growth areas. The Radiotherapy Dataset in particular is a valuable resource and must be used to its full potential. Theragnostics, the capture and linking of all relevant patient data which influence outcomes, is a particularly exciting area of research as this could be used to predict outcomes and influence treatment choices in the clinic. There is work to be done on ensuring that data is properly collected and standardised. Cloud computing also has the potential to improve data access and sharing.

More randomised control trials (RCTs) in advanced and innovative radiotherapy are needed to improve the evidence base for different types of interventions in radiotherapy. All patients who are suitable should be offered the opportunity to discuss and participate in a clinical trial and all centres should be in a position to recruit to national trials. The Radiotherapy Trials Quality Assurance group will provide ongoing support to RCTs, but existing barriers to clinical trials still need to be identified and addressed.

It should be acknowledged that, in some cases, it is harder to design RCTs for radiotherapy than it is, for example, in chemotherapy. There is a need to develop new approaches to producing high quality, practice changing, commissioner-influencing evidence outside the framework of RCTs. Commissioning through Evaluation will become an increasingly important mechanism for radiotherapy innovation to be evaluated and adopted into practice.

The results of research and innovation must be rapidly implemented into practice where there is evidence of patient benefit - something which the NHS has not always been successful at in a consistent and equitable way. Research

being carried out should have a strong focus on translation. A culture which is geared towards research is key.

Areas which would particularly benefit from further research include:

- The effectiveness (both patient benefit and cost-effectiveness) of combining MRI scanners with linacs.
- Novel biomarkers.
- Molecular imaging.
- Molecular radiotherapy, in particular patient specific dosimetry and new isotopes.
- Functional imaging.
- Radiotherapy and drug interactions.
- High Intensity Focussed Ultrasound (HIFU).
- Radiobiology.
- Reduction of harm to healthy organs.
- Work flow innovation.
- Motion management.
- Planning and treatment efficiency.
- Proton research including comparative planning, novel accelerator research, range verification and biological effectiveness.
- Total marrow and lymphatic irradiation.
- Theragnostics.

New and expensive technologies should also be tested for cost effectiveness during the research process.

Research cannot take place without appropriate funding and training. Funding should also be assigned to each of the key personnel groups involved (oncologists, physicists and radiographers) with an acknowledgment that research requires staffing above and beyond the time given for clinical service. Any savings made within the service should be directed towards funding for research rather than towards the system as a whole.

Making time within job plans for research is vital, as well as setting aside research time on radiotherapy devices. Staff at all levels and in all different roles must be supported and encouraged to actively engage. Research needs to be embedded into professional roles and radiographer and physicist led research in particular should be encouraged. Academic career paths should be developed for all the professions with post-graduate training, secondments and multi-disciplinary projects being made available. Academic roles more generally need to be increased in this field, with Higher Education Institutions helping to support research roles.

APPENDIX 1: LIST OF CONTRIBUTORS

Many thanks to all those listed below who contributed to this report.

The following people were on the **steering group** for this report:

Charlotte Beardmore	The Society and College of Radiographers
Tim Cooper	NHS Improving Quality Delivery Team
Adrian Crellin	Leeds Teaching Hospitals NHS Trust
Jon Currington	NHS England
Sean Duffy	NHS England
Kim Fell	NHS England
Emma Greenwood	Cancer Research UK
James Palmer (Chair)	NHS England
Matthias Radatz	National Centre of Stereotactic Radiosurgery Sheffield
Carl Rowbottom	The Institute for Physics and Engineering in Medicine
Nick Slevin	The Christie NHS Foundation Trust

At the expert meeting held on 8th and 9th October 2013, the following manufacturers presented:

- Accuray
- Advanced Oncotherapy Plc
- Brainlab Ltd
- Elekta
- Oncology Systems Ltd
- Philips Healthcare
- Raysearch UK Ltd
- Varian Medical Systems
- Xstrahl Ltd

The expert panel consisted of:

Charlotte Beardmore	The Society and College of Radiographers
Mike Brada	University College London Hospitals & Leaders in Oncology Care
Andy Brown	NHS Supply Chain
Neil Burnet	Cambridge University Dept of Oncology, Addenbrooke's Hospital
Tim Cooper	NHS IQ Delivery Team
Adrian Crellin	Leeds Teaching Hospitals NHS Trust
Jon Currington	NHS England

Derek D'Souza	UCLH NHS Foundation Trust
Sean Duffy	NHS England
Angela Dunigan	NHS Supply Chain
Duncan Ettles	Spire Hull and East Riding Hospital
Kim Fell	NHS England
Emma Greenwood	Cancer Research UK
Russell Hart	Nottingham University Hospitals NHS Trust
Ann Jarvis	NHS England
Helen McNair	The Royal Marsden NHS Foundation Trust
Tony Murphy	Patient representative
Rachel O'Connor	NHS England
James Palmer	NHS England
Nick Plowman	St Bartholomew's Hospital
Christine Richards	Kent Oncology Centre
Carl Rowbottom	The Institute for Physics and Engineering in Medicine
Emlyn Samuel	Cancer Research UK
Nick Slevin	The Christie NHS Foundation Trust
Diana Tait	The Royal College of Radiologists
Felicity Taylor	NHS England
Paula Taylor	Peterborough and Stamford Hospitals NHS Foundation Trust
Michael Williams	Addenbrookes Hospital
Diane Wilson	Department of Health
Wai-lup Wong	East and North Hertfordshire NHS Trust
John Yianni	Royal Hallamshire Hospital

Written evidence was received from:

Manufacturers:

- Accuray
- Brainlab Ltd
- Oncology Systems Limited
- Philips Healthcare
- Varian Medical Systems

Organisations:

- Addenbrooke's Hospital
- Arden Cancer Centre
- Beacon Centre, Musgrove Park Hospital
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- Leeds Cancer Centre multi-disciplinary team
- Macmillan Cancer Support

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- Radiotherapy Board
- Radiotherapy Clinical Information Group
- Royal College of Radiologists
- Royal Marsden Hospital, SBRT team
- SIG Imaging Group and Poole Hospital Radiotherapy Department
- Society and College of Radiographers
- The Wade Centre, The Christie NHS Foundation Trust

Individuals:

- Professor Neil Burnet – Professor of Radiation Oncology, Cambridge University Department of Oncology, Addenbrooke's Hospital and Chair of NCRI Clinical and Translational Radiotherapy Working Group
- Professor Luc Bidaut - Chair of Translational Imaging & Imaging Lead, University of Dundee
- Dr Ananya Choudhury - Consultant and Honorary Senior Clinical Lecturer, Clinical Oncology, The Christie NHS Foundation Trust
- Rhiannon Davies - Cyberknife Specialist Radiographer
- Dr Corinne Faivre-Finn - Consultant Clinical Oncologist and Reader, The Christie NHS Foundation Trust & University of Manchester
- Dr Mark Gaze – Consultant in Clinical Oncology, UCLH
- Professor Tim Maughan - Professor of Clinical Oncology, Gray Institute for Radiation Oncology and Biology, University of Oxford with input from Dr Maria Hawkins and Dr Mike Partridge
- Dr Philip Mayles - Head of Physics, The Clatterbridge Cancer Centre NHS Foundation Trust
- Dr Helen A McNair - Research Radiographer, Radiotherapy, The Royal Marsden NHS Foundation Trust
- Tony Murphy – Lay volunteer
- Professor Alan E. Nahum – Head of Physics Research and Visiting Professor (University of Liverpool), Clatterbridge Cancer Centre
- Dr Heidi Probst - Reader in Radiotherapy, Faculty of Health and Wellbeing, Sheffield Hallam University
- Paula Taylor, Radiotherapy manager, Radiotherapy Department, Peterborough City Hospital
- Dr Gillian Whitfield – Consultant Clinical Oncologist, The Christie NHS Foundation Trust

