The Future Organization of Cancer Care

Professor Karol Sikora
Chief Medical Officer, Cancer Partners UK, Dean, University of Buckingham Medical School, UK

Karol Sikora is The Medical Director of Cancer Partners UK which has created Britain's largest independent UK cancer network. He was Professor and Chairman of the Department of Cancer Medicine at Imperial College School of Medicine and is still honorary Consultant Oncologist at Hammersmith Hospital, London. He is Dean and Professor of Medicine at Britain's first independent Medical School at the University of Buckingham and a Fellow of Corpus Christi College, Cambridge.

Cancer care is expensive and getting more so. A wide range of new treatments, some of only marginal benefit, will become available over the next 5 years. Over 60 new cancer drugs are likely to be launched globally over the next 3 years with a price in excess of $100,000 for a year's supply. And the new does not replace the old so the costs of diagnostics, surgery, radiotherapy and general medical care will continue to escalate.

Controlling costs and yet providing the best care possible has become a major challenge for those involved in both purchasing and providing care. How much patients will be willing to pay for their care directly could drive a new honesty in communicating the real benefits of what are often perceived as breakthrough, miracle cures. As treatment does become more successful the number of people living with cancer will rise. Currently the prevalence of cancer in the UK is 1.4m but this will rise to over 3m by 2030 driven by increase in its incidence and better long term survival. The existence of a predominantly elderly population living with cancer together with multiple co-morbidities will have huge implications for all health-care systems. There are only four ways to pay for cancer care - tax, insurance, cash or charity and in democracies politician that need to get the public vote are striving to use their cancer policies as a sign of goodwill.

Introduction

In the field of cancer medicine, great strides have been made in understanding the fundamental biology of cancers and impressive treatments have emerged, resulting in markedly prolonged survival for many patients. These advances mean that cancer could well become a chronic disease within the next 20 years, but that promise depends on sustained investment in innovation, both in diagnostics and therapies, as well as on society's willingness to pay for continued increasing innovation.

The three great challenges facing cancer medicine in the future will be an understanding of the biology of the very wide range of cancers affecting different organs, the increased prevalence of the disease that can be expected in an aging population, and the optimal way in which to deliver care across a wide range of economic environments. How will biomedical science and health-care systems rise to these challenges? An understanding of the way in which advances have been applied in personalizing treatments in the past points a way ahead to address future challenges.

Our cancer future will emerge from the interaction of four factors: The success of new technology, society's willingness to pay, future health-care delivery systems, and the financial mechanisms that underpin them. The only way to reduce the costs of cancer care is to ensure that the right patient gets the right treatment. Investing in sophisticated diagnostics is a clear imperative in making personalized medicine for cancer a reality and delivering it as close to patients' homes as possible.

The age of the world's population is rising dramatically. This will increase the total burden of cancer, with many patients living with considerable co morbidity. At the same time, new technology in many areas of medicine is bringing improvements to the quality and length of life. Major innovations in the following six areas are likely to have the greatest impact on cancer:

- molecularly targeted drugs with associated sophisticated diagnostic systems to personalize care;
- biosensors to detect, monitor, and correct abnormal physiology and to provide surrogate measurements of cancer risk;
- our ability to modify the human genome through new, systemically administered targeted vectors;
- the continued miniaturisation of surgical intervention through robotics, nanotechnology, and precise imaging;
- computer-driven interactive devices to help with everyday living;
- the use of virtual reality systems, which, together with novel mood control drugs, will create an illusion of wellness.

Developments in all these areas will need to be anticipated in designing the future configuration of cancer services. Global

providers will arise to deliver optimal care tailored to the local economic environment. The future landscape of cancer service delivery will be very different from now: fast-paced, competitive, consumer-focused, and internet-driven, with far more real patient empowerment through educated choice. New organizations with associated franchises are likely to emerge to drive optimal cancer care in a world where national borders and cultures will be no barrier to excellence in service delivery. The same service changes that have occurred in mobile phones, airline travel and insurance will take place in health care. The consumer will be king. This is difficult to imagine when we see how cancer services are still provided today, even in some wealthy countries, especially Britain.

Over the last 20 years, a huge amount of fine detail of the basic biological processes that become disturbed in cancer has been amassed. We now know the key elements of growth factor binding, signal transduction, gene transcription control, cell cycle checkpoints, apoptosis, and angiogenesis. These have become fertile areas to hunt for rationally based anti-cancer drugs. This approach has already led to a record number of novel compounds currently in trials. Indeed expensive targeted drugs such as rituximab, herceptin, imatinib, gefitinib, avastin, and erbitux are now all in routine clinical use. Over the next decade, there will be a marked shift in the types of agents used in the systemic treatment of cancer.

Because we know the precise targets of these new agents, there will be a revolution in how we prescribe cancer therapy. Instead of defining drugs for use empirically and relatively ineffectively for different types of cancer, we will identify a series of molecular lesions in each tumor biopsy. Future patients will receive drugs that target these lesions directly. The Human Genome Project provides a vast repository of comparative information about normal and malignant cells. The new therapies will be more selective and less toxic, and will be given for prolonged periods of time, in some cases for the rest of the patient's life. Many will be given as tablets, requiring less frequent clinic visits but still with close monitoring. This will lead to a radical overhaul of how we provide cancer care.

Investment in more sophisticated diagnostics is going to be essential to target treatment to those in whom it will have the biggest impact. Holistic systems such as genomics, proteomics, metabolomics, and methylomics provide fascinating clues to understanding disturbed cell growth. By developing simple, reproducible, and cheap assays for specific biomarkers, a battery of companion diagnostics will emerge. It is likely that for the next decade, these will be firmly rooted in tissue pathology, making today's histopathologist essential to move this exciting field forward. Ultimately, the fusion of tissue analysis with imaging technologies may make virtual biopsies possible for any part of the body – normal and diseased. The radiologists of the future will be the new pathologists in a world without needles.

Individual cancer risk assessment by DNA analysis will lead to tailored prevention messages and a specific screening program to pick up early cancer. This will have far-reaching public health consequences. Cancer-preventive drugs will be developed to reduce the risk of further genetic deterioration. The use of gene arrays to monitor serum for fragments of DNA containing defined mutations could ultimately develop into an implanted gene chip. When a significant mutation is detected, the chip would signal the holder's home computer and set in train a series of investigations based on the most likely type and site of the primary tumor.

There will be an increase in the total prevalence of cancer as a result of improved survival, as well as a shift in the distribution of cancer types toward those with longer survival, such as prostate cancer. This will create new challenges for assessing the risks of recurrence, designing care pathways, use of information technology, and improving access to services. There will be new opportunities for further targeting and development of existing therapies as experience grows with risk factors over the longer term. Careful monitoring of patient experiences could help in improving results. Cancer could soon become a long-term management issue for many patients, where they enjoy a high quality of life even with a degree of chronic illness.

The funding of cancer care will become a significant problem. Already we are seeing inequity in access to the taxanes for breast and ovarian cancer, and gemcitabine for lung and pancreatic cancer. These drugs are only palliative, adding just a few months to life. The emerging compounds are likely to be far more successful and their long-term administration will be considerably more expensive. Increased consumerism in medicine will lead to increasingly informed and assertive patients seeking out novel therapies and bypassing traditional referral pathways through global information networks. It is likely that integrated molecular solutions for cancer will develop, leading to even greater inequity than at present. Cost-effectiveness analyses will be used to scrutinize novel diagnostic technology as well as therapies.

Delivering value

Future cancer services will be rigorously reviewed for their value. Two simple value equations pertain. The first relates value to access and quality of services.

VALUE = (access +quality)/ cost

Providing better access and increasing quality can obviously add costs to the service. Better value will be obtained from providers that can use new technology, recruit more productive staff, create incentives for greater efficiency, and deliver economies of scale. These improvements are unlikely to come from the public sector acting alone.

The second equation expresses the value of a specific treatment intervention. Sophisticated new diagnostics are likely to increase the value of treatments by guiding the right treatment to the right patient – heralding an era of personalized medicine. A revolution in diagnostics will lead to increased effectiveness of new therapies, because they will increasingly be given only to those patients who will benefit from them, thus increasing their value. Quantifying the top line of this equation is difficult, as can be seen in many recent health technology assessments. While increase in overall survival is easy to measure, the toxicity and lifestyle impact is much more difficult to quantify because of huge variability between patients.

VALUE = (benefit-toxicity-lifestyle change)/cost

However imperfect they may be, these two equations will relentlessly drive the economic future of cancer in all health-care systems.

The Future

Within 20 years, cancer will be considered a chronic disease, joining conditions such as diabetes, heart disease, and asthma. These conditions impact on the way people live, but do not inexorably lead to death. The model of prostate cancer, where many men die with it rather than from it, will become more usual. Progress will be made in preventing cancers. Even greater progress will be made in understanding the myriad causes of cancer. Our concepts will be different to those of today, and the new ways in which cancer will be detected, diagnosed, and treated will be crucial to understanding the future.

When a cancer does develop, refinements of current technologies and techniques – in imaging, radiotherapy, and surgery – together with the availability of targeted drugs, will make it controllable. Cure will still be sought, but it will not be the only satisfactory outcome. Patients will be closely monitored after treatment, but fear that cancer will definitely kill, still prevalent in the early years of the twenty-first century, will be replaced by an acceptance that many forms of cancer are a consequence of old age. Looking into the future is fraught with difficulties. Medicine will be overtaken by unexpected step-changes in innovation.

For this reason, economic analysis of the impact of developments in cancer care is difficult. The greatest benefit will be achieved simply by ensuring that the best care possible is on offer to the most patients. This would be irrespective of their socioeconomic circumstances and of any scientific developments. But this is unrealistic. Technologies are developing fast, particularly in imaging and the exploitation of the human genome. Well-informed patients, with adequate funds, will ensure that they have rapid access to the newest and the best, wherever it is in the world. More patients will benefit from better diagnosis and newer treatments, with greater emphasis on quality of life. Innovation will bring more inequality to health. The outcome of the same quality of care differs today between socioeconomic groups and it will continue to do so.

Clinicians in Europe will continue to be dependent on technologies primarily designed for the major health market in the world, the United States, which currently consumes nearly 55% of cancer medication but contains less than 5% of the population. European legislation covering clinical trials has threatened to bring research in the UK to a grinding halt, while ethicists – zealously over interpreting privacy legislation – could force the imposition of restrictions on the use of tissue. Targeted niche drugs will be less appealing to industry, because the costs of bringing each new generation of drugs to market will not be matched by the returns from the most economically successful drugs that are currently on the market. The delivery of innovation will be underpinned by patient expectation. The well-informed will be equal partners in deciding the health care they will receive. Much of it will take place close to their homes, using mechanisms devised by innovative service providers.

These developments will have huge implications for the training of health professionals and for the demarcations between specialties. Emerging technologies will drive the change. Intra-professional boundaries will blur; doctors from traditionally quite distinct specialties may find themselves doing the same job. Some clinical responsibilities will be taken up by health professionals who will not be medically qualified. All professionals are likely to find challenges to their territory hard to accept. Table 1 shows the challenges that need to be addressed in order to deliver most health benefit.

Table 1 The challenges of cancer care
• Increasing the focus on prevention
• Improving screening and diagnosis and the impact of this on treatment
• New targeted treatments – how effective and affordable will they be?
• How the expectation of patients and their carers will translate into care delivery
• Reconfiguration of health services to deliver optimal care
• The impact of reconfiguration on professional territories
• Will society accept the financial burden of these opportunities?

Prevention and Screening

At the beginning of the twenty-first century, 10 million people in the world developed cancer each year. The cause of these cancers is known in roughly 75% of cases: 3 million are tobacco-related; 3 million are a result of diet; and 1.5 million are caused by infection. In the UK, 130,000 people died from cancer each year, even though many of those cancers were preventable, with one-third related to smoking. But cancer prevention absorbs only 2% of the total funding of cancer care and research.

Antismoking initiatives are considered to be successful, although it has taken 50 years from the time the association between smoking and cancer was first identified. In the 1960s, 80% of the population smoked; by 2006 the average was under 30%. This masks real health inequality, the percentage of smokers in the higher socioeconomic classes is well under 10%, while the percentage in the deprived is still about 50% in some parts of the country. Despite the known risks, if friends and family smoke and there is no social pressure to stop, there is no incentive to stop. Banning smoking in public places will lead to a further drop of approximately 4%. Increases in tax have been a powerful disincentive to smoke, but the price of a packet of cigarettes is so high that smokers turn to the black market: As many as one in five cigarettes smoked is smuggled into the country. Lung cancer is now a rare disease in higher socioeconomic groups; it is a disease of poverty.

Lessons from antismoking initiatives will be instructive for prevention in the future. Although the link between poor diet, obesity, and lack of exercise and cancer has not been confirmed, there is sufficient circumstantial evidence to suggest that strong associations will be found. There will be bans on advertising for potato chips, candy, and soft drinks on television, the introduction

of a health tax on these products and a ban on sponsorship of any public event by manufacturers of these products. By 2020, obesity among the middle classes will be socially unacceptable, but it will remain common among the economically disadvantaged. Creating meaningful, imaginative incentives for people to adopt healthy lifestyles will be a major challenge.

The future prevention picture will be colored by post-genomic research. It is now accepted that about 100 genes are associated with the development of a whole range of cancers. The detection of polymorphisms in low-penetrance cancer-related genes – or a combination of changed genes – will identify people who are at increased risk. Within 20 years, most people will be genetically mapped. The information – gained from a simple blood test or buccal smear – will be easily stored on a smart-card. Legislation will be required to prevent this information being used to determine an individual's future health status for mortgage, insurance, and employment purposes. However, the process of mapping will reveal that every person who has been screened will carry a predisposition to certain diseases. People will learn to live with risk.

Today the average age at diagnosis of cancer is 68. Improvements in screening, detection, and diagnosis may reduce this for some cancers but increased longevity will could well increase this figure. A predisposition for some cancers that currently manifests in the seventh or eighth decade will in the future be detected in young adult life and corrected successfully while the patients are still in their 30s. Increasing age will remain the strongest risk predictor. Little of what has been described is not happening already in some form, but the computing power of the future will bring accurate calculation of risk, and risk predictions will take place on a currently unimaginable scale. Screening programs will be developed on a national basis if they are simple, robust, and cheap. Patients will expect that screening will take place at a convenient venue for them, such as shopping malls, and that it will not be painful or overly time-consuming. Health professionals will demand that any program be accurate and not give misleading results, and governments will demand that its costs lead to more effective use of other resources. Novel commercial providers of risk assessment services are likely to emerge (Table 2).

Table 2 Balancing cancer risk
• Great health inequity exists in smoking-related diseases
• Novel prevention strategies are likely to lead to similar inequity
• Creating meaningful incentives to reduce risk will be essential
• Individually tailored messages will have greater power to change lifestyles
• Biomarkers of risk will enhance the validation of cancer-preventive drugs
• Novel providers of risk assessment and correction will emerge

Detecting Cancer

Cancers are fundamentally somatic genetic diseases that result from several causes: physical, viral, radiation, and chemical damage. Other processes are also implicated, e.g., chronic inflammatory change, immunosurveillance and failure of programmed cell death (apoptosis).

In the future, cancer will no longer be understood as a single entity – it will be considered to be a cellular process that changes over time. Many diseases labeled as cancer today will be renamed, as their development will not reflect the new paradigm. Patients will accept that cancer is not a single disease and increasingly understand it as a cellular process. Many more old people will have increased risk or a precancer. This has huge implications for cancer services. Today, most diagnoses of cancer depend on human interpretation of changes in cell structures seen down a microscope. Microscopes will be superseded by a new generation of scanners to detect molecular changes. These scanners will build up a picture of change over time, imaging cellular activity rather than just a single snapshot. We will have the ability to probe molecular events that are markers for early malignant change. This dynamic imaging will lead to more sensitive screening and treatments; imaging agents that accumulate in cells will exhibit tell-tale signs of precancer activity and will be used to introduce treatment agents directly.

Imaging and diagnosis will be minimally invasive, and will enable the selection of the best and most effective targeted treatment (Table 3). Even better imaging will be able to pick up early disease phases and deal with them at a stage long before they are currently detectable. These techniques will also be crucial in successful follow-up. A patient who has a predisposition to a certain cancer process will be monitored regularly and offered treatment when necessary. Not all cancers will be diagnosed in these earliest of stages – some patients will inevitably fall through the screening net. Nevertheless, there will be opportunities to offer less invasive treatment than at present. Surgery and radiotherapy will continue, but in greatly modified form as a result of developments in imaging. Most significantly, surgery will become part of integrated care. Removal of tumours or even whole organs will remain necessary on occasion. However, the surgeon will be supported by 3D imaging, by radiolabeling techniques to guide incisions, and by robotic instruments. And although many of the new treatments made possible by improved imaging will be biologically driven, there will still be a role for radiotherapy – the most potent DNA-damaging agent – to treat cancer with great geographical accuracy. The targeting of radiotherapy will be greatly enhanced, enabling treatment to be more precise.

Table 3 Innovation in diagnostics
• Radiology and pathology will merge into cancer imaging and classicication
• Dynamic imaging will create a changing image of biochemical abnormalities
• Cancer changes will be detected prior to disease spread from primary site
• Greater precision in surgery and radiotherapy will be used for precancer
• Molecular signatures will determine treatment choice
• Cost control will be essential for health-care payers to avoid inefficient diagnostics

In addition to the reconfiguration and merging of the skills of clinicians, the delivery of care will also change. Minimally invasive treatments will reduce the need for long stays in hospital. As more patients are diagnosed with cancer, the need to provide the care close to where

patients live will be both desirable and possible, and it will be expected by the patients. The prospect of highly sophisticated scanning equipment and mobile surgical units being transported to where they are required is not unrealistic. Technicians, surgical assistants, and nurses would provide the hands-on care, while technical support will be provided by the new breed of clinician – a disease-specific imaging specialist working from a remote site. Cost control will be an essential component of the diagnostic phase. Health-care payers will create sophisticated systems to evaluate the economic benefits of innovative imaging and tissue analysis technology.

New Treatment Approaches

Future cancer care will be driven by the least invasive therapy that is consistent with long-term survival. Eradication, although still desirable, will no longer be the primary aim of treatment. Cancers will be identified earlier and the disease process regulated in a similar way to chronic diseases such as diabetes. Surgery and radiotherapy will still have a role, but how much will depend on the type of cancer a patient has and the stage at which disease is identified. It will also depend on how well the drugs being developed today perform in the future.

Cancer treatment will be shaped by a new generation of drugs (Figure 1). The profile of this new generation of drugs will depend critically on the relative success of agents currently in development. Over the next 3–5 years, we will understand more fully the benefits that compounds such as kinase inhibitors are likely to provide. It is estimated that there are about 500 drugs currently being tested in clinical trials. Of these, around 300 inhibit specific molecular targets. But this number is set to rise dramatically: 3,000 compounds will be available to enter clinical trials by 2020, and 5000 by 2025. Many of these drug candidates will be directed at the same molecular targets. The pharmaceutical industry is racing to screen those most likely to succeed in the development process. Tremendous commercial pressures have arisen from the loss of patent protection for the majority of older high-cost chemotherapy drugs in 2014. Unless new premium-priced innovative drugs are available, cancer drug provision will come from global generic manufacturers currently gearing up for this change.

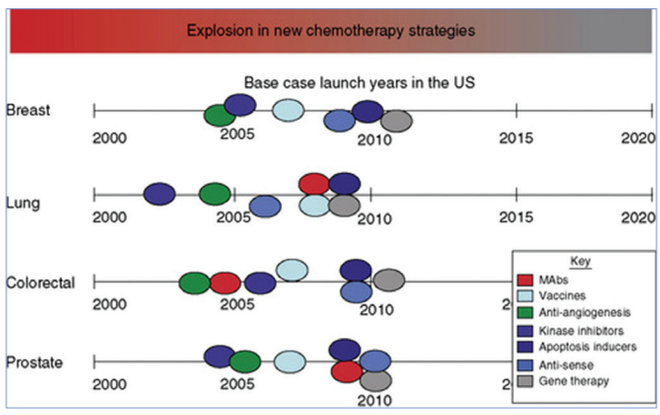

Figure 1. Predicted new drug application dates for molecular therapies in the United States. The years 2005–10 saw an explosion of novel therapies coming into clinical use outside the research setting.

So what will these drug candidates look like? Small molecules are the main focus of current research, most of which are designed to target specific gene products that control the biological processes associated with cancer, such as signal transduction, growth of new blood vessels (angiogenesis), cell cycle control, apoptosis, inflammation, invasion, and differentiation. Treatment strategies involving monoclonal antibodies, cancer vaccines, and gene therapy are also being explored. Although we do not know exactly what these targeted agents will look like, there is growing confidence that they will work. More uncertain is their overall efficacy at prolonging survival. Many could just be expensive palliatives. In future, advances will be driven by a better biological understanding of the disease process (Figure 2).

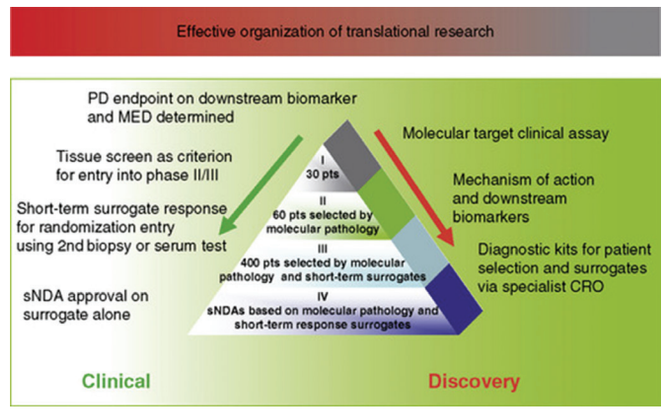

Figure 2. The future of cancer drug development. Drugs will enter patients for the first time accompanied by effective biomarkers. These in turn will be used to identify surrogate markers of response, thus selecting patients early in pivotal studies to either continue or stop a specific trial. In addition, continued laboratory research will be used to create diagnostic kits to identify signatures of response.

Already we are seeing the emergence of drugs targeted at a molecular level: Herceptin, directed at the HER2 protein, Glivec, which targets the Bcr-Abl tyrosine kinase, and Iressa and Tarceva, directed at EGFR tyrosine kinase. These therapies will be used across a range of cancers. What will be important in future is whether a person's cancer has particular biological or genetic characteristics. Traditional categories will continue to be broken down, and genetic profiling will enable treatment to be targeted at the right patients. Patients will understand that treatment options are dependent on their genetic profile. The risks and benefits of treatment will be much more predictable than today.

Therapies will emerge from our knowledge of the human genome and the use of sophisticated bioinformatics. Targeted imaging agents will be used to deliver therapy at the time of screening or diagnosis. Monitoring cancer patients will also change as further developments in technology allow the disease process to be tracked much more closely. Treatment strategies will reflect this, and drug resistance will become much more predictable. Biomarkers will allow specialists treating cancer patients to measure if a drug is working on its target. If it is not, an alternative treatment strategy will be sought. Tumor regression will become less important as clinicians look for molecular patterns of disease and its response.

There will be greater focus on therapies designed to prevent cancer. A tangible risk indicator and risk-reducing therapy, along the lines of cholesterol and statins, would allow people to monitor their risk and to intervene. Delivering treatment early in the disease process will also be possible because subtle changes in cellular activity will be detectable. This will lead to less aggressive treatment. The role of industry in the development of new therapies will continue to change. Smaller, more specialized companies, linked to universities, will increasingly deliver drug candidates and innovative diagnostics for the major pharmaceutical companies to market (Table 4).

Table 4: Cancer diagnostics — future	
Baseline 2015	Upside 2015
Risk predictoin in small subsets	· Population risk banding for cancer · Identify people for chemo-prevention
Examples of early cancer detection	· Massive expansion in patients with early cancer
Used for dose determinatoin for some mechanistically based drugs	· Unversal use
Accepted by regulators in some diseases	· Short tern surrogates used to register and obtain sNDAs

People will be used to living with risk and will have much more knowledge about their propensity for disease. Programs will enable people to determine their own predisposition to cancer. This in turn will encourage health-changing behavior and will lead people to seek out information about the treatment options available to them. Patients will become more involved in decision making as medicine becomes more personalized. Indeed, doctors may find themselves being directed by well-informed patients. This, and an environment in which patients are able to demonstrate choice, will help drive innovation toward those who will benefit. However, inequity based on education, wealth, and access will continue.

Barriers to Innovation

Innovation in cancer treatment is inevitable. However, there are certain prerequisites for the introduction of new therapies (Table 5). First, innovation has to be translated into usable therapies. These therapies must be deliverable, to the right biological target and to the right patient, in a way that is acceptable by patient, health-care professional, and society. Late-stage attrition – failure of a drug at a late stage in the development pipeline, with the loss of substantial research investment – must be minimized. Innovation must also be marketed successfully so that professionals, patients, and those picking up the cost understand the potential benefits. Those making the investment in research will inevitably create a market for innovation even if the benefits achieved are minimal. As one oncology marketing director said, "I enjoy my job for the challenges it brings. Selling drugs that work is no fun but oncology is about selling hope." The explosion of new therapies in cancer care will continue and the prices of these drugs will remain high. The cost of cancer drugs in 2005 is estimated to be $24 billion globally, of which $15 billion is spent in the United States. If effective drugs emerge from the research and development pipeline, the cancer drug market could reach $300 billion globally by 2025, with this cost spreading more widely around the world (Table 6).

Table 5 The uncertainty of novel drugs for cancer
• Will the new generation of small-molecule kinase inhibitors really make a difference or will they just provide expensive palliation?
• How will the major pharmaceutical companies cope when most of the current high-value cytotoxics lose patent protection in 2008 (when they can be supplied as cheaper generic drugs)?
• Can expensive late-stage attrition really be avoided in cancer drug development?
• How will sophisticated molecular diagnostic services be provided?
• Will effective surrogates for cancer-preventive agents emerge?
• Will patient choice involve cost considerations in guiding therapy?

Table 6 Marketed targeted therapies showing their high cost per year

Drug	Generic	Manufacturer	Yearly cost
Herceptin	Trastuzumab	Roche	$80K
Mabthera	Rituximab	Roche	$50K
Glivec	Imatinib	Novartis	$80K
Erbitux	Cetuximab	BMS	$80K
Avastin	Bevacizumab	Genentech	$90K
Tarceva	Erlotinib	Roche	$75K
Iressa	Gefitinib	AZ	$60K
Sutent	Sunitinib	Pfizer	$80K
Nexavar	Sorafenib	Bayer	$70K
Tykerb	Lapatinib	GSK	$60K

But parallel to this explosion in therapies and the increase in costs, a number of confounding factors will make markets smaller. The technology will be there to reveal which patients will not respond to therapy: blockbuster drugs that bring huge commercial rewards to the developer will become rare. Doctors will know the precise stage of the disease process at which treatment is necessary. And as cancer becomes transformed into a chronic disease, people will have more co morbidity, which will bring associated drug–drug interactions and an increase in care requirements.

How do we balance this equation? The pharmaceutical companies will not necessarily want to do the studies to fragment their market. Research leading to rational rationing will need to be driven by the payers of health care. There is a risk that pharmaceutical companies will stop developing drugs for cancer and focus instead on therapeutic areas where there is less individual variation and

therefore more scope for profit. Furthermore, development costs are rising. Ten years ago, the average cost of developing a new cancer drug was around $400 million. Now it is $1.2 billion. At this rate of growth, the cost of developing a new drug could soon reach $2 billion, an amount unsustainable in a shrinking market. With this in mind, the process of developing drugs needs to be made faster.

However, instead of research being made simpler, changes in legislation concerned with privacy and prior consent are making it more difficult. The EU Clinical Trials Directive will make quick, hypothesis-testing trials impossible. Other challenges exist, such as obtaining consent for new uses of existing, stored human tissue, following political anxiety when consent for removing and storing tissues had not been obtained in the early years of the twenty-first century. However, surveys have shown that patients who give consent for tissue to be used for one research purpose are happy for it to be used for another. They do not wish to be reminded of their cancer years later. To overcome these constraints, regulators will have to start accepting surrogate markers when approving therapies, rather than insisting on clinical outcomes. Outcome studies may well move to post registration surveillance of the efficacy of a drug, similar to the position for cholesterol-lowering agents today.

The rise of personalized medicine will mean the temptation to overtreat will disappear. Doctors and patients will know whether a particular treatment is justified. The evidence will be there to support the decisions. As a consequence of this, treatment failure – with all its associated costs – will be less common (Table 7).

Table 7 Barriers to innovation
• The drug industry will continue to compete for investment in a competitive, capitalist environment
• Blockbuster drugs drive profit; niche products are unattractive in today's market
• Personalized therapies are difficult for today's industry machine
• Surrogate endpoints will be essential to register new drugs
• Novel providers will emerge, providing both diagnostic and therapy services
• Payers will seek robust justification for the use of high-cost agents

The Cancer Patient's Experience

Two separate developments will determine the patient's experience of cancer care in future. Increasing expectations of patients as consumers will lead health services to become much more responsive to the individual, in the way that other service industries have already become. Targeted approaches to diagnosis and treatment will individualize care. People will have higher personal expectations, be less deferential to professionals and more willing to seek alternative care providers if dissatisfied. As a result, patients will be more involved in their care. They will take more responsibility for decisions, rather than accepting a paternalistic doctor knows best approach. This will partly be fueled by the internet and competitive provider systems. By 2025, the overwhelming majority of people in their 70s and 80s will be familiar with using the internet to access information through the massive computing power that they will carry personally.

Patients will need someone to interpret the huge volumes of accessible health information, to help them assess the risks and benefits, as well as to determine what is relevant to them. These patient brokers will be compassionate but independent advocates who will act as patients' champions, guiding them through the system. They will be helped by intelligent algorithms to ensure patients understand screening and the implications of early diagnosis. They will spell out what genetic susceptibility means and guide patients through the treatment options. Patients and health professionals will have confidence in computer-aided decision making because they will have evidence that the programs work.

The extent to which the service will be designed around patients' needs and expectations will be determined by the improved treatments available and their individualization (Figure 3). Care in the early stages will be provided near to where the patients live. Even the most sophisticated diagnostic machinery or robotic surgeon will be mobile, so much of this intervention will be carried out by technicians and nurses, with the most highly trained professionals in audiovisual contact from a distant base. When cancer centers developed in the mid-twentieth century, these diseases were relatively rare, and survival was low. Although distressing for patients when they were referred to a center, their existence concentrated expertise. Cancers will become commonly accepted chronic conditions, and even when inpatient care is required, patients will be able to choose many places in the world where they will receive care at a cancer hotel. But for many patients, even that option will not be necessary (Figure 4). Most new drugs will be given orally, so patients will be treated in their communities. However, this approach to cancer and other chronic conditions will place a huge burden on social services and families. Systems will be put in place to manage the ongoing control of these diseases and conditions, psychologically as well as physically. The relief of pain and the control of other symptoms associated with cancer treatment will be much improved. Figure 5 shows the integration required to reconfigure the entire cancer service around the patient at its center.

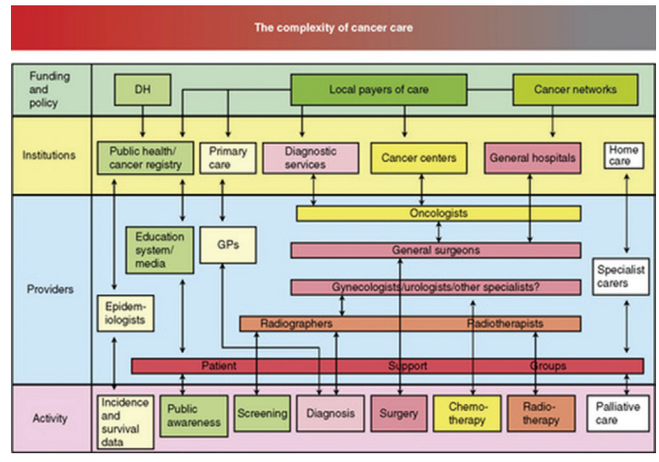

Figure 3. The integration of cancer services within the health-care system.

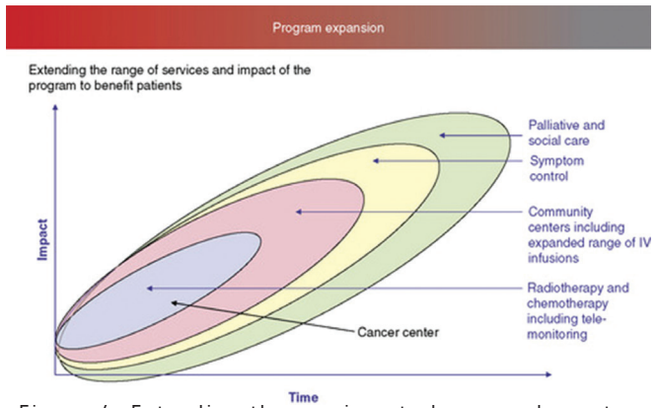

Figure 4. Extending the services to become closer to patients using distributive care models.

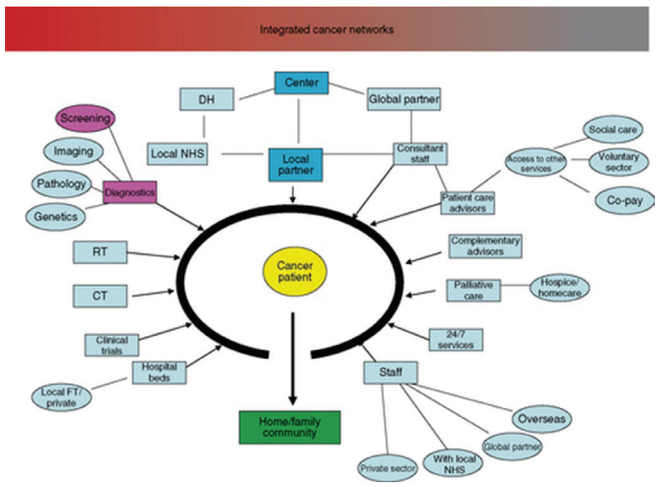

Figure 5. Creating an integrated cancer network around a patient.

Today, 70% of the cancer budget is spent on care associated with the last 6 months of people's lives. Although many recognize that such treatment has more to do with the management of fear than the management of cancer, medical professionals have relatively few treatment options available and there is limited awareness of which patients would benefit. There is also an institutional reluctance to destroy patients' hopes that leads to confusion between the limits of conventional medicines and reluctance to face the inevitable – by patients, their families, and their doctors. There is a widespread perception that if terminally ill patients continue to be offered anti-cancer treatment, there is the possibility that their health might be restored.

With better treatments, consumers of services will be able to focus on quality of life. Much of the fear now associated with cancer will be mitigated. Demand for treatments with few side effects or lower toxicity will be high, even if there are only quite modest survival gains. The transition between active and palliative care is often sudden, but in future, because patients will be in much greater control of their situation, the change in gear will not be as apparent (Table 8).

Table 8 Experiencing cancer in future
• Patient brokers will guide people with cancer through the system
• Choice will be real and will involve cost decisions
• Patients will make a contribution to the costs of their care
• Complementary therapies will be widely available and well regulated
• Themed death chosen by patients will be possible

Professional Reconfiguration

One of the greatest challenges to providing the best cancer care in future will be having the right people in the right jobs. It will be essential not to continue to train people for jobs that will no longer exist. Policy makers have begun to grasp some of the workforce difficulties that lie ahead. There are moves to ensure that health-care professionals have responsibilities that are commensurate with their level of education and professional skills. Nurses and pharmacists are being encouraged to take over some responsibilities that have been firmly held by doctors, such as prescribing, while some of their traditional roles are handed on to technicians and other support staff.

The appropriate skill mix will become even more critical. Barriers between health-care professions will have to be broken down so that new approaches to the care of patients with cancer and many other diseases can be delivered. Intra-professional barriers will disappear. The work of pathologists and radiologists will become one as their traditional skills are augmented by the new generation of diagnostic and treatment devices. Oncologists will find that many forms of chemotherapy will be delivered with the aid of the new technology, and surgeons will be using robots to enable them to operate. Fewer of the most highly trained specialists will be required, since much of their responsibility will be delegated to specialist technicians and nurses working to protocols. In addition, the most highly trained individuals will be able to work at a number of sites on the same day, since the technology will be mobile and their skills can deployed remotely. The balance between skills will be driven by a number of factors: the size of the medical workforce and the capacity of the system to provide care, as well as the availability of trained support staff (Table 9).

Table 9 The right person for the right job: key challenges
• Manpower planning for new technology
• Doctors and other health-care specialists
• Prescribing cancer drugs by nurses, pharmacists, and others
• Training carers for elderly people with substantial comorbidity
• Making patients equal partners in decision making

Conclusion

Cancer will become incidental to day-to-day living. A cancer will not necessarily be eradicated by treatment, but that will not cause patients the anxiety that it does today. People will have far greater control over their medical destinies. Patients in all

socioeconomic groups will be better informed. In addition, surgery and chemotherapy will no longer be rationed on grounds of age, since all interventions will be less damaging, psychologically as well as physically.

The accuracy of this image of the future depends on whether the technological innovations do actually emerge, and the extent to which they become widely available. For example, will people really live in smart houses where their televisions play a critical role in monitoring their health and well-being? It is also dependent on health-care professionals working alongside each other, valuing the input of carers who, even more than today, will provide voluntary support, because of the number of people in older age groups compared with those of working age. The reality for cancer care may be rather different. The ideal will exist for a minority of patients, but the majority may not have access to the full range of services. Old people, having been relatively poor all their lives, may suffer from cancer and a huge range of comorbidities that will limit their quality of life. Looking after them all – rich and poor – will place great strains on younger people: Will there be enough of them to provide the care? As with all health issues, the question of access will be determined by cost and political will. In 2006, a cancer patient consumes about £25 000 ($50 000) of direct medical care costs, 70% of which is spent in the last 6 months of life. Conservatively, with patients living with cancer, rather than dying from it, and with access to new technologies, this could reach £100 000 per patient per year by 2026. In theory, cancer care could absorb an ever-increasing proportion of the health-care budget. Would this be a reflection of what patients want? Probably yes. Surveys reveal that three-quarters of the population believe cancer care should be the main priority of the health-care system, with no other disease even a close second.

But to achieve that expenditure – and assuming that part of the health service will be funded from taxation – the tax rate might have to rise to 60%. Inevitably, there will be conflicting demands on resources: The choice may be drugs or care costs. And how are the costs computed? Although the technology will be expensive, it will be used more judiciously, since it will be better targeted. Another argument suggests that when patients are empowered they use fewer and less-expensive medicines, in effect lowering the overall costs. An extension of this argument is that although costs will increase for treating each individual patient, the overall costs will decrease because more care will be delivered at home. But because people will live longer, the life-time costs of cancer care will rise along with comorbidity costs. Politicians will be faced with a real dilemma: If the prevalence of cancer increases, the cost of delivering innovative care could be massive. Will cancer care need to be rationed in a draconian way?

One dilemma for the future will be the political power of old people. More will be living longer and their chronic problems will not necessarily incapacitate them physically or mentally. This educated elderly population will have high expectations, sharpened through the first two decades of the twenty-first century, and they will not tolerate the standards of care now offered to many old people. They will wield considerable influence. Will a tax-based health system be able to fund their expectations? Politicians will have to consider the alignment between patients' requirements, and taxpayers' and voters' wishes. Fewer than 50% of voters now pay tax, and the percentage of tax-paying voters is set to fall as the population ages. Will the younger taxpayers of the future tolerate the expensive wishes of non-taxpayers? The interests of voters may be very different from the interests of taxpayers. It seems likely, therefore, that the days of an exclusively tax-funded health service are numbered. Co-payments and deductibles will be an inevitable part of the new financial vocabulary. Figure 6 shows the four components of cancer's future: Innovation, delivery, finances, and society and Figure 7 looks at the four alternative scenarios.

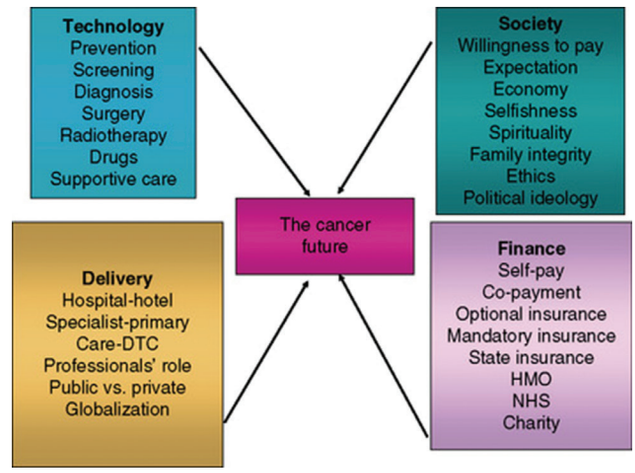

Figure 6. The four building blocks of cancer's future: Innovation, society, delivery, and finances.

Whatever system is put in place, there is the prospect of a major socioeconomic division in cancer care. A small percentage of the elderly population will have made suitable provision for their retirement, both in terms of health and welfare, but the vast majority will not be properly prepared. Policy makers need to start planning now. The most productive way forward is to start involving cancer patients and health advocacy groups in the debate, to ensure that difficult decisions are reached by consensus. Societal change will create new challenges in the provision of care. A decline in hierarchical religious structures, a reduction in family integrity through increasing divorce, greater international mobility, and the increased selfishness of a consumer-driven culture will leave many lonely and with no psychological crutch to lean on at the onset of serious illness. There will be a global shortage of carers – the unskilled, low-paid but essential component of any health-care delivery system. The richer parts of the world are now obtaining this resource from the poorer parts of the world, but the supply of this precious human capital will eventually dwindle.

New financial structures will emerge with novel consortia from the pharmaceutical, financial, and health-care sectors, enabling people to buy into the level of care they wish to pay for. Cancer, cardiovascular disease, and dementia will be controlled, and will join today's list of chronic diseases such as diabetes, asthma,

and hypertension. Hospitals will become attractive health hotels, run by competing private-sector providers. Global franchises will provide speciality therapies through these structures, similar to the internationally branded shops in today's malls. Governments will have long ceased to deliver care. Britain's NHS, one of the last centralized systems to disappear, will convert to UK Health, a regulator and safety-net insurer early in the twenty-first century.

The ability of technology to improve cancer care is assured. But this will come at a price: the direct costs of providing it and the costs of looking after the increasingly elderly population that it will produce. We will eventually simply run out of things to die from. New ethical and moral dilemmas will arise as we seek the holy grail of compressed morbidity. Living long and dying fast will become the mantra of twenty-first-century medicine. Our cancer future will emerge from the interaction of four factors: the success of new technology, society's willingness to pay, future health-care delivery systems, and the financial mechanisms that underpin them.

Fig 7. Alternative canser futures

· Patient power · New technology · Competitive intensity · Increasing numbers	
· Technological success · Sosiety willing to pay	· Technological success · Sosiety not willing to pay
· Longevity · Compressed morbidity	· Increased inequity
· Technological failure · Sosiety not willing to pay	· Technological failure · Sosiety willing to pay
· Prioritisation essential	· Quality of life · Social care

Further Reading

· Price, P. and Sikora, K., Treatment of Cancer. (2015), CRC Press, Oxford

· Bosanquet, N.; Sikora, K., The Economics of Cancer Care. (2006) Cambridge University Press, Cambridge, UK.

· Clinical Cancer Advances 2015: Annual Report on Progress Against Cancer From the American Society of Clinical Oncology J.Clin.Onc 33, 217,2015