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One hundred years of Operational Research in Health—UK 1948–2048☆

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This paper presents a personal view, drawing on some 30 years of working in this area, of past, present and future contributions of operational research (OR) in health in the UK. It considers developments in health and care and in OR contributions to these at local and national level since the creation of the National Health Service 60 years ago; likely future developments in health and care; and associated priorities for preparing now for OR to make a major impact on health and care in the next 40 years. The aim is to stimulate reflective thinking and promote anticipatory action among health OR practitioners of the future.

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Introduction

Readers may already have—correctly—judged the title of this paper as hubristic. Or perhaps—charitably—as an outline model. Either way, a more realistic heading would be 'Some brief observations on the development of health and care and on some associated contributions of Operational Research (OR) in the UK (mostly England) from 1948 to the present day (although much of the past is skipped over) and the outlook from now until 2048 (but it's necessarily pretty vague about the future)'.

This is a practitioner's perspective, a selective view not a systematic review, but it does draw on around 30 years of personal experience in the area, on literature in various shades of white and grey, and on views recently sought from a range of prominent UK health analysts (see Acknowledgements).

It is driven by concern with three questions about the past, present and future impact of OR in health:

Yesterday – What have been areas of health or health care where OR analysts have had a significant impact? How have we achieved this?
Tomorrow – What are coming challenges for health or health care where OR analysts should seek to make a significant impact? How could we best contribute?
Today – What lessons should OR analysts working in health take from the past to help make a bigger impact in the future? What should we do today to prepare the path?

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☆ This paper is based on a keynote talk given by the author at the OR 50 Conference in York in September 2008.

The paper falls into three main sections corresponding to the above three issues.

Yesterday: 1948–2007—birth and development

Development of the National Health Service

1948 was a seminal year for health care in the UK; it saw, on 5 July, the birth of the National Health Service (NHS).

Since then, activity, workforce and expenditure in the NHS have increased dramatically. For example when the NHS started there were about three million inpatient cases a year, now there are annually about 14 million episodes of such treatment. (This is not—see later—because people have become less healthy!) Six decades ago there were around 5000 hospital consultants working in the NHS, now there are some 35 000. NHS spend has risen from £447 *million* in 1949/1950 to £114 *billion* in 2007/2008; even after adjusting for inflation that is still about a tenfold increase.

There have been many changes in the organization, delivery and funding of care; even just in the last decade—new structures such as Strategic Health Authorities, Primary Care Trusts and Foundation Trusts; new agencies such as the National Institute of Health and Clinical Excellence, the National Patient Safety Agency and the Health Protection Agency; new care pathways and settings such as NHS Treatment Centres, NHS Walk-in Centres and NHS Direct; new transactional processes such as payment by results and health and social service resource pooling; and new modes of patient engagement such as choose and book and expert patient programmes.

Although many challenges remain, for example in variations and inequalities in treatment and access with people in lower socioeconomic groups at a particular disadvantage—for instance hip replacements are lower among these groups

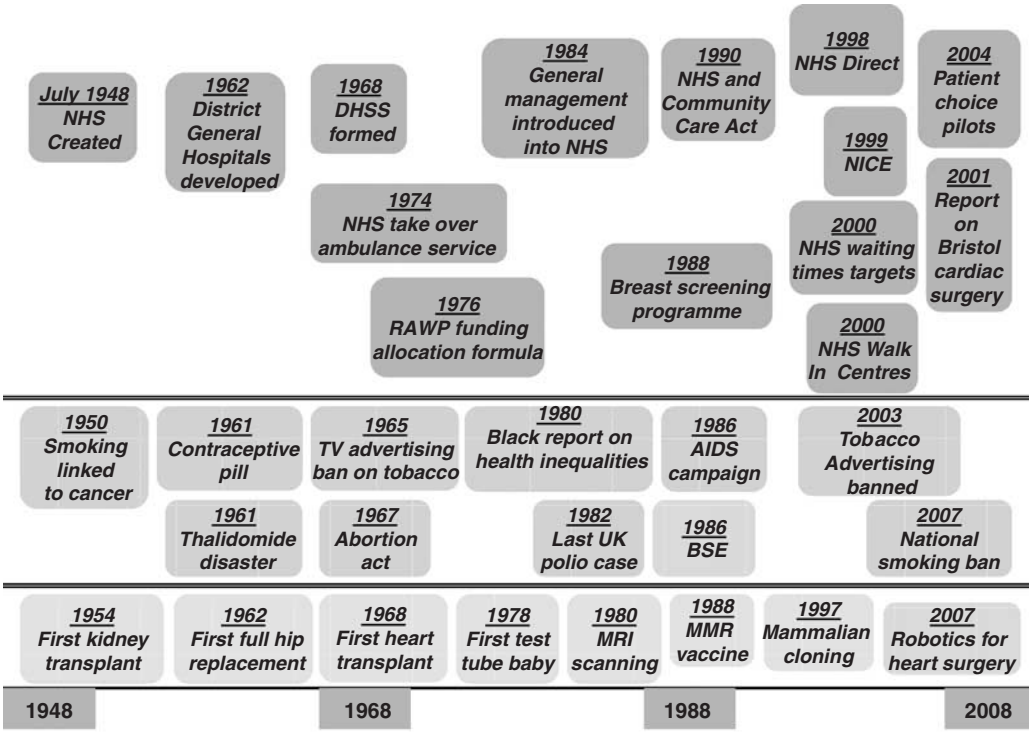

Figure 1 Some UK milestones in health care and health care management 1948–2007.

despite higher need (Dixon *et al*, 2004), many aspects of NHS care have hugely improved. A wide range of procedures that were unknown when the NHS began, such as joint replacement, organ transplants or computerized tomography, are now commonplace—for example there have now been well over 5000 UK heart transplants. More conditions can be treated effectively, and more people can be operated on safely—especially the very young and the very old: the record age for a UK hip replacement currently stands at 101! And access is faster—for example, a decade ago it was not uncommon to wait for over 12 months for an operation in hospital or over 12 hours for treatment in an Accident & Emergency (A&E) department, now hardly any people wait over 6 months for an operation or over 4 hours for treatment in A&E (Department of Health, 2007).

There have also been some significant measures to improve public health; in particular there has been a dramatic decline in cigarette smoking—from 65% in 1948 to 23% today for men (Office of National Statistics, 2006)—and vaccination has almost eliminated several childhood infectious diseases such as polio—the last natural case of which in the UK was in 1982. Although inequalities in health status persist with sizeable variations across the country—notably the north-south divide—and between different population groups—poverty and poor health tend to go together (Marmot and Wilkinson, 2005)—there have been major improvements in the health of the UK population as a whole. Mortality rates from infections, from cancers and from circulatory and respiratory illnesses have fallen considerably, for example in the last decade there has been an 18% decline in mortality rates from cancer and a 44% decline from heart disease and stroke (Department of Health, 2008a) and life expectancy has risen from 65 for men and 70 for women in 1948 to 77 for men and 82 for women today (Office of National Statistics, 2008)—an unprecedented rise of around 2 years every decade.

Figure 1 shows some milestones in health care and its management 1948–2007, drawn from a comprehensive source (www.nhshistory.net and www.nhs.uk, accessed July 2008). The top section relates to organizational and service areas, the middle section to public health and the bottom section to surgical and other clinical milestones.

Development of OR

1948 was also a seminal year for OR, as in April the forerunner of the OR Society, the OR Club, was inaugurated. Since then OR in the UK has developed with an expansion of UK OR into nationalized industries, civil government and the corporate sector, with OR Society membership rising from about 100 in 1955 to 3000 in 1975 , a strength that it has maintained since. Since 1975, UK OR has adapted to a changing economy, shrinking in industry but expanding in the service and public sectors—for example, civil Government Operational Research Service staff numbers have risen from about 100 to around 400 over the last two decades (Turner, 2007).

OR in health

Explicit UK health OR applications date from the 1950s, with two papers by Norman Bailey being notable early examples (Bailey, 1952a, 1957). There have of course been some significant contributions from UK OR in health over the intervening years.

As noted in the introduction, this paper does not attempt to provide a comprehensive overview, for which readers should refer to other publications (eg Brandeau *et al*, 2004), but the sustained contribution of UK OR in health since the 1950s can be illustrated by taking one small but important area—waiting in outpatient and accident and emergency departments. OR work in this field has been published in every decade, for example

- a study of queues and appointment systems in hospital outpatient departments (Bailey, 1952b);
- design of an appointment system (Jackson, 1964);
- an application of queuing theory to a congestion problem in an outpatient clinic (Keller and Laughhunn, 1973);
- investigating outpatient departments (O'Keefe, 1985);
- queueing models for outpatient appointment systems (Brahimi and Worthington, 1991);

and continues to this day for example

- using queuing theory to analyze the Government's 4h completion time target in A&E (Mayhew and Smith, 2008).

More generally UK health OR practitioners have contributed on a worldwide front, with contributions evident from landmark compilations such as:

- *'Patients, Hospitals and Operational Research'* (Luck *et al*, 1971).
- *'Operational Research Applied to Health Services'* (Boldy, 1981).
- *'Enhancing Health Services Management'* (Cropper and Forte, 1997).
- *'Health Operations Management'* (Vissers and Beech, 2005).

UK OR practitioners are active contributors to the European Working Group on OR Applied to Health Services, established in 1975, as a glance at their published proceedings for example *Operational Research for Health Policy: Making Better Decisions* (Brailsford and Harper, 2007a) or website (www.management.soton.ac.uk/ORAHS) will show.

National and local UK applications of health OR

There are wide ranging recent national UK applications of health OR. For instance, examples from the work of OR analysts in the Department of Health include:

Policies and strategies

- setting targets for waiting times;
- creation of NHS Direct;
- strategic framework for supporting self care;
- blood safety and vCJD risk strategy;
- chlamydia screening strategy;
- preparedness for a flu pandemic;
- vaccination programmes;
- emergency incident counter measures.

Implementation and delivery

- peak load capacity planning (hospitals, walk-in centres, NHS Direct);
- reducing waiting times (elective care and emergency care);
- improving stroke services (ASSET analytical toolkit);
- introducing total booking systems;
- estimating future demand for and supply of doctors;
- NHS pay deal costing;
- expenditure forecasts for services (children, mental health, patient safety etc).

Monitoring and evaluation

- developing performance ratings for hospitals;
- evaluating hospital improvement programmes;
- assessing the Expert Patient programme;
- understanding NHS financial deficits.

Recent, mainly local, UK applications are exemplified in special issues of both *JORS* (Davies and Bensley, 2005; Brailsford and Harper, 2007b) and of *Health Care Management Science* (Baker *et al*, 2008) such as (respectively):

- forecasting costs of long-term care at local authority level;
- assessing demand for nurses in intensive care units;
- planning regional oral surgery services across London;
- operational design of a NHS walk-in centre;
- design of an integrated musculoskeletal service;
- involving public and patients in improving services.

- cancer staging and treatment;
- ambulance dispatch and location;
- scheduling surgical clinics;
- blood supply;
- monitoring surgical infection;
- hospital and community care for older patients.

- gauging future demand for social care for older people;
- strategic commissioning for example, for diabetes care;
- managing care of elderly patients in emergency departments;
- optimizing inventory of hospital supplies;
- evaluating outcomes in patient-centred health monitoring services.

UK health OR has a good reputation among its professional peers with a recent Research Council Review (EPSRC, 2004) concluding: '*Unique selling points of significant strength within the British OR agenda are soft OR and applications in healthcare*'.

Some concerns about health OR in the UK

The number and organization of health OR analysts in England have had their ups and downs. There are some structural strengths: a number of university groups have been working in health OR/management science (MS) since the 1950s and 1960s and of course play a key role both in research and in training in health OR; several management consultancies have people with skills in health OR/MS (although often not explicitly badged as such); the Department of Health (DHSS as was) set up an OR group in the early 1970s (it had around 15 health OR analysts in the 1980s, and it now has more than twice that number, working with economists and statisticians in multidisciplinary teams embedded in policy and delivery commands) ; a national clinical OR unit was established in 1983 and recently celebrated its 25th anniversary; an OR Society UK health and care study/special interest group has been in existence since at least the early 1970s and there have been more specialized such groups from time to time such as the AIDS study group (Dangerfield and Roberts, 1994) and there are new health modelling networks notably MASHnet.

However, there are also some structural weaknesses. Only a few of the national health agencies—notably NICE and the NHS Blood and Transplant Service—appear to make extensive use of the services of OR analysts. In the 1980's, as many as nine of the then 14 NHS Regional Health Authorities (RHAs) had OR groups; but the RHAs were abolished in the mid-1990s and their modern counterparts (Strategic Health Authorities) do not have a recognizable OR function. And at hospital level the situation is neatly summarized in an editorial in the BMJ (Buhaug, 2002), which concluded that '*Compared with many other organisations, hospitals have been slow in adopting operational research as a means to improve their performance. Applications are scattered and the results not always used, even if they are relevant and reliable. The implication is that, so far, hospitals have largely failed to use one of the most potent methods currently available for improving the performance of complex organisations*'.

A specific concern is that UK health OR does not appear very visible to managers or clinicians. (This is not, of course, a problem unique to health; many fashionable approaches in management generally—for example lean thinking, theory of constraints, system and process mapping—do not recognize their debt to OR. What they often do, however, is get straight to the point; which may hold a lesson for us.) Although there has been a large growth in publication of papers on health topics in OR/MS journals such as *JORS* or *Health Care Management Science*, there is vastly lower exposure of OR in the literature that managers and clinicians read such as the *Health Service Journal* or the *British Medical Journal (BMJ)*. (Some of the recent few exceptions include *BMJ* papers by Young *et al*, 2004 and by Gallivan *et al*, 2002.) Table 1 illustrates this using a search (Google Scholar, July 2008) on *operational (*or *operations) research*. (An analogous search on *management science* scored somewhat higher in 'all publications' but no better—indeed worse—in '*BMJ* group publications only'.)

Other disciplines have higher visibility, for example while in 2007 OR got just nine mentions in *British Medical Journal* group publications, a similar search (Google Scholar, July 2008) for mentions of health services research, economics, and statistics found respectively, 105, 183 and 966 mentions. Other disciplines do however share concerns about perceptions and use—a paper on the impact of health services research (Dash *et al*, 2003) noted that *'researchers are frustrated that their work is not used more widely'* while *'NHS managers see little of relevance in the research available to them and see health services research as poor value for money'* and *'policy makers are concerned about the timeliness of research*!'

There are also—probably related—issues about lack of implementation of modelling work. For example, a 1981 review (Wilson, 1981) of 200 simulation projects in health care found that only 16 reported successful implementation and a 2003 review (Fone *et al*, 2003) found 182 papers on simulation in health (1980–1999), but so few reported on implementation (in itself a revealing and worrying sign!) that their *'value could not be assessed'*.

The requirements for user engagement and support and for effective implementation of OR in health, as in other areas, form a long chain. OR needs to be: available, visible, relevant, affordable, comprehensible, convincing, practical and timely. A weak link anywhere can lead to failure of the whole implementation chain.

If OR is to be part of 'mainstreaming' modelling and evidence-based management in health care then working harder on implementation must be a key requirement. Recent papers (Harper and Pitt, 2004; Proudlove *et al*, 2007; Eldabi *et al*, 2007) have considered these issues further.

However, important as this is, it is not the whole picture. Although one indicator of success in health OR is the implementation of published OR work, another is the impact of OR on health service developments, much of which may never reach the academic journals. OR *has* made some major contributions to UK health care since 1948. For example, the selection of milestones in UK health care policy and management was influenced by personal knowledge that many had benefited from, and in some instances were driven by, work of OR analysts. See Figure 2. (These examples relate to the largely organizational and service changes shown in the top section of Figure 1, there would be further examples in the public health or clinical arenas.)

Table 1 OR publications in health have grown considerably, but not in the literature that managers and clinicians read

Year [Search using Google Scholar, July 2008]	*In all publications [Search on operational (or operations) research + health]*	*In BMJ group publications only [Search on operational (or operations) research]*
1975	114	0
1985	126	0
1990	146	0
2000	681	4
2005	1260	5
2007	1720	9

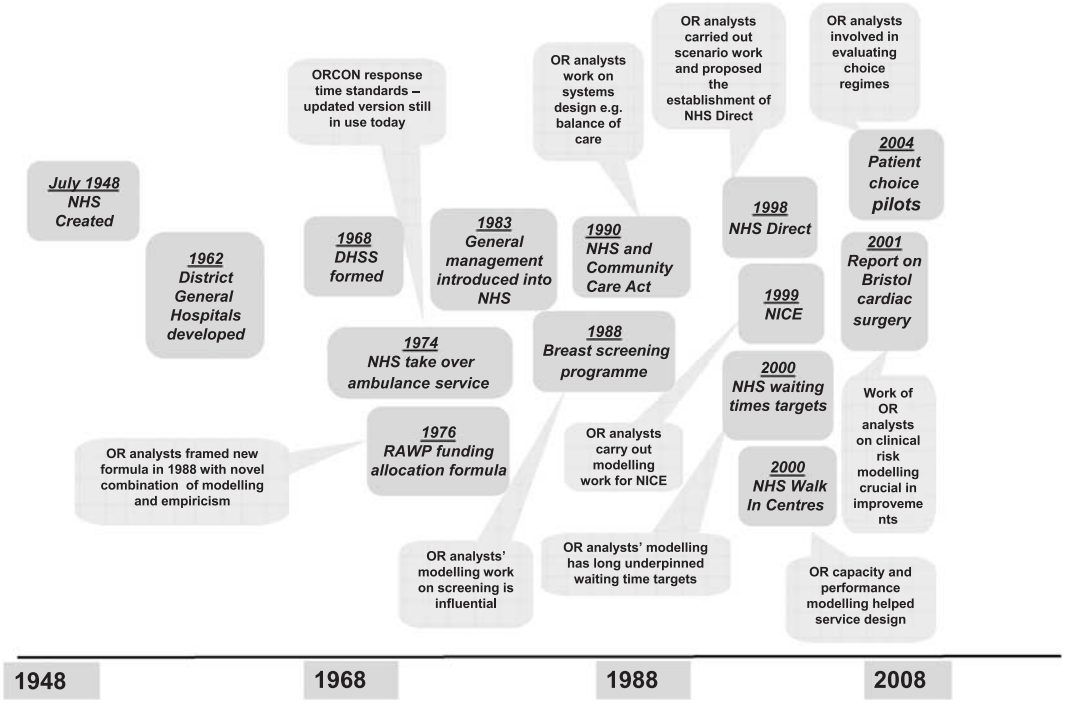

Figure 2 OR has contributed to a number of milestones in UK health care policy and management.

Tomorrow: 2009–2048—challenges of change

Health and care futures

Health care is likely to continue as a major UK growth area. Medical advance continues to expand what is possible, an ageing population increases what is required, and a more prosperous society increases what is affordable and expected. The proportion of UK GDP spent on health care has risen steadily from about 3% when the NHS was created, to about 6% in 1990, and to about 9% today. For most countries health care spend increases with (indeed faster than) GDP and, barring perhaps long lasting economic recession, UK health spend is expected to rise to around 12% of GDP by 2020 (Wanless, 2002).

Moves will continue to reform the NHS to strengthen patient choice and voice, to encourage more diverse, efficient and innovative provision, and to ensure a high quality, safe, fair and value for money health system. Recent White Papers–*Choosing Health* (Department of Health, 2004), *Our Health, Our Care, Our Say* (Department of Health, 2006), *High Quality Care for All* (Department of Health, 2008b)—map out the envisaged path. We should for example see more care safely and cost-effectively delivered 'upstream'—in or closer to home, aided by advances in telecare and a better integration between health and social care , better chronic disease management—with more risk profiling for anticipatory, preventative, care and more support for 'expert patients' and self care, and a greater emphasis on promoting health and well-being across the whole population.

There remains much scope for improvement in efficiency and productivity; for example, in surgery there are still huge national and local variations in rates of procedures,

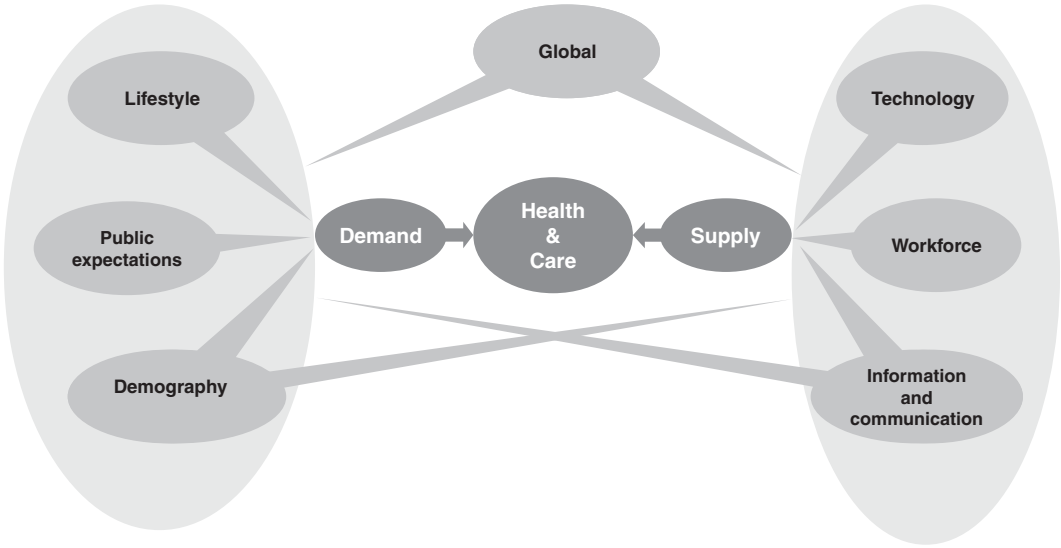

Figure 3 A simple system view of external factors impacting on future health and care.

in length of hospital stay and in use of day cases, which is a focus of the work of the NHS Institute for Innovation and Improvement (www.productivity.nhs.uk, accessed October 2008). Improvements will need to be supported by modern—indeed transformational—information and communication technology and by good financial management, both of which have proved a challenge for the NHS. And changes in patterns and pathways of care can involve major system redesign and will not be problem free—for example, on the one hand specialization requiring more tertiary care and on the other a shift to providing more care in a community setting puts strain on the traditional model of care centred on the acute district general hospital.

Looking further ahead, there are many possible health futures. (This is now quite an active research area eg Government Office for Science, 2007; Kendall, 2001; Dargie, 2000; Royston, 1998; Harrison and Prentice, 1996; Nicholson *et al*, 1995). We need to watch for trends—the 'white sails' we can clearly see coming over the horizon—eg an ageing population, obesity, telecare—and also be ready for discontinuities or 'black swans' (Taleb, 2007)—think of AIDS, viagra or avian flu. Our uncertainty about the future increases with time, although the track record in health crystal ball gazing is sometimes not too bad. For example, 10 years ago a 'technology calendar' (Smith, 1998) suggested that full medical records would be stored on smart cards by 2000 (achieved in 2002 in Taiwan) and that the whole human DNA base sequence would be determined by 2005 (achieved earlier—in 2001!). And there are growing signs in favour of the BT calendar predictions of robots being used extensively for routine hospital tasks (2012). Time will tell in regard to other forecasts such as an individual's genome forming part of their medical record (2015) and extension of average human life span to 100 years (2020).

So we need to scan a range of major external factors influencing health and care: demography, lifestyle, public expectations, technology, information, workforce and global factors (economic, environmental, epidemiological etc). These will affect both the demand and supply of health care as the simple system view in Figure 3 illustrates.

Their combined effect on the health and care system is likely to be profound. For example:

- An ageing baby boomer population will put increasing pressure on both demand for and supply of NHS care.
- Our lifestyles are offsetting the gains made in public and personal health care.
- The public will expect far more from public services, tailored to their individual needs.
- Medical technology – genomics, robotics, nanotechnology - holds out the prospect of a new era in personalized care.
- Information will become ever more accessible, with ubiquitous connectivity.
- The workforce is likely to become increasingly diverse, and depend more on women and immigrants.
- Neither health not health care will escape impact from turbulence in the global economy.
- Climate change is expected to increasingly impact on health and care.
- Security of world food and water supply is also emerging as a key issue.
- Emerging diseases can come from abroad, but the UK is also highly susceptible to home grown diseases.

OR to meet the challenges of change—back to the future?

How can OR meet these future challenges of change? We do have a significant contribution to offer on many specific

Table 2 OR can help meet the future challenges of change in health and health care

Challenges (eg)	*OR contribution (eg)*	*Analytical tools (eg)*
Aging 'Baby Boomer' Generation: Ensuring provision for older people is more joined up—hospital and social care working together	Helping understand and manage the interface between health and social care	'Whole system' mapping and modelling
Rising expectations: Changing services to allow care to be tailored to individual needs—more choice and responsiveness	Helping to set, implement and monitor standards for customer service	Waiting time and capacity modelling
Changing lifestyles: Promoting healthy lifestyles—shifting care upstream from treatment to prevention	Exploring balance and timing of impact for treatment and prevention options	System dynamics modelling, decision analysis

Table 3 Factors affecting success or failure of OR applications

Factors supporting project success	*Factors leading to project failure*
• Management support/involvement • User support/involvement • Understanding true spirit of request • Verifiable and useful results • Economic benefits/business results • Timeliness • Well organized/communicated/presented	• Too technical/abstract approach • Customer not sold on the project • Poor problem definition/planning • Lack of professional competence • Over budget, not timely • Poor communication

Source: Abdel-Malek *et al*, 1999.

challenges, drawing on a range of methodologies (See Table 2 for an illustration).

Some more detailed thoughts on this were given in an earlier paper (Royston, 1998) and will not be repeated here; this paper will focus on some of the more generic factors that are likely to determine an effective response.

We should remember some wise words from the past—looking back again to our starting year of 1948 when Blackett's war-time principles for effective OR were published (Blackett, 1948) which included:

> *Collaborative* 'An OR section should be an integral part of a command and should work in the closest collaboration with the various departments at the command'
>
> *Grounded* 'All members of an OR section should spend part of their time at operational stations in close touch with the personnel actually on the job'
>
> *Pathfinding* ' An OR section which contents itself with the routine production of statistical reports and narratives will be of very limited value'

and also looking back to 1974, with Tomlinson's principles (Tomlinson, 1998) including:

> *Catholic* – OR should not be hide bound in techniques but should be wide ranging in the problems it addresses and the methods it is prepared to use

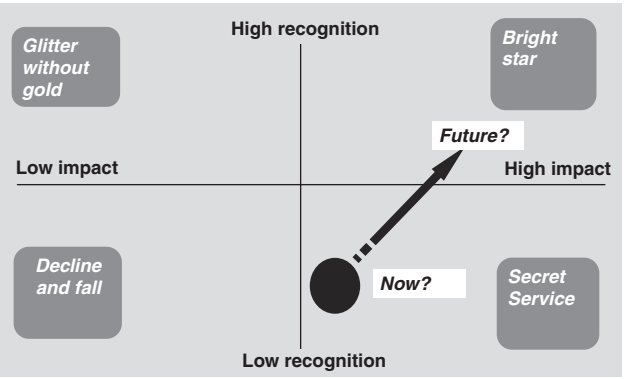

Figure 4 There are many possible futures for health OR—depending on its impact and its visibility.

> *Balanced* – the programme of the OR group should be balanced between long and short projects, tactical and strategic work and between old and new work
>
> *Catalytic* – OR is an agent of change within the organisation

It's *not* rocket science—technical advance is important but this is not one of the greatest challenges facing OR in health—or indeed many other areas. In health, as elsewhere, we are generally dealing with complex adaptive human activity systems (Plsek and Greenhalgh, 2001) where 'softer' contextual factors play a crucial role. Table 3, from an *INFORMS* survey of OR practice (Abdel-Malek *et al*, 1999) makes the point clear.

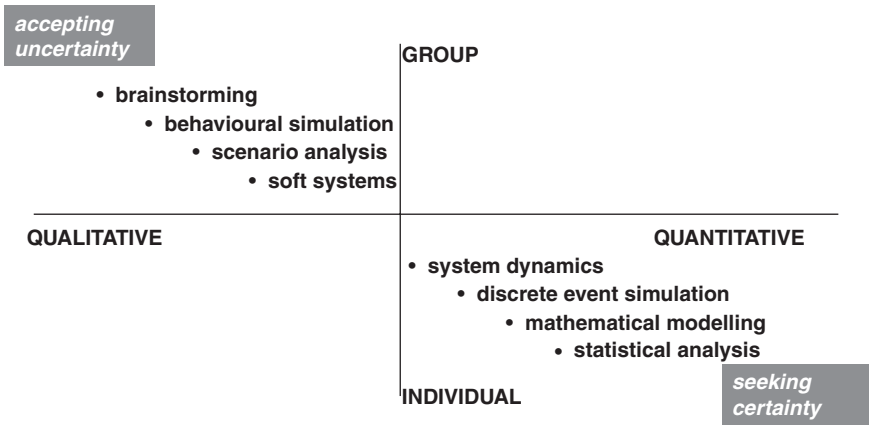

Figure 5 We have a spectrum of methods to scan for and assess challenges on the horizon.

There are many possible futures for health OR depending on its impact and its visibility (See Figure 4).

If we want to move successfully forward we will need to prepare the path, which is the subject of the next section.

Today: 2008—preparing the path

What do we need to do *today* so health OR is equipped to make a strong contribution *tomorrow*? Five suggested key areas for investment are:

— *Focusing on the key emerging challenges* for the UK health and care system at local, national and global levels—so we work on the right problems at the right time.
— *Equipping ourselves to help tackle them*—so we have the right skills, positioned in the right places.
Gaining powerful champions who own the problems—so we work with the right people who can embed solutions in their organization.
— *Making success plainly visible* to and recognized by our stakeholders—so we get the right messages to the right audiences.
— *Understanding better what we need to do*—this list is not exhaustive!

What might be important ingredients for these?

Firstly, for *focusing on key emerging challenges* we can draw on our spectrum of methods to scan for and to assess challenges on the horizon (See Figure 5.)

We can also develop and use intelligence such as the emerging 'hot' topics for health managers. For instance, the categories for the Health Service Journal awards are quite revealing—this year features: managing long-term care, data-driven service improvement, world class commissioning, patient safety, improving care with technology, social marketing, patient centred care, clinical service redesign, innovation, workforce development, improving patient access and reducing health inequalities. In many of these areas policy makers, managers and clinicians will be looking for (to borrow a term from the former NHS Modernisation Agency) 'high impact changes'—how they can get the best out of necessarily limited resources—surely a challenge with which OR can assist.

Secondly, to *equip ourselves to help tackle the key challenges* we need to build strength in key problem solving areas. Surveys across OR generally (Fildes and Ranyard, 1997), across civil government (Turner, 2007) and of OR analysts in the Department of Health have all shown that it is not the more esoteric methods but the fundamental skills—notably problem structuring, spreadsheet modelling, basic statistics, consulting, project management and presentation—that are generally most valued and used by OR practitioners. Those involved in training health OR practitioners of the future are, of course, key to building firm foundations in these areas. (Like the construction and use of a samurai sword, developing fundamental OR skills, honed to a fine edge and wielded effectively, is not as simple as it might appear; perhaps we need more of an apprenticeship type approach to training OR analysts.)

Equally we need to develop a networked presence at all levels to allow both tactical and strategic work. To (just once) go back to before 1948—in fact, back over 300 years—we might note the words of Sir Isaac Newton:

> *'If, instead of sending the observations of able seamen to able mathematicians on land, the land would send able mathematicians to sea, it would signify much more to the improvement of navigation and to the safety of men's lives and estates on that element.'* (Sir Isaac Newton, 1694).

In a more devolved and decentralized care system effective OR requires a strong grass root presence in patient groups, primary care trusts, and hospitals, as well as in regional strategic health authorities, in national bodies (NICE, NHS Institute for Health Care Improvement, National Patient Safety Agency, Health Care Commission etc) and in the

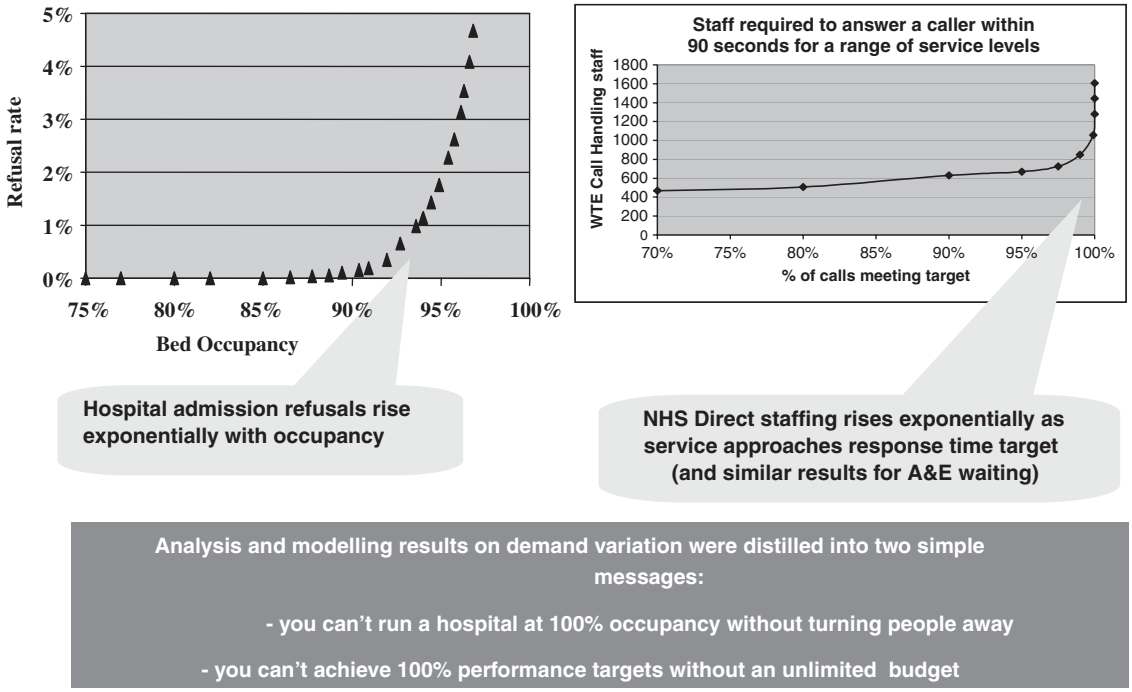

Figure 6 Look for simple but powerful generic messages that will stick in users' minds.

Department of Health. There should also be an opportunity for OR to play a role in the work of the recently announced Academic Health Science Centres (Department of Health, 2008b).

Thirdly, to *gain powerful champions* we need to focus on adding crucial value for key problem owners, which entails understanding their business, appreciating their environment, focusing on their needs and offering something distinctive. For the latter, we need to remember that OR analysts' value to any business depends on being able to work closely with clients to help with a number of thorny problem areas such as understanding how systems work, clarifying complex and messy problems, coping with uncertainty and risk, and creating, developing and appraising options for change. In short, remembering the characterization of OR as the *science of better*. (Which suggests incidentally that we might usefully develop closer links with the current movement on '*the science of improvement*' in health! (Berwick, 2008).)

Fourthly, to *make our success plainly visible* and recognized by our stakeholders we need to publish and publicize in the right way to the right audiences in the right places. Recalling Table 1, it is noteworthy that Bailey's 1952 paper on queues and hospital appointment systems in the analytical literature was accompanied by a publication in the medical literature (Welch and Bailey, 1952). Such parallel or twin publication could usefully be much more common practice. (A paper covering some of the arguments of this paper is also to be published in the *British Journal of Health Care Management* (Pitt *et al*, 2009).)

Of course making success visible requires successes, so as noted earlier, health OR needs to pay much more attention to implementation issues—both in designing projects for impact and evaluating the impact they actually have. Again a twin approach–seeking to get more published OR work showing a follow through to implementation and to get more OR work focused on tackling policy and delivery 'milestone' issues, and publishing it—should bear fruit.

There is a second aspect to being 'plainly' visible—clarity and force of message. So a further contribution to both visibility and implementation would come from OR looking for simple but powerful *generic messages* that will stick in users' minds. (There is also incidentally a—related—case for making more use of *generic models* see, eg, Fletcher *et al*, 2007). For example, modelling results by Department of Health and other analysts on peak load demand variation (Department of Health, 1997; Bagust *et al*, 1999; Royston *et al*, 2003) had greater impact with policy makers when they were distilled into two simple messages 'you can't run a hospital at 100% occupancy without turning people away' and 'you can't achieve 100% performance targets without an unlimited budget' (See Figure 6). Similar views about the importance of simple models and clear messages have been expressed in the context of using OR modelling to improve patient flows (Proudlove *et al*, 2007). We should search for other types of simple but powerful generic messages from OR/MS for health care policy and management, such as on feedback effects in systems (see, eg, Taylor and Dangerfield, 2005).

Fifthly, to *understand better what we need to do*, we must continuously seek to learn about how to enhance our impact. For example, it is hoped that MASHnet will be able to follow up its pilot survey on the three questions posed at the beginning of this paper.

Conclusion

This paper has considered developments in health and care and in OR contributions to these at local and national level since the creation of the NHS 60 years ago; likely future developments in health and care; and associated priorities for preparing now for OR to make a major impact on health and care in the next 40 years.

What that future holds must fall somewhere between a 'white sails' and a 'black swan' dominated scenario (a grey mist?). But the future is not to be discovered but to be created. The foundations for successful OR and MS in health in the coming decades will be formed through historical reflection, innovative thinking and anticipatory action among today's—and tomorrow's—practitioners.

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References

Abdel-Malek L, Wolf C, Johnson F and Spencer III T (1999). OR practice: Survey results and reflections of practising INFORMS members. *J Opl Res Soc* **50**: 994–1003.

Bagust A, Place M and Posnett JW (1999). Dynamics of bed use in accommodating emergency admissions: Stochastic simulation model. *BMJ* **319**: 155–158.

Bailey NT (1952). Operational research in medicine. *OR Qtly* **3**: 24–30.

Bailey NT (1952). A study of queues and appointment systems in hospital outpatient departments. *J R Stat Soc* **14**: 185–199.

Bailey NT (1957). Operational research in hospital planning and design. *OR Qtly* **8**: 149–157.

Baker RD, Chaussalet TJ and Utley M (eds) (2008). Special issue on IMA conference. *Health Care Mngt Sci* **11**: 87–213.

Berwick D (2008). The science of improvement. *JAMA* **299**: 1182–1184.

Blackett PMS (1948). Scientists at the operational level. *Advancement of Science* **5**: 30–38.

Boldy D (ed) (1981). *Operational Research Applied to Health Services*. Palgrave Macmillan: Basingstoke, UK.

Brahimi M and Worthington DJ (1991). Queueing models for outpatient appointment systems—A case study. *J Opl Res Soc* **42**: 733–746.

Brailsford S and Harper P (2007). Operational research for health policy: Making better decisions. *Proceedings of the 31st Annual Conference of the European Working Group of Operational Research Applied to Health Services*. Peter Lang: Oxford, UK,

Brailsford S and Harper P (eds) (2007b). Special issue: Operational research in health. *J Opl Res Soc* 58: 141–270.

Brandeau ML, Sainfort F and Pierskalla WP (eds) (2004). *Operations Research and Health Care: A Handbook of Methods and Applications*. Springer: Berlin.

Buhaug T (2002). Long waiting lists in hospitals. *BMJ* **324**: 252–253.

Cropper S and Forte P (eds) (1997). *Enhancing Health Services Management*. Open University Press: Buckingham.

Dangerfield B and Roberts C (eds) (1994). *OR Work in HIV/AIDS*, 2nd edn. OR Society: Birmingham.

Dargie C (2000). Policy futures for UK health. *Foresight* **2**(4): 401–409.

Dash P, Gowman N and Traynor M (2003). Increasing the impact of health services research. *BMJ* **327**: 1339–1341.

Davies R and Bensley D (eds) (2005). Special issue: Meeting health challenges with OR. *J Opl Res Soc* **56**: 123–233.

Department of Health (1997). The use of simulation modelling to examine the local balance between elective and non-elective demands for treatment. Appendix by Economics and Operational Research Division. *DH Executive Letter EL(97) 42*.

Department of Health (2004). *Choosing Health*. Department of Health: London.

Department of Health (2006). *Our Health, Our Care, Our Say*. Department of Health: London.

Department of Health (2007). *Annual Report*. Department of Health: London.

Department of Health (2008a). *Mortality Target Monitoring Update for 2007*. Department of Health: London.

Department of Health (2008b). *High Quality Care for All*. Department of Health: London.

Dixon T, Shaw M, Ebrahim S and Dieppe P (2004). Trends in hip and knee joint replacement: Socioeconomic inequalities and projections of need. *Ann Rheum Dis* **63**: 825–830.

Eldabi T, Paul RJ and Young T (2007). Simulation modelling in healthcare: Reviewing legacies and investigating futures. *J Opl Res Soc* **58**: 262–270.

EPSRC, ESRC and OR Society (2004). *Review of Research Status of OR in the UK*.

Fildes R and Ranyard J (1997). Success and survival of operational research groups–A review. *J Opl Res Soc* **48**: 336–360.

Fletcher A, Halsall D, Huxham S and Worthington D (2007). The DH accident and emergency department model: A national generic model used locally. *J Opl Res Soc* **58**: 1554–1562.

Fone D, Hollinghurst S, Temple M, Round A, Lester N, Weightman A, Roberts K, Coyle E, Bevan G and Palmer S (2003). Systematic review of the use and value of computer simulation modelling in population health and health care delivery. *J Public Health Med* **25**: 325–335.

Gallivan S, Utley M, Treasure T and Valencia O (2002). Booked inpatient admission and hospital capacity: Mathematical modelling study. *BMJ* **324**: 280–282.

Government Office for Science (2007). *Tacking Obesities: Future Choices*. Department of Innovation Universities and Skills, London.

Harper PR and Pitt MA (2004). On the challenges of healthcare modelling and a proposed project life cycle for successful implementation. *J Opl Res Soc* **55**: 657–661.

Harrison A and Prentice S (1996). *Acute Futures*. Kings Fund: London.

Jackson RRP (1964). Design of an appointments system. *OR Qtly* **15**: 219–224.

Keller TF and Laughhunn. An application of queuing theory to a congestion problem in an outpatient clinic. *Decision Sci* **4**: 379–394.

Kendall L (2001). *The Future Patient*. Institute for Public Policy Research, London.

Luck GM, Luckman J, Smith BW and Stringer J (1971). *Patients, Hospitals, and Operational Research*. Tavistock: London.

Marmot M and Wilkinson RG (eds) (2005). *Social Determinants of Health*. 2nd edn. Oxford University Press: Oxford.

Mayhew L and Smith D (2008). Using queuing theory to analyse the Government's 4h completion time target in accident and emergency departments. *Health Care Mngt Sci* **11**: 11–21.

Nicholson D, Hadridge P and Royston G (1995). Some practical hints for newcomers to health futures. *Futures* **27**(9/10): 1059–1065.

Office for National Statistics (2006). *General Household Survey*. Office for National Statistics: London.

Office for National Statistics (2008). *Interim Life Tables 2005–2007*. Office for National Statistics: London.

O'Keefe RM (1985). Investigating outpatient departments: Implementable policies and qualitative approaches. *J Opl Res Soc* **36**: 705–712.

Pitt M, Bensley S, Royston G and Stein K (2009). The potential for operational research. *Br J Health Care Mngt* **15**: 346–351.

Plsek PE and Greenhalgh T (2001). The challenge of complexity in health care. *BMJ* **323**: 625–628.

Proudlove NC, Black S and Fletcher A (2007). OR and the challenge to improve the NHS: Modelling for insight and improvement in in-patient flows. *J Opl Res Soc* **58**: 145–158.

Royston G (1998). Shifting the balance of health care into the 21st century. *European J Opl Res* **105**: 267–276.

Royston G, Halsall J, Halsall D and Braithwaite C (2003). Operational research for informed innovation: NHS Direct as a case study in the design, implementation and evaluation of a new public service. *J Opl Res Soc* **54**: 1022–1028.

Smith R (ed) (1998). Imagining futures for the NHS. *BMJ* **317**: 3–4.

Taleb NN (2007). *The Black Swan*. Allen Lane: London.

Taylor K and Dangerfield B (2005). Modelling the feedback effects of reconfiguring health services. *J Opl Res Soc* **56**: 659–675.

Tomlinson R (1998). The six principles for effective OR—Their relevance in the 90s (from Presidential Address to OR Society in 1974). *J Opl Res Soc* **49**: 403–407.

Turner H (2007). Government operational research service: Civil OR in UK central government. *J Opl Res Soc* **58**: 1–15.

Vissers J and Beech R (eds) (2005). *Health Operations Management*. Routledge: London.

Welch JD and Bailey NT (1952). Appointment systems in hospital outpatient departments. *Lancet* **1**: 1105–1108.

Wanless D (2002). *Securing Our Future Health: Taking A Long-Term View*. HM Treasury: London.

Wilson JCT (1981). Implementation of computer simulation projects in health care. *J Opl Res Soc* **32**: 825–832.

Young T, Brailsford S, Connell C, Davies R, Harper P and Klein JH (2004). Using industrial processes to improve patient care. *BMJ* **328**: 162–164.

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