

HaCIRIC 11

HaCIRIC International Conference 2011

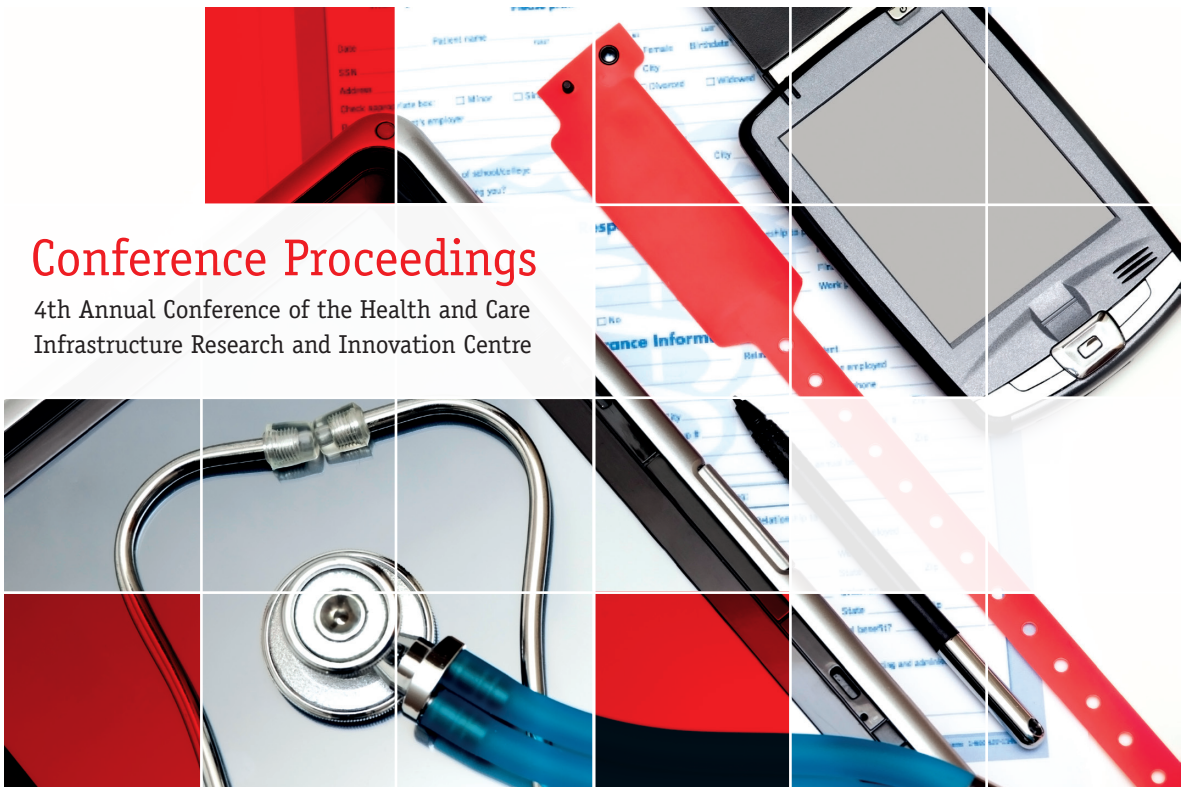
26 - 28 September, Manchester, UK

Global health infrastructure – challenges for the next decade

Delivering innovation, demonstrating the benefits

Conference Proceedings

4th Annual Conference of the Health and Care
Infrastructure Research and Innovation Centre



PROCEEDINGS
HaCIRIC INTERNATIONAL CONFERENCE
2011

**Global health infrastructure - challenges for the next
decade. Delivering innovation, demonstrating the benefits.**

Manchester, UK

September 26-28, 2011

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PREFACE

Since HaCIRIC started in 2006, we have expanded the scale of our activities and depth of our knowledge of healthcare infrastructure challenges. We are now established as an international centre of expertise and research.

But the world around us has not stood still. Our future programme is responding to the changing global context for delivering healthcare. The UK is no different from all major developed countries in its need to meet an expanding demand for healthcare while simultaneously controlling rising costs and improving quality and safety.

Business as usual will not be an option for governments and healthcare organisations. The solutions may require system redesign, involving new combinations of technology, services and infrastructure. Four steps are likely to be particularly important in the years to come: shifting care patterns between different healthcare settings, rethinking the use of technological and physical infrastructure to support that change, developing new organisational and funding models to make it work, and encouraging change by generating rigorous and accessible evidence to demonstrate the changes that really do work.

The right combinations of technology, people and infrastructure may be hard to identify and will involve difficult implementation challenges. The political environment – how to accommodate diverse stakeholders to optimise outcomes – will add another layer of complexity. And today's preference for 'local solutions' can mean that decision-makers may lack expertise in tackling tricky issues, as well as leading to increased fragmentation of the system.

HaCIRIC's work is therefore essential – unless the key questions are researched, with solutions properly modelled and the learning effectively disseminated, health systems may not be able to accomplish the innovations that are needed.

From a standing start, in a field where research was largely uncoordinated and almost entirely conducted in disciplinary silos, HaCIRIC has developed a programme focused on a series of healthcare infrastructure challenges. A research and practice community has begun to develop around HaCIRIC. Our annual conference forms an important part of this process. By bringing together our growing community of researchers we are able to share and discuss findings from the most up-to-date work in our field. The growth in the size of delegate numbers since 2008 has been impressive. Our first annual conference was held at Imperial College London in April 2008. This was attended by fifty researchers and representatives from industry and the government. The 2009 conference was held in Brighton and attended by ninety delegates. Last year's conference in Edinburgh and this year's conference have over one hundred attendees from eleven countries around the world.

Our 2011 conference received over sixty papers from around the world. Twenty one were offered a platform presentation. The papers address a number of themes, from managing change to simulation modelling, from finance in healthcare and infrastructure design.

These proceedings are the result of the hard work of many people. We would like to thank all the authors who submitted abstracts and papers to the conference. We also very much appreciate the help provided by the referees.

On behalf of HaCIRIC, we would like to welcome you to our 2011 international conference.

James Barlow and Colin Gray

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A CASE STUDY OF CHANGES IN HEALTHCARE SERVICE UTILISATION FOLLOWING THE INTRODUCTION OF A TECHNOLOGICAL INNOVATION

T. Cravo Oliveira¹

ABSTRACT

Technological change is considered the main driver of rising healthcare costs. As a number of new technologies are actually associated with lower unit costs, researchers have focused their attention in volume. This study focuses on the mechanisms through which the introduction of new technologies in healthcare leads to changes in service utilisation. Using a case study design and the system dynamics methodology, a model of teleconsultations in Alentejo, a region in Portugal, is developed. The preliminary results suggest that teleconsultations might help deal with an increasing demand for medical care, but may raise total costs through higher volume of services. This study may provide a better understanding of how the introduction of new technologies leads to changes in utilisation, and ultimately total costs. The use of modelling and simulation may lead to important insights concerning the effects of current and future policies.

KEYWORDS

costs, service utilisation, system dynamics, telemedicine, treatment expansion

INTRODUCTION

Healthcare costs have been growing at a faster pace than the gross domestic product in many developed nations for more than 40 years (Cutler, 1995, OECD, 2010, Reinhardt et al., 2004). Consequently, a growing percentage of the economy is being allocated to healthcare at the expense of other sectors. With non-healthcare spending starting to decline by as early as 2039, we are reaching a period of very tough choices (Chernew et al., 2003). David Cutler (1995) – who has written extensively on the subject of healthcare costs – argues that at least half of the total increase in expenditure between 1940-1999 is attributable to only one factor: technological change. This view is generally accepted by other health economists (Bosanquet, 2009, Okunade and Murthy, 2002, Bodenheimer, 2005, Jones, 2002, Baker, 2010, Baker et al., 2010, Baker et al., 2008, Baker et al., 2003). And while income, ageing and other factors do contribute to cost growth, they also do so via demand for more technological change.

A puzzling feature of many new technologies is that they are simultaneously associated with lower unit costs and higher total costs. This apparent paradox can be resolved through volume: the lower cost per person is offset by the fact that more people are treated, more treatments are provided for each person, or both. These effects are grouped under the term ‘treatment expansion’. A new technology being used instead of the conventional treatment is termed ‘treatment substitution’. How expansion and

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substitution happen is not fully understood. While several different types of technological change (e.g. imaging techniques and surgical procedures) affect utilisation, the mechanisms are not clear. How the introduction of new technologies affects patients' and physicians' behaviours and decisions, is essential to understanding how expansion and substitution occur. And, in turn, these changes affect the total costs associated with the technology. This study focuses on how the introduction of new technologies affects service utilisation and consequently total costs. To answer this question, the effects of technological innovation on three areas are explored: patients' decisions, physicians' decisions, and quality and costs of care.

This paper describes the study's current progress. In the following section, a review of the literatures on technological innovation and service utilisation is presented. The initial focus is on the high-level concepts of expansion and substitution but, as these are a direct consequence of individual decisions made by patients and physicians, the discussion focuses also on the determinants of these decisions. The methods section introduces the approach to the research problem. The aim is to use a case study (teleconsultation in Alentejo, Portugal) to develop a framework of how the introduction of new technologies leads to changes in volume. The system dynamics methodology is adopted as it provides an adequate way to deal with the dynamic complexity of technological change in healthcare. Different medical specialties are studied in order to identify differences in technical characteristics and organisational processes, which can be incorporated into the model through the use of different parameters. Thus, the model effectively constitutes a potentially generalisable framework exploring different mechanisms. By simulating the model, interventions can be tested resulting in potential policy implications. Early empirical findings – from the literature review, exploratory interviews and preliminary simulations – suggest that teleconsultations might help deal with an increasing demand for medical care, but may raise total costs through higher volume of services. Finally, the last section focuses on the potential contributions and future work.

TECHNOLOGICAL INNOVATION AND SERVICE UTILISATION

Throughout this paper, the terms 'technological innovation', 'technological change' and 'new technologies' will be used interchangeably to identify medical technologies with the following three key characteristics: they involve reorganisation of work processes by either challenging existing roles and responsibilities, shifting the location of care, or both; the existing clinical evidence to support both its initially intended uses and the newly found indications for use is still developing and is sometimes unclear or even conflicting; and finally, they involve care for which demand tends to be elastic rather than inelastic or for which clinical need is difficult to assess and perceive. Examples of technologies which, in differing levels, seem to exhibit these three characteristics include: magnetic resonance imaging (MRI), CT angiography, laparoscopic cholecystectomy, some elective surgery and teleconsultation.

TECHNOLOGY-DRIVEN EXPANSION AND SUBSTITUTION

Many researchers believe that technological advances are associated with greater utilisation (Bosanquet, 2009, Baker et al., 2003). Several explanations have been proposed. Kim and colleagues (2001) find that across the US, Canada and European

countries, people are generally more interested in medical technologies than in other non-medical innovations. This special interest might result in more demand for medical technologies, which is in accordance with reports that people have come to expect more from healthcare systems, especially if we also consider ageing and income (Department of Health, 2008).

Other explanations have been proposed. Medical training gives greater emphasis to thoroughness rather than effectiveness and new technologies provide new ways of testing and diagnosing (Emanuel and Fuchs, 2008, Hillman and Goldsmith, 2010). Related to this is the technology imperative: once a technology exists physicians do not feel that they can withhold treatment from patients (Cutler, 1995). New technologies also provide new ways for physicians to defend themselves from liability or malpractice suits. Junior physicians may also find comfort in the reassurance provided by new tests and procedures. A different explanation is marketing. Physician-directed pharmaceutical marketing in the US amounts to more than \$7 billion annually and direct-to-consumer marketing is associated with increased patient requests for prescription drugs (Emanuel and Fuchs, 2008). Although the latter is fairly limited to the US, physician-directed marketing exists in European countries as well. A final explanation relates to financial incentives. In the US, many physicians are reimbursed under fee-for-service thus having an incentive to supply more services (Donaldson and Gerard, 2005). Some argue that this may explain the expanded service use (Bodenheimer, 2005). However, the fact that fee-for-service is not used in most European countries, suggests the inexistence of negative financial incentives may be more important than the existence of positive ones.

All these factors may lead to an increased use of healthcare services. While in some cases some substitution occurs, this is not true for many new technologies (Bodenheimer, 2005). In part, the expansion may reflect previously unmet need for treatment; however, in many cases physicians have defined new indications for use with questionable value. Spinal fusion surgery is increasingly used in conditions for which no evidence of benefits exists, and for which reoperations and complications are common (Bodenheimer, 2005). In the US, there has been a nearly three-fold absolute rise in rates of radionuclide imaging without any clear evidence to support their routine use (Ayanian, 2006). Despite there being no evidence of benefits, there has been a progressive liberalisation of criteria for earlier initiation of dialysis in the treatment of end stage renal disease (Knauf and Aronson, 2009).

Baker et al. (2010) have studied the use of CT angiography as a safer and less expensive procedure than the traditional invasive catheter angiogram. The authors found that for every 100 new CT angiography users, 68 would not have previously received either procedure, 22 would have received a catheter angiogram instead of CT angiography, and 10 would have received only catheter angiogram but wound up receiving both. Thus, the new technology substituted for the conventional procedure in only 22 cases. The authors explored whether the expanded use resulted in more carotid endarterectomies, the treatment for carotid artery disease. The rate of endarterectomies was largely unchanged, suggesting that the increased use of CT angiography was not picking up any new cases of carotid artery disease. Similarly, Skinner and colleagues (2006) found no association between regional differences in spending on AMI and survival gains.

While it has been shown that some technologies expand treatment, others substitute for it and others simultaneously do both, there is limited understanding of why these effects occur and what consequences they have for both quality and costs of healthcare services. While the literature on financial incentives has found considerable echo in studies at the lower individual level, much less has been written about how individual patients perceive technological change and how it affects their decisions, as well as how individual physicians react to the introduction of new technologies and how it affects their behaviour. Even though the high-level concepts of expansion and substitution are disconnected from the low-level decisions made by individuals, expansion and substitution are direct results of decisions made every day by patients and physicians.

TECHNOLOGY AND DECISIONS IN THE CARE PATHWAY

In an article on the interactions between supply and demand in the United Kingdom National Health Service (NHS), van Ackere and Smith (1999) reflected on what they called the *black boxes* of supply and demand. The authors considered that modelling the stages in the pathway whereby potential demand is converted into realised demand would be complex, but could yield immense value. These stages involve various decisions by patients, general practitioners (GPs) and specialists. For the sake of simplicity, the next sections will be limited to patients' decisions to see a GP and GPs' decisions to refer to specialist care (these are the most relevant decisions with regard to the case study).

Patients' decisions to seek care

Patient demand for physician visits is a function of multiple factors, or determinants, including, but not limited to, the price per visit, the patient's coinsurance rate, the time price, the price of other goods and services, and the patient's income, health status, age and education (Folland et al., 2009). Patient preferences are important but are difficult to determine. According to basic supply and demand theory, changes in one determinant cause changes in demand, *ceteris paribus*. In the real world patient preferences change, health status is difficult to determine, the prices of other goods and services are hardly static, and all these changes happen simultaneously. The dynamic characteristics of the demand schedule limit our ability to study and understand its behaviour.

In 1992, van de Kar and colleagues set out to answer why patients consult a GP (van de Kar, 1992). The patient's perception of the need for a consultation and the severity of the complaint were unsurprisingly the most important determinants of the decision to seek care. More interesting was the finding that advice from friends and family, the efficacy of the GP as perceived by the patient, and the patient's belief that he/she was able to cope without care, were all important. The need for information was another reason for consulting a GP. Van de Kar et al. (1992) drew attention to the fact that patients consult their GP for reasons other than health status or medical need, raising concerns that some healthcare utilisation might be unnecessary or inappropriate. Studies on the use of accident and emergency departments and antibiotics further explore the role of patient expectations (Sempere-Selva et al., 2001, Singh, 1988, Mortensen, 2010, Mangione-Smith et al., 2004, Kesselheim and Outtersen, 2010).

According to Scott (2000), decisions to consult a GP are further influenced by decisions at later stages: whether the patient perceives the GP will refer or treat, and the cost, distance, and time-price of secondary care. The availability of GPs in a region and the ability of patients to choose their GP are also important factors (Gerard et al., 2008, Rubin et al., 2006, Hjelmgren and Anell, 2007).

Physicians' decisions to refer

In most developed countries and in some parts of the US, GPs act as gatekeepers. The interest in GP decision making has been largely driven by the discovery of large variations in rates of referrals, and the fact that much of this variation remains unexplained after controlling for clinical and diagnostic factors (Scott, 2000, Iversen and Lurås, 2000, Mehrotra et al., 2011). It has been estimated that 10-34 percent of referrals are inappropriate (O'Donnell, 2000, Fertig et al., 1993). In one study, more than half of hospital consultants (i.e. specialists) felt GPs could do more before referring (O'Donnell, 2000). However, Navaneethan and colleagues have argued that more important might be late or no referral, since these can potentially lead to adverse health outcomes (Navaneethan et al., 2008).

The determinants of GPs' referrals can be divided into four categories: practice characteristics, access to specialty care, GP characteristics, and patient characteristics. Concerning the first, evidence suggests that urban GP practices refer more than rural ones, a finding that is likely associated to the availability of specialists in rural areas: access to specialty care restricts referrals (Carlsen et al., 2008, Forrest et al., 2006, Noone et al., 1989). Furthermore, practices with more patients refer more than practices with fewer patients, especially if they are funded through capitation. It has been shown that GPs with fewer patients provide more services per patient, while those with more patients 'share the burden' with specialists by referring more frequently (Iversen and Lurås, 2000).

Regarding GP characteristics, sex, age, years and type of experience, and psychological factors such as risk-aversion and tolerance of uncertainty, have all been identified as possible determinants. There is conflicting evidence regarding sex, age, and years of experience (Carlsen et al., 2008, Franks et al., 2000, Forrest et al., 2006, O'Donnell, 2000). GPs with a special interest in a specific specialty are less likely to refer patients for that specialty, however they are also more likely to see patients from that specialty, and thus the overall effect on referral rates is unclear (O'Donnell, 2000). Franks and colleagues (2000) assessed the impact of psychological factors on referral behaviour: risk-averseness was the most important factor (risk-averse GPs were more likely to refer).

With regard to patient characteristics, there is again conflicting evidence concerning the role of sex, age, social class, and case mix (Carlsen et al., 2008, Bertakis et al., 2001, O'Donnell, 2000, Sullivan et al., 2005). The number of previous consultations is associated with an increased likelihood of referral, which is not surprising (Carlsen et al., 2008, Bertakis et al., 2001). Although the patient's health status is important, GPs also take into account the price, distance and time-price of specialty care (Scott, 2000). Patients' expectations of referral, as well as the level of anxiety, are also valued (Webb

and Lloyd, 1994, Cockburn and Pit, 1997, Newton et al., 1991). Pressure from patients, as perceived by GPs, may influence between 30-60 percent of referrals (Scott, 2000). As patients have growing expectations of healthcare services and play a bigger role in decisions concerning their healthcare, it is likely that non-clinical factors such as reassurance and information-seeking will be increasingly important.

RESEARCH QUESTIONS

This study's research questions are:

- How does the introduction of new technologies affect service utilisation?
 - How does it affect patients' decisions?
 - How does it affect physicians' decisions?
 - How does it affect quality and costs of care?

METHODS

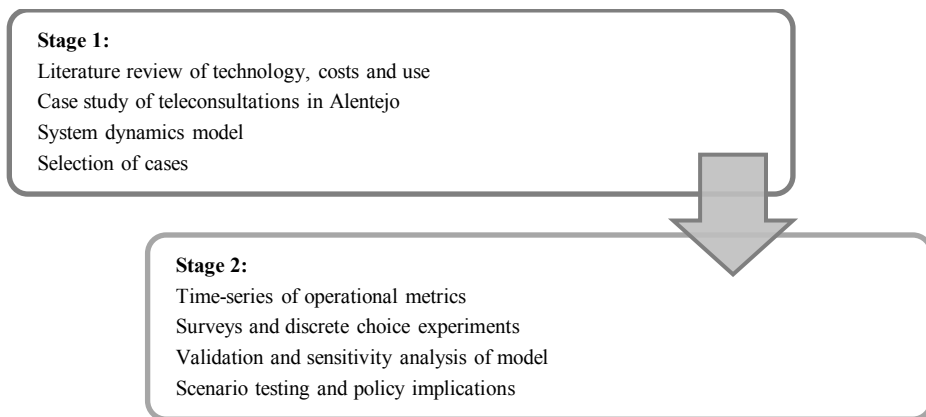


Fig. 1. Stages in the research design

This study is divided into two stages (see Fig. 1). The first stage included a review of the literatures as well as exploratory interviews with physicians and managers in Alentejo. The findings from the review and the early empirical work have been articulated in a preliminary system dynamics model. The first stage culminates with the selection of cases and a fully developed version of the model.

The second stage involves an iterative process of testing, validating and refining the model. For that purpose, a time-series analysis of operational metrics will be triangulated and enriched with data from surveys and discrete choice experiments (DCEs). A DCE is an attribute-based survey method for measuring benefits (utility) and is described in greater detail in the section on data collection. The data will then be used to parameterise the model, test it via simulation, and validate the results. The study of three different medical specialties allows the identification of differences in technical characteristics and organisational processes which are incorporated into the model through the use of different parameters. The model effectively constitutes a generalisable theoretical

framework (the model is the same but the parameters change). Through simulation, interventions can be tested and may result in policy implications.

CASE STUDY DESIGN

A case study approach is considered the preferred method when: the research questions are ‘how’ and ‘why’ questions, the investigator has little or no control over events, and the focus is on contemporary phenomena within a real-life context (Yin, 2009). All these apply to this study. Although case studies can produce results with strong internal validity, an obvious concern is generalisability and external validity. To ensure this concern is minimised, three different specialties are studied so that some mechanisms lead to similar results (literal replication) and others predict contrasting results for anticipatable reasons (theoretical replication). A key step is the development of a theoretical framework stating the conditions under which literal or theoretical replications are expected. As stated, the framework is the system dynamics model.

The technology is teleconsultation and the setting is Alentejo, in Portugal. In the conventional pathway for specialist consultations, a patient is referred by a GP and has to physically travel to the specialist’s office. With the introduction of teleconsultations, patients referred to specialist care need only to travel to the GP’s office where, using videoconferencing equipment, the two of them interact with the specialist remotely. Both the literature and exploratory interviews indicate that teleconsultation simultaneously expands and substitutes for face-to-face consultation. It is thus a suitable case study to answer the research questions.

The unit of analysis is a medical service provided by a group of physicians (typically one GP and one specialist) to a group of patients. The service involves a series of stages and decision points (e.g. to seek care, to refer). This service can be provided using teleconsultation or through a face-to-face consultation, and is associated with a medical specialty. The key dimensions are thus the use of teleconsultation or face-to-face and the associated medical specialty. Because the same technology is used differently across specialties, selecting cases based on the specialty is a good strategy to study different effects. Fig. 2 illustrates the selected cases and Table 1 summarises the main differences between cases A to C, i.e. those using teleconsultation.

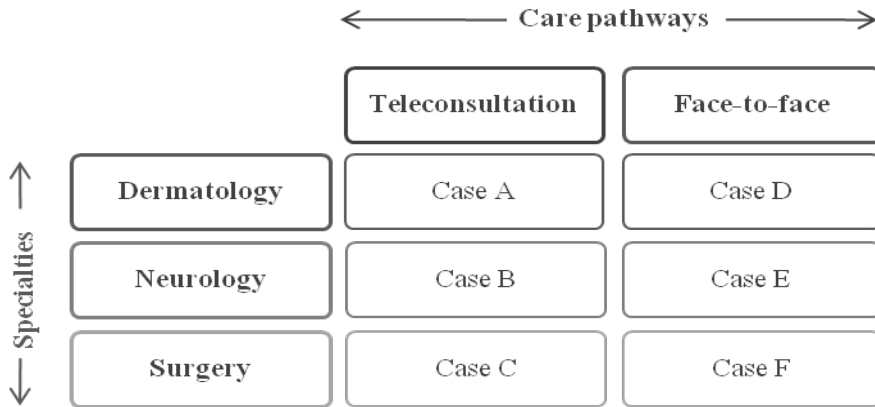


Fig. 2. Selection of cases

Table 1. Key differences between specialties in the teleconsultation pathway

Specialty	Key differences
Dermatology	Consultations take half as long as a face-to-face; less need for subsequent teleconsultation; virtually no need for subsequent face-to-face consultation.
Neurology	Three to four times quicker than face-to-face; waiting times for teleconsultations are increasing; there is often a need for subsequent face-to-face.
Surgery	Faster access to surgical waiting list; provision of care not previously possible.

Source: exploratory interviews with physicians and managers

Adoption involves setting up the equipment and agreeing a weekly timeslot for the teleconsultations between the specialist and the GPs. The majority of health centres have a policy that patients cannot be referred to a face-to-face consultation before first having a teleconsultation. This effectively means that patients have no choice of whether to be referred for a face-to-face consultation or for a teleconsultation, which simplifies sampling. Health centres that use the technology extensively can be compared with other health centres with similar characteristics that do not use teleconsultation.

SYSTEM DYNAMICS

System dynamics is a method to enhance learning in complex systems (Sterman, 2000). Technological change in healthcare is one such system. Not only are the relationships between different parts of the system difficult to perceive, they are also dynamic. The basic assumption behind the system dynamics methodology is that the behaviour of a system is a direct consequence of its structure. A system dynamics model is essentially a theoretical framework of how a system is structured and why that structure leads to different behaviours. It is thus an adequate methodology for answering ‘how’ and ‘why’ questions. Not only does it aggregate the hypothesised relationships between variables in a refutable causal model, it enables testing, through simulation, of the completeness and coherence of the proposed relationships.

This research builds upon Smith and van Ackere's work in the study of waiting lists for elective surgery and supply and demand (Smith and van Ackere, 2002, van Ackere and Smith, 1999). The authors' statement that economic evaluation methods, which are essentially static, can gain from the insights of system dynamics models, provides additional motivation.

Validity and sensitivity

In testing the framework, there are three validity concerns: the structure in the model corresponds to what is known about the real system; the estimated or observed relationships support the theory; and the behaviour of the system can be explained using the structural components. To address these concerns, the model is calibrated (i.e. parameters are changed) to fit the structure and behaviour of a specific technological innovation in a specific setting. To address the structural validity – the extent to which the model captures the elements of the real system – the model is calibrated using different data sources such as archival data, surveys, interviews, DCEs and time-series analysis. Replicative validity is tested through historical fit of the model. The dynamic significance of the structural components is tested through sensitivity analysis. Extended simulations are used to test the overall dynamic hypothesis articulated by the theory. A useful example of validation tests is present in van Ackere and Smith (1999). The authors tested the model for extreme conditions, for historical fit and reproduction of past behaviour, and for the impact of different initial conditions. Although no theory (whether analytic or using computer simulation) can ever be truly validated, these tests ensure the face validity of the results (Sterman, 2000).

DATA COLLECTION

Data collection is divided into two stages (see Fig. 1). In the first stage, exploratory semi-structured interviews with GPs, specialists and managers were conducted onsite (Alentejo) and archival documentation was retrieved. The findings from the interviews were used to select the most interesting medical specialties, and were combined with the evidence from the literature review to build the preliminary model.

Once the model development is complete, the second stage of data collection will begin. This involves quantitative and qualitative methods and will provide the bulk of the data used in the model. A time-series analysis of operational metrics (e.g. number of teleconsultations, waiting lists, number of NHS-paid transportations, etc.) will be performed as done by Baker (2010), and Cutler and Huckman (2003). The patterns observed in the qualitative data will be enriched and triangulated with data from surveys and DCEs.

A DCE is an attribute-based survey method for measuring benefits (utility). The method is based on the assumption that any good or service can be described by a set of attributes and that the extent to which individuals value that good or service is determined by the nature and levels of the characteristics (Ryan et al., 2001). DCEs involve presenting respondents with hypothetical scenarios. The idea is that individuals choose the option that maximises their utility. From their choices over a number of scenarios, the researcher can then extract the relative importance of the attributes, and

how individuals give up one unit of an attribute for an increase in another (i.e. the marginal rate of substitution). The marginal rates of substitution can be used to estimate willingness to pay or willingness to wait. DCEs can also collect data on the respondents so that different respondent characteristics can be associated with different preferences and trade-offs. The use of multiple data collection methods allows triangulation and adds value to the research design. The survey instruments are currently under development.

EARLY EMPIRICAL FINDINGS

EXPLORATORY INTERVIEWS

As part of stage 1 data collection, twelve semi-structured interviews were conducted in Alentejo, resulting in a total of 8 hours and 50 minutes of recordings, which were transcribed and analysed. Participants included six specialists (dermatology, cardiology, psychiatry, physical and rehabilitation medicine, neurology and gastroenterology, general surgery), two managers and three GPs. Results from the interviews are in agreement with the review of evidence on teleconsultations: there is simultaneous substitution and expansion, teleconsultations take less time than face-to-face consultations, waiting times for teleconsultations are shorter, there is no evidence of clinical shortcomings associated with teleconsultations, distances and time-prices are clearly reduced, patient satisfaction is high, there is a learning effect from GP participation in specialist consultations potentially leading to less referrals, and teleconsultations are considered cheaper than face-to-face care.

MODEL AND SIMULATIONS

Findings from the interviews were combined with published evidence on teleconsultations to develop the initial model. The preliminary model has been parameterised with data from the Portuguese National Statistics office and the interviews. The model has been specified for teledermatology. A number of simulations for a 5-year period were undertaken in order to test whether the method could produce appropriate results, as well as gain initial insights into the system-wide effects of teleconsultation. All of the simulations are based on a hypothetical regional healthcare system composed of two health centres, one in the teleconsultation pathway and the other in the face-to-face pathway.

In the base run, there is a good fit with the statistical data, providing some initial validation. The most interesting result is that only 60 percent of teleconsultation capacity is filled (every week, 4 more patients could be seen). The reason for the spare capacity is upstream: GPs do not refer enough patients to fill a weekly one hour slot. More complex scenarios are then simulated: an annual change in demand of 2.4 percent, in line with van Ackere and Smith (1999); an initial waiting list for specialist care equivalent to 1 month of referrals; the GP experience effect from attending specialist consultations (this loop illustrates that, by participating in teleconsultations in a specific specialty, GPs learn about specialist care, which in turn allows them to identify, diagnose, and manage more patients at primary care level, without having to refer them); unmet demand for secondary care consultations.

The early findings indicate that teleconsultations might be a way to deal with rising demand (although the possibility that they might stimulate demand has not yet been incorporated into the model). The learning effect proves to be a very powerful mechanism potentially reducing referrals drastically. Interestingly, the cost per patient is cheaper in the teleconsultation pathway (mainly because there is a shift towards cheaper primary care), but because the number of patients in that pathway is so much higher it actually drives up total costs, when compared to face-to-face. These results are in accordance with the literature review: new technologies increase costs through utilisation rather than unit costs. As the model is further developed and made more general, the mechanisms that are causing changes in utilisation should be increasingly clear.

CONCLUSION

Early empirical results are in accordance with the evidence from the literature review, and provide initial insights into how technologies with lower unit costs can lead to higher total costs. Future work will focus on incorporating actual data from the case study into the model; exploring the role of mechanisms such as GP learning and demand inducement; testing the validity of the relationships and assumptions in the model; simulating current and future policies. It is expected that this research will lead to a number of contributions: theoretical, methodological and to policy. These are discussed below.

THEORETICAL CONTRIBUTION

The main theoretical contribution of this study is a potentially better understanding of how the introduction of new technologies in healthcare affects both patients' and physicians' decisions, and how these lead to service expansion and substitution or simultaneously both. The study contributes to the literature on technologically-driven expansion and substitution, and its impact on costs, topics which have been written on extensively by Cutler, McClellan, Skinner, and Baker, to name a few (Cutler, 1995, Skinner et al., 2006, Cutler and McClellan, 2001, Baker et al., 2010, Baker, 2010).

METHODOLOGICAL CONTRIBUTION

Economic evaluation methods have been increasingly used to assess the value of new technologies. It is good practice to compare the technology under evaluation with an alternative, usually the conventional treatment. Data used and assumptions made in these evaluations are often based on pilot studies but a technology's effects can change considerably with both time and diffusion; secondly, if service expands as a consequence of introducing the technology, we cannot compare the expanded use with the conventional treatment. With this study, it is possible to explore how current methods of economic evaluation can be enriched through the integration of system dynamics models, building on the work of Smith and van Ackere (2002).

POLICY IMPLICATIONS

There is no doubt that technological innovations will be essential towards addressing the challenges we face in healthcare. It is less clear whether technological innovation, and

calls for more technological change, are actually creating challenges of their own. As policy makers set out to achieve certain objectives, they must bear in mind that their decisions will affect the healthcare system as a whole, potentially creating unintended problems and difficulties. This study aims to give a whole system view of the medium- to long-term impact of a specific technological innovation on healthcare service use and, ultimately, cost. Using modelling and simulation, I can test the effects of current efforts to mainstream certain technologies, and investigate future interventions. System dynamics provides a virtual world to experiment without impacting on real world service delivery and outcomes. The use of modelling and simulation in healthcare has received increasing attention from healthcare policy makers recently, emphasising the potential for meaningful policy contributions.

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AN EXAMINATION OF DIFFERENT MECHANISMS AIMED AT FACILITATING KNOWLEDGE TRANSFER ACROSS PROFESSIONAL AND ORGANISATIONAL BOUNDARIES IN HEALTHCARE

L. Pomeroy¹

ABSTRACT

Literature suggests there is no ‘magic bullet’ to move healthcare research into improved clinical practice. This difficulty is linked to NHS structures and organizational complexity; there are multiple stakeholders, networks and boundaries. We know that knowledge ‘sticks’ at many of these professional and organisational boundaries. Drawing on the work of Wenger we have identified three potential knowledge transfer mechanisms; social interactions, people (i.e. individual skills and brokerage) and boundary bridging objects (i.e. artefacts and documents). Alongside these mechanisms we examine the role of network structures in achieving optimal levels of knowledge transfer. Initial findings suggest that the level of top down control over the mission and scope of local networks determines the effectiveness of local uptake. Also, internally developed mechanisms may have limited impact on external knowledge transfer, due to a lack of shared navigation points and common purpose. Finally, the sustainability of the facilitated networks and mechanisms appears limited.

KEYWORDS

boundary spanning, knowledge transfer, networks, organisational boundaries, professional boundaries

INTRODUCTION

Of particular concern within the healthcare field is the issue of research informing practice, as often a substantial time lag exists between research being taken up and utilised in a reliable or consistent fashion (Seddon et al, 2001). This problem has been the subject of debate since the 1950’s and still continues today (Lomas, 2000, Lomas, 2007, Niccolini et al, 2008, Kontos and Poland 2009, Oborn et al, 2010). The failure to translate knowledge from research into practice has consequences, in terms of wasting resources and leading to an inefficient and unproductive health system. A requirement remains for effective techniques and approaches to address this knowledge gap (defined in policy as the ‘second translational gap’) (Cooksey, 2006, Darzi, 2007). A large part of the focus has been on closing the translational gap through improved knowledge transfer (KT). Alongside this move towards improved KT, the National Health Service (NHS) has also moved toward more networked forms of organising (Ferlie et al, 2010). This has been part of a deliberate operation of policy, as literature indicates that networks improve knowledge transfer (Ferlie et al, 2010). Within this study we are concerned with

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determining the processes of knowledge transfer across different networks, and evaluating the effectiveness of different KT mechanisms currently being used throughout the UK NHS.

LITERATURE OVERVIEW

There are a number of barriers highlighted within the literature regarding knowledge transfer (Williams and Dickinson, 2008). These range from the specific knowledge that is being transferred through to individuals obtaining and utilising knowledge, and organisational and structural context. These multiple barriers are seen to change over time, with corresponding changes in process (Williams and Dickinson, 2008, Greenhalgh, 2004). A particular consideration of this study surrounds the concept that networks do not exist in isolation. Knowledge may transfer well across a network however this is not the case between networks i.e. at the boundary. Here, knowledge may 'stick' (Ferlie et al, 2005).

The literature does not propose a 'magic bullet' to this problem rather a multi-faceted approach (Williams and Dickinson, 2008, Ferlie, 2010). There are mechanisms proposed to counteract these problems of stickiness including: Evidence base, dissemination, support tools, networks and leadership development (Goodwin et al, 2004, Williams and Dickinson, 2008). With regard to traversing boundaries, the different mechanisms can be categorised into three aspects – boundary objects, interactions and people (Wenger, 2000).

Social network researchers have offered evidence of knowledge diffusion occurring via social relations (Rogers, 1995). In fact, according to Levin and Cross, 2004 early work of Pelz and Andrews (1968), Mintzberg, (1973) and Allen (1977) has demonstrated that people prefer to look to people for information as opposed to a document or the like. A great deal of focus has been on structural properties of networks, for example, structural holes, ties strength etc (Burt, 1992, Granovetter, 1973). However, there has more recently been a movement toward observing the substantive characteristics of relationships that promote receipt of knowledge i.e. relational characteristics such as trust (Levin and Cross, 2004). Focusing on the crucial importance of individuals and the relevant social relations we can start to look at how the boundary processes can be employed to overcome the 'sticky' boundary issue.

Literature has given little consideration to the interaction of social structures and knowledge exchange in conjunction with mechanisms aimed at mediating boundaries (Greenhalgh, 2004, Ferlie, 2010). In essence, it rarely discusses how and to what extent different mechanisms can facilitate knowledge transfer across boundaries, particularly boundaries in healthcare. This is probably as a result of the difficulties inherent with healthcare boundaries, in that they are multifaceted with high degrees of professionalism, power issues and specialisms against a fragmented organisational backdrop (Currie & Suhomlinova, 2006, Ferlie et al, 2005). The studies that do focus on this area tend to be multi-faceted in terms of the intervention mechanisms being studied, but not in terms of mechanisms to successfully cross boundary domains (DofH, 2007). Equally, a criticism levied at the majority of studies undertaken to date include for example, contradictory findings possibly due to cross-setting generalisations.

Furthermore evidence of the relationship between boundary spanning mechanisms and best practice uptake is poor despite the literature often citing the need for further study (DofH, 2007, Grimshaw et al, 2004, Wensing et al, 2006, Greenhalgh, 2004).

As a result of this gap within the literature we have chosen a case study to investigate a multi-faceted intervention (across boundary bridging domains), which is currently being rolled out in the UK NHS, borne out of a policy initiative to close the second translational gap. This intervention is the Collaborations of Leadership in Applied Health Research and Care (CLAHRC). Our research questions are concerned with how and to what extent do different knowledge transfer mechanisms employed facilitate knowledge transfer across network boundaries in healthcare. This is with a specific focus on knowledge transfer across professional, internal and external organisational boundaries.

RESEARCH DESIGN

The research approach is a ‘mixed method’ (Quantitative and Qualitative) methodology. This will include methods of in-depth semi-structured interviews, ethnography (direct observation and participation) and Social Network Analysis (SNA). Whilst a number of studies have been conducted based on one approach alone there has been increased attention within methodological debates in the social sciences and a swell of support for a mixed method approach has ensued. The mixed method approach is deemed as complementary and enables a more complete understanding (Jack 2010, Edwards, 2010, Edwards and Crossley, 2009, Bechky, 2006).

A cross-sectional approach is being taken with a longitudinal element to the data collection (Saunders, 1959). A purposive approach to case study (CLAHRC) selection has been employed based on CLAHRC being a policy initiated intervention which incorporates a number of mechanisms aimed at facilitating knowledge transfer. The embedded units of analysis have been chosen via theoretical sampling and boundary has been defined via a nominalist approach i.e. that set from our theoretical interest (Doreian, 1994). This approach has been chosen as it is achievable and recommended by DoH’s 2007 review of healthcare interventions if a RCT is not feasible.

CASE STUDY SELECTION

A case study approach is deemed as the optimum approach for studying complex phenomena (Yin, 1984). Also, case studies are deemed as particularly well suited for constructing, adapting, extending and refining theory. Yin (1984) stated that case studies were appropriate when the research question was ‘how’ or ‘why’. This study focuses on explaining ‘how’ knowledge transfer is facilitated and ‘why’ various mechanisms do so or otherwise. It should, however, be noted that case study research is strong on internal validity but weak on external validity. Yin (1994) highlighted that multiple case studies should have a replication logic i.e. each case serves a specific purpose. By using several different units of analysis, the study offers replication logic and enables a compare and contrast approach which adds to external validity and is also useful in theory development (Gummesson, 2006, Eisenhardt and Graebner, 2007).

Eisenhardt (1989) suggested theoretically driven sampling facilitates comparison and theory building. We undertook theoretical rather than random sampling, choosing a total of twelve units of analysis. Each unit has been selected to serve a specific purpose within the overall scope of inquiry. To ensure appropriate selection, before data gathering commenced, attendance at events and meetings was conducted along with document review. As a result the overall inclusion criteria was based on professional boundaries alone and professional and external organisational boundaries. In summary, the research will analyse 12 units of analysis within the NW London CLAHRC case study. The table below summarises the projects chosen and defining features.

Table 1. Table of units of analysis to be studied

Unit of Analysis	Number	Distinguishing features
Professional boundaries	6	<ul style="list-style-type: none"> • Early stage • Mature • New setting
Professional and external organisational boundaries	6	<ul style="list-style-type: none"> • Early stage • Mature • New setting • Individual level

OVERALL STUDY CONTEXT - CLAHRC

In order to investigate the overall research question we are going to specifically look at the three categories of mechanisms outlined in the previous section, aimed at mediating the boundary of networks. These are Boundary objects, Interaction and People – brokerage and skills. Within NW London there is a government initiative that incorporates each of these categories of mechanisms, with the primary aim of improving transfer of knowledge across professional and organisational boundaries. This initiative is termed Collaborations of Leadership in Applied Health Research and Care (CLAHRC).

Within this paper I have outlined the ‘top level’ funding/delivery of care issue surrounding healthcare and the resulting need to address the ‘translational gap’ between research and clinical uptake. At a policy level the ‘fix’ has been outlined as a need to establish a new approach to a) the adoption of technologies, interventions and processes in the NHS b) the improved mobilisation of research-based knowledge and c) the increased capacity within the NHS to make use of that knowledge (Cooksey, 2006, Darzi, 2007).

In April 2009, a briefing document outlining the new innovation landscape in the UK was produced. It outlines the organisational structures that have been developed in order to create a landscape that stimulates and disseminates innovation and increases research capacity through a series of interactive networks (HSRN, 2009).

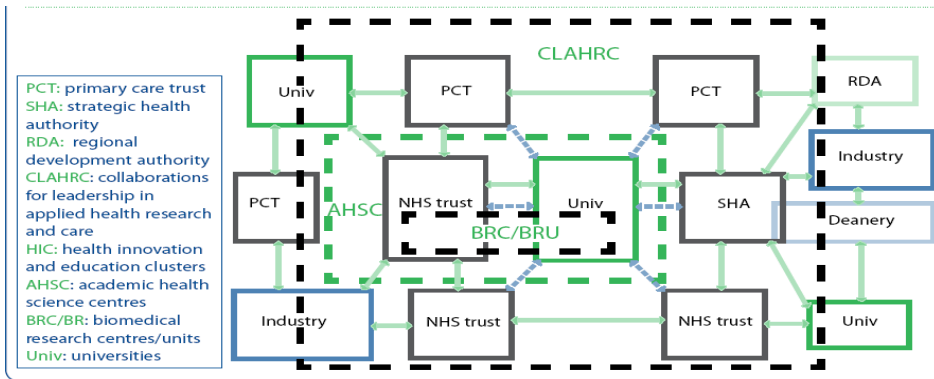


Fig.1. CLAHRIC

There are nine National Institute for Health Research Collaborations of Leadership in Applied Health Research and Care (CLAHRIC). They were set up in 2008 and have funding for five years. All nine CLAHRICs share a set of broad purposes and aims. However they are distilled down in different ways according to the local context and the related research focus. In essence, the CLAHRIC moves research evidence into practice thereby facilitating improvements to patient care, faster than it would have been otherwise. It does this by facilitating interaction between patients, carers, healthcare staff and researchers and then evaluating how this alternative approach translates into actual benefits along with how far these benefits reach.

There are four project streams running in NW London CLAHRIC. Streams 1–3 are 18-month duration and are set off on a rolling timetable of 12-months, stream 4 is a more individual approach (Fellows) and is 12 months duration.

CLAHRIC offers a context in which we can appropriately study the research question posed. NW London CLAHRIC is acting as an organisational broker i.e. a separate organisation that facilitates interaction and utilises various mechanisms in order to facilitate Knowledge Transfer across boundaries in healthcare.

The organisational broker’s approach has been predominantly two-fold, the creation of a group level broker (project teams) and an individual broker (fellows). Both of these we view as a mechanism employed to mediate knowledge transfer. Equally, the organisational broker (CLAHRIC) employs other mechanisms through the group and individual level brokers to ensure these two approaches work effectively. These include, creating and facilitating Communities of Practice (CoP), utilising boundary objects such as ICT/guidelines and leadership and skill development. We can, therefore, investigate each of the three mechanisms highlighted as important in knowledge transfer across boundaries as outlined in our literature review.

RESEARCH QUESTIONS INVESTIGATION

The first investigation with regard the research questions was to understand the mechanisms employed by the CLAHRIC management team (Organisational broker). The

mechanisms employed have been researched and categorised with reference to this study. This was carried out through ethnographic approaches (direct observation and participation) and documentary analysis. For details of the mechanisms employed and the categorisation of them in reference to this study please see the next section on early empirical findings.

The next stage is to conduct semi-structured interviews with key personnel in the organisational brokerage structure (CLAHRC). We expect this to generate an understanding of their perception of these mechanisms, rationale for employing them, the manner in which they apply them and what they expect them to achieve.

Following on from this question 1 necessitates establishing how and to what extent knowledge transfer occurs across the *internal* NW London CLAHRC organisational boundaries. This will be established through a Socio metric questionnaire (a quantitative study of interpersonal relationships), and semi structured interviews with each individual within the overall CLAHRC case study. This includes the personnel employed specifically in CLAHRC and those individuals in the units of analysis being analysed. In addition to this a part of the sociometric questionnaire will include an ego-centric snowball approach referencing alters that are part of CLAHRC but not the management team or a part of the units of analysis an individual belongs to.

We propose to conduct the socio metric questionnaire at two time points (t0, Oct 2011 and t1, March 2012). Analysis of this will provide a quantitative measure over time, aiding understanding of 'extent' with regard the usefulness or otherwise of the mechanisms employed to facilitate KT across boundaries. It will also when combined with qualitative interview data enable analysis of 'how' as relational structure (from SNA) such as links to other people, advice, information sharing, frequency of contact and quality of relationship is synthesised with thematic analysis of interview data. It also enables us, through the longitudinal nature of this study, to ascertain whether changes within these relationship aspects are related to improved knowledge transfer or not and vice versa. Equally, if a relationship is found to occur are these brought about by the mechanisms employed, the attributes of the individuals involved and/or the manner in which adherence is enforced.

Question 2 and Question 3 also necessitate establishing how and to what extent knowledge transfer occur across *external* organisational and *professional* boundaries respectively. For both of these this will be established through a socio metric questionnaire and semi structured interviews with each individual identified as part of the embedded units of analysis.

We propose to conduct the socio metric questionnaire at two time points (t0, Oct 2011 and t1, March 2012). Analysis of this will provide a quantitative measure over time, aiding understanding of 'extent'. It will also when combined with qualitative interview data enable analysis of 'how' as relational structure (from SNA) such as links to other people, advice, information sharing, frequency of contact and quality of relationship is synthesised with thematic analysis of interview data. It also enables us, through the longitudinal nature of this study, to ascertain whether changes within these relationship aspects are related to improved knowledge transfer or not and vice versa. Equally, if a

relationship is found to occur are these brought about by the mechanisms employed, the attributes of the individuals involved and/or the manner in which adherence is enforced. In addition to this a part of the sociometric questionnaire will include an ego-centric snowball approach referencing alters that are not a part of CLAHRC in any way.

Finally, across the timeframe of data collection ethnographic data (direct observation and participation) alongside relevant documentary analysis will continue to be undertaken. Resulting analysis will offer additional context to each of the research questions.

DATA COLLECTION AND ANALYSIS

In order to outline effectively the facets of data collection it is necessary to reiterate the definition of knowledge transfer within this study. Within this study we use knowledge transfer as an encompassing term to include knowledge transfer and knowledge sharing, its dissemination and use. In essence, we use the following definitions for the respective breakdown of terms. The distinction in terminology and definition with regard 'knowledge transfer' and 'knowledge sharing' relates specifically to the distinction between explicit and tacit knowledge, dissemination as 'knowledge spread' and use the putting of 'knowledge into practice'.

Mechanisms are categorised as a result of ethnographic and documentary analysis.

Firstly, our research design is longitudinal and enables at least two data points. We propose to 'measure' relational contact, frequency, trust, knowledge transfer (explicit knowledge), Knowledge sharing (Tacit knowledge), value of exchange, level of exchange and the three types of knowledge use (Conceptual, Instrumental and Symbolic) as described by Estabrook, 1999. These will be measured using a roster method i.e. all members of a community are interviewed and given a list of everyone and asked several network questions (Valente, 2010). Knowledge spread will be measured taking an ego-centric approach i.e. individuals are asked to name alters and questioned on the interaction between those named (Valente, 2010).

The use of a ranked scale to measure knowledge is often quoted within the literature, although differing approaches are often employed (Sudsawad, 2007, Amara, 2004). We propose to use a likert ranked scale via questionnaire addressing each of the knowledge measures in relation to each of the mechanisms identified. A Likert scale was chosen as it is a well established and tested ranked methodology and it removes the middle option, deemed important in this type of study. We expect to measure consistency using Cronbach's alpha analysis and content validity via peer review (Sudsawad, 2007).

Alongside the interrogation of the actual relational network, we also propose to undertake data collection with regard perception of the networks investigated i.e. Cognitive Social Structure (CSS) (Krackhardt, 1990). The approach we propose to undertake will be to 'measure' perception of relational contact, frequency, trust, knowledge transfer (explicit knowledge), Knowledge sharing (Tacit knowledge), level of exchange and knowledge use.

Whole network information is required for SNA and due to the tightly bounded nature of the units of analysis we are in a position to identify the individuals who make up the network. We plan to use the roster method within the survey (Valente, 2010). This is when each respondent is provided with a list of names within the network. The network member will be asked to tick against the names according to network questions corresponding with the studies interest. There is also an opportunity for individuals to be added to the roster, which enables us to capture any additional members not initially identified. This approach is consistent with socio-metric work on network interactions (Balkundi and Kilduff, 2006) and provides reliable data which avoids mono-source bias (Friedkin, 1981). Furthermore, the data can generate measures at the individual level of analysis (e.g. the centrality of each individual) or at the network level of analysis (e.g. the extent to which the network is centralised around a few actors) (Valente, 2010).

It should be noted that within the literature this practice of asking a single socio-metric question to measure a relationship is sometimes challenged. However, Marsden (2003) has suggested that these measures are reliable when participants are assisted in the understanding of the measures, with pre testing the questionnaire and honing the questions to ensure specificity. This will be tested through peer review and at least the first time participants will be assisted in understanding the measures. Once the data has been collected from the socio-metric survey, we will construct matrices to reflect the extent to which each actor was connected to every other actor in the network and conduct various statistical measures of analysis.

Each of the approaches outlined above will enable at least two data points in order for any change over time to be identified in relation to the various mechanisms used. Semi-structured interviews, ethnographic data and documentary analysis will add context and combined enable insight into a complex intervention.

Data collection will be through secure electronic and paper documents, which will be entered in a using Microsoft Word and Excel (Microsoft Inc., USA). The data are likely to include numerical scale, yes / no responses, transcribed qualitative response and open text as well as ethnographic observations. The analysis will be principally carried out using UCInet (Borgatti et al, 2002) and thematic analysis of interviews and ethnographic reports.

EARLY EMPIRICAL WORK

Early empirical work conducted includes c.100 hours of ethnographic data gathering (direct observation and participation), eight semi structured interviews, review of core team transcripts and documentary analysis. This has formed a necessary part of the first stage of the study as it has enabled an understanding of the complexity of the case study (CLAHRC) along with an informed choice of the units of analysis and categorising of the mechanisms involved.

NW London CLAHRC acts as an organisational broker, which utilises a number of mechanisms aimed at improving knowledge transfer across boundaries. The overriding focus is to provide and create facilitated interaction, thereby creating networks at a boundary level. As a part of this they use mechanisms to train at an individual skill level

(project and fellows) enabling the formation of group-level brokers (projects) and an individual level broker (fellows).

We have classified the mechanism employed in reference to Wenger’s three boundary process categories – Interaction, People and Boundary objects

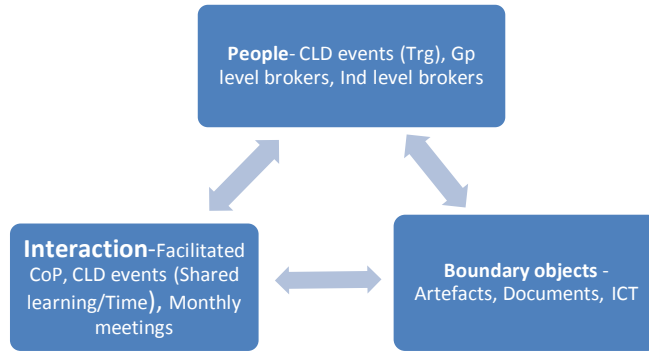


Fig. 2. Categorisation of mechanisms employed within the case study

NW London CLAHRC has offered the opportunity for healthcare professionals to bid for a project or a fellows programme. The mainstay of a project or fellows application is to alter process in line with a piece of research knowledge that would offer benefits if implemented.

A project consists of 8-12 individuals usually consisting of a GP, nurse, physiotherapist, Community nurse and patient representative etc depending on what is appropriate. Once accepted by CLAHRC, they are brought together in order to conduct the project. From a theoretical perspective they form a facilitated CoP, which are trained through CLAHRC’s mechanisms and approaches to act as a group level broker within the relevant system’s process.

The fellows programme consists of nine individuals each a sole representative of the particular area they work in. As with the project stream once accepted they are brought together to form a CoP. However, the project remains their individual domain. As a result of forming a facilitated CoP they are trained through CLAHRC’s mechanisms and approaches to act as an individual level broker within the relevant system’s process.

CONCLUSION

The approach to the study was initiated as a balance between a precise-hypothesis testing one and that of a pure ‘grounded theory’ strategy. Following on from an initial review of literature and early ethnographic work a framework to the research was developed. This structure enabled the identification of the research gap the questions would address, the identification of suitable units of analysis and the classification of mechanisms utilised as outlined above. Following on from this stage the analysis of the early data collection

will enable the construction of hypotheses that will be specifically tested as a part of the overall data collection.

It is too early at this point to offer any meaningful conclusions regarding the research questions (how and to what extent do different knowledge transfer mechanisms employed facilitate knowledge transfer across network boundaries in healthcare; specifically across professional, internal and external organisational boundaries). However, it is possible to outline some initial findings that can be drawn at this stage and that will be used to inform the content of both the qualitative and quantitative data collections.

As a result of discussions and analysis of data collection, to date, the following diagram represents a conceptual diagram for the CLAHRC case study. CLAHRC operates as an organisational broker i.e. it coordinates between different parties without actually being a part of the entities. It then uses a number of mechanisms in order to build networks and facilitate knowledge transfer and training. Broadly, this can be characterised as Individual broker, Group level broker and boundary objects.

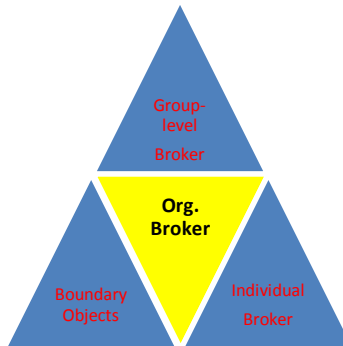


Fig. 3. Diagrammatic representation of CLAHRC and the mechanisms employed

From the ethnographic data collected initial findings suggest that the level of top down control over the mission and scope of local networks determines the effectiveness of local uptake. In other words, the extent to which the networks are perceived as being centrally or locally mandated can impact the perception of the mechanisms, project and ultimately the uptake and success of Knowledge Transfer mechanisms. Equally, internally developed mechanisms may have limited impact on external knowledge transfer, due to a lack of shared navigation points and common purpose. Finally, the sustainability of Knowledge Transfer within the facilitated networks appears limited, possibly due to the attitudes developed toward the initiative, time constraints and/or the mechanisms do not truly enact an embedded change of culture and method of working.

The next phase of this study includes further analysis of initial data collection, the development of the semi-structured interviews and the Social Network Analysis questionnaire testing. Following this the interviews will be conducted in October 2011, including the first SNA data collection. This will be followed up with a second SNA data collection in March 2012.

Following completion of the data collection and analysis this study will inform theory, practice and policy by opening up a new theoretical discussion on the role of different mechanisms needed to effectively mediate knowledge transfer across network boundaries within healthcare.

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APPLYING THE REAL OPTIONS THEORY FOR IDENTIFYING FLEXIBILITY IN PROJECT DELIVERY OF HEALTH ORGANISATIONS

M. van Reedt Dortland¹, G. Dewulf² and J. Voordijk³

ABSTRACT

Healthcare is influenced by many uncertainties. Uncertainties affecting health organisations also influence real estate since this facilitates the primary process. Within real estate management, decisions have to be made today while there is little knowledge about the future. Therefore, flexibility is needed in the process of designing, constructing and operating real estate. A case study has been done to gain insight about how health organisations deal with flexibility. The real options approach is used to show what types of flexibility have been used. The case study shows real estate managers that uncertainties also creates opportunities and that the real options approach is a useful method to describe what types of flexibility have to be created.

KEYWORDS

case study, flexibility, health care, real estate management, real options

INTRODUCTION

Already since WWII, an important means to control health care expenditures by the government has been the control on expenses on construction and maintenance of buildings. Since the 1980's, in the Netherlands, liberalisation was thought of one measure to limit costs. In 2008, liberalisation got a new impulse with new regulations which implied a more business like operation of health organisations, resulting in an increasing importance of efficient real estate management (Bellers, 2008; Raad voor de Volksgezondheid en Zorg, 2006). An approach for managing real estate strategically is known as Corporate Real Estate Management (CREM). CREM implies that future and current supply and demand have to be met, by setting out a real estate strategy. CREM considers both the design and construction of a building, as well as the management of the building during its lifetime. Many uncertainties influence healthcare organisations, which make it difficult to which strategy to choose. A way to deal with future uncertainties is flexibility (Kreiner, 1995; N. O. E. Olsson, 2006), which enables adaptations to these changing circumstances.

However, several government bodies (Bellers, 2008; College bouw ziekenhuisvoorzieningen, 2005) notice that health organisations in the Netherlands have little experience with strategic real estate management. Therefore insights are needed in

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how flexibility can be incorporated in their real estate strategy. A promising approach to provide these insights is the real options theory, as suggested by different authors (Gehner, 2008; Olsson, 2004; Vlek, 2005). Real options are being applied in real estate, also in health, but only in valuing real estate. As a way of thinking, real options in project management is a new approach, in health no examples can be found. A real option is a right, not an obligation to exercise an option, where the option has been developed against a certain investment. The real option enables flexibility and attributes value to it. More uncertainty implies a higher value for flexibility. Using real options as a way of thinking helps real estate managers recognising that uncertainty is not something negative, but even can provide value (Amram, 1999; McGrath, 1999).

The aims of the research are first to discover which uncertainties require what type of flexibility and secondly what the implications are for the type of real options that (subconsciously) is being applied by real estate managers in health. Besides, we look at if and how the development of uncertainties influences the price and timing of exercising the real option.

Moreover, the application in real estate management and health has not been further developed by other researchers. Therefore we want to explore whether it is a useful approach. The research question we want to answer in this paper is:

- What kind of real options are applied in real estate management and what are consequences of uncertainties for the timing and exercising of the real options?

This paper will first introduce the framework consisting of two elements: flexibility and real options. The objective of the research is to find the relation between these two elements to provide more insight into flexibility by using the real options as a way to describe and communicate flexibility. We use the critical events technique, which we apply to a case study. We describe the critical events that incur a change in the process and influence flexibility. In the conclusion we reflect on the relations we found between flexibility and real options.

THEORETICAL FRAMEWORK

The concept of flexibility will be explored in this section. Flexibility in project management and especially in construction (management) is a widely used term with different meanings. In this research we use the classification of Olsson (2006) because it provides an overview of useful elements of flexibility in project management. Flexibility in this research is defined as room for manoeuvre in decision making. Olsson (2006) uses three different categorisations of flexibility, of which we will only use types of flexibility.

TYPES OF FLEXIBILITY

The first type is flexibility in the decision process. According to Olsson (2006), process flexibility is based on an approach where decisions and commitments are made sequentially over time. It also has to do with ways to make irreversible decision more reversible or postponing irreversible decisions until more information is available. In our research we look how project delivery systems enable process flexibility. Olsson also

mentions product flexibility, which is similar to design flexibility (Blanken, 2008), technical flexibility (Cbz, 2005, Carthey et. al. 2010) and spatial flexibility (Jonge, 2009).

Within design flexibility a further distinction can be made between different time-spans the flexibility is applicable. We use the level of time-span as a subdivision of types of flexibility and we mainly focus on the latter in our research. Blanken (2008) refers to Yun (2007) to point at two types of design flexibility: tactical and strategic flexibility. For example, strategic design flexibility is long term flexibility and might imply changes of size of the building. Tactical flexibility is on the short term without changing the overall size and functionality of the building. Besides strategic and tactical level, Carthey et.al. (2010) add the operational level, which means that changes are easy to implement, with low impact on time and cost.

Another type used by Blanken (2008) is financial flexibility. VAG (2007) defines financial flexibility as the possibility to satisfy both current and future demand and meet financial obligations, as to respond to future demand and longer-term obligations. Means to enable this are increasing revenues and decreasing costs by short term lease contracts, value creation of real estate, better use of land, attuning investment decision in buildings, ICT and medical inventory, contract options and financial arrangements.

Service flexibility is also mentioned by Blanken (2008). This is applicable if services are transferred to the SPV (special purpose vehicle) in case of an integrated project delivery system. Service flexibility can be both on a strategic and tactical level. On a strategic level that would be adaptation of the price by benchmarking or market-testing the services. Tactical flexibility means flexibility on an ad-hoc basis.

Finally, organisational flexibility is mentioned by the former advising board of the Dutch government, the *College Bouw Zorgvoorzieningen* (2005), as well as by Jonge et.al. (2009). This is the optimisation of the use of the spaces in the building by clustering facilities, adjusting operating hours, implementing new ways of working and density control.

REAL OPTIONS AND FLEXIBILITY IN CORPORATE REAL ESTATE MANAGEMENT IN HEALTH

Black, Merton and Scholes found a way in the finance sector to describe and value flexibility by means of options, which delivered them the Nobel price. Together with Myers they recognised the applicability of options on real assets, the *real* options. The basic idea of the theory is that flexibility (the real option) is created by paying for the opportunity for a future investment, or to withdraw from investment, i.e. respectively a call and a put option. Good timing of exercising the option is important to make optimal use of the real option. The option has value, and can even be more valuable in case of more uncertainty (Winch, 2010) and (Alessandri, 2003). The price for the option is a fraction of the overall investment required, called the option premium. Besides valuation, some authors explain that real options also can be used as a way of thinking to obtain insight into how opportunities for future flexibility can be created by current

actions (Miller and Lessard, 2001; Ford et.al., 2002; Miller and Waller, 2003; Alessandri et.al., 2004; Cornelius, 2005; Winch, 2010).

A real option is an investment strategy to reach flexibility. In real estate management for example, an investment to easily change spaces provides flexibility to change the function within the building, such as switching hospital bed rooms into offices. The extra investment to build in such flexible walls is the investment premium. The right exercising time for example would be when there is a lack in offices and sufficient bed spaces. Waiting until the demand for offices drops would diminish the value of the option. The real options approach demands the formulation of a desired future. By comparing the current situation and this desired future situation, certain strategies (options) have to be formulated to reach that future situation. The real options approach considers the effects of internal and external uncertainties on the outcome of the investment strategy or real option. According to Amram and Kulatilaka (1999) the real options approach can better show the effect of uncertainties by further detailing the size and timing of the real options. By comparing different real options or strategies on their effect on desired flexibility, a well-considered decision can be made. For example, staging is a real option, described on the next page, which can be applied in the construction of real estate. When a contextual uncertainty, such as the price of construction materials, goes into a certain direction, the client might decide to defer further investment in the project. However, this also depends on another real option: the contractual terms with the contractor, in which is stated whether deferring the project is allowed or not. Therefore, based on how much flexibility might be needed in the future, the client should weigh different types of contract to invest in as a real option in order to choose the most valuable real option in his or her situation.

Several authors propose to apply this theory to real estate management. Olsson (2006) notes that the real options theory is especially useful for users and project owners since the project flexibility represented by real options mainly deals with changes in the objectives of the stakeholders. We link the different types of flexibility to real options, which results in a model which forms the basis of further analysis in the research. Investments in real estate in health that can be recognised as real options are for example types of contracts in project coalitions, and the type of design.

Winch (2010) determines seven types of real options that are useful in project management based on Fichman et.al (2005) and Sommer and Loch (2004). These are:

Stage, where after each stage the progress of the project is reconsidered based on more knowledge of uncertainties. Staging is an important real option in construction, often applied in for example the traditional project delivery system, by determining after each phase whether will be continued to the next phase. After each phase more information is available, also about the requirement of the client. In hospital construction, this is often a long process. The resulting project will then be more according to the needs of the client which adds value. The real option premium then is for example the investment in a conceptual design. Concluding from this, it will not always be beneficial to integrate different tasks which are executed by one contractor, since different options will be lost. This is especially the case in projects with a high uncertainty, since the value of different options then also increases.

An abandon option is an exit strategy in a project, if uncertainties turn out to have a too negative effect on the project. For example, in the Netherlands the budget for capital investments per treatment is not yet determined in the care. When this budget appears to be lower than assumed during the design phase of the project, the building might be not rentable and therefore abandoning the project is the best solution. After each stage in a staged project, theoretically the project can be stopped. However, there are other issues that play a role when deciding to stop the project: there have been sunk costs; costs that cannot be recovered and will be lost, and image damage for the initiators of the project.

Defer options enables postponing decisions until more information is available. Waiting until more information is available is the option to defer. However, one should be aware of the risk that the real option will not expire. For example, a permit for construction might expire. However, just waiting until more information is available in itself is not a real option. Therefore, more alternatives should be considered when the uncertainty/ies develop in different directions. For example, certain adaptations in a building enable deferring the decision about the target groups of certain rooms, when there is still uncertainty about the demand from different target groups. This is also called *safeguarding* (Winch 2010). Technological flexibility can be a defer option. For example in a house for elderly care: by means of building in installations to enable future installation of bathrooms, the option is created to do this in the future when the demand for single rooms with private bathrooms increases. In the same time this is an example of a switch option since the function of the space can be changed. A switch means that the building can be used for other functions

A growth option is created when a baseline investment enables potential future expansion of the project. An example of a growth option is keeping a site in ownership: an investment is done to own the site, and options for the purpose of the site are still open. This is related to the scale options, in which the asset can be scaled up or down when there is more knowledge on uncertainties related to the use of the asset.

A select option is created when several alternatives are developed in parallel, to have the option to choose when there is more knowledge about conditions. An example is the invitation of different architects in case of procurement. They all receive a remuneration for their preparations, which is the option fee, and the client has several options to select from. Different alternatives pass by which might generate ideas by the client who gains deeper knowledge about the project. Further, the client can choose from different options which he/she wouldn't have had by only inviting one architect.

Contractual options are mentioned by Amram and Kulatilaka (1999, p. 92), 'which are specific contract terms that change the risk profile faced by asset owners'. Such as the example mentioned before: the inclusion in the contract of the ability of the client to continue with the contractor after finishing a certain phase in the project, or not.

COMBINING FLEXIBILITY AND REAL OPTIONS IN REAL ESTATE MANAGEMENT

When comparing the types of flexibility and levels and the real options and reasoning logically, it appears that certain real options can be identified as the enablers of certain

types of flexibility. Therefore we propose the combination of real options and types of flexibility as presented in table 1, which we will test in the case study.

Table 1. Real options enabling types of flexibility

Types of flexibility	Real options						
	Stage	Abandon	Defer	Growth	Scale	Switch	Select
Process	X	X	X				X
Product Technical/design, Spatial	X			X	X	X	X
Financial	X	X	X				
Service					X	X	
Organisational							

METHODOLOGY: CRITICAL EVENT TECHNIQUE

The aim of the research is to find the relation between flexibility and real options in real estate management in health. We expect that flexibility is created and undone in decision making, which occurs on many levels and in very different forms. Therefore we do an exploratory, in-depth case study in order to catch all different aspects of the decision making process.

CASE STUDY RESEARCH

The value of a single case study is that phenomena can be qualitatively described with more nuances on the development of phenomena than a quantitative methodology (van de Ven, 2007; Yin, 1989). Only few construction projects will be executed in the same way since all have their own stakeholders and interests and therefore their own dynamics. This makes every case unique and therefore also valuable (Siggelkow, 2007). We will shortly introduce the case study in our research.

Our case study is Utopia, the feigned name of a building which is being redeveloped and part of the real estate portfolio of a large welfare organisation in a middle large town in the Netherlands. The welfare organisation, called Ibis in this case, offers different welfare-, living- and care services over the total line of life. Ibis is the result of a merger in 2008, between the organisations Parrot and Crane. With the start of the project in 2005, Utopia was owned by Parrot.

Since the project had to deal with the major policy change regarding real estate in health, it is a good example of a project dealing with uncertainties with large consequences and therefore a substantial need for flexibility.

PROCESS RESEARCH

We want to answer the question *how* real options are applied and exercised. Therefore, the process theory approach is very suitable (van de Ven, 2007). The process theory approach is different from the variance theory approach, defined by Mohr (1982). In the variance theory, the causal effects between variables is explained statistically, while in the process theory the process is more fine-grained and narrative analysed by identifying all events, activities and choices, on different levels, that influence the process. Besides, the time aspect in the process theory is important since entities acting in the events change over time, as well as the variables used in the research: flexibility, uncertainties and real options. *Incidents* and *events* in a process theory are analogous to the distinction between *variables* and *constructs* in variance theory. Langley (1999) proposes to not artificially separate variables and events, but use both elements in research. We do this by referring to flexibility, uncertainties and real options as variables, while they are being reflected in incidents and events. Where incidents are direct observable activity, events are on a more abstract level and might be a longer during event. In the following section we will explain how we defined the critical incidents and events in our research.

In our research we define a critical event as a decision that influences the direction of the process. This can be a change within one of the elements of the project which are associated with types of flexibility, following van de Ven (2007): process, technical/spatial/product, financial, service, organisational. In the analysis we will see whether these decisions can be related to real options. When collecting process data, we attempted to document as completely as possible the sequence of events, pertinent to the processes studied (Langley, 1999).

From these events we further distilled which events had influence on flexibility and the creation, price, timing and types of real options. In a case study report we chronologically described each incident, the development that motivated for this incident, and the consequences for flexibility.

VALIDATION OF THE RESEARCH

Triangulation was reached by using different information sources. The information in the process models has been mainly gathered from minutes of meetings, of which some were attended by one of the researchers. This information was verified by other documents such as provisions of permits and notifications by different governmental and municipal bodies, and contracts with contractors. Unclear or missing data was retrieved by interviews. We also checked a rough version of the process with the participants of a workshop with Duota. Some participants in the workshop were involved in the project and others experienced the process from the outset. Process data are analysed by using the Visual Mapping Strategy (Langley, 1999). Additional advantages besides narrative approaches are that they 'allow the presentation of large quantities of information in relatively little space, and they can be useful tools for the development and verification of theoretical ideas' (Miles and Huberman, 1994; Langley, 1999). We used the mapping of the incidents to verify our findings during the aforementioned workshop, in which the participants could reflect on it. We used Nvivo to code incidents within documents with one of the concepts described above.

Critical events were identified both retrospectively and actually. The part of the project that took place before this research started was recovered retrospectively by interviews and document review. Information on the part of the project that was executed in the duration of the research was retrieved by both document review and participating in project group meetings.

RESULTS

In this section we present the findings of the case study. First we shortly describe the reason for the redevelopment of Utopia. The development process including the critical events is depicted in a process flowchart. Then we outline on the different types of flexibility that we found and we link these types of flexibility to types of real options.

THE DEVELOPMENT OF UTOPIA

The building of Utopia exists of two parts: the original nursing home, the “Old Structure”, and the Somatic House, which are mutually connected. The Old Structure dates for a small part from 1967 and the rest from 1977. No large adaptations have occurred. The Somatic House has been newly built after demolishing of the old building in 1994. A part of the staff areas dates from 1977. In 2003, the most recent Long Term Housing Plan was written, a strategy formulation about the type of buildings and their capacity and how to reach this. Also under the new regime this is obligatory in order to keep control on the capacity. Some points of departure are formulated in the LTHP were the organisational vision is expressed in a strategy. After a technical and functional analysis of the whole building portfolio of Parrot, it appeared that among others the building of Utopia needed redevelopment.

The initiation- design phase took a long time and is still continuing, as can be seen in Figure 2.

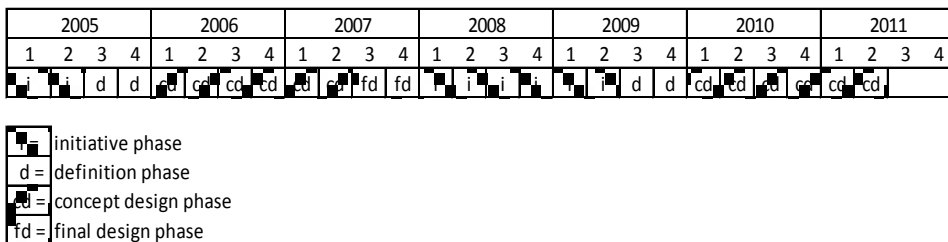


Fig. 2. Development phases of Utopia

In the Process flowchart below, the main critical events are depicted. They are arranged in the different areas in which also the different types of flexibility have been recognised. In the next section we describe what types of flexibility we found, which we link with different types of real options.

FLEXIBILITY AND REAL OPTIONS

Process flexibility We can identify different types of flexibility within the process, enabled by different real options. The main driver of flexibility is uncertainty. Most real options are realised because of uncertain development in the future, and exercised if there is more knowledge about that certain development. A major uncertainty comes from stakeholders outside the organisation, such as the government and the municipality. An important delaying factor in construction projects can be the change of the zoning plan for a certain area. Therefore, involvement of the municipality early in the process increases the probability that a permit request will be approved sooner. It is a process type of flexibility that creates flexibility in the planning of the project. The permit requests to the ministry and the municipality where critical incidents in the process, since they created the flexibility to continue with the development project, or not. Since there are mere alternatives, one can speak of a real option. The premium is the investment in the option. On the other hand, a permit limits flexibility when the zoning plan is changed, implying that the purpose for the area is fixed. However, in the Utopia case, the timing of the option, i.e. the request for the permit, had not been appropriate since after receiving the permit, the plan was changed and a new request had to be handed in. This will have a negative on the relationship with the municipality. However, negative effects can be limited by creating understanding by the municipality by keeping them informed about the decision making process.

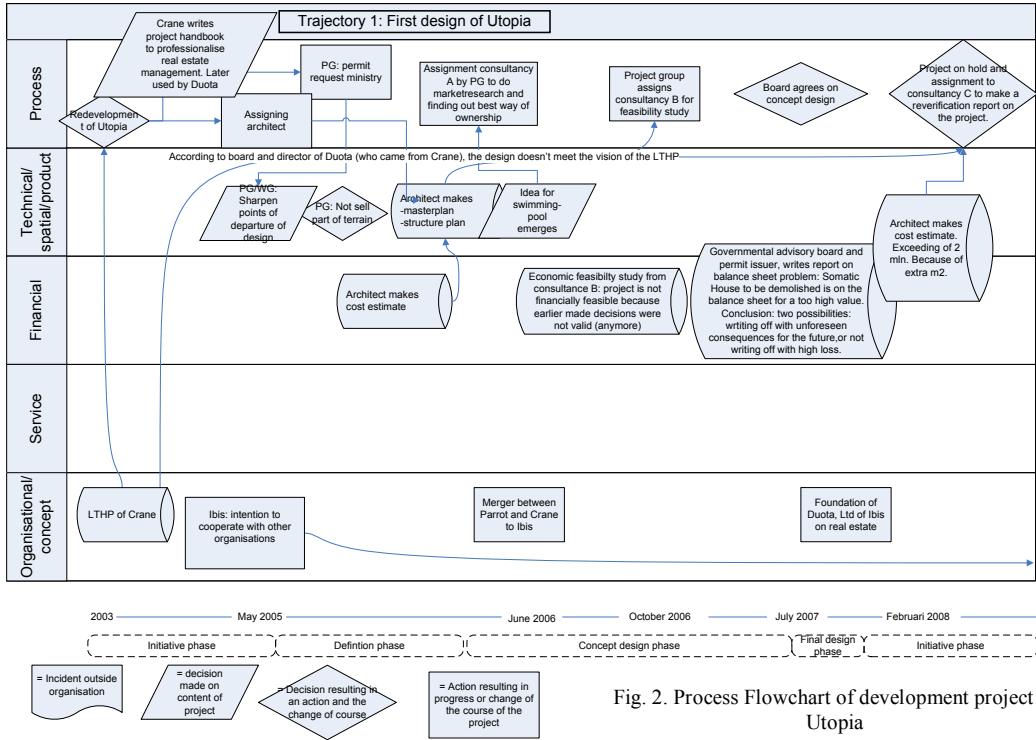
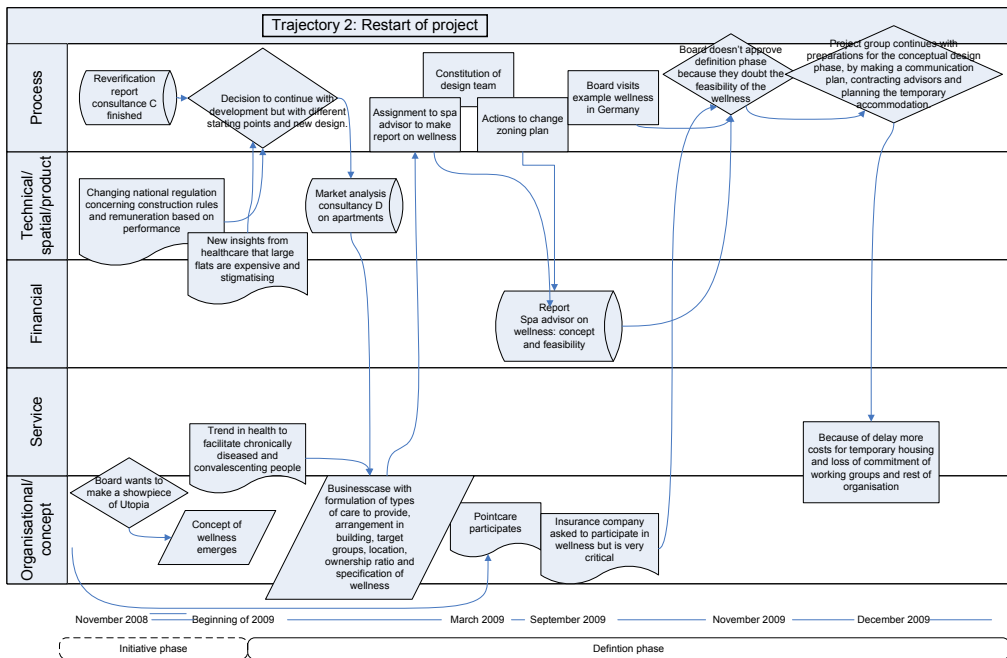
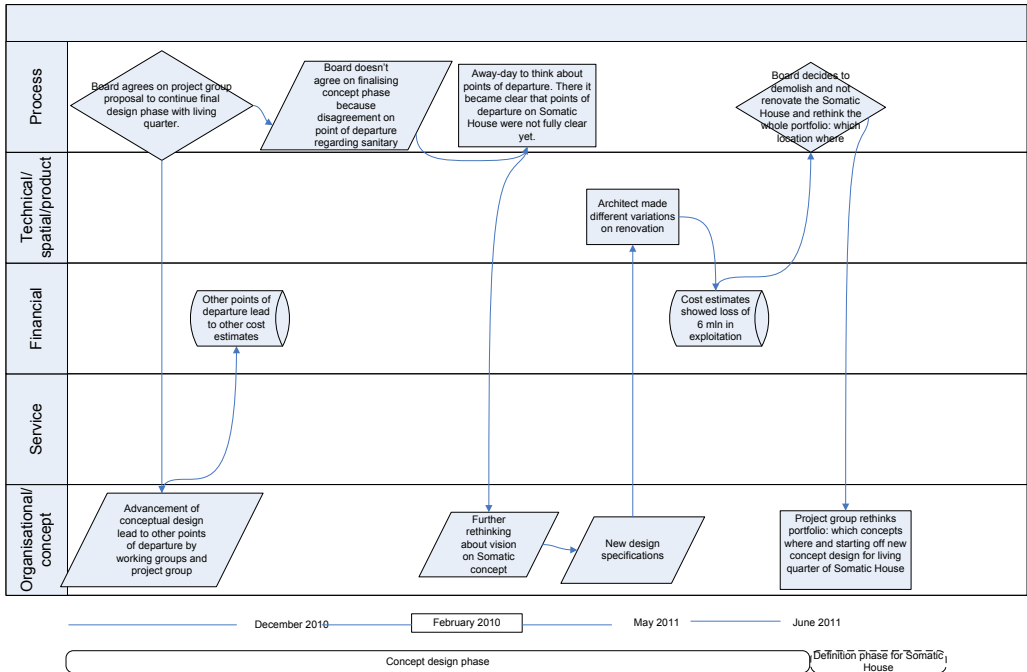
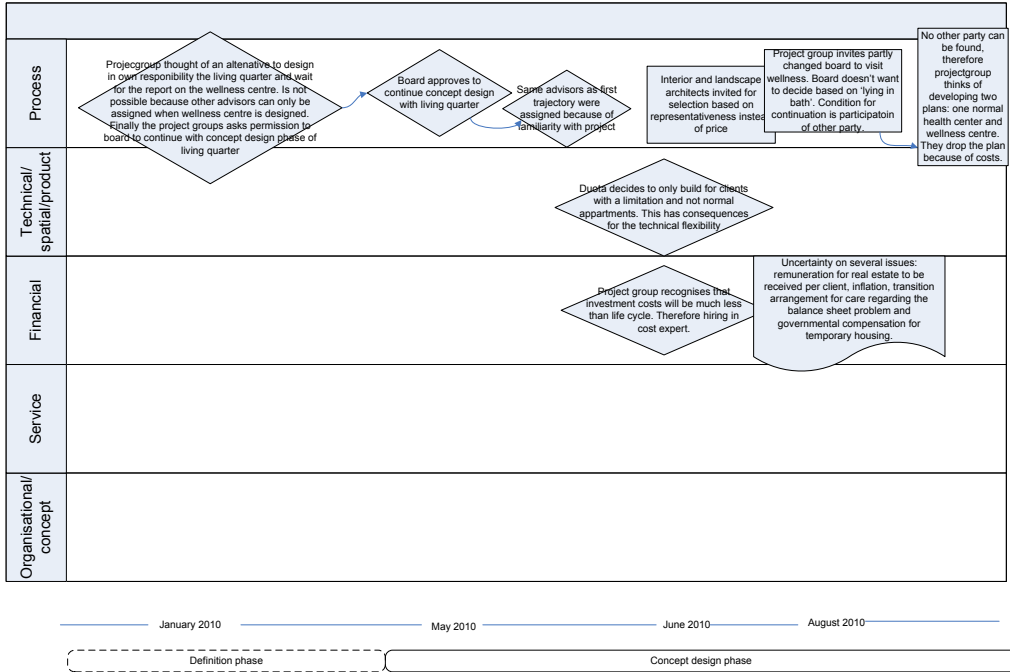


Fig. 2. Process Flowchart of development project of Utopia





The project, as are all projects of Duota, is phased. This creates stage options since after each phase there is flexibility to abandon or defer. A disadvantage is that procuring contractors after each phase costs time and contractors might take less advantage of each other's knowledge.

In the first trajectory which took place under the previous regime, a permit had to be obtained from the ministry as well. While disapproval could lead to serious delays, when it was approved it meant that funding was guaranteed and extra costs during exploitation were remunerated. Therefore flexibility to be more efficient was not an issue. When the governmental policy changed, stakeholders of Utopia decided to look more carefully at the financial and qualitative consequences of the project, leading to the reverification report. This is one example of uncertainty reductions in this process, as well as the report from consultancy A on real estate management and the feasibility study on the wellness centre. These all can be viewed as sunk costs, but as real option premiums as well, which would less probably have been made in a non-staged project since that was already a moving train. The investment resulted in more knowledge and change of the direction of the conceptual design phase, just before the project continued further and would be less flexible.

Investing in a concept design was also a real option, since during this process more knowledge was gained from the users about requirements of the design. Just as in investing time to let the users participate in the design process. This was done more elaborate in the second trajectory, also because of the involvement of another health organisation. This would have prevented changes later on in the process. Even though in the first trajectory the final design had nearly been finalised, the board still decided to abandon the project because more knowledge was gained about the feasibility and the costs of the project.

The project group proposed a select option, by developing two different conceptual designs of the wellness centre. They dropped this plan, but when considering the consequences they might have decided otherwise. The value of the select option would have been the prevented extra costs of adaptations in the design of the living quarter, and extra information on routing, logistics, the character of the concept that has to be present in the whole complex etc. Something similar was done by starting the concept design phase of the living quarter and wait for the design of the wellness. However, this cannot be recognised as a real option since no alternatives were developed and no additional investment had been done.

The project group invited different interior- and landscape architects, which created a select option: they could choose from different alternatives and also created more knowledge on what they actually wanted for their project. However, since comparison was based on the plans of the participants and not the costs of the project, one consultant objected that the plans could not be compared in that sense and probably not the best price will come out, which was determined after the selection. The project group didn't do this for the architect and electric – and heating advisors, since they saw advantage in their knowledge of the project. Creating a select option on this area would have been useful as well. See figure 4 for a summary of the findings.

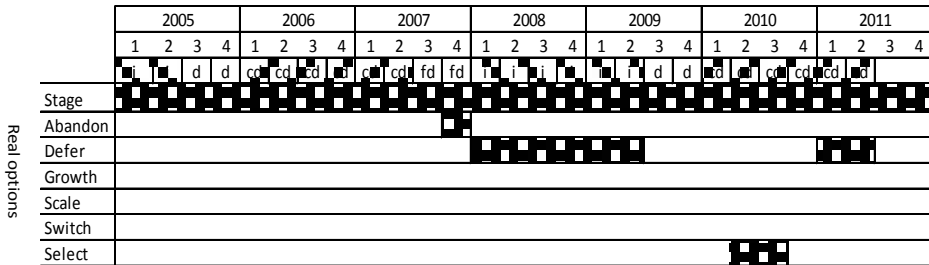


Fig. 4. Flexibility in the process within different project phases.

Technical flexibility. The final decision in the process to not renovate but demolish and reconstruct the Somatic House created more space for application of different concepts. This is both a growth and select option, related to external flexibility and scope (what) and internal flexibility (how). The writing off of the balance sheet value can be seen as the option premium, while the value of the option is the added value which will be repaid during the exploitation minus this premium. However, if the project group and the board had recognised this option, the long process of redesigning and calculating costs had been prevented, which was costly, time consuming and didn't create an option.

The project groups also added value to flexibility by means of the ability to convert function within the building, i.e. a switch option. Although the level of applicability was limited to a certain level, since a too flexible design which will never be used would be a waste of money and not worth the real option premium.

Related to the area, Ibis decided not to sell part of the terrain. This can be recognised as a spatial type of flexibility and a growth option. Although the zoning plan might have to change, it can also be a switch option since the area can be used for different purposes. This was made more concrete by consultancy A, who concluded that the design in the first trajectory was not marketable because of its monolithic appearance. A smaller design would be better, and the loss for places could be solved by other projects on the terrain, which would make the project financially feasible. Investing in changing the points of departure regarding urban planning, would also create added value because of the view and the connection with the other buildings in the neighbourhood, which is also a switch option in order to eventually change the function in the future. A summary of findings regarding technical flexibility can be found in figure 5.

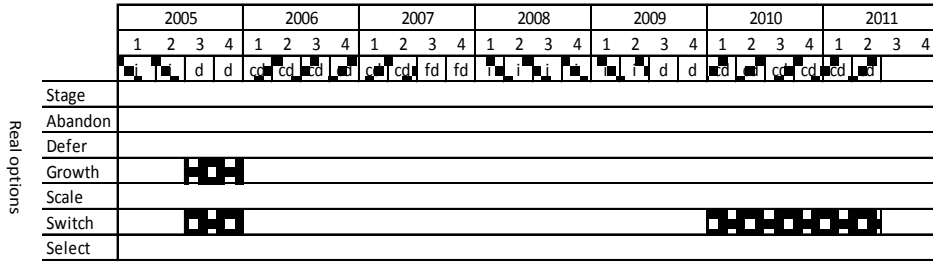


Fig. 5. Technical flexibility within different project phases

Financial-, service- and organisational flexibility. Concerning finance, there is little flexibility. The bank provided a loan, for the duration of five years based on a business plan. Change of the project also needs a new request for the loan. Service flexibility is not yet applicable in this project since no organisations have been appointed for this aim. Also regarding organisational flexibility, we could not find examples of this yet. Although the new design of Utopia requires adjustments to the way of working, there are no concrete plans regarding investing in capabilities of employees.

CONCLUSION AND DISCUSSION

This case study shows several real options within in the development of one construction project. Although the process might seem extraordinary with much reconsideration about the points of departure and requirements of the design, it appears that more construction processes in health are not that straight forward. In this section we will answer the research question. Nevertheless, some need of flexibility could have been reduced by already gaining more knowledge on uncertainties or lack of knowledge within the organisation, such as determining the primary process of the organisation, i.e. what type of care is delivered, how is it being done and how is that translated to requirements for a building. For that purpose, in 2008 Ibis appointed a policy co-worker.

The real option of stage is the most used real option in this case and enables flexibility in the process. The option to abandon and defer are in this case enabled by the stage option: after each phase it had been possible to abandon or defer the next phase. The option to select was considered but not applied because of the high costs. When considering this flexibility as a real option, the advantages of this flexibility had become more visible.

Other real options that have been applied relate to technical flexibility, on a strategic level. These were the option to grow and switch. We didn't recognise any real options related to financial and service flexibility, nor related to organisational flexibility, to which we neither could appoint real options based on literature. Table 2 shows what real options are found in the case study related to what types of flexibility.

Table 2. Real options found in the case study related to types of flexibility

Types of flexibility	Real options						
	Stage	Abandon	Defer	Growth	Scale	Switch	Select
Process	X	X	X				X
Product Technical/design, Spatial				X		X	
Financial							
Service							
Organisational							

We also asked the question what the consequences were of uncertainties on the timing and exercising of options. The main uncertainty in this case is the national policy change from remuneration based on re-calculation towards normative housing components, which requires real estate that is rentable over the life cycle. The stage option allowed deferment of the process to reduce the information gap by allowing time for more research on the project. Although postponement of the project had negative consequences for other stakeholders in the process, in the end probably it will result in a building that much more reflects the needs of the users and clients and is more resilient to future changes.

A major uncertainty for the project group, being the main problem owner in this research, was the board that approved continuation with the project. The stage option therefore was more an advantage for the board than for the project managers. Both real estate managers and directors of Ibis took place in the project group, which ensures that both the organisational as the real estate strategy are safeguarded and related, so in that sense no additional role had to be played by the board. It was already suggested during the process to more involve the board in the process, in order to prevent disapproval of the previous phase, because this leads to negative side effects as described above. Although this process design might add to the effectiveness, more could be done within the decision making process to make this, besides the real estate itself, more efficient as well.

This paper showed how flexibility can be enabled by real options. It adds to the body of knowledge on flexibility, which is still a broad concept. Using real options provides insight into the value of flexibility. Ford et.al. (2002) propose a simple method to value flexibility, which can also be applied in this case when real estate managers would like to have more insight into the monetary value of flexibility as ground for decision making. In this research we found some real options by analysing the project ex ante. However, we assume that if project managers and real estate managers are aware of the real options approach and apply it to their project, they will gain more insight into the

value of flexibility and will probably create more real options than we found in this first exploration.

Within the process, several times the consultancy made use of scenario's to depict the consequences of decisions. In combination with real options this would be a better method to gain insight into the need and value of flexibility, as proposed by Miller and Waller (2003). One can think of many uncertainties to happen. For convenience of comparison 3 different options should be worked out, as has been done in the example above. Miller and Waller (2003) propose to use the real options theory in combination with scenario planning. When using one or two extreme scenario's and one trend scenario with a qualitative description of uncertainties, decision makers will have a manageable overview of the uncertainties they have to deal with and which they have to consider in determining the real options.

This case shows that advantages of a traditional project delivery system where the project can be staged. However, literature shows advantages of integrated project delivery systems. Therefore it would be useful to analyse an integrated project process, to see what real options are available there. The case study in our research had not yet reached the construction and operation phase, therefore some real options such as related to technical flexibility, could not be evaluated. As well as other real options that we assume to be incorporated in other phases of the project. Such as real options in the area of service- and organisational flexibility which are more likely to be found in the operating phase. We didn't find proof for these types of flexibility since these are not an issue in the first stages of a traditionally arranged project. It would be useful to follow this project further or do case studies on projects which are in a more advanced stage and use different types of project coalitions.

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REAL ESTATE ADDED VALUE AND DECISION-MAKING IN HOSPITAL INFRASTRUCTURE

Johan van der Zwart¹

ABSTRACT

This paper explores the concept of adding value to corporate performance by real estate, and how this concept could be applied in decision-making processes for new hospital infrastructure. A literature review forms the starting point for interviews carried out with hospitals' CEOs on how real estate added value is perceived and used in design-related decision-making processes. A ranking of real estate added value as perceived by hospital decision makers is then made. While flexibility is often mentioned as an important added value, it is never given top priority. Confronted with added values from literature, the main objective seems to shift to organizational strategic objectives e.g. stimulating innovation, improving culture and increasing user satisfaction. The architectural designs of a number of hospitals are analyzed in order to investigate tools for assessing organizational objectives by using the concept of real estate added value.

KEYWORDS

architectural design assessment, corporate real estate management, healthcare real estate, hospital infrastructure, added value

INTRODUCTION

Corporate Real Estate Management is usually defined as the management of the real estate portfolio of a corporation by aligning the portfolio and services to the needs of the core business, in order to obtain maximum added value for the business and to contribute optimally to the overall performance of the organization (Dewulf, Krumm, & De Jonge, 2000). This definition refers to the notion that real estate can add value to the overall corporate performance, or in other words, that real estate has an added value. Different authors have addressed possible added value of real estate (Van der Voordt & Van der Zwart, 2011). The main research question of this paper is how the concept of adding value by real estate is perceived and used by hospital decision makers. Insight in added value of real estate can be gained by comparing different lists, definitions, strategies and objectives from literature. This comparison will be used to define the added value of real estate that are further on discussed with CEOs of hospitals.

ADDING VALUE BY REAL ESTATE

In 1993 Nourse & Roulac listed possible interventions on how real estate could be linked to corporate business processes. Since then, De Jonge (1996), Lindholm (Lindholm, Gibler, & Leviäinen, 2006), Scheffer et al (2006), De Vries (2007; De Vries, De Jonge, & van der Voordt, 2008) and Den Heijer (2011) have contributed to research

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on this topic. The different types of added value of real estate that result from this research are partly overlapping. Nourse and Roulac (1993) and De Jonge (1996) provide definitions of added values of real estate, Lindholm (2008; Lindholm et al., 2006) and Den Heijer (2011) use also descriptions to clarify the added value. All these authors give examples of possible real estate strategies connected to the added value. Besides this, Lindholm (2006) and Scheffer (2006) also give measurable objectives.

Table 1. Lists of added value of real estate

Nourse & Roulac 1993	De Jonge 1996	Lindholm 2006	Scheffer et al 2006	De Vries 2008	Den Heijer 2011
Real Estate Strategies	Added Values	Real Estate Strategies	Added Values	Real estate added values	Added values of Real Estate
Occupancy cost minimalization	reduce cost	reduce costs	cost reduction	reducing costs	decreasing costs
Facilitate and control production, operations and service delivery	improve productivity	increase productivity	increasing productivity	increase productivity	supporting user activities
	improve culture	increase employee satisfaction	changing the culture	increasing satisfaction	increasing (user) satisfaction
improving culture				improving quality of place	
Facilitate managerial proces and knowledge work		increase innovation	stimulating innovation	stimulating collaboration	
Promote sales and selling proces	marketing	promote marketing and sale	PR and marketing	supporting image	supporting image
promote marketing message					
Flexibility	increase flexibility	increase flexibility	increase of flexibility	enhancing flexibility	increase flexibility
Capture real estate value creation	improve availability of finance (increase of value)	increase value of assets	increase of value	expanding funding possibilities	increase real estate value
	risk management		risk control	controlling risks	controlling risk
					reducing ecological footprint

Table 1 gives an overview of the different types of added value of real estate. This table shows that the original eight alternative real estate strategies by Nourse and Roulac have been redefined over the years into real estate added value. Other types of added value are combined or split up or have been added new to the list. ‘Promote Human resource objectives’ is divided between ‘improve productivity’ and ‘increase employee satisfaction’. ‘Facilitate managerial process and knowledge work’ is divided into ‘increase innovation’ and ‘improve culture’. ‘Promote marketing message’ and ‘promote sales and selling processes seems to be combined into ‘promote marketing and sales’ and later into ‘support image’. As can also be seen in table 1, nine types of added value are mentioned by most authors. These are: (1) reducing costs; (2) improving productivity; (3) increasing user satisfaction; (4) improving flexibility; (5) supporting image; (6) increasing innovation; (7) improving culture; (8) controlling risks and (9) improving the financial position. Table 2 gives an overview with the definitions and the categories derived from literature. These 9 categories are used later in the paper to structure the analysis of the case study interviews.

Table 2. Nine types of added value of real estate defined from CREM literature

		Lindholm	De Vries	Jensen	Den Heijer
		2006	2008	2010	2011
		Maximize shareholders wealth	Performance for Stakeholders	Impact on core business	CREM stakeholder model
reduce costs	To reduce investment costs, capital costs, operational costs and other real estate related costs.	profitability growth	profitability	economy	controller
improve productivity	To increase production with the same amount of resources for production through a more effective use of real estate.	profitability growth	competitive advantage	process	user
increase user satisfaction	To create functional, pleasant and comfortable places for visitors, consumers and employees.	revenue growth and profitability growth	productivity	people	user
improve culture	To improve interpersonal relations and communication by real estate.		competitive advantage	people	policy maker
increase innovation	To stimulate renewal and improvement of primary processes, products and services by real estate.	revenue growth	productivity	process	policy maker
support image	To expose corporate objectives by using real estate as an icon for the organizational culture.	revenue growth	competitive advantage	people	policy maker
improve flexibility	To structure a real estate portfolio in a way that future spatial, technical, organizational and juridical adjustments are possible.	profitability growth	profitability	process	user
improve finance position	To attract external financing to reinvest in the primary process or to improve the overall financial position of the organization by regarding real estate as an asset.	revenue growth	profitability	economy	controller
controlling risks	To anticipate on future real estate related technical and financial opportunities and risks.		profitability	process	controller

RESEARCH METHOD

These types of nine added value were starting point for interviews carried out with hospitals' CEOs on how real estate added value is perceived and used in design-related decision-making processes. A ranking of real estate added value perceived by hospital decision makers was then made. Although other stakeholders (e.g. insurance companies, clinicians and patient representatives), play an important part in the decision-making process of new hospitals, the chosen main perspective of this paper is that of hospital CEOs and project managers. They are perceived to be the key decision-makers who have to weigh all the different stakeholder perspectives to come to final decisions in the design process of healthcare buildings. In order to select appropriate respondents, a selection of cases was made in search for heterogeneity on three characteristics: 1) general, top clinical and academic hospitals; 2) size in number of beds and turn-over; 3) position in the building process (i.e. initiation, briefing, design, construction, or use – see Table 3). The selected cases represent approximately 10% of all Dutch hospitals and 50% of all Dutch hospitals that were/are planning or building a new hospital in 2004-2012.

Table 3. Characteristics of the cases

	place	code	category	size	beds	m2	phase	respondent
Geire Ziekenhuis	Zutphen	GZ	general	S	217	26.500	use	CEO
Gemini Ziekenhuis	Den Helder	GD	general	S	244	25.000	initiation	manager
Vlietland Ziekenhuis	Schiedam	VS	general	M	421	55.000	use	CEO
Deventer Ziekenhuis	Deventer	DD	top clinical	M	390	55.000	use	CEO
Reinier de Graaf Gasthuis	Delft	RD	top clinical	M	397	55.000	initiation	manager
Albert Schweitzer Ziekenhuis	Dordrecht	AD	top clinical	L	475	n.a.	construction	manager
Meander MC	Amersfoort	MA	top clinical	L	600	75.800	construction	manager
Maasstad Ziekenhuis	Rotterdam	MR	top clinical	L	620	84.000	construction	CEO
Erasmus UMC	Rotterdam	ER	UMC	XL	1320	n.a.	construction	manager
UMC Groningen	Groningen	UG	UMC	XL	1097	n.a.	use	CEO

Before each interview, background research was carried out for each case, including public documents available on the internet. The semi structured interviews comprised two main parts. Firstly there was an open interview, where respondents were asked which values were, or are, taken into account in the real estate decision-making process. In the second and more structured part of the interview, the respondents were asked to prioritize nine types of added value derived from literature that were presented on little cards. After this ranking assignment, the respondents were asked how these types of added value are visible in the (design of the) hospital building. After the interviews transcripts were made of the recorded interviews. These transcripts were summarized and sent back to the respondents for feedback.

RESULTS

The research findings are presented in two steps. First (a) a cross-case analysis of prioritized values, from 1 (highest) to 9 (lowest) is given. Secondly (b) accommodation choices supporting adding value are brought together by decoding the transcripts on the nine previous defined fields of adding value by real estate and comparing these descriptions with the definitions from literature.

a) *Prioritizing added value*

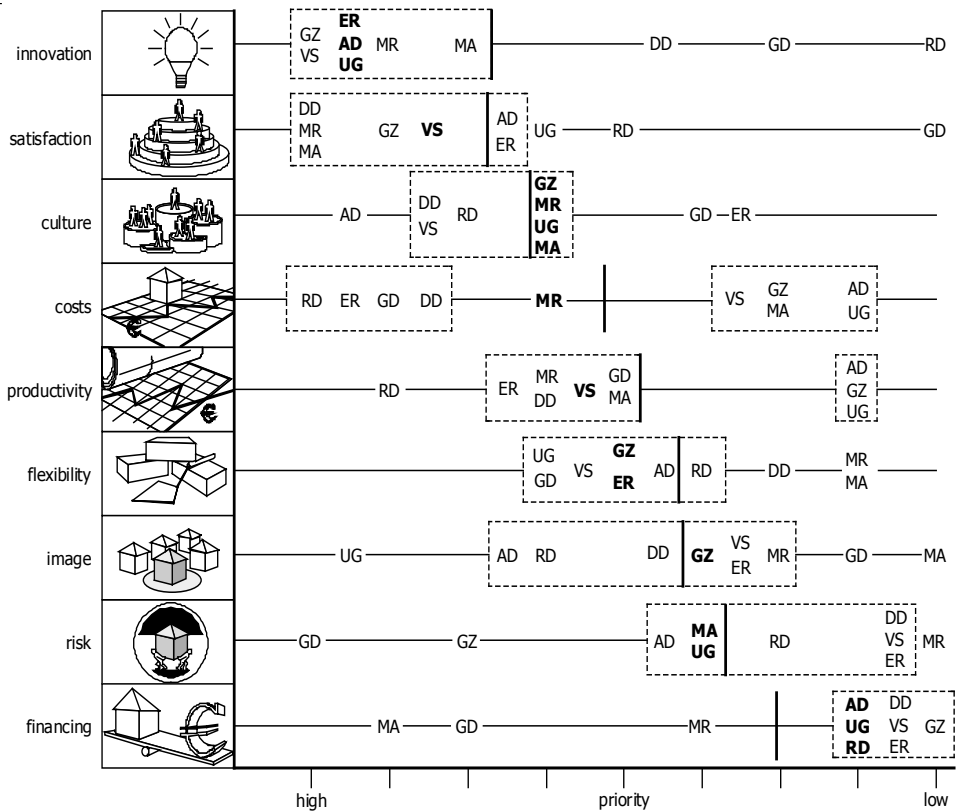
The results of prioritizing the nine types of added value by CEOs and project managers of ten hospitals are presented in figure 1. The horizontal axis is scaled from 1 = highest priority to 9 = lowest priority according to the respondents. The nine types of added value are presented on the vertical axis of the diagram. Next to these different types of added value, the priority ranks are plotted of all interviewed hospitals with their names abbreviated according to table 3. When two or more types of added value were given the same priority, they received the same average rank. The dashed-lined boxes cluster the most frequently given answers, usually showing a maximum of three exceptional ranks per added value type. The bold vertical lines show the average ranking per added value. The bold abbreviations show the hospitals with a median ranking for that particular added value. The types of added value on the vertical axis are ordered from the highest median rank (above) to the lowest median rank (below). If two types of added value share the same median, the average was used to choose the priority rank.

Figure 1 shows that supporting innovation, increasing user satisfaction and improving the organization’s culture are generally highly appreciated as added value by hospital decision makers. Cost reduction is highly prioritized by four respondents, but not ranked

as very important by five other hospitals. Because of this variety, the average rank is not very representative to express the different thoughts. Increasing productivity, optimizing flexibility and supporting corporate image are prioritized in the middle. Risk control and increasing financing possibilities are usually given low priority.

One hospital (GD) ranked the priorities of the nine types of added value almost opposite to (clusters of) most other answers. This hospital is currently planning a new hospital according to the so-called living building concept (LBC), a new form of Public Private Initiative. This leads to a preliminary hypothesis that building phase (initial; design / construction and exploitation phase) seems to influence the priority that CEOs give to the added value. Added value connected to the physical building (image, controlling risks and flexibility) is often higher in the initial/design phase; in the exploitation phase more organization-related added value (stimulating innovation, improving culture and user satisfaction) seem to gain importance.

Fig. 1. Plot diagram of ranking prioritized real estate added value



b) Added values of hospital real estate

Each paragraph in this chapter firstly describes one type of added value based on the literature review, and secondly descriptions are presented of that added value resulting from the interviews.

INCREASING INNOVATION

Organizations in competitive markets are depended on innovations to survive and grow. These organizations need to provide workspaces that encourage and support innovative thinking and working. This requires the participation of the space users in planning spaces and providing the type, size, and design of workspace that creates an inspiring working atmosphere (Lindholm et al., 2006). Another possible real estate strategy is to emphasize knowledge work settings over traditional industrial paradigm (Nourse & Roulac, 1993). Also part of this strategy could be adding to ‘serendipity’: unintentionally making discoveries or finding new solutions by interference of others that results from planned and unplanned encounters between users (Den Heijer, 2011).

In the interviews hospital managers recognize stimulating innovation as the most important added value of real estate. Innovation is a continuous process of optimizing healthcare services for the benefit of patients. Hospitals are knowledge intensive environments where innovation can be stimulated by real estate if places are created where medical staff can meet. Most hospitals create meeting places such as a knowledge centre, study centre, or skills lab. Another real estate intervention to stimulate innovations is the spatial integration of different types of cure and care, but the present financing system with separate funding streams is mentioned to be an obstacle here.

INCREASING USER SATISFACTION

This added value is extra important in a labor market with many competitors (Den Heijer, 2011). User satisfaction is seen as a possibility to enhance profitability; many firms in a range of industries have recognized this indirect path to profit (Lindholm et al., 2006). By offering functional, pleasant and comfortable working environments with the requested level of amenities, the architecture of workplaces can lead to a lower staff turnover. From the perspective of real estate management it is important to react adequate to users’ requests. Also the choice for a good accessible location with an area of high quality of living for staff is a possible strategy.

In hospitals, it is not only patient satisfaction that is important: visitors, staff and personnel need to be considered. Therefore, this added value may be split up in satisfaction of consumers (potential customers of the hospital), customers (people that come to the hospital to visit a patient) and patients on one side and staff on the other side. Customer value increases in importance as added value in hospital real estate. Besides processes in which patients are central, there are also processes in which the healthcare process is central, or as reported by several respondents: it is in the best interest of patients if healthcare processes are well organized.

Patient satisfaction is connected to well being and concepts like healing environment and planetree, employee satisfaction results from an attractive and inspiring working environment. Places where patients stay deserve extra attention in materialization, important aspects are safety, visibility by personnel, daylight, use of color, orientation in the building, privacy and architectural quality of spaces. A central waiting concept can contribute to better waiting facilities. In this concept, patients are notified ten minutes before an appointment to go from the central waiting room to the decentralized small waiting rooms near the consultant rooms. Also single bed rooms contribute to patient satisfaction. Privacy and healing environment that result from single bed rooms are often mentioned as beneficial, as well as less bed movements and disturbance by personnel.

Most respondents emphasize that good staff with excellent medical skills and a customer-friendly attitude and behavior are of utmost importance. Happy employees make happy patients. Therefore good facilities for staff and healthcare professionals are important as well. Staff satisfaction depends on consult rooms, treatment rooms and separation of front-office and back-office; short walking distances and daylight.

IMPROVING CULTURE

De Jonge (1996) defines improving culture as using real estate as a means of effecting cultural change and improve interpersonal relations. This also relates matching the use of the real estate with the organizational or corporate culture (Den Heijer, 2011). This could be done by offering alternative working situations. Office concepts like an open floor plan or flexible workplaces could improve communication in the organization.

Though culture is merely a matter of shared values and behavioral rules focusing on high quality care, reliability and customer-friendly behavior, (changing) culture can also be supported by real estate. One interviewee mentioned that real estate is regarded as the outboard engine of the organization: creating another working environment changes the culture of the organization. Stimulating encounters between medical staff is seen as an important added value of real estate on the organization's culture. This can be done by paying extra attention to places where medical staff and personnel can meet and change information. Almost all newly built hospitals have introduced a front-back-office concept. Front offices are the examination, treatment and consulting rooms where specialists meet their patients, the back offices are the places where healthcare professionals do their deskwork. These back offices are mostly located besides or above the polyclinics, where most of the front offices are. For the back office different office-concepts are used, like office-boxes where each specialist has an own desk; desk sharing in an open office landscape or; flex-workplaces, where specialists have no own desk.

REDUCING COSTS

Nourse and Roulac (1993) describe 'occupancy cost minimalization' as the lowest cost decision, cost effective for quality space sought. Den Heijer (2011) refers to cost reduction not only to real estate costs, but also to overall costs or personnel costs, when a concept adds to a higher production or a lower percentage of absence. Reducing costs in any area has a direct and immediate impact on the financial position of the

organization (Lindholm et al., 2006). Creating insight into cost structure (De Jonge, 1996) and minimizing of life cycle costs, acquisition costs, operational costs, financing costs and other real estate related costs (Lindholm et al., 2006) are useable strategies for reducing costs as added value of real estate. Other possible strategies are outsourcing of real estate services; using corporate real estate expertise in real estate transactions of business units; centralization of activities; architecture of facilities with low exploitation and maintenance costs; efficient use of available space and periodical maintenance of the buildings in order to avoid unexpected high renovation costs. Investment in sustainability, leading to lower energy use for heating and cooling the buildings, can also be part of reducing costs as added value.

Since the introduction of the regulated market system in the Netherlands, reducing life cycle costs and total costs of ownership has become more and more important. Reducing costs of hospital real estate focuses on controlling investment costs and real estate related costs. Real estate measures to stimulate cost reduction include co-operation in building, design and management of hospital real estate with other care organizations and commercial parties, new ways of contracting such as Design and Build, or DBFMO (Design-Build-Finance-Maintain-Operate), strict space budgeting and space reduction by shared workplaces. This includes choosing an investment level that fits to the scale of the building. This is done by making life-cycle-costs, including long term real estate costs for maintenance, energy and facility, visible in business plans; slim-fit buildings with no more square meters then necessary and; strict budgeting of square meters per department. Quite often extra investments are needed to reduce life-cycle-costs of the building, e.g. sustainable measures in order to reduce energy consumption. Used energy-saving methods are underground cold-warm storage and activating the concrete construction for cooling and heating the hospital building. Decreasing investment costs is done by making slim-fit plans. Instead of building more square meters for future flexibility, future developments are anticipated upon by incorporating possible expansion possibilities to the building plans. These expansions can be presented later as separate business cases.

IMPROVING PRODUCTIVITY

Improving productivity will lead to increased profitability (Lindholm et al., 2006). This added value combines two alternative real estate strategies: 'Facilitate and control production, operations and service delivery' and 'promote human resource objectives' (Nourse & Roulac, 1993). The main objective of improving productivity as added value is to create 'efficient environments to enhance productivity and greater efficiency' and 'control of operations aligning to the corporate strategy' (Nourse & Roulac, 1993), or in other words: 'use real estate as a means of working more efficiently' (De Jonge, 1996). This could be done by increasing production by the same available space and/or the same production with less space. Possible real estate strategies are offering adequate accommodation by architecture and floor-plans that support primary processes and location choice that support business objectives. Possibilities and consequences of Information and Communication Technology (ICT) plays an important role in improving productivity by real estate. Real Estate management is focused on good maintenance in order to avoid disturbance of the primary processes. Lindholm (2006) states that real estate and facilities decisions influence a number of personnel and

system factors, which influence the level of productivity of the individual and, subsequently, the level of productivity of teams and the profitability of the organization (Lindholm et al., 2006). Improving productivity is also connected to user satisfaction as added value, as several researches show that the working environment of employees also has impact on productivity. In this aspect, important objectives are: individual control on indoor climate; quiet workplaces; individual workplaces; visual attractive working environment and, last but not least, daylight and a window view outside. Therefore Den Heijer (2011) proposed to change this added value into ‘supporting user activities’, which could refer to increasing production or satisfying employees to make them more loyal to the organization but also to improving product’s and service’s quality by optimally supporting the primary process by real estate.

The main organizational objective behind increasing productivity as real estate added value in hospitals, as reported in the interviews, is ensuring that healthcare professionals can do their work as efficient as possible. This includes optimally facilitating medical care processes and supporting activities by spatial clustering of departments and centralization of the high technological functions in a hot floor. Another way to increase productivity is found in the use of a front-back-office concept. In this concept consult and treatment rooms are the front offices in which the doctors and patients meet, separated from the back offices in which the doctors do their desk work. This has to be supported by Information and Communication Technology (ICT) that makes place and time independent access to digital data possible. Combined consult and treatment rooms on the other hand lead to decrease of productivity because healthcare professional have to wait while patients (un)dress. Also expanding opening hours is reported as a possibility to increase productivity of real estate capacity.

Separating patient and personnel streams from logistical streams also contributes to increasing productivity. Separate logistics makes just in time delivery possible with decentralized storage facilities. Besides logistics of goods, also patient types have to be considered. Dividing patients in different groups (e.g. acute, urgent, elective and chronic) contributes to a clear building layout in which patients can easily find their way. Locations with high flow rates near the entrance avoid unnecessary patient flows within the building.

Also healing environment and single rooms can contribute to increased productivity due to shorter stay of patients and more efficient use of capacity. Single person bedrooms evoke fewer infections and speed up the healing process that might shorten the average stay in hospital. It also avoids problems of empty beds due to difficulties in mixing people with different cultural backgrounds or different gender. One hospital calculated that extra investments in real estate that are necessary for single person bedrooms, are reimbursed by decreasing the average stay from 5.2 until 4.8 days.

IMPROVING FLEXIBILITY

A strategy of increasing flexibility may include both physical workspace and financial terms. Many organizations form and reform work teams within their offices on a regular basis (Lindholm et al., 2006). Organizational, legal, spatial and technical flexibility of real estate contributes to minimizing occupancy costs over the long run (Nourse &

Roulac, 1993). Legal flexibility is the choice between ownership, lease or rent of real estate and the subsequently possibilities of alteration and disposal of surplus square meters. Spatial flexibility is the physical adaptability of the building in external expansions or internal alterations of the floor-plans. Technical flexibility is the possibility to change the building installations and construction. Organizational flexibility is alterations in primary processes in order to make a more efficient use of the available real estate. Examples of organizational flexibility are opening hours, flexible use of workspace and innovative office concepts. Increasing flexibility also includes real estate interventions that implement more standardized space or more flexible multi-functional or multi-user concepts without individually territory or exclusive use for certain groups (Den Heijer, 2011). Lindholm (2006) states that some operating decisions that would follow from a flexible real estate strategy include choosing spaces that can be adapted to multiple uses and workers, creating flexible workspaces within the structures, negotiating short- term leases including options for expansion and contraction, and leasing rather than purchasing properties that are not essential to the core business (Lindholm et al., 2006).

Flexibility has to ensure that a hospital building is able to support changing business processes for at least 40 years. This means a robust building with construction measures that make different layouts possible. This has large consequences for the installation technology in the building that should be adaptable to these different layouts by using installation cable free walls when ever possible. Real estate measurements include standardization; multifunctional use of space; a clear separation between the supporting structure and fill-in, because of their different life cycles; extra power of load-bearing walls and floors, in order to cope with future functions; easy-to-adapt bed rooms (from a two bed room in two one bed rooms and vice versa) and; facilities that make an enlargement of the building easily possible. The organization of people is the most flexible factor in a hospital building, sharing consult, treatment and wards between departments are examples of organizational flexibility. Multi-functional and generic consultant rooms and a standardized back-office make this exchangeability between departments possible. Although flexibility is a very important issue in the initiative and design phase, after realization of the building it is seen as given fact that supports other organizational objectives like increasing productivity or user satisfaction.

SUPPORTING IMAGE

This added value combines two alternative real estate strategies by Nourse and Roulac (1993): ‘promote marketing message’ and ‘promote sales and selling processes. It is seen as physical institutional advertising (Nourse & Roulac, 1993) by exploiting the positive impact of real estate as a symbol of the organization (De Jonge, 1996) to express organizational objectives and culture. In terms of “practicing what you preach”, supporting image is usually closely linked to the organization’s primary goals, for instance by emphasizing the innovative, creative, sustainable or exclusive character of an organization (Den Heijer, 2011). Lindholm (2006) states that accessibility and visibility are key issues to attract customers and increase revenues. Physical design can be used to create an image for the company among its suppliers, employees, customers, and investors, an indirect way of adding value to the organization (Lindholm et al.,

2006). Possible real estate strategies are standardizing of the corporate identity, location choice and architecture that supports the corporate identity.

Although a hospital as an institute has a strong image on its own, many interviewees recognize that good architecture can contribute to the image of a hospital. Marketing by real estate is merely managed by steering on a nice and easy to access location in a lively and safe environment; a pleasant overall appearance; an attractive “healing” environment with a high percentage of one bed rooms; nice colors, materials and light and; nice facilities, in order to improve patient satisfaction and as a consequence to improve competitive advantage. This image is not only external for patients and consumers, but also internal for medical staff and employees. Some hospitals use pictures from their building as a marketing tool in personnel advertisements. Most interviewees report that patient should feel at ease soon, but how this could be done diverse into two directions. On the one hand, it is mentioned that a hospital should not look like a hospital, but more like comfortable known environments like houses or shopping malls. This is related to the planetree concept in which a hospital tries to give patients some of their house-like recognizable environment back. On the other hand, interviewees mentioned that a hospital should be recognizable as a hospital, a place where patients should feel free to walk in the main hall with their infuse palls to the restaurant.

CONTROLLING RISK

Real estate comes together with financial risks due to its relative long time horizon and large investment. These risks can be controlled by opting for different forms of tenure with mix of ownership, rent and lease and; monitoring of the local real estate market, human resource market and other contextual factors like legislation and regulation. Possible strategies are making space available for third parties and selecting suitable locations. Besides financial risks that can be controlled by being able to easily adjust the size and character of the real estate portfolio, Den Heijer (2011) refers also to controlling technical and functional risks by carefully monitoring the technical condition to make sure that primary processes are not hindered.

Real estate related risks are controlled by hospitals in different ways. This added value is least discussed and is mainly managed by real estate choices improving flexibility and marketability, a well elaborated business case and outsourcing of maintenance for a long period. The most mentioned way of controlling risks are slim fit buildings with no more square meters than necessary with expansion possibilities based on new business cases in the future and creating generic square meters that can be used by different departments or can be led to third parties if internal demand decreases. To control risks, some hospitals have brought their real estate under a separate Private Limited Company. External polyclinics are mostly rented, to be flexible in the future. Also longer opening hours in order to optimize the available capacity to avoid expanding the building is mentioned.

Besides these real estate risks, also risk reduction in the healthcare process is mentioned as added value of real estate. Timely renovation or rebuilding the hot floors, good

maintenance on technical installations and air control are necessary to avoid cross infections between patients and other medical risks in the future.

IMPROVING THE FINANCIAL POSITION

Here real estate is seen as a capital asset that can contribute to optimizing the organization's overall financial position. The objectives may be to maximize the value of the property portfolio or ensure that the lowest cost alternative is chosen considering all short - and long - term costs of owning versus renting (Lindholm et al., 2006). This includes also all real estate interventions that aim at resulting in a higher potential (market) value of land and buildings (Den Heijer, 2011). Profitability can increase by reinvesting surplus value of real estate in the primary process of the organization. Possible real estate strategies include way of financing real estate, location value with an acceptable current location and real estate value with current architecture, sale-and-lease-back, timely purchase and sale of real estate and redevelopment of obsolete locations (De Jonge, 1996), making buildings rentable and marketable to third parties, suitable for external (paying) users or by acquiring land on valuable locations in the real estate market (Den Heijer, 2011). However, proper management of the company's portfolio must start with an inventory and valuation of current facilities, then management via a property information system (Lindholm et al., 2006).

Hospitals are built for delivering healthcare and not for increasing finance possibilities by real estate. A choice has to be made between optimizing the healthcare process during the functional lifespan or marketability in the future. This means that a hospital building is not regarded as an asset by most interviewees, but more as a resource for production. The layer approach that divides the function package of a (general) hospital according to building typology into four layers - hot floor, hotel, office and industry – with a focus on marketability of the different layers, is only partly used in newly built hospitals. Small hospitals seems to be more focused on marketability of the real estate then larger hospitals; although the profitability of the layer approach is lower in the case of small hospitals. Larger hospitals have a more functional and architectural perspectives on the layer approach, dividing a hospital in different parts that are installation technical and constructively different. Although there is a lot of skepticism on the end value of hospital real estate after 40 or 50 years, location value may be a possibility to increase the finance possibilities of the organization. Location value can be created by developing the urban area around a hospital with other parties (e.g. a healthcare boulevard). If this strategy is used, a hospital should be willing to relocate somewhere else, to be able to capture the location value in the future.

DISCUSSION

The qualitative approach of this research – using semi-structured interviews with open questions – delivered much information on how different types of real estate added value are perceived by hospital managers and how they are prioritized in hospital real estate decision-making. The results contribute to a better understanding of adding value by real estate and the values mentioned in literature, in general and specifically for the healthcare sector. Although quantitative concepts have been used to summarize and interpret the research findings - modus, mean, average, a plot-box - these results should

be regarded as qualitative data as well. As the priority diagram (figure 1) is a representation of only ten separate configurations, this diagram is not more than a first exploration of priority clusters. The validity of the results can be improved by conducting more interviews and organizing expert meetings to discuss and compare individual rankings. The same methods could be applied in other sectors like office organizations or higher education in order to explore similarities and dissimilarities in different fields.

A practical implication of this research is that it helps hospital decision makers to translate their organizational objectives into real estate goals. The research findings show that it is of utmost importance that added value is clearly defined in literature and made applicable to a certain sector. Current heterogeneity of the added value is visible in the different categories of added values derived from literature (table 2). This heterogeneity is a result of the attempts to categorize the different types of added value or to connect these values one-to-one to a specific stakeholder. Another concept could be defining different perspectives on each added value. Following Den Heijer's CREM stakeholder model (2011), four perspectives on the added value of real estate could be defined: (1) strategic; (2) financial; (3) functional and; (4) physical. This concept is shown in table 4, in which these four perspectives are used to describe and summarize the perception of the added value of real estate by hospital decision-makers that result from the interviews. The balance between these perspectives make that one added value could be logically connected to a certain stakeholder, but not necessarily. If a certain type of added value gains in importance in time due to changing circumstances, it could transfer to the more strategic perspective of the policy maker.

What can also be learned from this paper is that in cases of a service organization like hospitals, *user satisfaction* as real estate added value may be better split up into *employee satisfaction* and *customer satisfaction*, or more specific to the healthcare sector, *patient satisfaction*. Although *stimulating innovation* is highly appreciated as added value of real estate, in the given descriptions it seems to be largely overlapping with *improving culture* as added value. This arises the question if *stimulating innovation* is a separate added value or that it could be perceived as part of *improving culture* as added value, with the specific goal of stimulating a culture where innovative processes arise. As many respondents referred to *controlling risks* as avoiding accidents in healthcare delivery, an added value that could be added to the list is *improving safety* as risk reduction in the primary process.

Table 4. Perspectives on hospital real estate added value

Perspectives on real estate				
	Strategic	Financial	Functional	Physical
	adding value to organizational goals: how and to what extent are strategic organizational objectives achieved or obstructed ?	value, resources and costs: what are consequences on financial impact on resources, real estate value, and life cycle costs?	fitness for use: how and to what extent is the user's functional primary process supported or obstructed?	(im)possibilities of real estate: physical consequences of real estate.
increase innovation	. As added value highly prioritized		. Innovation as a continuous process of optimizing healthcare services . ICT patient information	. Places for medical staff to meet each other . Facilities like skill slabs and knowledge centers
increase user satisfaction	. Attracting and retaining good personnel . Human in general is central	. Extra investment in real estate for healing environment	. Well being of patients . Planetree concept . Central waiting concept . Processes where medical process is central versus processes where patient stands	. Architectural quality of patient rooms
improve culture	. Real estate as the outboard engine of the organization		. Front/back-office concept . Office concept (flex working, desk sharing or boxes)	. Paying attention to places where people can meet.
reduce costs	. Investments based on business plan . No more square meters as necessary . Future expansions based on new business plans	. Investment level that fits the scale of the building . Controlling investment costs and real estate related costs	. Space reduction by shared workspaces . Strict budgeting of space per department	. Life cycle costs including maintenance and energy . Sober plans with slim-fit buildings
improve productivity	. Ensuring that healthcare professionals can do their work as efficient as possible	. Yearly space budgeting per department based on production and turnover	. Optimally facilitating the healthcare processes . Front/back-office concepts . Healing environment . Single person bedrooms	. Centralization high technical functions in hot floor . Separating logistics from patient and personnel streams
improve flexibility	. Supporting changing business processes during the lifespan of the building	. Extra investments in future flexibility . Pre investments in expandability	. Adaptability . Multi functional use of space . Sharing consultant and treatment rooms, wards and other facilities . Standardizing spaces . Flexible office concept	. Robust building that makes different layouts possible . Separated technical installations . Standardization . Supporting structure and fill-in . Expanding possibilities
support image	. Improve competitive advantage by using the building as a marketing tool, both for (potential) patients as employees	. Extra investment in architectural quality	. Healing environment . Percentage single bedrooms . Hospital as hospital recognizable	. Nice and easy access location . Nice overall architectural appearance
controlling risks		. Marketability of real estate . Real estate in Private Limited Company . External clinics rented	. Longer opening hours to optimize available capacity . Risk reduction in healthcare processes	. Slim fit building with no more square meters as necessary . Outsourcing maintenance for a longer period
improve finance position	. Real estate is more a resource for production than an asset	. Banks as stakeholder . Marketability of real estate . Real estate as an asset . (Potential) location value . Urban Area Development	. Choice between optimizing healthcare processes during liganespan of building or marketability afterwards.	. Layer approach (hot floor, hotel, office and industry)

CONCLUDING REMARKS

This paper has relevance for both further research, in terms of testing out the proposed ideas, and practice, in terms of applying the concepts in the design decision-making process of healthcare facilities. With this paper a first step is made in prioritizing, describing and defining the added value of real estate from the perspective of hospital decision-makers. The research design of this paper could be improved by including two more cases at the initiation phase, in order to make the cases in this phase equivalent to

those in the other two phases. Additional research is needed, in order to improve our understanding of how the concept of adding value by real estate appeals to different stakeholders and to establish also the perceptions of real estate added value from the perspective of other project participants or users. Besides this, more interviews with CEOs and real estate project managers of hospitals are necessary in order to test the results in a broader selection of cases. The data captured through the interviews could be triangulated by analyzing also documents related to the design decision process, including initial documents, Long Term Accommodation Plans, briefs for new hospitals and design drawings. In further research, the results will also be linked to building assessments on the added value of real estate, including floor plan analysis, in a number of case studies.

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BEYOND SCORING: FACILITATING ENHANCED EVALUATION OF THE DESIGN QUALITY OF NHS HEALTHCARE BUILDINGS

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ABSTRACT

The evaluation of design quality using prescribed instruments, as now mandated by the UK National Health Service (NHS), provides a research opportunity to acquire understanding of the social interaction of the project stakeholder groups when they are engaged in design evaluation activities. This paper argues that there is a pressing need for such a study, as without it, such evaluations may be unnecessarily limited. This paper argues for a fresh and pluralistic approach to be applied to the evaluation of the design quality of NHS healthcare facilities which complements the methods currently used which are enshrined within prescribed instruments. The new approach uses an interpretative research paradigm to understand the social interactions of the project stakeholders whilst they use the prescribed instruments. The decision to adopt such a pluralistic approach is discussed. The users of this work may include those who seek to improve the design quality of NHS healthcare buildings.

KEYWORDS

design evaluation, design quality, epistemology, NHS policy intent, pluralism, social interaction

INTRODUCTION

In the UK, the election of New Labour in 1997 initiated, as the subject of immediate political attention, the promotion of design quality specifically in relation to public-sector buildings. New Labour wanted better public buildings. ‘Good design’ and ‘design quality’ was placed, by its political leaders⁴, at the vanguard of a concerted number of government initiatives and unprecedented national programmes of capital investment. These were aimed at radically transforming both the performance of the UK public sector and the physical condition of its existing and future built estate.

In 2000 the NHS embarked upon a ‘once in a life-time’ national programme of capital investment into new healthcare facilities that is currently amongst the largest of its kind anywhere in the world. In doing so it has taken the opportunity, consistent with New

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Labour's manifesto, to introduce in 2004, for the first time in NHS's history, a prescribed design quality policy. This policy mandates the collaboration of project stakeholders to iteratively undertake design evaluation workshops using prescribed instruments, in an effort to improve the design quality of NHS healthcare facilities.

The approach prescribed by this NHS design quality policy (including its prescribed design evaluation instruments, published guidance and associated initiatives and directives) are for the sake of brevity in this research henceforth referred to as the NHS's 'design quality project'. This design quality project (DQP) will be shown to represent a normative and confined approach that is premised on a theory based rationalist paradigm especially concerned with the notion of measuring design quality. Prior to construction commencing, the measurement instruments mandated by the DQP require the project stakeholders to score the design iteratively at key stages of the design, against predetermined criteria derived from the literature of evidenced based design and other notions of 'good' healthcare building design. The project stakeholders review the scores at each stage of the design. The scores are also required for inputs into business cases submitted for approval by NHS organisations to government departments.

Notwithstanding the acknowledged merits of the DQP, (which will be addressed below and shown to represent a significant step forward in the quest for NHS design quality), the principal claim of this research is that, prior to construction, *'the evaluation of the design quality of NHS buildings should not be limited to the principal consideration of scoring the design as promoted by the current approach enshrined in the DQP'*. In other words, whilst the DQP is regarded by this research to have merit and is considered necessary to the quest for design quality of NHS buildings, it is also considered to be insufficient, and in certain aspects, problematic. An argument for this claim is presented along with the proposal of a fresh approach to the design evaluation of NHS buildings that may address the perceived problems of the DQP.

The remaining part of this paper is organised in two parts. The first part will highlight the merits of them as key components of the DQP, followed by a critique that will unveil aspects of the prescribed DQP instruments that are perceived to be problematic or unproblematised. The second part will provide a justification for the introduction of a fresh approach to the design evaluation of NHS buildings that may help to address the perceived problems.

THE MERITS OF THE DQP

To understand the merits and the significance of the DQP is to understand the history of design quality within the NHS since its inception in 1948. An inescapable conclusion of this history is the dominance of the NHS and its policies in relation to healthcare building design quality in the UK. Both are inextricably linked. This is evident from Francis *et al.*'s *50 Years of Ideas in Health Care Building* (Francis et al., 1999) in which it is clear that, prior to the introduction of the DQP, NHS building design quality was dominated by a narrow view of functionality that sought standardisation and systemisation of the construction of hospitals with attendant economies of scale. Little post-occupancy evaluation of buildings took place and research into design quality was

limited. Active participation in the project design process by clinicians or public-patient representatives simply did not exist as a policy or as any other requirement. A narrow functionalist approach fostered the proliferation of prescriptive design standards and codes that effectively constrained and dictated the practice of healthcare design within the NHS. This approach evidently took its toll: Prasad in Macmillan (2004, p176) indicated that this approach had inevitably led to a “*condition where there is so much mediocre and worse-than-average design*” and a need to “*reach in a direct way those commissioning buildings and provide them with the means to raise the game*” (*ibid*).

Noting the poverty of NHS building design quality prior to the introduction of the DQP, the most significant aspects of the DQP, apart from its status as NHS Policy, has been its mandate for the evaluation of the design by project stakeholders. This raised the profile of design quality to all parties involved in the delivery of the capital programme and established a place for the consideration of values embedded in the prescribed instruments of AEDET and ASPECT. Lawson in Stark (2007, p93) cites unpublished systematic research suggesting that *AEDET* and *ASPECT* are reliable suggesting they can be used consistently and iteratively during design development. By way of endorsement, AEDET and ASPECT have been used in various by CABE in nation-wide research studies (CABE, 2008) to specifically assess design quality in particular types of procurement. Such studies show how these prescribed instruments have empowered stakeholders and have allowed them to participate with designers at various (including early) stages of the design. Further aspects of the DQP included policy initiatives to mandate the creation of ‘Design Champions’ and ‘Design Reviews’ (NHS Estates, 2001; Francis, 2007) and the sponsorship of numerous studies aimed at improving design quality (CABE, 2011). There can be little doubt that the DQP has raised the profile and significance of healthcare design quality to NHS investment decision makers, NHS staff, public-patient representatives, the design community and the UK construction industry realising the current significant programme of capital investment in NHS healthcare buildings.

A CRITIQUE OF THE DQP: UNVEILING PROBLEMATIC ASPECTS

PROBLEMS WITH THE NHS GUIDANCE PROVIDED FOR AEDET AND ASPECT

Several problems are found within the NHS guidance for the prescribed instruments. These relate to privileging particular types of knowledge and advice that explicitly stifle debate. Furthermore, mindful of CRISP’s originating stipulation of ‘intensive piloting’ noted above, the NHS published guidance directing AEDET and ASPECT to design evaluation workshops is arguably ambivalent with CRISP’s requirements.

The guidance (with emphasis added by the researcher’s) comments that: “design evaluation workshops as *perhaps* the most common way of using ASPECT or AEDET”. The technical advisors are required, at such workshops, to provide as much “pre-analysed information as possible” to give the evaluation team “more time to make key judgments”. Again, conditionally, the guidance states that:

“User clients such as patient representatives and members of the general public *should* also be able to use AEDET. *However it may* be more

appropriate for them to do so in workshops working alongside other more *experienced professionals*".

Furthermore the guidance states that at the same time "*it is probably desirable that an experienced user of AEDET should facilitate the group to avoid excessively lengthy debate*". These statements are considered problematical for two reasons. First, they indicate a privileging of the role of experienced professionals that could be construed negatively in relation to the importance placed on the role, voice and viewpoint of members of the public or other non-professionals; see Gesler, et al, (2004, pages, 118-119) and Gillespie, (2002, page 218) cited in Gesler (*ibid*, page 201). Second, what is the avoidance of excessively lengthy debate? It is difficult to reconcile the guidance material's comments on "avoiding lengthy debate" with comments regarding how, at the same time, the prescribed instruments "may be a helpful tool to enable a group to come to a common understanding". Furthermore these conflicting statements appear incongruent to the espoused aims of the originating CRISP's call for research that cites the Japanese organisational cultural example of "*listening and debating at length before committing to a form or product*", and the pursuit of "*understanding, not knowledge alone and investing time in this process*".

Apart from not indicating what is meant by 'lengthy', avoiding debate is regarded in this research as being profoundly contrary to the importance of social interaction between the project stakeholders: this also is discussed further below in the section that justifies the importance of social interaction to design evaluation.

The guidance stipulates that facilitators should be in attendance to ensure that "any representatives of the public or patients who *may lack experience of technical knowledge* are able to express their views and have them listened to". The possession of only 'technical knowledge' is thus privileged. This is further reflected by an analysis of the percentage of criteria concerned with clinical efficiency that dominates the questionnaires within the instruments. This is considered epistemologically problematic and is discussed further below.

The guidance also lacks explanation. For example, larger projects are required to hold "an interactive multidisciplinary decisions analysis workshop" but without further explanation. The guidance also omits any ample reference to the realities of the context and constraints of the project environment or to the sociology of any of the relations between any of the project stakeholder groups. Any consequences of such social interactions between the project stakeholders are omitted. No scope or provision for any comments on the nature or extent of any social relations between the project stakeholder groups during the course of undertaking evaluation workshop is included in the guidance. No opportunity for the project stakeholder to discuss or communicate what their ideas of what is good design at any stage is suggested. The guidance limits itself to the comment that, conditionally, (with researcher's emphasis added) "AEDET [or ASPECT] *may* be a helpful tool to enable *a* group to come to a common understanding." (NHS Estates, 2008b; NHS Estates, 2008a). Any comments about the prospect or need for common understanding between groups however is not included. All of these

omissions are therefore *completely inconsistent* with CRISP's comments previously highlighted above that stresses the need for such activities.

In contrast to these omissions about the social interactions or local project context, the guidance goes into relatively detailed instructions about the use of the scoring and weighting mechanisms. It also provides a pre-formatted user-friendly Excel spreadsheet complete with an in-built macro for the uniform recording and presentation of results.

Furthermore, noting that many of the project participants will have a professional background, the omission of any explicit theoretical basis within the NHS guidance material for the prescribed instruments may be considered remiss when compared, say, to the literature on good stakeholder engagement practice. See Foy et al. (2011) for an example of the role of an appropriate theoretical basis when improving best practice initiatives for clinicians within a NHS healthcare context. Groh et al (2007) and Wilkson and Powell (2011) present current arguments for including such a theoretical basis and its benefits in terms improving clinical engagement respectively.

PROBLEMATIC EPISTEMOLOGICAL ASPECTS OF AEDET/ASPECT: THEIR NARROW RATIONALIST BASIS

Epistemologically, AEDET and ASPECT are similar. AEDET is theory based. It is endowed with a theory of architecture developed by Marcus Vitruvius based on Platonic and Aristotelian ideals of beauty and symmetry contained in his architectural treatise, *De architectura libri decem* (Ten Books of Architecture) published probably in 15 BC (Vitruvius, n.d.), and for this research as translated by Morris Hicky Morgan in 1914. Vitruvius' theory is conceptually based on an idealistic triad of abstractions that must be referenced when preparing any design for all 'good' buildings. These abstractions are *firmitas, utilitas, and venustas* (*ibid*, p.17).

Sir Henry Wotton (1568-1639) is remembered for the definitive declaration made in his book 'The Elements of Architecture' published in 1624 that translates the Vitruvian triad, respectively as conditions of firmness, commodity and delight.

Wotton's triad is further Anglicised and operationalised specifically for the evaluation of modern building design in the Construction Industry Council (CIC)'s Design Quality Indicators (DQI's) as build quality, functionality and impact. NHS Estates, CIC and the University of Sheffield mirrored this triad of abstractions into AEDET. By virtue of being based on Vitruvian theory derived itself ultimately from Platonic and Aristotelian ideologies, AEDET is thus by definition, epistemologically deemed universal, rationalistic, atemporal and context-independent.

Epistemologically, ASPECT is based on a "database of 600 pieces of research" (Department of Health Estates and Facilities 2008a, p.2) and an 'Evidence Layer' (*ibid*, p.21) which in turn refers to a UK Department of Health website, although this evidence is not presented directly in the published NHS guidance supporting ASPECT. The Department of Health website however lists only a total of 15 published research articles drawn principally from behavioural and environmental psychology 'evidenced-

based design' (EBD) studies spanning between 1977 to 2003. This reliance on EBD is considered problematic and is discussed below.

In summary, AEDET and ASPECT are unveiled as being epistemologically rationalistic in approach and deterministically based on theory. As indicated above, the guidance privileges 'technical knowledge'. This research regards these epistemic preferences as confined, narrow and problematic because they ignore, without justification, the significant body of literature that contests what counts as '*design knowledge*' (Simon, 1996; Schön, 1995; Rowe, 1991; Krippendorff, 2007; Dorst & Dijkhuis 1995; Forlizzi et al. 2008; Webster and Brookes, 2008).

As an example of this contested literature, Rowe (1991) refers to the form of knowledge used in design as intuitionism. AEDET or ASPECT makes no reference to such design knowledge. The paradigm of intuitionism differs significantly from the paradigm used adopted by AEDET and ASPECT. Intuitionism is considered a received source of knowledge, which is to say that integrated knowledge may be intuited, - acquired - in a 'flash of insight' as a gestalt (although the constituent patterns assembled may have been gestating for some time) that is both complete and holistic (Duggan, 2007). This relationship between the design problem and intuition is described by Rowe (1991) who, like Rittel and Weber (1973), characterises design problems as ill-defined or wicked and messy, precluding their resolution by a simple, orderly rational theoretical approach (such as that assumed in AEDET and ASPECT). In practice such problems are resolved using heuristic reasoning embedded in a priori knowledge.

Design problems are projective in nature. That is, they do not already exist waiting to be discovered, as is the practice in rational paradigm typical of scientific 'discoveries.' The buildings and other artefacts that later manifest themselves as realities are not yet in physical existence during design. The use of intuitionism invokes creative insight that can move towards a solution that resolves an ill-defined problem. Truth in this paradigm is regarded as the eventual correspondence of the finished design of the finished building with the intended outcome as envisaged a priori: the actual outcome is not as important as this correspondence with intentionality.

PROBLEMATIC EPISTEMOLOGICAL ASPECTS OF AEDET/ASPECT: QUESTIONS OF VALIDITY OF HEALTHCARE EVIDENCED BASED DESIGN AND EPISTEMIC INCOMMENSURABILITY WITH 'DESIGN KNOWLEDGE'

Significantly, AEDET includes references to Evidenced Based Design (EBD) as the basis of idiocratic criteria in its and ASPECT's questionnaire instruments used by the project stakeholders to evaluate a design scoring its performance against an abstracted, generic notion of 'good.'. EBD is regarded "the natural and parallel analog to evidenced based medicine (EBM)" (Hamilton, 2004). EBM is defined as "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients" (Sackett et al., 1996).

The practice of evidenced based medicine means "integrating individual clinical expertise with the best available external clinical evidence from systematic research" (*ibid*, 1996). Such systematic research is based on a well-established, science-based

epistemology, which conceptually is context independent and pursuant to universal truth. As such, it can be considered (in the Kuhnian sense) commensurate with the Vitruvian theory adopted by AEDET and ASPECT. The worldwide adherence by the medical profession to such research and the systematic scientific philosophical approach is evidenced and manifest by The Cochrane Collaboration.

The references to evidenced-based design made by AEDET and ASPECT represent an epistemological privileging of the greater use of scientific based evidence to support decision making (Codinhoto et al., 2010). However EBD, in stark contrast to EBM, is not well established and does not enjoy the same systematic review underpinning EBM because, amongst other reasons, it lacks an organisational equivalent to the rigor of the Cochrane Collection for EBM. Thus for EBD (in contrast to EBM) there is no universally accepted standard for what actually constitutes best evidence raising questions as to how that adopted by AEDET and ASPECT was selected.

Recent and extensive Dutch and American studies have questioned the validity and reliability of EBD used in healthcare design *per se* (Dijkstra et al. 2006; Dijkstra, 2009; American Society for Healthcare Engineering, 2009). These studies found that, when scrutinising the effects of specific environmental stimuli, conclusive evidence of the rigour of EBM is still very limited and difficult to generalise. In practice then, EBD must not be used uncritically and without caution because it may be incommensurate with the more stringent and rigorous practice of EBM. Significantly, this profound issue of incommensurability is not discussed in the current DQP discourse.

PROBLEMS WITH THE NOTION OF MEASURING DESIGN WITHIN THE DQP AND CONFLATION OF SUBJECTIVITIES AND VALUES WITH ‘OBJECTIVE’ SCORES

Notwithstanding the historical importance of its place to represent subjective values in the DQP (as noted above setting out the merits of the DQP), nevertheless the use of the word ‘Impact’ as an Anglicisation for Vitruvius’s *venustas* is problematic for numerous reasons. Prasad comments that it is less than a poetic interpretation (in Macmillan, 2004, p181) however this paper regards it as being more problematical in that it is as more of adaptation than an interpretation. That the use of ‘Impact’ is an adaptation and not a translation is evident from an exegesis of the Ten Books of Architecture (*ibid*), which reveals that Vitruvius’ concept of *venustas*, is both subjective and complex. Vitruvius develops this in his theory of architecture to mean "when the appearance of the work is pleasing and in good taste, and when its members are in due proportion according to the correct principles of symmetry" (*ibid*, p.17). It is therefore centred on matters of symmetry and proportion as experienced visually. The Vitruvian principles of symmetry are concerned with a “proper agreement between the members of the work itself, and relation between the different parts and the whole general scheme, in accordance with a certain part selected as standard” (*ibid*, p.15). In a genealogical sense, Vitruvius’ conception of *venustas* is entirely consistent with the pervasive ocularcentric paradigm originated by the Greeks in western culture (Pallasmaa, 2005) that is likely to have influenced him.

Impact as used in the DQP is concerned with several values and opinions. It is addressed by a total of 22 questions within the AEDET questionnaire instrument. These

questions gather scores from stakeholders on subjective matters such as “does this building appropriately express the values of the NHS” and numerous other questions using the same adverb (for example in relation to levels of dignity; to a caring image). Space does not permit any further listing but three points are relevant here. First, there are multiple considerations of Impact far beyond the considerations of visually pleasing symmetry and proportion represented by *venustas*. Second, is the more substantive fact value problem: AEDET’s ‘Impact’ section refers to the evaluation of subjective elements. These subjective elements necessitate consideration of values. The evaluation of objective elements involves the consideration of facts. Values do not lend themselves to measurement in the same manner as objective facts by virtue of their inherent subjectivity. This is referred to in the philosophical literature as the ‘fact-value problem’ (Michlewski, 2008; Schwartz, 2006; Schwartz 2009; E. House 2001). Philosophically, values are not capable of being quantitatively measured objectively: they are always subjective and must be regarded as originating from the first person. Furthermore, existentially, values implicate and invoke sense of commitment, or strong personal emotions. As Pascal once eloquently put it, the “heart has its reasons which reason does not know” (Pascal, 2007, p73). Values are also intrinsically temporal (Harris, 2005).

The originators of the Design Quality Indicator upon which AEDET is based - Gann et al. (2003) - discuss at length and admit to this essentially axiological difficulty several times (*ibid*, p319, 320, 322). They conclude that, at best, scores from the [DQI] “cannot provide an absolute measure of the design quality of a building but can be used to articulate the subjective qualities felt by different stakeholders”. Lawson (in Stark, 2007, p90) states, “a great deal of what is in the [...] Impact section is not yet substantiated by empirical knowledge and is largely informed [by what he calls] ‘best practice’”

In contrast to the above authors, this important axiological problem is not addressed at all in the published AEDET or ASPECT guidance. Third, ‘scores’ of subjective impact are simply, but erroneously, ‘conflated’ with those from objective functionality and build-quality criteria. This fact-value measurement problem is in practice yet further exacerbated as another problem within the DQP by the insistence and apparent preoccupation of AEDET and ASPECT with ‘scoring’ the design by the project stakeholders. Gelsner, et al., (2004) provides a detailed discussion of the detrimental consequences of such preoccupation with scoring in relation to public accountability and axiological concerns for ‘scoring’ within prescribed instruments.

Another facet of this concern of reconciling subjective values with objective facts raised by Prasad (Macmillan, 2004, page 177) is the human preference for oculo-centric symmetry and visual appearance as an inversion of any functionalist doctrine. Subjective values *may be represented* by numerical values in a well-understood context but far more important axiologically is to ensure that the relationship of such subjective fields to the objective is made explicit within any evaluation framework. This is not the case within the DQP. This problem of itself raises the importance of the context of use of such measures within evaluation instruments. The published guidance for AEDET does not acknowledge any of these problems of scoring.

In practice, this issue means that the cumulative scores or outputs from DQP design evaluation workshops cannot be regarded as being in any way ‘scientifically’ valid but this is then somewhat incongruent with the conventions typical of the rationalist paradigm that sits behind the DQP. The scores are essentially a convenient ranking of judgments, and in effect an unproblematised operationalisation of the real problem of dealing with subjective matters within a predominately objective framework. It is not then quantification against an interval scale (Lowson et al., 2006). There may be three risks here. First, that which Prasad (*ibid*, p183) called the “intrinsic ossification of evidence orientated bureaucracies” and, second, the erosion of creativity, innovation, novelty, the ineffable, the surprising, the civilising, the rebellious - none of which are included in the Impact quality field – that is found to distinguish architecture from mediocre building design (Shai et al., 2009; Hatchuel. 2002). The third risk is that of the possibility of reification of scores as output from the prescribed instruments if used uncritically by the project stakeholders as inputs as ‘quality thresholds’ for approval purposes, as for instance as indicated by CABE (2008) or as currently prescribed within the DQP for business case and gateway approvals.

PROBLEMS WITH THE OPERATIONALISATION OF INTENTIONALITY WITHIN THE DQP

The importance of intentionality in relation to the contested nature of design knowledge and an intuitive paradigm is discussed by Rowe (1991). Rowe draws attention to the habitual logic of enquiry used typically in the practice of design that employs heuristic, intuitive reasoning coupled with use of experience and tacit knowledge. This is applied iteratively and compared with intentionality during design development. In this the practice of design is concerned with finding solutions to problems that are holistic, projection and which correspond with original intentionality. The emblematic story concerning architect Matt Fineout tearing up plans as described previously provides a vivid example of this quest for correspondence with intentionality in the practice of design. Designers are not content with finding a solution: they strive for the solution that resonates in the first instance with their intentionality.

This is considered to be quite different from the effort to capture intentionality structured by the DQP’s use of a weighting criteria prescribed by Gann et al. (2004) as being either 0, 1 or 2 in quantitative terms within the DQI’s rationalist paradigm. The representation of intentionality by objectively weighting criteria in AEDET and ASPECT departs from the iterative act typical of the actual practice of design in which the designer subjectively and periodically compares the projected design with the original intentionality known to the designer. Thus the rationality and objective logic used in AEDET and ASPECT amounts to, in essence, an attempt to operationalise and, by virtue of scoring design, conflate intentionality. This is problematic as it ignores and departs from the actuality of intentionality of design practice. This problem is caused by a fundamental discord between the understanding of intentionality as known by designers to that held by project stakeholders who, as non-designers, are simply following the prescriptions of the AEDET and ASPECT instruments. These instruments do not acknowledge the designer’s understanding. Again, the NHS guidance fails to articulate the nature of design practice in the requirements of the prescribed instruments.

THE ADVERSE CONSEQUENCES OF CONTEXT INDEPENDENCE WITHIN THE DQP: THE OMISSION/UNARTICULATION OF THE SOCIAL INTERACTIONS OF THE PRACTICE OF DESIGN

In the literature, many assertions as to what design *is* focus on the descriptions of the activities of individual designers forwarded by Herbert Simon's (1969) seminal work. Simon's view of design is grounded in the concern of the artificial and the influential in characterising design as a rational problem-solving activity with attendant similarities to the rationalist and determinism of 'science' based approaches. On the basis of the above critique, Simon's influence can be seen in the development of the DQI and similarly within the prescribed instruments of the DQP by virtue of the absence of consideration of the social context of design evaluation. More recently, Dorst and Dijkhuis (1995) reframed and contested Simon's view to regard design is as dialectic between Simon's paradigm of technical rationality and the reflective approach of Schön (1983). Schön's approach embraces the inherent complexity of the act of design and regards the reductivist tendencies found in Simon's paradigm (and, as shown above, embedded in the DQP's rationalist paradigm) as failing to acknowledge the realities of design in practice.

Many successful designs begin with very little external information yet the practice of design creates highly influential outputs and ideals. Intuitive knowledge used in the practice of design involves designers applies knowledge in a way that even the designer does not understand or can articulate (Lawson, 2006). This suggests the presence and use of tacit knowledge as an important part of design practice (Tsoukas, 2002; Gourlay, 2006; Peile, 2006).

What is not contested within the wider design discourse, other than in a purely theoretically context (or if say, designing for oneself alone), is that design within a project environment *is essentially a social activity between the stakeholder groups and the stakeholder groups and the emerging artefact*. Therefore communication and language play an important part, as do the various social interactions between the groups of project stakeholders engaged in the activity of evaluating design. This view of design is substantiated by the significant body of literature drawn from ethnographic, linguistic and sociological studies (for examples see Bucciarelli (1998), Whyte et al., (2006) and Luck (2007)) and the supporting interaction, discourse and semiotic analyses (for examples of these see the work done on the DTSR7 dataset within Luck and McDonnell, (2006)).

As such, it is noted that these important social aspects of design practice are missing in the NHS published guidance on the use of the prescribed instruments. There is therefore a risk that the potential influence of these fundamental social interactions on the appropriate practice of NHS design evaluation workshops remains unarticulated. Reflections on the reality of the actual practice of design suggest the need to understand these social interactions and interpretations; especially those related to values and subjectivity.

In summary, the prescribed instruments of the NHS published guidance and other aspects of the DQP raise numerous concerns. These relate to: generic limitations; omission of any explicit theoretical basis; epistemic and axiological incommensurability; limitations and concerns associated with ‘scoring’ *per se*; attempts to conflate the scores of subjective values with objective facts; the apparent unarticulation of the importance of social interaction in relation to design knowledge; and the failure to explicitly regard design knowledge as being distinct from other types of knowledge found in rationalist and scientific discourses that are incommensurate with the practice of design.

This critique concludes by stating that the above discussion shows that, while confining the design evaluation of NHS healthcare facilities to the instruments prescribed by the current DQP may be argued to be necessary, it is not sufficient. This supports the claim, that prior to construction: *‘the evaluation of the design quality of NHS buildings should not be limited to the principal consideration of scoring the design as promoted by the current approach as enshrined in the DQP’*. This is because to do so may unnecessarily limit the understanding of what, *from the perspective of each of the different groups of project stakeholders*, constitutes *valid design knowledge* and *acceptable design practice*. As noted previously such knowledge and practice is both contested and varied across different groups of project stakeholders. In this research what each group of stakeholders constitutes as *valid design knowledge* and *accepted good design practice*, will be referred to henceforth as their *legitimate design perspective* (LDP).

TOWARDS A REORIENTATION OF THE CURRENT DQP

THE NEED FOR UNDERSTANDING (VERSTEHEN)

At the core of the argued limitations of the current paradigm used within the DQP is the need to ensure that all project stakeholders attain a high level of mutual *understanding* of each other’s epistemic positions, and different practices of design. This is significantly complicated by the “totality of disciplines, phenomena, knowledge, analytical instruments and philosophies [...] that the design must take into account” (Vitta and Nelles, 2007) that contributes to what will be referred to as the *design evaluation context*. On-going research may show that these epistemic and practice disputes and prevalent contextual complexities may remain as what will be referred to as *unarticulated latencies* within the current DQP discourse. And, unless efforts are made to identify, elicit and fundamentally, *understand* the potential for their existence and possible consequences, (i.e. if left unattended), their existence is likely to be fundamentally problematic to the pursuit of evaluating the design quality of NHS buildings. This problem of unarticulated latencies also points to the need for all project stakeholders to attain a high level of mutual understanding. The challenge, then, to improving the DQP may be to ensure, prior to engagement for a design evaluation workshop or similar collaborative vehicle, that all project stakeholders attend to any unarticulated latencies within the local project context and to strive to actively seek and acquire a mutual understanding of them and their respective LDPs.

An interpretative paradigm is one that adopts the position that knowledge of reality is a construction of the social interactions of the human actors and the local context in which

such interactions take place. An interpretative paradigm strives to acquire understanding is sought in contrast to causal explanations that can be derived from the use of a rationalist paradigm. Verstehen as originally introduced by Weber (Walsham, 1995) is regarded as a synonym for such understanding. Verstehen refers to the understanding of another's point of view. Verstehen in relation to design evaluation recognises that to fully understand each project stakeholder group's attitude and beliefs are in relation to 'good design'. From this interpretative paradigm, to evaluate design is to understand design. As a means of possible improvement of the current DQP this suggests privileging the social interactions of the project stakeholders (rather than solely the current DPQ's preoccupation with scoring) as a means of acquiring knowledge, via verstehen, to pluralistically augment and possibly improve the evaluation of NHS healthcare buildings.

CONCLUSION

In conclusion, the potential to understand the social interactions of project stakeholders engaged in the evaluation of NHS building design justifies the introduction of an interpretative paradigm to pluralistically augment the current rationalist paradigm of the DQP. Ongoing research will pursue the potential dimensions of an interpretative paradigm congruent with the reality of the social interactions forming the local project context of 'design.' It is anticipated that this will inform future empirical studies.

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PLANNING FOR MAJOR SERVICE AND INFRASTRUCTURE TRANSITIONS: AN INTERNATIONAL COMPARATIVE STUDY OF UK, US AND CANADIAN HOSPITALS

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ABSTRACT

Healthcare services are undergoing rapid and fundamental change through technological innovation and new policy imperatives, with implications for how services are organised and delivered and for their underlying built infrastructure. Managing these changes to enable a smooth transformation from an old to a new model of care is critically important for healthcare organisations if services are to be maintained with minimal disruption.

This paper presents analysis from the first stage of a two year longitudinal study across three case studies in the US, UK and Canada. We use case studies of acute hospitals undergoing change in their care processes (a redesign around single bed rooms) alongside a move to a new-build facility. Such radical organisational change requires careful planning and management, the involvement of stakeholders, within a time critical period. Each of our case studies has taken a different approach to planning and managing the transition. Data collection is ongoing but currently includes the analysis of 85 interviews complemented by documentary evidence and observations collected over two phases.

We investigate local processes involved in transition planning with the aim of determining organisational factors that influence successful stakeholder engagement, exploring levels of organisational planning and resources needed at different stages of transition.

We found mixed levels of change management and engagement across our three sites. Contrary to current thinking, engagement was often most successful when focused on communicating with those who had most to gain from the transition, rather than being inclusive across the whole organisation.

Initial indications suggest that successful transition management does need to include all stakeholders, that the impact of resistant or dysfunctional groups can be mitigated with strong buy-in from both top management and frontline staff.

KEYWORDS:

organisational change, stakeholder engagement, transition planning

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CONSENSUAL POLITICS IN HEALTHCARE: THE NATIONAL EHEALTH PROJECT OF SLOVENIA

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ABSTRACT

This paper discusses the efficacy of consensual politics in advancing healthcare reform through supporting innovation adoption. The case examined is the Slovene national eHealth project funded by the government of Slovenia and the EU. Its objectives have been to deliver a new national eHealth network, eHealth portal and national Electronic Health Record (EHR), education and training for health professionals. Project design and implementation have been supported by a formal project management structure effecting deliberation and negotiation of decisions by domestic stakeholders. This structure has operated in tandem with a programme Managing Authority, Monitoring Committee, payments control and evaluation as per the EU cohesion policy regulations. The paper draws on qualitative methods of inquiry to report on the extent that stakeholder requirements have been constructively reconciled through an analysis of progress achieved and specific issues arising during implementation. Consensus formation transpires as a process contested by stakeholders seeking to influence reform, based on opportunities afforded by consensual policy-making structures.

KEYWORDS

consensual, innovation, stakeholder participation, eHealth, Slovenia

INTRODUCTION

This paper looks at the national eHealth project of Slovenia through a theoretical perspective based on consensual politics and public sector innovation theories. It focuses on how decisions concerning healthcare infrastructure may be facilitated during difficult times, understood as times of progressively worsening contextual conditions in healthcare and the public sector, through a consensual policy making approach.

The paper draws upon the case study of the national eHealth project of Slovenia. This national project is in the process of delivering new electronic infrastructure intended to support administration and planning of healthcare infrastructure and services. The project started in 2009, at a time understood as difficult due to reduced availability of public funds for investment because of the financial crisis, access to care in the neighbouring EU countries of Austria, Hungary or Italy available to Slovene citizens, a

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domestic ageing population, a changing population health profile and disease patterns (Albrecht *et al*, 2009:8-15).

The term eHealth encompasses a diverse range of information and communication technology (ICT) applications and services utilised in the context of health care delivery. It may also refer to more loosely defined care delivery concepts involving activities, stakeholders, outcomes, and commercial aspects. The systematic review of Oh *et al* (2005) elicits fifty one (51) unique definitions; the words “internet” and “ICTs” feature in twenty seven (27) and seventeen (17) of these respectively. The definition put forward by the World Health Organisation (WHO) reflects these attributes: eHealth is understood as “the transfer of health resources and health care by electronic means”, encompassing the three main areas of:

- delivery of health information to health professionals and health consumers via the Internet and telecommunications;
- improvement of public health services by use of the power of information technology and e-commerce, e.g. through health workers’ education and training;
- use of e-business and e-commerce practices in health systems management.²

The next section discusses the concept of consensual politics, its links with stakeholder participation and association with public sector and healthcare innovation, and specifies the contribution of this paper. Section 2 details the research design and is followed by an account of the case study. Conclusions are discussed in the last section.

CONSENSUAL POLITICS AND PUBLIC SECTOR INNOVATION

Stakeholder participation in the form of engagement and involvement in policy design, management and implementation has been shown to underpin innovation in areas such as e-government (Brown, 2003), environment (Reed, 2008), and health policy (Mathur *et al*, 2008). This is due to the expertise and knowledge stakeholders possess and may choose to contribute through participation. However, the impact of different modes of policy-making, structures and procedures introduced to effect stakeholder engagement and involvement is contentious (Renn *et al*, 1993:189). Political science literature identifies consensual politics as a policy-making mode centred on fostering agreement on policy objectives among social groups, organisations and individuals (Kavanagh, 1985).

Earlier health policy research suggests that establishing consensus at a national level has encouraged innovation in the early days of the NHS (Webster, 1990:117). More recently, procedures enabling stakeholder participation at the regional, community, organisational and individual actor level have also been shown to support innovation (see e.g. Gibson *et al*, 2004). The national political and social context and prevailing cultural norms, beliefs and values are also viewed as important (Atun *et al*, 2010). The

² The WHO definition is available at www.who.int/trade/glossary/story021/en/index.html (accessed on 20th June 2011).

specific impact of political culture, and of consensual politics as a policy-making mode on stakeholder participation, innovation adoption and diffusion in healthcare reform, are less well understood.

The notion of consensual politics has been developed and applied in several streams of political science literature. The term *consensual politics* has been used to describe post-WWII politics and policy-making in Britain as oriented towards achieving consensus in policy design, until the mid-1980s when it was replaced by *conviction politics* of the Thatcher and Major governments (Kavanagh, 1985; Kavanagh & Morris, 1994). The literature on national policy systems and related research streams suggest that the practice of consensual politics can be identified in national democratic systems associated with diverse administrative and policy-making structures, and political cultures (see McRae, 1997).

Consensual politics has been foremost associated with the national policy systems of Scandinavian countries (Elder *et al*, 1982) and those of Austria, Belgium, the Netherlands and Switzerland (Katzenstein, 1987; Kloeti, 2001; Kuipers, 2006). The countries of the latter group are identified with a particular system type, that of consociational democracy (Lijphart, 1969; 1979; 1994). Terms most frequently used as alternatives include ‘consociationalism’, ‘the politics of accommodation’, ‘segmented pluralism’, ‘*Proporzdemokratie*’ and ‘*Konkordanzdemokratie*’ (Lijphart, 1979; Rathkolb, 2005). Consociationalism is discussed as a constitutional model pervading the workings of the national policy system, society and polity of democratic states such as those mentioned above. The concept is put forward as part of Lijphart’s (1969:210-212) classification of Western democracies, which builds on earlier contributions by Almond (1958, 1960), Kallenberg (1966), and Lipset (1960).

Lijphart’s classification of democratic national policy systems is based on two criteria, those of (i) political culture homogeneity; and (ii) social group and subsystem autonomy and role structure, that is the extent that governmental actor organisations, parties, interest groups (e.g. professional) and associations operate independently of one another. The USA, the UK, Canada and other former countries of the British Commonwealth and Scandinavia are found to have political cultures that are homogenous or “fusional” of modern and traditional elements, and a high degree of autonomy of social groups and subsystems. By contrast, the continental European systems of France, Italy, Germany, the Low Countries, Austria and Switzerland have been associated with fragmented national political cultures, a low social subsystem autonomy and substantial degree of osmosis among these.

These continental national policy systems include some which have traditionally been democratically stable, and others that have historically been highly unstable. Austria, as well as the Low Countries and Switzerland have not historically exhibited the frequently unstable political trajectories of Italy or Germany. Lijphart distinguishes these deviating cases on the basis of the behaviour of political elites and describes these as “consociational democracies”. Their elites or leaders of social groups and subsystems may engage competitively with each other in seeking to meet own ends, thus exacerbating mutual tensions. However, they may deliberately seek collaboration and consensus to counteract the destabilising effects of fragmentation and low social group

autonomy (Lijphart, 1969:211-212; see also Rathkolb, 2005:77-78). In this regard, consociational democracy is conceived as a national policy system model based on consensus (McRae, 1997). Consensual politics in the form of consociationalism is understood as the resulting policy-making mode within these systems.

Consensual politics and consociationalism are both associated with such institutional structures and policy mechanisms or devices. These are aimed towards effecting collaboration among social groups, achieving consensus on policy objectives and the manner in which these are to be attained (Lijphart, 1969:213-214). They facilitate deliberation on possible policy approaches, negotiation among groups (Papadopoulos, 2000:211, 215-216), and are observed at the macro, meso and micro level of a national policy system (see e.g. Frank, 1994:40). Lijphart notes that, in consociational democracies, these are not as essential as are the conscious efforts of elites to stabilise the policy system (*ibid.*). Furthermore, the literature has questioned whether consensual politics can be better defined in terms of a piecemeal application of consensus-building structures, mechanisms or devices introduced in any policy system, or the concept can ultimately be bound to a coherent model of policy-making, part of a specific ideal-type national policy system (McRae, 1997).

The policy-making agenda permeates the national policy system and impacts on organisations, groups and individuals operating within a policy area at a macro or national level, meso e.g. regional or organisational level and micro or actor level of analysis (see Berg et al, 2004:36; Kapiriri et al, 2007:79; and D'Amour & Oandasan, 2005). Social groups may include political parties, special interest groups in the form of civil society organisations, professional and local associations. These are understood as 'stakeholders', defined as those individuals, organizations and groups that have (i) an interest in the actions of a particular organization, (ii) expertise in different aspects of the its business and (iii) the ability to exert influence (see Blair & Fottler, 1990; Savage et al, 1991; Moss, 2002:4-5). This definition enables the conceptualization of a national healthcare system as an 'organization', and policy-making aimed at healthcare reform as an instance of 'organisational action'.

Have these theoretical approaches been applied in the analysis of healthcare infrastructure decision-making, healthcare reform or public sector innovation more generally? A systematic review elicits contributions focusing primarily on the merits of stakeholder voluntary, conscious collaboration towards the pursuit of innovation, drawing on public sector research in Europe, North America and Australia (Roberts & Bradley, 1991; O'Toole Jr *et al*, 1997:143-145; Flynn, 2007:185-197; Metcalfe, 2008). In Europe, consensual politics were the backdrop to establishing the NHS and British welfare state after WWII. Consensual politics formed a platform for stakeholders to agree on the aims of a national health service, whilst disagreeing on the means to achieve these (Webster, 1990:117, 149). In the Netherlands, consensual political culture offered the ground to corporatist stakeholders to stall market-oriented reforms in Dutch healthcare in the late 1970s and 1980s, and supported the co-production of evidence used to design health policy (Schut, 1995; Bekker *et al*, 2010).

Moreover, in Canada broad stakeholder support to infrastructure investment and consensus building around one new, system-wide organisational and funding model has

seemed one of two plausible approaches to the development of primary care. The alternative approach considered was incremental reform based on several models implemented by stakeholders at the meso level (Hutchison *et al*, 2001:127). In the USA, the Department of Health and Human Services (HHS) sponsored a national stakeholder consensus conference on a national health information infrastructure in 2003, which has now been taken forward in the recent US health IT legislation (USC, 2009:112-121; Yasnoff *et al*, 2004; Stead *et al*, 2005).

This review is suggestive of a positive correlation between consensual politics, stakeholder participation, collaboration and innovation adoption at the start of healthcare reform (see also Greer, 1977; USC, 2009:116, 118). In addition, current mainstream literature on healthcare innovation recognises the importance of the political, cultural and social context, consensus among adopters and influence of prevailing cultural norms, beliefs and values on the adoption and diffusion of innovation during reform (Atun *et al*, 2010; Atun *et al*, 2007). It further recognises the complexity of healthcare infrastructure projects, and the merits of stakeholder dialogue, involvement and cooperation at the supra-national, national, organisational and local level (Barlow *et al*, 2006; see also Braun *et al*, 2003). However, these contributions do not study the effect of political culture and chosen mode of policy-making in healthcare in a particular national policy system, at the start and during the healthcare innovation journey.

This paper aims to remedy this by looking at a case of healthcare reform in infrastructure decision-making at a time of progressively worsening contextual conditions. It examines the impact of consensual politics on innovation adoption at the start of and during a multi-annual healthcare reform project. The country case selected is Slovenia, a national policy system which has been in transition to democracy and a market economy in recent years, previously being a federal republic of the former Yugoslavia and part of multi-ethnic Austria-Hungary. Specifically, it examines whether the introduction and practice of consensual politics during the design and implementation of the Slovene national eHealth project has helped the project realise its innovative outcomes. In doing so, it first examines whether the Slovene national policy system bears consensual attributes and the possible sources of such. It then offers an account of the national eHealth project background, objectives and the special management structure set up to advance implementation, in addition to the EU management and monitoring requirements. It outlines the key stakeholders, their engagement and involvement in this two-tier management structure, discusses developments and progress to date, and concludes by recounting the key results and contributions of this research.

RESEARCH DESIGN

The case study selected is the national eHealth project of Slovenia, a country in transition since its independence from ex-Yugoslavia in 1991. Continuous economic growth since independence has supported transition and convergence with other EU states. Formerly a part of Austria-Hungary having a predominantly Germanic, Hungarian and Slavonic population since the Middle Ages, Slovenia became part of Yugoslavia in 1918. It declared independence in 1991, joined the EU in 2004 and EMU

in 2007; it has a population of 2.03 million. The national eHealth (*eZdravje*) project of Slovenia is part of the Operational Programme (OP) “Human Resources Development”, co-financed by the Slovene government and the EU cohesion, regional or structural policy during the programming period 2007-2013.

This case study lends evidence to test the hypothesis that the introduction and practice of consensual politics enhances the adoption of innovation in healthcare as part of the design and implementation of a national reform programme. The construction of the above analytical framework, interpretation of findings and hypothesis testing has been completed on the basis of material collected through the following four qualitative research tasks:

- a systematic review of the literature on consensual politics, health care infrastructure decision-making, reform and public sector innovation.
- a review of key academic papers and books on Austrian and Slovene history, politics and policy-making;
- transcription of semi-structured interviews with key informants who have been purposefully sampled and contacted as subject matter experts and representatives of stakeholder organisations to the Slovene national eHealth project;
- a review of key academic papers, policy studies, press reports and programme documentation with a focus on the Slovene national eHealth project.

The systematic review of the literature on consensual politics, health care infrastructure decision-making, reform and public sector innovation has been conducted using the keywords “consensual”; “politics”; “health”; “care”; “innovation”; “consensus”; “infrastructure”; “decision-making”; “public sector” in Google Scholar, business, humanities, life sciences and medicine electronic journal databases. In total, thirty one (31) papers have been elicited as directly relevant to our hypothesis testing. A review of six (6) key academic papers and books on Austrian and Slovene history, politics and policy-making has examined material available in English and German, in electronic and print form. Fieldwork has comprised of face-to-face interview meetings in Slovenia and telephone interviews with seventeen (17) subject matter expert informants conducted between November 2010 and May 2011, who were purposefully selected based on their expertise on the Slovene national eHealth project. Fieldwork has been supported by the EUREGIO III research programme funded by the Executive Agency for Health and Consumers (EAHC) of the European Commission and HaCIRIC; their support is gratefully acknowledged. The review of nine (9) key papers, policy studies, press reports and project documentation with a focus on the Slovene eHealth project was based on a systematic search in EU, Slovene government and media portals through internet search engines, using the keywords “eHealth”; “health”; “information”; “technology”; “Slovenia”; “Slovene”.

Material elicited in each of the four research tasks has been analysed through the qualitative content analysis method of Flick (2002:190-192). The following steps were undertaken:

- identification of the relevant material to answering the research question;
- analysis of the data collection situation;

- composition of the research question;
- definition of the analytical technique;
- definition of analytic units;
- conduct of the analysis;
- interpretation of results.

The following research questions were formulated towards the objectives of this work:

- is there evidence of consociationalism and the practice of consensual policy-making in the Slovene national policy system?
- how has consensual politics been introduced in the design and implementation of the Slovene national eHealth project?
- who are the main stakeholders in the Slovene national eHealth project?
- which examples of innovation are identified in project design and implementation?
- how has this process performed during 2000-2008 and what are the challenges?

The analytical technique used has been the one of summarizing content analysis, using key words in data as analytic units (Flick, 2002:191). Social constructivism has been used as the method of examining stakeholder action on the basis of their ‘embeddedness’ in the context of their organization, national political economy and policy system (see Granovetter, 1985). The main findings elicited are as follows.

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CONSENSUAL POLITICS IN SLOVENIA

The literature on Slovene politics and policy observes attributes of consociationalism and consensual policy-making. This national policy system features a bicameral legislature comprising a National Assembly and a National Council. State administration and executive power are exercised by the government (Albrecht et al, 2009:6). Slovene society has been marked by rapid, large, multi-level change and mobility after 1991. Social cleavages can be identified among different ideological factions, as well as between the transition process’ “winners” and “losers”. After independence, a grand coalition government was established as early as after the second election (Adam, 1994). The National Council was formed to offer functional representation to organised interest groups. Its formation is taken as evidence to suggest that, after 1991, Slovenia turned to embrace the Austrian consociational partnership model (Bischof and Pelinka, 1996:3).³ However, a crucial consideration for the Slovene polity has been the creation of a framework for future stability in the aftermath of conflicts in the Balkans (Adam, 1994). While historical experience and neighbouring relations with Austria may have played a part, the development of consensual politics

³ The roots of consensual politics in Austria-Hungary are traced to the 19th century as a way of overcoming differences and effecting collaboration between the two main, socialist and catholic, social subsystems or *Lager* (Chan & Leslie, 2008:9). Consensualism functioned as a conflict channelling, resolution and settlement system for social groups (Rathkolb, 2005:77-78, see also Bluhm, 1973). In the aftermath of WWII, it became the prevailing policy-making mode in Austria after 1945 (Rathkolb, 2005).

seems to have primarily stemmed from deliberate efforts to stabilise the policy system, mainly through the piecemeal introduction of mechanisms facilitating policy design and implementation.⁴

Healthcare is understood by informants as a policy area affected by current political culture and developments within their national policy system. In turn these have had an effect on the manner in which this national project has been approached by stakeholders. Informants noted that, while consensualism is not as salient an aspect of the national policy system compared to those of other EU countries, consensual politics has been the chosen policy-making mode for large, transformational change projects in health and education requiring the collaboration of several stakeholders. They perceive this policy-making mode and associated structures to determine and offer opportunities available for their engagement and involvement. They note further that knowledge of and proximity to other stakeholder organisations, anticipated problems during implementation, and a professionalised approach to reform management, have all led to the enactment of consensus-building activities and structures.

NATIONAL EHEALTH PROJECT STRUCTURE AND BACKGROUND

The Slovene national eHealth project (*eZdravje*) spans the period of September 2008 to June 2015. Its expenditure, estimated at approx. €67 million, is funded by the Slovene Ministry of Health (MoH), the European Social Fund (ESF), and other public funds as follows:

- Slovene MoH ordinary budget: €26 million;
- ESF: €27 million;
- Other Slovene public funds: €15 million.

A follow-up project is anticipated in 2015-2023, of approx. €67 million forecasted expenditure. The objectives of the project are to (SMoH, 2009; see also Albrecht, 2009:1-2):

- provide unified, secure and reliable access to all key patient information for all healthcare providers, specialists, GPs and pharmacists via a standardised Electronic Health Record (EHR) platform and other data sets;
- facilitate better planning and management in the national health system based on good quality, accurate administrative, clinical and economic data;
- improve access to all necessary information and the ability of citizens to participate in the development of quality healthcare services;
- promote an active role and responsibility of citizens for their health and healthcare;
- improve access to healthcare for persons excluded due to disability, age or other reasons.

⁴ A notable example has been the organised manner that civil society and interest groups were consulted by the government that led negotiations for EU membership (Adam, 1994; Luksic, 1996; Fink-Hafner & Lajh, 2006:16).

The structure of *eZdravje* was designed to comprise five project modules. There are three system delivery modules, delivering components of the national electronic Health Information System (eHIS), an organisational module featuring the creation of the National Centre for eHealth, and an Education, Training and Promotion module. Eighteen subprojects and a number of trial, sample or ‘pilot’ projects fall under each of these.

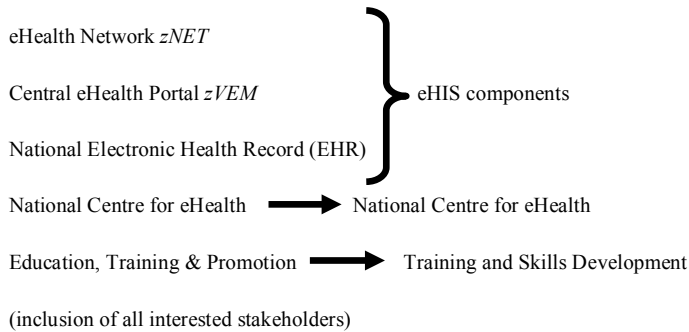


Fig.1. Organisational and System Modules of *eZdravje* (SMoH, 2009)

The use of information technology in the Slovene health sector dates to the mid-1980s; heterogeneous health informatics applications, supported by stand-alone (offline) PCs, have facilitated administrative tasks of e.g. record-keeping, payments, in primary and acute care. Since the 1990s, use of e-mail in booking appointments and electronic health record keeping has been adopted by some GP practices. A handful of private pharmacists’ and medical doctors’ web portals have also been operating since 2000.

A project of similar, nation-wide scale was launched in 1995 to introduce smart cards in the management of state medical insurance claims, led by the Slovene Health Insurance Institute (HIIS). Patient and physician smartcards were distributed to be used in tandem at the physician’s premises to access, exchange and store on the patient card insurance data through proprietary applications on stand-alone PCs. Self-service and information terminals, where patients may update their insurance status and seek specialist care, were installed and linked to a database server located at HIIS. Draft legislation, a cost-benefit analysis, project planning and evaluation studies were put together as part of the project. The infrastructure, managed by HIIS, went live in 2000 featuring: 1,946,000 health insurance cards; 20,000 health physician cards; 5,400 card readers; 270 self-service terminals at 218 locations; 1,036 participating institutions providing care; use of symmetric cryptography for electronic communications’ security (Trcek *et al*, 2001).

This infrastructure was viewed as a potential backbone for a national healthcare information system. However, the lack of data format, communication protocol and e-business process specifications in healthcare meant that it remained a *database access* rather than a *data communication* system; a current renovation project aims to address this. Further, a national project titled “Health Sector Management Project”, partially

funded by the World Bank during 2002-2004, formed a basis for the elaboration of the Slovene eHealth strategy (Albrecht, 2009:3).

CONSENSUAL POLITICS IN EHEALTH: STRUCTURES, STAKEHOLDERS AND OUTCOMES

Consensual politics was introduced in the design and management of *eZdravje* from the start, as the project formed a major part of the Slovene eHealth strategy implementation. The strategy document was elaborated by the MoH and healthcare stakeholder organisations, and was published in 2006. The conceptual model of the national eHIS was put together in 2007. Based on these two documents, the *eZdravje* Feasibility Study, action plan and subproject design documents were completed in 2009. Through this process the management structure of the project was developed to comprise four committees as follows (see also SMOH, 2009; Krapez & Kronegger, 2007:48):

- (i) the Council for Healthcare Informatics (the Council);
- (ii) the *eZdravje* Project High Level Steering Group (*eZdravje* HLSG);
- (iii) the Committee for Healthcare Informatics Standards (CHIS or *OZIS*);
- (iv) the *eZdravje Collegium*.

The practice of consensual politics has involved deliberation and negotiation on decisions concerning technology adoption, strategy and standards-setting among stakeholders in the committees (i)-(iii) above. Specifically, the stakeholder organisations invited to participate in these by the Slovene MoH include the HIIS, the National Institute of Public Health, the Association of Health Institutions of Slovenia, the Medical Chamber, and the Chamber of Pharmacists/Pharmaceutical Chamber. In the Council, stakeholders were represented by their Chief Information Officer (CIO) or equivalent official. The *eZdravje* HLSG featured deliberation and negotiation among Chief Executive Officers (CEOs) or equivalent. Experts in technological standards convened in CHIS to discuss and reach decisions on the adoption of national technological standards, in formal collaboration with the Slovenian Institute for Standardisation (SIST), the national organisation responsible for standards-setting.

This project management structure engaged a total of forty five (45) experts of the afore-mentioned and other organisations, such as the Ministries of Public Administration, Higher Education and Science and Technology (SMoH, 2010). Other organisations, such as ProREC, the Slovene national institute promoting the introduction of the European HER, participate in working groups initiated by CHIS to elaborate technical specifications. Professional stakeholder organisations, e.g. the Medical and Pharmaceutical Chambers, and the HIIS have aggregated interests and perspectives of their members, adopted positions on this basis on various aspects of the project, and have represented these in sessions of committees (i)-(iii). Lastly, the *eZdravje Collegium* is the project management team staffed by and located at the MoH, bestowed with the day-to-day project management tasks and led by the *eZdravje* CEO.

The MoH has adopted the role of promoting consensus among stakeholders towards the formulation of key project decisions. Furthermore, the Slovene MoH has come in contact with care professionals and elicited their feedback through the education and training module of *eZdravje*. The focus of seminars and workshops organised has been to familiarise care professionals with the system modules the project has aimed to

deliver, the implications for their work, and offer feedback to the MoH. Informants cite the project modules themselves as the key examples of innovation in the project design phase with regard to current planning of healthcare delivery and access to personal health information, and understand pilot projects as examples of innovation in the project build phase.

This management framework operates in addition to the OP Human Resources Development management structure comprising the OP Managing Authority, Monitoring Committee, payments' control and evaluation, as per the requirements of EU Cohesion policy regulations for 2007-2013. Other than joint memberships of stakeholder representatives in committees (i)-(iii) and the OP Monitoring Committee, no formal links have been identified between the MA, MC and the committees discussed above.

The Role of the ESF

The availability of EU funding through the ESF is understood to have provided additional impetus to the project at the time of a developing global financial crisis. The ESF and national funding are thought to have stimulated innovation by advancing collaboration among stakeholder organisations to develop key aspects of the project. However, since 2008 the complexity of ESF monitoring and management have added to delays incurred in the project. Nonetheless, the ESF is perceived as supportive to the specification and implementation of innovative solutions by the MoH and other stakeholders, in line with the eHealth strategy and *eZdravje* project feasibility study.

CURRENT STAGE OF PROJECT

At the end of 2010, one pilot project, *Lab-Poštar*, the *zNET* network implementation, and the Education, Training and Promotion strand of *eZdravje* had progressed. The National Waiting Lists and Teleradiology pilot projects, *zVEM* portal and EHR platform were lagging behind. The project is understood to be delayed, in the first instance due to consensus-building activities taking time to deliver key decisions. An example cited is the decision concerning *zNET*, to install and operate a separate physical telecommunications network, rather than support services through the internet or cloud computing. The decision has been based on the high sensitivity of personal health information and the current EU privacy protection regime.

The two professional stakeholder organisations engaged in the project from the start, the Medical and Pharmaceutical Chambers, felt that their views regarding specific aspects of the project had not been adequately considered in the course of formulating and implementing decisions. Furthermore, certain public tenders have been legally challenged by IT service providers who felt unable to contest them, adding to the delay. The engagement and involvement of the IT industry with the project was then sought as a remedial measure.

The new Health Minister appointed in August 2010 requested a project update and audit, and a new project CEO was appointed at the MoH in February 2011. Subsequently, the revision of the strategy document and feasibility study was led by the

MoH in manner that acknowledged recent professional stakeholder organisations' feedback on the management of the consensual process by the previous *eZdravje Collegium* leadership and resulting level of stakeholder involvement. Improvements have also been introduced based on new knowledge and experience in the use of ICT for health. The main change concerns the *zVEM* portal, which has been discontinued. Following these remedial steps, committees (i)-(iii) have recently convened to agree EHR standards for introduction as part of the project.

A new pilot project has been introduced, ePrescription, and is scheduled for implementation in regions where system platforms of stakeholder organisations are already interconnected. The new *Collegium* leadership is keen not to "reinvent the wheel", but to collaborate closely with domestic stakeholders and the European Commission towards evaluating progress and introducing best 'ICT for health'. Current challenges cited include the potential reduction of financial resources available, consistency in and among decisions still required to be reached, and the availability of expertise and qualified human resources to advance the project further.

CONCLUSIONS

This paper has drawn on the national eHealth project of Slovenia, part of its OP Human Resources Development 2007-2013, and focused on the manner in which the implementation of a national eHealth strategy, elaborated through stakeholder participation and setting patient empowerment as a key objective, has been supported by the practice of consensual politics.

This case study suggests that healthcare is a policy area where reform is influenced by the domestic political culture and mode of policy-making chosen to bring about reform. It further shows that consensual structures introduced to facilitate policy design contribute positively to the adoption of innovation at the start of healthcare reform. However, stakeholders may also take advantage of opportunities offered by consensual policy-making structures and use their leverage to delay or stall reform. Consensus formation appears to be a contested process by stakeholders, those invited to engage with consensual structures in the first place, as well as those whose input is sought at a later stage and during the reform process.

Based on their perception of the stakes or risks involved, stakeholders wish to be engaged and seek to decisively influence outcomes. Once the opportunity for engagement in consensual structures has been granted, stakeholder motivation to delay reform may hinge upon their wish to ensure that consensus is indeed built by taking sufficient heed of the expertise, subject matter knowledge and views offered. In this regard, the role of the two professional organisations mentioned above is confirmed as influential in Slovene healthcare (Albreht et al, 2009:27, 29, 33-34, 68-69). Further, qualitative methods used in this research, based on content analysis of stakeholder subject matter interview transcripts and published material, were useful in bringing out these patterns of stakeholder engagement and involvement.

This research further shows how the challenges of existing, heterogeneous IT systems use in healthcare and different stakeholder requirements may be constructively

reconciled through consensual politics. This case features participation of key healthcare and standard-setting stakeholder organisations in project management committees and working groups of specific remit to elaborate technical specifications, and training activities for healthcare professionals. This formal structure has operated in tandem with a programme Managing Authority, Monitoring Committee, payments control and evaluation as per the requirements of the EU cohesion policy. It has helped advance this national eHealth project beyond its initial stage. Future progress of this project lends itself to further examination by policy makers and scholars interested in the introduction of information technology as part of healthcare reform.

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EXPLORING THE CONCEPT AND REALITY OF EVIDENCE-BASED IMPLEMENTATION.

J.E. Reed¹ and D.Bell²

ABSTRACT

In the current political and economic climate the drive to improve quality in healthcare must be met by the delivery of evidence based practices that benefit patients at a population level. To maximise outputs from the production and synthesis of knowledge that underpins Evidence-Based Medicine, the research agenda must support Evidence-Based Implementation.

This paper explores the concept of Evidence-Based Implementation (EBI) and proposes a high level framework that considers different types of 'evidence' and different academic disciplines that can contribute to development, understanding and execution of EBI; namely evidence of '*what*' to implement, evidence of '*how*' to implement and evidence of the '*impact*' of implementation.

The proposed framework is intended to i) provide a starting point for discussion, ii) support the review of current theoretical ideas, iii) engage both academic and practitioner input to develop a systematic and scientific approach to EBI and iv) support the conduct of implementation in real-world settings that result in improvements to patient care and outcomes.

To explore the success and challenges of EBI in the 'real-world' 5 case studies from the NIHR CLAHRC for Northwest London are used. The findings suggest that EBI is feasible, but that further work is required to operationalise current knowledge through optimisation of tools, methods, education and support infrastructures to facilitate a systematic approach to EBI.

This paper argues that any approach to Evidence-Based Implementation needs to be integrated into routine clinical practice if Evidence-Based Medicine is to be widely implemented and sustained. To achieve a generalisable and transferable approach to EBI we need not only to understand the 'reality' of EBI in health care but that researchers must work across disciplines and epistemological approaches and engage directly with frontline staff to develop fit-for-purpose approaches to deliver improvements in patient care and outcomes.

KEYWORDS

evidence-based implementation, quality improvement, evidence-based medicine, translational research

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INTRODUCTION

The drive to improve quality in healthcare needs to be met by the ability to deliver high quality evidence based practice that benefits patients at a population level. The last decade has placed quality at the centre of the international healthcare agenda and this will be more contextually important in the current political and economic climate where cost effectiveness will be closely scrutinised. Influential reports including the Institute of Medicine Crossing the Quality Chasm (Institute_of_Medicine:, 2001) and the Cooksey report (Cooksey, 2006) have highlighted variation in quality of care for patients, delays in adoption and lack of compliance with evidence based standards of care. Other published data suggest that over 50% of patients are not receiving ‘ideal’ care (McGlynn et al., 2003). More recent political developments in the UK have echoed these concerns placing the delivery of evidence based care and improvement in quality and value as cornerstones of the healthcare strategy (2010-2011).

Despite the increasing evidence base and public awareness of variation in ‘actual’ quality of care versus ‘ideal’ care the vast majority of healthcare research still focuses on developing the evidence base for medicine rather than how to apply, deliver and assess the implementation of new evidence. The UK government is investing record amounts in medical research with over £1 billion invested by the Department of Health per annum (HM_Treasury, 2010). However, at present it is estimated that only 1% of medical research budget supports research into ensuring and promoting optimal implementation of Evidence-Based Medicine (EBM) into everyday care (Eccles et al., 2009, Woolf, 2008).

This paper explores the concept of Evidence-Based Implementation as a mechanism for productive dialogue between different academic perspectives and the important link to staff who deliver healthcare. The paper reviews aspects of five case studies led by frontline staff involved with the NIHR CLAHRC for Northwest London research programme to explore the reality of Evidence-Based Implementation (EBI).

WHY DO WE NEED EVIDENCE-BASED IMPLEMENTATION?

To realise benefits from the production and synthesis of health knowledge that constitutes Evidence-Based Medicine the research agenda must now support Evidence-Based Implementation to ensure patients receive best care. (Thomson, 2009).

Presenting at the 1997 “Evidence Today : Practice Tomorrow” conference Dr Onion asked “*What does evidence say of how we should implement evidence-base medicine*” (Onion, 2001). At this time he was, perhaps unknowingly, at the forefront of the development of a new field of research which in current terminology is often referred to as Implementation Science, Implementation Research, Quality Improvement Methods or Improvement Science (Health_Foundation, 2011). These terms all describe research relating to the improvement of quality in real world settings.

The growing body of literature in this emerging field challenges common perceptions about the nature and uptake of evidence into clinical practice (Shojania and Grimshaw, 2005, Greenhalgh et al., 2004) Studies highlight the almost impossible task of any

individual staying up-to-date with relevant medical literature (Alper et al., 2004) and have dispelled the belief that peer-reviewed publications alone will routinely result in changes to everyday clinical practice (Grol and Grimshaw, 2003) (Grimshaw et al., 2006).

The research evidence re-emphasises the complex nature of healthcare and the importance of the culture, context, systems and pathways that underpin the delivery of care that if ignored may be detrimental to the uptake and implementation of Evidence-Based Medicine (Greenhalgh et al., 2004, Plsek and Wilson, 2001, Bate P, 2008, Grol et al., 2008). In understanding the integrated roles and functions of multiple professional inputs and processes in any care scenario it becomes obvious why research performed in artificial, controlled and well-resourced settings is not simply transferrable into routine practice within the complex, variable and sometimes under-resourced settings of everyday healthcare (Ting et al., 2009).

The development of implementation research has increased the evidence-base about how EBM should be implemented and as such begins to answer Onion's question. However, despite some advances the gap between 'ideal' and 'actual' care still exists and is a focus for current political health priorities (2010-2011). Whilst generating increasing knowledge about how to (and how not to) implement EBM, systematic implementation approaches are not yet routine in healthcare and a further translational gap appears to be developing between knowledge of 'how' to implement and frontline implementation practice. It is evident that further research is needed to increase our understanding of factors that influence the gap between 'ideal' and 'actual' care and perhaps more importantly to identify reliable approaches to Evidence-Based Implementation that can be utilised by all frontline staff responsible for effecting change.

WHAT IS EVIDENCE-BASED IMPLEMENTATION?

Evidence-Based Implementation was described in the literature in the 1990's as a call to ensure patients realise the benefits from medical research (Onion, 2001) (Grimshaw and Eccles, 2004, Grol and Grimshaw, 2003) (Grol and Grimshaw, 1999). The term Evidence-Based Implementation has developed as a complementary concept to Evidence-Based Medicine (which typically produces recommendations or guidelines that outline 'best' care but rarely support actual implementation through describing what to do and how to do) and seeks to reliably implement Evidence-Based Medicine into everyday clinical practice. As the evidence from the fields of implementation research grows we believe it is timely to revisit the concept of Evidence-Based Implementation.

The development of a clear definition and understanding of EBI will support its acceptance as an important component of the research continuum necessary to deliver improvements in patient care. In turn this will support the urgent need to increase awareness of implementation at political, academic and practitioner levels where practice suggests there is still a low awareness of the complexities of implementation and change management (Walshe, 2010). Equally the development of a systematic framework to explore EBI will support a better understanding of how different academic disciplines and theoretical ideas currently or potentially can contribute to the EBI

agenda and support collaborative working between the diverse disciplines engaged in implementation research.

Whilst many areas and concepts relevant to the idea of EBI have been explored through implementation research, to the author’s knowledge, no definition of EBI exists. A proposed definition is that EBI is the utilisation of current evidence and generation of new evidence to support the implementation of EBM into routine patient care to achieve measurable improvement in patient outcomes and experience.

CATEGORIES OF EVIDENCE THAT CONTRIBUTE TO EBI

To explore the concept of Evidence-Based Implementation it is useful to consider the types of ‘evidence’ that contribute to implementation activities, how the varying aspects of evidence link together and how they align to different research agendas and academic disciplines.

Three broad categories of evidence contribute to Evidence-Based Implementation;

- Evidence of what to implement
- Evidence of how to implement and
- Evidence of impact of implementation.

We propose that rather than considering these as static or discrete components applied in a linear and rational approach, that these different categories of evidence overlap and interact to support an iterative cycle of EBI that aims to deliver measurable improvements in patient care, outcomes and experience, as depicted in Figure 1.

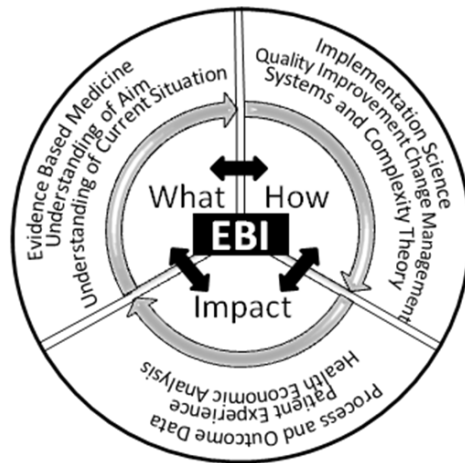


Fig. 1. Evidence-Based Implementation Cycle
 A framework for considering the contribution of evidence and academic disciplines.

Viewed together these categories provide a framework to support cross-disciplinary discussion about the complexity and challenge of EBI, and ultimately to support

practitioners to harness academic knowledge to achieve real improvements. The work presented in this paper provides an initial reflection on the three categories, their interaction and contribution to EBI, and highlight questions that further research needs to address.

EVIDENCE OF WHAT TO IMPLEMENT:

Evidence of what to implement relates closely to EBM which identifies existing evidence whether in a synthesised form such as national guidelines, meta-analyses or drawn from specific experiments (e.g. randomised controlled trials (RCT's)) or locally gathered evidence. The identified evidence typically defines the hard-core component of any implementation effort, that is well defined and fixed (Denis et al., 2002). In addition to the hard core components of an implementation effort it is also important to consider the soft periphery, that is less clear and more flexible to support manipulation and uptake by the adopting system (Denis et al., 2002, Langley and Denis, 2011). Whilst the distinction and importance of these elements is recognised in improvement literature, such considerations are rarely explored at the point at which EBM is generated or guidelines and recommendations produced. Further research is needed to identify the hard and soft components of EBM in order to support implementation activities.

Evidence of what to implement also relates to an understanding of what the goals of any implementation aim to deliver combined with evidence of the current systems and service provision at a local level. This allows implementers to assess how relevant the identified EBM is to address a specific problem or achieve a specific improvement aim and its alignment with professional consensus and patient needs (Rycroft-Malone et al., 2002). Further research is needed on how to rapidly identify fit with local needs problem and readiness of organisations to implement EBM.

EVIDENCE OF HOW TO IMPLEMENT:

Evidence of how to implement draws on the growing field of implementation research which links knowledge from multiple academic disciplines aimed to deliver an improved understanding of the mechanisms and context that influence implementation in complex systems. Importantly, research into how to implement needs to identify lessons from successful as well as less successful approaches.

As the field of implementation research develops so does the understanding of the complexity of managing change in healthcare (Plsek and Wilson, 2001, Plsek and Greenhalgh, 2001). The care of patients requires coordination and resource allocation often with multiple contacts spread over the continuum of a care pathway involving different professional groups and organisations. Focusing on the behaviour or context change of a single group of individuals (e.g. clinicians) is of itself not sufficient to optimise the delivery of care involving many other professionals and non-professionals (Greenhalgh et al., 2004). Indeed, evidence suggests that professional communities of practice are often unidisciplinary and great effort is needed to create functioning multidisciplinary communities of practice ((Brown and Duguid, 2001, Wenger, 1998). Further work to understand how to build communities of practice across professional and organisational interfaces of care is needed, in particular to identify how such

collaborative approaches can be supported within the mainstream of healthcare provision.

The role of context and organisational and professional cultures has been recognised as highly influential on ability to implement change. Organisational research suggests that it is the ability to observe, reflect and respond to local situations that allows organisations to optimise care provision and achieve high quality care at a local level (Bate P, 2008). Indeed research of how to implement suggests that there is no single method or quick fix approach to deliver sustainable improvements in care provision (Department_of_Health, 2007). Whilst research has progressed knowledge in understanding the factors that contribute to a receptive change environment and successful implementation (Pettigrew, 1992, Pettigrew, 1991) there remains less certainty about how to translate this knowledge into organisational change and improvements in patient care.

The importance of addressing complexity and the need for locally tailored solutions that are responsive and contextually relevant highlights the balance between the development of generalisable theories and findings and the need for contextually relevant implementation to achieve local and national goals. It has been suggested that useful knowledge in organizations is often best developed not by “specialists” detached from a problem (whether management, consultants or academics), but by those “who directly benefit from a solution”. (Morrison et al., 2000, Brown and Duguid, 2001, Somekh, 1995). The applicability of action learning, action research and action science to producing locally relevant knowledge and solutions have been identified in the literature (Parkin, 2009) and have been summarised as *‘planned engagement and collective reflection on experience that can expand and even create knowledge while at the same time serving to improve practice’* (Raelin, 2009). However, these modalities have had limited reported impact on the day to day working in healthcare and further research is needed to understand the utilisation and uptake of these practices within day to day healthcare settings (including support requirements to optimise their use).

Understanding the effect of expected and unexpected variation in quality of care has been an important development in recognising the challenge of optimising care in real-world settings (Ting et al., 2009). Whilst contributions from engineering and statistics have introduced the methods of statistical process control as a method to interpret and act upon variation, greater understanding of how high quality care can be delivered in variable settings or contexts is needed. This requires the further use and development of research methods that help to interpret and understand variation to support EBI in real world settings, and implies a focus on local contextually relevant research. However doing so shifts the focus from controlled and artificial settings typical of randomised controlled trials, that for a long time has dominated the world of healthcare research, and challenges assumptions and traditions at the core of the epistemological divide between EBI and EBM (Auerbach et al., 2007, Berwick, 2008).

EVIDENCE OF IMPACT OF IMPLEMENTATION

To complete the cycle of EBI it is necessary to understand the impact of the intervention or change. Impact can be observed at two levels 1) the extent to which implementation

took place/was successful 2) the extent to which implementation of the intervention achieved improvement towards the aim (namely improvements in patient care, outcomes or experience).

Recognising that healthcare is complex and strongly influenced by local processes, systems and context, measuring impact at all stages is crucial to understand whether results from EBM (e.g. RCT or guidelines) can be replicated in real-world settings, and achieve the same results consistently with no adverse impact.

Measuring impact in complex settings draws on a diverse range of skills and academic expertise and includes the collection and reporting of agreed data at a local level to permit an understanding of the extent to which an intervention has been beneficially implemented, and ideally partnered by data collection at an outcome level to ensure desired improvements have been achieved.

Table 1. Categories of evidence and associated academic disciplines

Evidence-Based Implementation category	Exemplars of 'evidence' that contribute to category	Exemplars of academic disciplines that contribute to category
Evidence of what to implement	Existing evidence base (inc. Evidence-Based Medicine guidelines) Evidence of aim of implementation effort Evidence of baseline situation	Experimental Medicine Basic Sciences Randomised Controlled Trials Public Health Epidemiology
Evidence of how to implement	Implementation Science Quality Improvement Change Management Systems Theory Complexity Theory Social Worlds Theory	Sociology Psychology Management Education Engineering
Evidence of impact from implementation	Process and Outcome measures Patient Experience Health Economic Analysis	Public Health Epidemiology Statistics Engineering Health Economic

INTERPLAY BETWEEN CATEGORIES OF EVIDENCE

While all 3 elements of EBI are important it is the interplay between the different contributions that will give most benefit but also pose the greatest challenges to the delivery of EBI.

‘WHAT’ AND ‘HOW’

Increasing evidence within the field of implementation science recognises the influence of the choice of ‘what’ to implement on one’s ability to successfully deliver change (Pettigrew, 1991, Rycroft-Malone et al., 2002). For example the evidence selected can influence perceptions of the credibility of evidence, stakeholder buy-in and alignment with strategic priorities, which in turn influence the success of an implementation attempt (Ferlie et al., 2005, McCormack et al., 2002, Rycroft-Malone et al., 2002, Wenger, 1998).

It is clear that whilst research findings of ‘what’ to implement are necessary they are not sufficient alone to bring about change (Lomas et al., 1993) and the mutual influence between innovations and adopting systems has been demonstrated (Denis et al., 2002). Understanding the ‘soft periphery’ of implementation efforts and how practitioners can adopt and adapt within a variety of local settings is necessary to improve the translation of research into practice (Michie et al., 2011). Complexity theory and action research recognise the complexity and unpredictability of change in healthcare and propose a continuous process of change is necessary that engages relevant stakeholders and allows fit-for-purpose solutions to emerge at a local level ((Plsek and Greenhalgh, 2001, Weick and Quinn, 1999).

The interplay between the evidence relating to ‘what’ and ‘how’ reflects the tensions between EBM generated in controlled, artificial settings, and the challenge of delivering consistently high quality care in complex real world settings. Questions raised during investigations as to ‘how’ to implement may challenge the relevance of evidence purported as ‘what’ to implement, and inform the dialogue between different epistemological approaches around the current ‘hierarchy of evidence’ favoured within health research.

‘HOW’ AND ‘IMPACT’

The interplay between ‘how’ and ‘impact’ are explicit in many implementation and improvement approaches, with the regular measurement of impact utilised as a method to understand the success of the implementation phase. Critical measurement and observation supports reflective practice and allows work to be adopted and optimised within a local context. Despite the key role of measurement in implementation approaches, the lack of rigorously collected process data means it is often difficult to ensure ‘fine tuning’ locally and can reduce the certainty that a change has been an improvement (Vos et al., 2010, Benn et al., 2009).

To understand the effectiveness of different implementation approaches it is important to collect outcome and cost effectiveness data to understand the impact of different approaches of ‘how’ to implement. Further research is needed, potentially utilising new experimental approaches, to address widely held concerns that there is little evidence of the effectiveness of different implementation approaches (Auerbach et al., 2007).

‘IMPACT’ AND ‘WHAT’

Increased understanding of the ‘impact’ of an implementation attempt should directly support identification of ‘what’ to implement in future EBI cycles to further improve care. This may come from an improved understanding of the problem, the context or behaviours and improve knowledge of why previous attempts achieved their level of success. It may also provide important information to guide priorities and funding for future generation of EBM.

A FRAMEWORK FOR EXPLORING EVIDENCE-BASED IMPLEMENTATION

Combining the three elements of evidence needed to support EBI recognises the continuum of evidence created and how it needs to be utilised more effectively to support improvements in patient care.

Using the framework outlined in Figure 1 allows us to breakdown the concept of EBI in to more manageable components and reflect on what actors and epistemologies contribute evidence at different stages and what tensions exist between the different stages. The proposed framework helps articulate the need for further engagement with other academic disciplines including exploration of links to EBM, public health and epidemiology. Academic engagement with the whole EBI cycle will support researchers to see the entire research continuum, thus promoting trans-disciplinary working to drive improvements, rather than a singular disciplinary or epistemological focus. In turn this will facilitate dialogue and explore tensions between different epistemological approaches of EBM and EBI (Auerbach et al., 2007, Berwick, 2008).

Ultimately any framework for EBI need to support the adoption of an evidence based approach to implementation as routine in the NHS and build NHS capacity for change. To deliver this further insight is needed into the conduct of implementation in real-world settings so that any approach will help staff with the practicalities of making change happen across a range of healthcare settings. A systematic and scientific approach to EBI needs to be user friendly, and co-designed with involvement of stakeholders including frontline staff and patients so that it can support work in variable systems and be adapted to the local context. We need to better understand what the support requirements are and how they relate to the NHS’s ability to respond to and deliver beneficial change within the current financial envelope.

This can only be achieved through active dialogue and continuous action and reflection from all stakeholders. The EBI cycle demonstrates the significant number of disciplines contributing to implementation knowledge and practice, but we currently lack a way of connecting, testing, utilising and optimising this knowledge for the broader purpose of achieving improvements in patient care. The EBI cycle can provide a framework to guide action research at a macro level, between different disciplines and between academics and practitioners. This is essential to bridge the gap between knowledge focused academia and problem focused practitioners to result in a more scientific conduct of practice.

EXPLORING THE REALITY OF EVIDENCE-BASED IMPLEMENTATION: NIHR CLAHRC FOR NORTHWEST LONDON CASE STUDIES.

To understand the reality of EBI from the perspective of frontline project teams this paper explores the EBI cycle utilising exemplar data from the first 5 projects supported by the NIHR CLAHRC for Northwest London (CLAHRC_NWL) programme (See Box 1 for details). All projects are self-evaluated as well as participating in a broader cross-project analysis undertaken by the CLAHRC_NWL. This evaluation approach is designed to support project delivery as well as allow iterative development of the CLAHRC_NWL support roles and to identify transferable lessons and generalisable trends. This paper presents early high level findings from data gathered as part of the cross project analysis and supported by the reflections of the CLAHRC_NWL staff who are engaged as participant observers.

The 5 projects covered a broad range of topics and clinical areas:

Project A) Implementation of NICE guidelines relating to a respiratory disease. A care bundle was developed to support implementation. An acute respiratory ward was the principle setting for the project but professionals from other care settings including community and primary care were engaged.

Box 1 - Innovative infrastructures to support the development of a systematic and scientific approach to EBI

The NIHR CLAHRC research programme was established to study the translation of research into everyday care. Nine CLAHRC programmes were funded in England each with an average budget of £10 million over 5 years from the NIHR. Whilst all CLAHRC's have adopted distinct approaches and themes they share common aims to build research capacity within the NHS and harness the power of academia to work with the NHS to deliver improvements in patient care.

The NIHR CLAHRC for Northwest London has uniquely focused on building a comprehensive programme of work to support implementation of EBM into everyday care across the local health economy. One of the key aims of CLAHRC_NWL is to develop a systematic and scientific approach to EBI that is generalisable and transferable across the NHS.

To achieve this aim the CLAHRC_NWL has adopted an innovative and collaborative infrastructure that directly supports frontline NHS teams and utilises a broad range of academic expertise that allows iterative developments as the programme evolves.

As a starting point the CLAHRC_NWL has drawn from various quality improvement approaches that have been utilised to deliver EBM in everyday care, but recognises the current limitations of these approaches including:

- Lack of rigour in relation to previous evaluation of 'impact' of such approaches
- Failure to adopt these approaches as routine in the NHS
- Variable understanding of how the approaches are utilised and whether they are utilised well.

The direct engagements of the academic staff with frontline teams supports understanding of how teams respond to and engage with the concepts of EBI and supports identification of success factors, barriers and challenges staff face. These close working relationships are crucial to the co-design of more effective tools, methods and infrastructures to support the delivery of EBI in frontline settings.

Project B) Implementation of NICE guidelines relating to a infectious disease. A care bundle was developed to support implementation. An acute medical ward was the principle setting for the project but professionals from other care settings including emergency department were also engaged.

Project C) Implementation of targeted professional input and remote monitoring to support medications management following an acute stay in hospital. An acute medical ward was the principle setting for the project but professionals from other care settings including community and primary care were engaged.

Project D) Implementation of a case management system to support integrated management of complex patients, The study was led by a primary care site and engaged multiple professional and community groups.

Project E) Implementation of an HIV screening test in an accident and emergency department.

All projects received facilitation in utilisation of an EBI approach including knowledge exchange and learning events, bespoke training and on-going support from CLAHRC_NWL core team members. All project teams were supported to develop as multi-professional communities of practice, develop a shared aim and work together utilising continuous action and reflection to achieve improvements in patient care.

RESULTS AND DISCUSSION

Data and reflections from the 5 CLAHRC_NWL projects are presented in line with the EBI framework, previously outlined, to explore the reality of ‘what to implement’ ‘how to implement’ and the ‘impact of implementation’ as experienced by frontline teams within a research focused quality improvement programme. A summary of high level results are presented in Table 2.

Table 2. Experiences of Evidence Based Implementation from 5 CLAHRC_NWL projects

Evidence of What to implement		Evidence of how to implement			Evidence of impact		
Project	Source of ‘Evidence’ used to inform project	Process Mapping Performed	Number PDSA cycles*	Number of PDSA cycles* completed	Improvement Measures Used	% weeks improvement measures collected*	Outcome Measures Collected
A	National guidelines	Yes	19	3	Yes	41%	No
B	National guidelines	Yes	12	0	Yes	89%	Yes
C	Peer-Reviewed literature	Yes	2	0	Yes	75%	No
D	Peer-Reviewed literature	Yes	2	0	No	0	No
E	National Policy	Yes	6	1	Yes	34%	Yes

* Information gathered from self-reported project team data on CLAHRC_NWL web reporting tool

EVIDENCE OF ‘WHAT’ TO IMPLEMENT

Project teams initially identified the evidence for the change they planned to implement in support of a ‘bottom up’ approach but were also required to have senior management ‘top down’ support. Evidence selected by the project teams was derived from national guidelines, including NICE (2/5 projects), from national policy documents (1/5 projects) and peer reviewed literature articles (2/5 projects) (See Table 1). A description of the

perceived benefits and problems encountered from the different evidence sources is presented in Table 3.

Four of the five projects were enhancements to existing services and one wished to introduce a new service option. To support identification of local needs baseline data was collected for the 4 projects involved with existing services. All identified deficiencies in the current service and challenged staff assumptions. This supported these teams to believe that the proposed innovations were necessary and could have real benefits which was perceived as important in establishing a shared vision and a sense of urgency (Kotter, 1995).

The implementation of evidence of 'what' to implement into everyday care posed a number of common challenges. There was a lack of detail about how interventions were to be translated into practice and whilst the 'hard-core' of the intervention was agreed upon there was a lack of awareness or knowledge regarding the 'soft periphery' (Denis et al., 2002). Published guidelines and peer-reviewed literature articles provided evidence about what could be achieved. However, to successfully implement the prescribed changes in service there were often unwritten assumptions about basic systems and processes required to support successful change. Our teams found that frequently these systems and processes were not present or operating well and were not delivering minimum standards of care. Projects uncovered serious quality issues within current systems that demonstrated significant amount of pre-work would be necessary before implementation could take place. This discrepancy was particularly noticeable in projects where more complex or technical interventions were being implemented based on evidence from peer-reviewed literature articles. As a result there was a general feeling that some evidence was not applicable to the local setting or current level of knowledge or training of staff. So whilst evidence at face value met with professional consensus and addressed patient needs (Rycroft-Malone et al., 2002) the 'system' needs were not always evaluated and sufficiently considered prior to the commencement of the project.

EVIDENCE OF 'HOW' TO IMPLEMENT

The CLAHRC_NWL core team provided training and advice on a wide range of methodologies aimed to support project teams with implementation. The initial CLAHRC_NWL approach incorporated elements of various quality improvement approaches such as the model for improvement including Plan-Do-Study-Act cycles, lean and six sigma including statistical process control and process mapping and emphasised multi-professional and, patient engagement and utilised a collaborative framework to support training and knowledge mobilisation (Boaden, 2008, AE Powell, 2009). The approach was designed to support and promote action research amongst project teams as active and reflective communities of practice.

Whilst recognising the interaction and overlap between all methodologies used, for the purpose of this paper two elements of the methodology are reviewed to provide insight into implementation in real word settings. The methodologies discussed are:

1) Process mapping – Various approaches to process mapping were utilised by the teams with the broad aim of understanding current process and systems and utilising both qualitative and quantitative methods.

2) Plan-Do-Study-Act cycles (PDSA) – PDSA cycles were promoted to support iterative learning and change through cycles of experimentation and reflection.

For all project teams process mapping and PDSA cycles were perceived as new methodologies and there was variation in willingness and capability to engage with these methods. Reluctance to engage was perceived to relate to low previous exposure to methods (education, training or participation) as well as underlying perceptions of the value and evidence underpinning quality improvement approaches (Ferlie et al., 2005).

As can be seen in Table 2, all projects utilised process mapping at some stage of the project, and provided useful insights to the project, uncovering systemic problems and unanticipated challenges. The activity was conducted at different levels of detail and teams did not repeat process mapping as the project progressed, perceiving it as a one-off activity. Process mapping was introduced as a method to support the teams in developing a community of practice and to support reflection on actual practice. However, some teams were reluctant to engage many stakeholders in the exercise, and all teams struggled to engage all necessary stakeholders due to pragmatic constraints. This practice appeared to represent a tendency amongst staff to produce formal abstract descriptions of work rather than descriptions of actual practice. Without a clear understanding of those intricacies and the role they play, the practice itself cannot be well understood, engendered or enhanced (BROWN, 1991).

The use of PDSA cycles was more variable (see Table 2). Generally teams were unfamiliar with the methodology and did not plan to test small cycles of change.

Table 3. Examples of perceive benefits and problems encountered by frontline teams using process mapping and PDSA cycles.

Evidence of How to Implement		
Utilisation of elements of methodology	Examples of Perceived Benefits	Examples of Problems Encountered
Process Mapping	Identify ‘what actually happens’ Reveal problems with current system that help shape scope/focus of project. Identify key members of staff involved with the process not initially recognised as part of team Increase multidisciplinary nature of team and relevance to project Increase stakeholder engagement.	Lack of familiarity with method Reluctance to participate in ‘new’ methodology and to dedicate time Belief that it can be completed by a single member of staff Difficulty engaging all necessary staff in constructing process map Delay in ‘proper’ process mapping delays identification of problems that impact on scope of project Methods applied differently by different teams, some perceived benefit greater than others. Perceived as one-off exercise and not repeated through-out life of projected.
PDSAs	Supported iterative development of implementation to optimise intervention and ensure fit with local processes and systems. Used appropriately allows mistakes to be identified on a small scale rather than after full roll out with less resource impact and negative messaging.	Lack of familiarity with method Reluctance to participate in ‘new’ methodology and to dedicated time. Variable uptake and utilisation by different projects Most teams performed ‘planning’ and ‘doing’ but did not complete cycles through ‘study’ and ‘act’. Some teams performed PDSA type cycles through their project work but did not recognise them as such or did not perceive the importance of documenting them. When PDSA cycles were documented they rarely had predictions or clear experiment plan. Many were observations or statements of tasks. Study sections of PDSA cycles rarely linked to data collected to support the project.

One team did not use PDSA cycles at all and invested significant resource in preparing a technical solution that was later demonstrated to not be compatible with the time constraints of real world settings. These results relate to a wider issue within healthcare, that implementation is still widely perceived as unproblematic (Diefenbach, 2007, Saka, 2003) and that the application of a linear and rational approach will be successful (Ashford, 1999).

Most teams were observed to act in a responsive and intuitive way to emerging issues or perceived problems. Document analysis and participant observation of the PDSA cycles reveals that the majority of cycles were only followed as far as Plan-Do, and the Study and Act phases were frequently not addressed. Many teams performed informal Plan-Do activities that were discussed in team meetings, but did not perceive the importance or value in documenting them. These observations resonate with the recognition that action research approaches require multiple skills and expertise and needs sufficient rigour to be conducted well and cope with an emergent model (Eden, 1996). If healthcare is to support the development of communities of practice to engage in local problem solving as a form of continuous improvement ((Brown and Duguid, 2001, Parkin, 2009, Weick and Quinn, 1999)); then it is important to understand how to build capacity for the NHS to operate in this manner with sufficient staff engagement and scientific standards to achieve and demonstrate the intended improvements.

EVIDENCE OF 'IMPACT' OF IMPLEMENTATION.

All projects were encouraged to construct ways to measure the impact of their implementation project using both quantitative and qualitative measures. In line with model for improvement and measurement for improvement teams were encouraged to select a small group of measures to be reviewed on a regular (e.g. weekly) basis to track progress and adapt plans based on emerging evidence. Typically improvement measures link to processes rather than outcomes as they are more timely to measure and influence through immediate actions, e.g. compliance with a care standard. The CLAHRC_NWL core team provided support to define measures and establish data collection procedures and a web reporting tool was provided to facilitate data collection with automated production of run charts.

To support a more rigorous approach to implementation teams were also supported to collect data regarding the impact of their work against achieving the overall project aim. These measures were typically related to improvement in patient outcomes, such as readmissions, length of stay or mortality rates. These by definition take longer to collect the data (e.g. time lag to receive 30 day readmissions or mortality data) and were assessed through ongoing work within the project teams.

Project teams were unfamiliar with the concept of regular measurement to inform progress and there was variation in the extent to which measurement for improvement was utilised by the teams. Teams who engaged with measurement for improvement had limited capacity to define, collect and analyse relevant data and significant support was required to facilitate this approach. Even in instances when regular data was collected this was not necessarily reviewed by project teams, rarely linked to the 'Study' phase of PDSA cycles and teams were not comfortable with the interpretation of run charts or concepts of expected and unexpected variation.

Teams and individuals who were resistant to the concept of measurement for improvement either viewed it as measurement for judgement as opposed to improvement, or did not consider run charts and statistical process control to be academically rigorous methods. The problems encountered are in part due to differing epistemological perspectives (Ferlie et al., 2005), the difficulties in defining and interpreting process measures (Eden, 1996, Langley, 1999) and lack of experience of participating in action research type approaches.

Table 4. Examples of perceive benefits and problems encountered by frontline teams measuring the impact of implementation

Evidence of Impact of Implementation		
Data Type	Examples of Perceived Benefits	Examples of Problems Encountered
Improvement Measures	Allow regular reflection on progress of implementation Optimise implementation by providing locally context relevant data. Support understanding of expected and unexpected variation within a process	Staff capacity to define, collect and analyse data was limited Difficulty in defining rigorous measures (link to poorly defined aims and poor process mapping) Difficulty in collecting data on a regular basis Weekly 'real time' data not perceived as important by many staff Low awareness of how to interpret variation in data
Outcome Measures	Evidence that implementation has been successful in achieving overall aim (extent to which results reproduce existing evidence base) Necessary to secure stakeholder engagement and support for continuation of work.	Clinical coding of data poor which limited ability to collect relevant data. Difficulty connecting data across systems or pathways of care Ability of teams to define expected improvements in outcomes

Project teams were more familiar with the concept of outcome measurement and recognised this as an important result of the project and necessary to secure stakeholder buy-in. 2/5 projects successfully reported outcome measures, but 3/5 were unable to. Technical difficulties included the access to relevant and accurately coded clinical data and the ability to link data across boundaries of care (e.g. primary and secondary care data sets).

CONCLUSION

Exploring EBI at a conceptual level reveals multiple types of evidence and academic disciplines that contribute to the delivery of an EBI approach to improve healthcare. However, it is the frontline teams responsible for implementation and healthcare improvement that by necessity need to view and act within the entire EBI cycle, piecing together all contributing evidence to support their work. Currently, frontline staff perform this work without a systematic approach guide them and work often takes place in busy settings where improvement work is conducted in addition to a full time job. Academics on the other hand often have the luxury of focusing on one limited component of evidence at a time to gain an in-depth understanding within their particular academic discipline. But by doing so are academics missing whole picture? In depth learning needs to be balanced by more general learning, so that academics can

better understand the complexity of challenge faced by frontline staff that have minimal training or support to conduct EBI.

Exploring the 'reality' of EBI using examples from the NIHR CLAHRC for Northwest London has revealed some of the challenges faced in delivering EBI in real world settings. All 5 projects supported by CLAHRC_NWL have delivered some change, including work which has now been developed or adopted at a regional level and national level. The timing of uptake and use of different aspects of EBI approach has varied by the project teams. This in part relates to the original level of knowledge or understanding in many cases but also cultural and behavioural barriers implicit within individuals or professional groups.

Learning from the success and challenges of the 5 CLAHRC_NWL project teams has identified key issues and problems to be recognised and addressed by the academic community to support improvements in healthcare delivery.

Evidence of What to Implement. Findings highlight the difficulty of applying EBM guidelines and recommendations in complex real world settings. Further work is needed to support understanding of how to conduct real-world research which is more directly transferable to frontline settings.

Evidence of How to Implement. The quality improvement approach utilised by CLAHRC_NWL demonstrated benefits, but lack of previous experience and capacity to deliver were key barriers to uptake and effective utilisation by project teams. Further work to clarify the purpose of quality improvement tools and methods, and how they can most effectively be taught and utilised by communities of practice within the NHS is required.

Evidence of Impact of Implementation. Limited capability and capacity to define, collect and interpret measurement for improvement and outcome measures was a barrier to individual project success but also directly impacts on our ability to learn which approaches to implementation are most effective. The lack of rigorous data regarding implementation is a frequently cited frustration in implementation research (Auerbach et al., 2007, Walshe, 2009) and so understanding how to support frontline staff achieve this is an important agenda for academics as well as those responsible for delivering care.

Implementing evidence into practice should be recognised as hard and resources in terms of time and staff must be released if they are to realise this goal. A systematic and scientific approach to Evidence-Based Implementation will support staff to maximise improvement efforts but understanding how to build capacity, what support requirements are and if and how these can be met by academia are important considerations in building such an approach.

The learning to date from CLAHRC_NWL projects suggests that to deliver a systematic and scientific approach to Evidence-Based Implementation it is necessary to adopt an iterative approach that engages frontline staff responsible for delivering change. This is necessary to support the development of appropriate tools and methods to facilitate the

up-take of an Evidence-Based Implementation approach and to build capacity at a national level to deliver improvements in healthcare.

This paper does not set out a final solution to the intellectual or operational requirements for the delivery of Evidence-Based Implementation, but sets out a framework that can be used to explore the contributions of different forms of evidence and academic disciplines, and suggests how this framework might be utilised to understand the reality of implementation from the perspective of frontline staff. However, it is essential that we stop distinguishing between knowledge based and problem focused research and recognise the need for these different epistemologies to work together, synergistically, if we are to deliver evidence based improvements in patient care.

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DISRUPTIVE INNOVATION IN STROKE DIAGNOSIS IN REMOTE LOCATIONS: FIELD-BASED ULTRASOUND

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ABSTRACT

The number of patients presenting with symptoms of stroke early enough to qualify for potentially reversing thrombolytic therapy is constrained partly by the availability of imaging technology to determine that the stroke is ischemic, rather than hemorrhagic. Field-based ultrasound devices on ambulances, particularly in geographical locations distant from stroke treatment centers, represents a disruptive innovation: making use of smaller, cheaper ultrasound devices, which are ‘good enough’ to determine the type of stroke. We argue that off-the-shelf transcranial ultrasound offers a convenient and reliable means to rule out the diagnosis of hemorrhage and improve the effectiveness of the early management of stroke. This technology could potentially facilitate faster diagnosis, earlier therapeutic administration of thrombolytic agents, and lead to improved mortality and morbidity. We also suggest a discrete-event simulation study, focusing on alternative patient pathways. This allows us to evaluate the potential health systems effect of field-based diagnostic devices and of teleradiology.

KEYWORDS

disruptive innovation, point of care testing, simulation, stroke, ultrasound

INTRODUCTION

The treatment of stroke and its consequences exacts an enormous financial and social burden, especially in developed countries, with huge consequences for public policy. It is the third leading cause of death and the leading cause of disability in the UK and the US. Despite improvements in the organization of stroke care, we have yet to see the innovations that have led to significant changes in the model of care for some other conditions. The treatment of patients with myocardial infarction, for example, has moved from a position where thrombolytic drugs could only be administered in an emergency department with a cardiologist present to one that requires only someone to interpret the ECG output and a mid-level provider to administer the drug. Our contention is that the emergency phase of stroke care now needs to undergo a similar revolution.

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For acute ischaemic stroke (AIS) the early use of recombinant tissue plasminogen activator (tPA) to dissolve blood clots (thrombolysis) is increasingly seen as standard practice. Thrombolysis has been shown to result in a one-in-three greater chance of a patient returning to normal or nearly normal lives within three months of the event (Kendall, 2008). The use of tPA for certain types of patient with AIS was licensed by the FDA in 1996 and by the EU in 2002, yet rates of thrombolysis for eligible patients are still low in most countries (Rudd and Williams, 2009). The use of tPA is time critical and dependent on a brain scan to determine eligibility (There is a risk of secondary bleeding in the brain with administration of tPA, so it is inappropriate for patients with pre-existing bleeding, such as a hemorrhagic stroke, recent surgery or other bleeding risks). Lack of timely access to CT or MRI equipment is therefore a potentially significant factor influencing thrombolysis rates. In the US the approach is to treat stroke as an acute heart attack type emergency and provide intervention, tPA, as rapidly as possible. However, there are still severe problems in accessibility to imaging in many regions and acute stroke management practices in rural areas are suboptimal (Leira et al., 2008).

We argue that there is potential for disruptive innovation in the processes for acquiring data on a stroke patient's condition, its transmission and analysis, and treatment during the medical management of the acute phase of AIS. Quite apart from the impact on the quality of life of individual patients, the economic benefits in doing this may be substantial. To evaluate the economic benefits of field-based care, we suggest a simulation study that considers the likely cost of the new care model and the benefit gained by avoiding the long term costs of stroke-related disability.

In the next section we discuss the concept of disruptive innovation and its application to point of care testing. We then outline the dimensions of the stroke care problem. Next we discuss field-based scanning and administration of tPA as a possible solution. Then we discuss our simulation study considering Scotland as a location where geography can make the access to timely diagnostic of stroke challenging. Finally we draw conclusions on the challenges for the introduction of field-based care.

DISRUPTIVE INNOVATION AND POINT OF CARE TESTING

Calls for 'disruptive innovation' as potential solution for some of the problems of the health care system are increasingly common (Hwang and Christensen, 2008, Smith, 2007). Conventionally, a disruptive innovation has lower performance characteristics than existing products or services, but is more affordable, convenient and simpler to use – essentially it is one that is 'good enough and cheap enough' to meet the needs of less demanding customers who were previously ignored. Eventually disruptive innovations extend their market share to invade the territory of incumbent firms and disrupt their business. Disruptive innovations are not necessarily superior to existing models and may never entirely replace that of the incumbent, but they often change the overall value proposition (Markides, 2006).

There are some prominent examples of disruptive innovation in health care. Coronary angioplasty and the ensuing product innovations in balloon tip catheters and stents have disrupted the more resource intensive practice of coronary bypass surgery (table 1). This

has spawned a new generation of clinical professionals, interventional cardiologists and radiologists, whose procedures require fewer days of inpatient hospitalization and result in more rapid recovery. In fact this disruptive technology has been so successful that it has generated a high demand for the service, which may have led to greater costs than if it had not been introduced: the ‘market’ has been extended as more patients can be treated than previously.

Table 1. Treatment of coronary artery disease as a disruptive innovation (Neale, 2010, Nagle and Smith, 2004)

<p>Old standard of practice: <i>Coronary Artery Bypass Graft (CABG)</i> Professional group: <i>cardiac surgeons</i> Cost: <i>\$170,000 for surgery, pre-op, post-op and follow up care</i></p>
<p>Disruptive technology: <i>balloon angioplasty with stents</i> Professional Group: <i>interventional cardiologists</i> Cost: <i>\$29,000</i></p>
<p>Impact of disruptive technology: <i>Huge growth in volume of patients receiving treatment. Health care costs rise greatly rather than fall</i></p>

Another area where disruptive innovation in healthcare is occurring is point of care testing (POCT). Rapid developments in analytical technology are making it easier to conduct many diagnostic tests at or near the site of patient care, speeding up the delivery of results. Using portable and handheld diagnostic instruments and test kits, costs can be reduced; patients can receive feedback in a single appointment and access to healthcare can be improved by bringing the test to the patient.

Some types of POCT can be seen as disruptive innovations because they provide less functionality (although the quality typically improves over time) and are far less expensive than traditional laboratory testing. High priced, high functionality laboratory testing equipment operated by skilled laboratory technicians is displaced by new simpler and cheaper equipment used by nurses, healthcare assistants, paramedics and doctors. The latter may be prepared to trade-off slightly less accurate results against improved convenience, thus extending the range of patients that can be tested. Further, new markets are emerging in the form of the general public, which is increasingly prepared to purchase self-testing devices for cholesterol, blood glucose and pregnancy.

The use of the seven minute test of throat swab samples for the presence of streptococcal bacteria (‘rapid strep test’) is an example of POCT which has revolutionized outpatient pediatric clinics. This is especially so in areas at high risk of post-strep rheumatic fever, where the mortality and morbidity can rival that of stroke (Kohler et al., 2010). Consistent with our description of disruptive technologies, the rapid strep test has a diminished performance threshold manifest as lowered sensitivity. The consequence of this is to require a throat swab to double check negative results (Bisno et al., 2002, Cooper et al., 2001). As with coronary stents, several authors have pointed out the economic disadvantages of widespread rapid strep testing (Frey, 2010), which we will further discuss later.

The use of POCT is growing (TriMark, 2010), largely in chronic care management, where therapeutic decisions do not have to be made so quickly. Its potential in intensive care and emergency situations has also been discussed, but to date its use has been limited. Routine use of point of care cardiac marker testing in the emergency department

may improve the time to treatment with no reduction in diagnostic accuracy, with a potentially beneficial impact on patient outcomes compared to standard laboratory tests (Storror et al., 2006). Just under half of intensive care clinicians were happy to base their clinical decisions on the results obtained from POCT for assessing potassium levels (Jose and Preller, 2008).

The advantages and disadvantages of POCT have been widely debated and are summarized in table 2 below:

Table 2. Advantages and disadvantages of POCT

Potential advantages	Potential disadvantages
<i>Increase in self management of chronic conditions, leading to benefits such as improved adverse experience management and behavior change</i>	<i>Untrained staff may not recognize aberrant results</i>
<i>Economic benefits such as reduced number of clinic visits, reduced length of hospital stay, better optimized drug treatment. Decreased staffing/capital expenditures for simple lab tests.</i>	<i>Tests may be expensive without the economies of scale associated with central laboratory tests.</i>
<i>Decreased test turnaround time, allowing shorter therapeutic response interval</i>	<i>Many tests require subsequent follow up</i>
<i>Better triaging of patients in emergencies, e.g. diagnosis of myocardial infarction with minimum delay (higher sensitivity)</i>	<i>Lower specificity – the default is to follow up to manage risk</i>

Since the POCT devices are designed to be simple to use, extensive training or capital investment in laboratory infrastructure is not needed. However, the economics of POCT are not straightforward as it involves a trade-off between physician time, improved patient management, shorter length of stay and decreased resource utilization (St-Louis, 2000), in addition to any impact of the technology on demand. In certain specialist areas such as diabetes management and sexually transmitted infections the benefits of quick diagnosis outweigh the increased expense associated with POCT. The benefits are less clear in the context of routine diagnostic tests.

CURRENT CHALLENGES IN STROKE CARE

Stroke causes 150,000 and 60,000 deaths annually in the US and UK respectively, and the societal costs are huge – \$65.5bn and £8.9bn (Saka, 2009, Di Carlo, 2009). The need for rapid intervention, coupled with the risk of wrongly administering tPA, means the stakes are high. In both the US and UK, the standard therapeutic window for intravenous tPA is 3 hours from onset of symptoms, with some suggestions this can be extended to 4½ hours (Hacke et al., 2008). There is also an experimental protocol of direct arterial tPA which extends the window to 6 hours, but this is only available at highly specialized stroke centers.

Given the risks of hemorrhage associated with tPA, its administration is generally recommended to occur only in a hospital unit capable of providing intensive monitoring of the neurologic status. In both the UK and US this means availability of critical care beds and specialists (a neurologist in the US, stroke physician in the UK) who are able to administer tPA.

Timely access to CT scanning is also essential. Scanners sufficient for imaging in the acute phase have low operating costs (other than electricity) but very high capital costs, with a limited lifespan (often less than full depreciation) and high labor costs – the true cost needs to factor in radiologists to interpret the scans and technicians to operate the scanning facility. Nevertheless, the strategy of CT scanning to determine eligibility for tPA makes economic sense as more rapid diagnosis and thrombolysis reduces morbidity, in-hospital length of stay and subsequent disability and rehabilitation costs. Other factors also improve the economics of scanning. The capital costs of CT scanners can be amortized over many patients if they are concentrated into stroke centers, speeding up the return on investment. Moreover, the scanner is likely to be used for other procedures, allowing the cost to be subsidized by other conditions. It has been argued that a strategy of “scan all patients immediately” is the least costly of all potential strategies and this is specified in the current US stroke care protocol (Wardlaw et al., 2004).

Estimates of the potential number of patients treatable with tPA, compared to the actual number treated, suggest that there is some way to go before rates of administration are optimized. Studies have found that 24% and 28.6% (Boode et al., 2007, CASPR, 2005) of stroke patients could be eligible if system delays were avoided. Actual rates in the US, UK and elsewhere are much lower. As a significant proportion of delays are caused by patients themselves, there has been an emphasis on campaigns to improve the public awareness of stroke symptoms and the need to take rapid action. These have had a beneficial impact on reducing delays in treatment. Problems still remain, though, especially in rural and remote areas (Leira et al., 2008).

THE NEED FOR DISRUPTIVE INNOVATION IN STROKE CARE

As the administration of tPA is time critical, journey times to reach the location where the imaging can take place are very important. There are various models of locating stroke care, each with certain disadvantages (table 3).

Table 3. Organizational models for stroke care

<i>Model</i>	<i>Concerns</i>
<i>Services are coordinated and concentrated on a regional basis. If the patient is taken to the nearest hospital travelling times are short resulting in faster treatment.</i>	<i>The quality of care received will vary with services available at the particular hospital at that time such as the availability of specialists and CT scanners, beds in the stroke unit, or out of hours cover.</i>
<i>Patients are taken to a specialist centre for the acute phase of stroke, after which sub-acute treatment and rehabilitation would be given in the local general hospital or specialized rehabilitation center.</i>	<i>Travelling times might be too high for thrombolysis, especially if distances to the next specialized centre are large or traffic is congested.</i>
<i>Acute treatment is provided in the nearest general hospital, with a telemedicine link to a specialist neurological centre for provide the expert advice needed for the administration of tPA.</i>	<i>Issues include the availability of a CT scanner in the local hospital, the need for 24h cover in the district general hospital, and the needs of patient requiring specialist care which cannot be delivered in the general hospital even with telemedicine back-up.</i>

But even where stroke centers are the norm and the principle that stroke is an emergency is well established – as in the US – accessibility to imaging is suboptimal.

We suggest that disruptive innovation in scanning technology could help. In order to screen patients for tPA, in most cases a detailed picture of the brain such as produced by CT scanners is not required. This clinical decision needs to be based on a determination of whether there is bleeding in the brain, as this is a contraindication to tPA. This raises the question whether concepts from POCT could be applied to determine whether tPA is appropriate by trading-off detail against accessibility. New scanning devices deployed in the ambulance need not offer state of the art image processing and visualization, but merely show whether or not a patient is experiencing a hemorrhagic stroke.

The principle of remote decision making via telemedicine for the safe use of intravenous thrombolysis at multiple local sites is being established (Pollock et al., 2010). In addition, there are examples of field based application of medical devices where cheaper technology with lower performance extend access and simultaneously impact on the skill level required to perform and interpret scans prior to treatment. For example, GE has developed a hand-held electrocardiogram (ECG), greatly simplified and selling for \$800 instead of \$2,000 for a conventional device, for use to developing countries (The Economist, 2010). Other relevant developments are coming from the military environment, where mobile field scanning units are being developed and work is underway on the possible role of ultra-sound scanners as viable alternatives to CT machines (Smith et al., 2009).

The technology requirements for field based stroke imaging and tPA administration are summarized in table 4. It appears that such a technology for scanning already exists. Research has suggested that when compared with the gold standard of CT, transcranial ultrasound (TCCS) potentially offers a convenient and reliable means to rule out the diagnosis of hemorrhage in the early management of strokes (Becker et al., 1993, Seidel et al., 1995, Mäurer et al., 1998).

Table 4. Innovation requirements for field-based stroke imaging and tPA administration

<i>Field imaging</i>	<i>Field tPA administration</i>
<i>Cheaper (and safer) than currently available equipment</i>	<i>This is similar to existing experience in field based ST-Elevation myocardial infarction care (STEMI) through field based use of tPA since the risk of tPA is from the medication, rather than the underlying condition.</i>

Introducing field based imaging and tPA would require significant organizational innovation. Decisions would need to be made where to locate the new field based solutions, for example in community hospitals (not designated for acute stroke care) or in mobile units. Such decisions would require changes in the structure of the care networks.

The innovations we have described would also have workforce consequences, especially for radiology and paramedics – a generation of medical professionals qualified to conduct the procedure, possibly as well as telemetry to someone capable of interpreting the output would be needed. Telestroke is already well established as a model for remote transmission and interpretation of data, as is ambulance-based transmission of ECG, so the underlying data infrastructure is unlikely to be a barrier to implementation

(Schwamm et al., 2009). But professional and cultural concerns may be more problematic. In the UK these have become apparent in discussions around new regional stroke services in some areas, where radiologists have raised doubts about the service's viability, given financial and staff shortages, and thrombolysis services lack a leading voice from the radiological profession (Choi, 2010).

Perhaps the principal challenge, however, is the possible impact of the prevailing payment and reimbursement structures across systems, and how these potentially influence stroke care (Luengo-Fernandez et al., 2009). There seems little doubt that improving tPA infusion rates confers systemic financial benefits (Demaerschalk and Yip, 2005), however health systems may perceive differently to whom those benefits occur. In the US for example, a tPA hospital stay is reimbursed at nearly twice the rate of a non tPA stay, a mechanism which in itself has been a powerful influencer of clinical stroke policy and practice (Demaerschalk and Durocher, 2007). As seen in the US, a tPA infusion is a desirable revenue item which any given hospital may not easily relinquish to field based services, e.g. ambulance services. In contrast, other health systems such as the UK may account for a tPA infusion as a cost item, and may in fact have fiscal incentives to cost shift that component of care to other providers.

In such economic-centric deliberations, the underlying tenet of care should ideally be blinded to funding mechanisms and instead be founded on evidence based best practice. But while this is an ideal, it would be naïve not to acknowledge the potential impact of systems disruption arising from disruptive innovation in the stroke care pathway.

Could the technologies described above turn out to be a disruptive innovation, facilitating process innovation of the type that could improve outcomes by expanding access while reducing, or at least not increasing costs? If successful this model would provide access to timely brain imaging to previous 'non-consumers' – i.e. those who do not arrive at a stroke unit within the required time frame – and make assessment not only cheaper, but also through more widely available geographically.

It is not always obvious whether a disruptive innovation will turn out to be cost saving or cost increasing. In the case of angioplasty the procedure reduces costs per treatment, but led to an increase in demand for the treatment and hence increased overall costs. The effects on unit and overall costs of field based imaging in hyper acute stroke are less clear cut. With our simulation study, we aim to analyze the cost effectiveness of field-based care. This analysis aims to consider important long-term factors, for example, delayed diagnosis is more likely to lead to severe disability than death, with a subsequent need for substantial health and social care expenditure.

More research is needed to investigate the precise nature of the relationships involved in determining the potential impact of field based imaging for stroke diagnosis, and their relative importance. We can hypothesize that because time to diagnosis is so important in stroke care, the disruptive innovation of field based imaging is much more attractive for stroke than the POCT test investigating the presence of streptococcal bacteria. However, in the stroke case the trade-offs between the quality of diagnosis, time to diagnosis and patient outcomes are untested. For this reason we propose that the use of simulation modeling can help identify the potential impact of such an innovation. In the

next section we outline the proposed application of simulation modeling to a case involving a low population density geographical area. The delivery of stroke care in rural Scotland is especially challenging as hospital transfer times are a crucial factor in the eligibility of patients for time-critical thrombolysis administration.

SIMULATION MODEL FOR STROKE CARE DELIVERY ANALYSIS IN SCOTLAND

Stroke is the third leading cause of death and the greatest cause of disability in Scotland, consuming approximately 5% of the NHS budget. Since the first report of the Scottish Stroke Care Audit (SSCA) was published in 2005, stroke care in Scotland has been changing rapidly. The percentage of stroke patients receiving brain imaging on the day of admission almost doubled from 2005 to 2009 (Scottish Stroke Care Audit, 2010).

However, in the SSCA 2010 report, it is noted that many hospitals have not met NHS Quality and Improvement Scotland (QIS) standards (38). For example, as illustrated in the Figure 1, no hospital satisfied the QIS standard of 80% brain imaging on the day of admission in 2008.

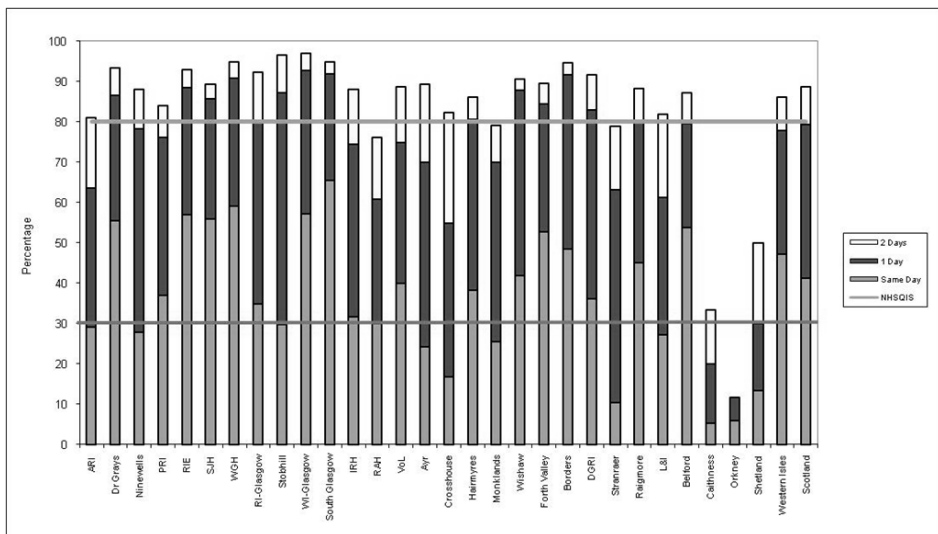


Fig. 1. Percentage of stroke patients with a brain scan by number of days to scanning 2008 data
Source: (Scottish Stroke Care Audit, 2010)

One key challenge that has been identified is the need for fundamental redesign in the way stroke services are structured and organized to ensure that they meet the QIS standards in future years. Brain imaging on the day of admission is especially important as the most effective method to decrease disability for ischemic stroke patients is the administration of thrombolysis within 3 hours of the onset of stroke.

In Figure 2, we marked all the hospitals in Scotland, and the hospitals marked with plus sign denote the hospitals that fall below the 30% line in the percentage of stroke patients

with a brain scan on the day of admission. The delivery of stroke care in rural Scotland is especially challenging as hospital transfer times are a crucial factor in the eligibility of patients for time-critical thrombolysis administration.

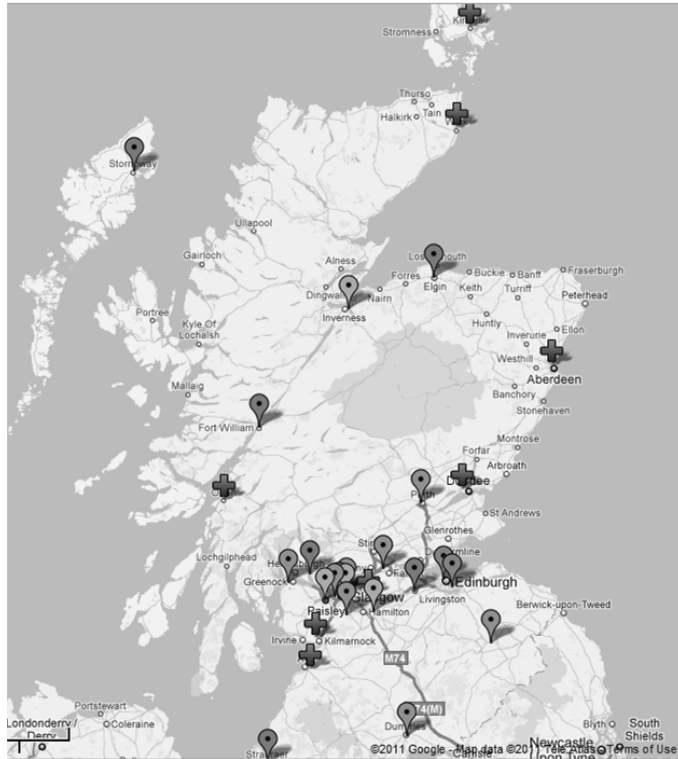


Fig. 2. Hospitals in Scotland (Plus sign: Hospitals with less than 30% scanned on same day)

In the SSCA 2010 report, one key challenge that has been identified is the need for fundamental redesign in the way stroke services are structured and organized to ensure that they meet the QIS standards in future years (Scottish Stroke Care Audit, 2010). In order to do so, we use simulation modeling to compare the impact of the three scenarios in table 3 as well as field-based care in community hospitals and field-based care in mobile units to understand whether the proposed new care method reaches its targets in Scotland.

We have chosen to model the system using discrete-event simulation (DES). This type of modelling is suitable for application to highly complex processes, such as stroke care, and can be used successfully as a communication and decision making tool before committing real resources.

DES focuses on visualizing the journey of individuals, while the other major simulation method, system dynamics, favours visualization of systemic relationships such as feedback loops. DES is a better fit for our analysis since considering every patient and the variations around each patient's journey is crucial. For example, a patient admitted to a hospital as an emergency might be the only stroke patient admitted on that day, but their further journey in the hospital depends on wider system-level factors such as bed availability in the stroke unit and/or the availability of scanning within an appropriate period of time. It is therefore important to know whether a bed or scan is available at a specific point in time.

With our simulation model, we will evaluate the stroke care delivery for the five scenarios consisting of the three scenarios given in table 3, plus field-based care in community hospitals and field-based care in mobile units. The performance measures that we will consider include the QALY after having a stroke, the percentage of patients thrombolysed, the percentage of patients scanned within 1 hour and 24 hours of admittance to the hospital, the percentage of patients admitted to a stroke unit, and the percentage of patients having received aspirin on the day of arrival.

This type of simulation has been used for many different healthcare applications including stroke care as studied by Bayer et al (2010) and National Audit Office (2010). This study differs from the previous work as we focus on a system-wide overview of stroke care delivery, especially the interaction within a network of hospitals and alternative patient pathways of stroke care delivery, whereas Bayer et al and NOA consider stroke care in a specific hospital. On the other hand, we benefit from our previous work for a specific hospital when building our model of a network of hospitals.

In order to illustrate our approach, figure 1 shows an overview of the preliminary prototype for the acute phase of our proposed simulation model. Stroke patients arrive to the system at the time of the call for an ambulance. At their arrival in the system, each patient is identified by their attributes including their age, sex, the postcode of the place where they had the stroke, and the time that has passed since the patient was last seen in a normal condition.

Each step of stroke care is modelled as a station with patients flowing between stations. These stations include waiting for an ambulance, examination at the site of call, transfer to the hospital, examination at the hospital, waiting for a CT scan, etc. We first consider the base case which corresponds to the current situation with no field-based ultrasound. Figure 2 gives us a partial illustration of the base case demonstrating the stations in a hospital. Next, we consider the field-based care scenario and compare it with the base case. For each patient pathway under consideration, as well as the stations illustrated in figures 3 and 4 for the acute stage, there are stations for the preventive stage and rehabilitation stage of stroke care, and all these stages involve many different health care resources.

In the next phase of this research we will apply this modelling approach, using data from the Scottish national stroke audit, to explore the potential impact of the various intervention scenarios on the flows of stroke patients in rural Scotland.

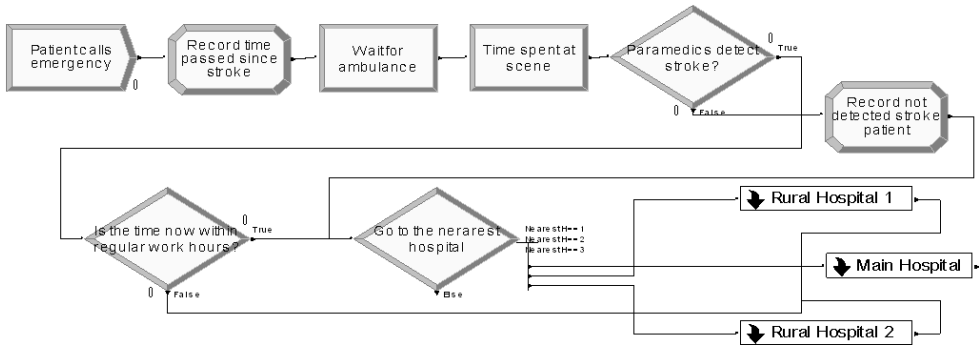


Fig. 3. Overview of a sample simulation model

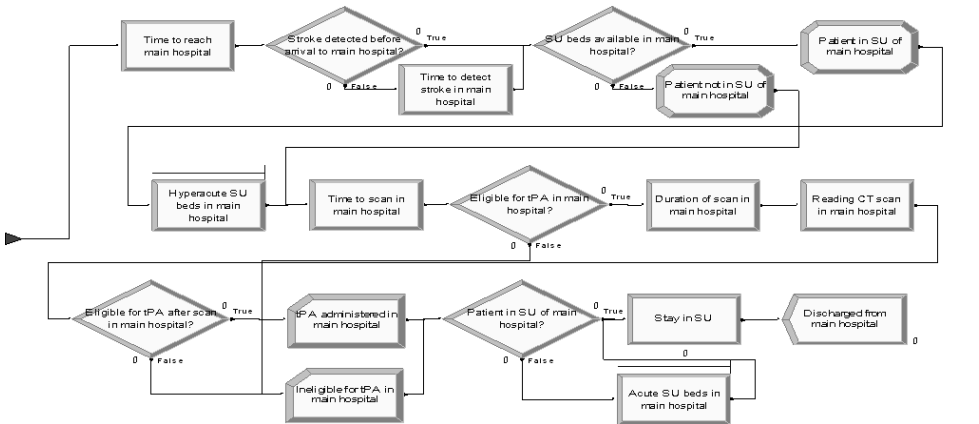


Fig. 4. Details of the model representing the acute stage operations in a hospital

CONCLUSIONS

When a patient suffering an acute stroke is brought to the hospital, CT imaging is needed to determine merely whether there is intracranial bleeding, which would rule out his or her candidacy for thrombolytic therapy. The device used to produce the CT image is the same high performance device, and the same highly trained technician is needed, when the goal is a diagnosis requiring high image resolution and skilled image interpretation. This should not be necessary.

Point-of-care diagnosis has become commonplace in many settings and has been shown to offer prospects of improving access to treatment while offering cost effective care. These include applications ranging from managing infectious diseases in developing countries to rapid assessment of whether a child presenting with pharyngitis in London or Boston needs antibiotic treatment. The technologies inform crucial decisions, but not ones that are time critical and need to be made urgently. Our stroke example suggests

that there is merit in investigating the deployment of field-based, point of care technology in urgent, acute care settings.

We believe that the proposed changes in the care model for stroke will improve clinical outcomes while reducing, or at least not adding to the costs of care. This is achieved by offering the opportunity for earlier treatment, moving part of the care away from the highest cost facilities, and by unbundling the tasks in the care pathway, affording that some of them can be accomplished by non-physician health professionals. The particular, field based, point-of-care technology that we have described to detect intracranial bleeding will have applications beyond candidate selection for thrombolysis in the management of stroke such as detection of intracranial bleeding in falls. This will improve its economics.

Disruptive technologies offer the potential to address the widely observed phenomenon that technological innovation in health care – differently from in other industries – tends to be cost increasing. This effect is the opposite of what is commonly seen in other industries. In health care, we need to disrupt the axiom that advancing technology is synonymous with higher cost. We need to identify and invest in development of technology that offers capability to break down complex processes into units of care that can be provided by professionals whose skill sets are matched to the setting.

Field-based imaging using ultrasound promises to substantially improve stroke care by enabling the more widespread use of tPA. Given the increasing burden placed by stroke on society, the UK and US should not miss these opportunities.

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WHAT ARE THE POTENTIAL BROADER IMPLICATIONS AND VALUE FROM THE USE OF ELECTRONIC HEALTH RECORDS?

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ABSTRACT

In recent years Electronic Health Record (EHR) systems have been introduced in the health care practice of many countries and numerous studies have been carried out to analyze them. The premise of this paper is that the incorporation of more information in the EHR and the access to this information databases by various organizations can have a catalyzing effect and lead to revolutionary changes in health care systems. The thrust of this paper is to explore the broader value and implications from the use of the information that EHR provide, by healthcare organizations and pharmaceutical companies and aims to answer the following main question and secondary questions:

What is the value of current EHR?

- What other kinds of information can EHR include, apart from clinical data?
- How can health organizations, health care service providers and pharmaceuticals best use the information from EHR?
- What is the broader value of EHR?

Our methodology is based on the theoretical background of Cost Benefit Analysis which is applied to the context of EHR and the results show a promising future from EHR usage by health care organization.

KEYWORDS

cost-benefit analysis, EHR, NHS, value

INTRODUCTION

In recent years, Electronic Health Record (EHR) systems have been introduced in the health care practice of many countries and numerous studies had carried out to analyze their future potentials and the drawbacks that their implementation may involve. Past literature emphasizes and tries to examine the potential benefits of the usage of Electronic Health Records in the health care field from 1958 when the first programs to store patient data in computers were starting to be developed (Stead, 2007). During 1991, the Institute of Medicine supported the view that the use of EHR in healthcare is a vital issue and EHR should be considered as a very important technological application in health care. The American Recovery and Reinvestment Act and particularly its section Health Information Technology for Economic and Clinical Health (HITECH)

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Act in 2009, recognizing the usefulness and the potential transformation of health care through the use of EHR systems, provided more than \$20 billion in incentives for the implementation and use of these systems. However, from those points in time until the recent days, there is still a big debate among the scientific community about the benefits, the costs and the value that is related to the implementation and usage of EHR.

Moreover, their use is still not as widespread as it was expected, and various ethical and security issues accompany their development and application. A survey conducted by the Centers for Disease Control and Prevention (CDC) (Hsiao et al., 2009), revealed that less than the 50% of the office based health care providers in USA were using an EHR system. In addition to this, the survey also brought to light that only 13-17% of all the USA registered physicians were using at least a basic EHR system while only 4% of them were using a fully functional EHR system with advanced functions, such as the ability to send electronically prescriptions and medical test results.

This research aims to examine further the benefits and costs, related to the EHR implementation and use, and also to examine the additional information that an EHR can incorporate and the security and ethical issues that may arise from each adaptation.

Attempts were made to estimate not only the value achieved (current value of EHR) but also to assess the “invisible” broader value of HER and the value that certain organization and the society can have if certain assumptions made for the their future use.

Until now, most of EHR systems have been focusing on data from clinical processes, while the incorporation of more types of data, such as behavioral and psychological data would be highly beneficial. The thrust of this paper is to explore the broader value and implications from the use of the information that EHR provide, by healthcare organizations, health care service providers and pharmaceutical companies, assuming that the system will provide open access to all these parties in the future, under appropriate restrictions and regulations. The broader use of EHR systems can have multidimensional and unexpected value outcomes, ranging from maximizing social “wellfarism” and health care efficiency to negative value due to failures in application, functionality, or utility.

In the following section, first the benefits and drawbacks and the current value of EHR systems in health care are examined, in a financial and non-financial context. Data from past researches dated from 2005 to 2008 are used to assess the costs and financial impact of EHR in health care, since they are the only comprehensive studies on the topic, and there are almost no other resources of data. Secondly, it examines the range of new information that can be integrated in EHR in order to enhance their functionality, utility and efficiency as well as the law, security and ethical implications that this adaptation may involve. Furthermore, it examines also the impact that this integration of new information may have on the costs and benefits of EHR as well as its impact under the assumption that this information will be open to the pharmaceutical industry and other sectors related to health care.

COST-BENEFIT ANALYSIS OF EHR

The benefits that are related with the use of Electronic Health Records can include reduction of billing errors and thus enhancement of the revenues, reduction in supply and transcription costs and improvement in test management and interpretation, since the results of the clinical trials can be instantly available to the doctors without the need of printing hardcopies and other bureaucratic processes (Menachemi et.al, 2006; Millard, 2010). In the case of a solo pediatric practice, past research (Cooper, 2004) has showed that revenue enhancement can reach the 271% compare to previous the implementation year revenue, resulting in a 102% profit increase for the health care provider. Moreover, through EHR, health care organizations can achieve better availability of information between various medical departments and doctors, who can have in their hands in a couple of seconds all patient's demographics, medical record, medication, transcriptions and immunizations (Menachemi et.al, 2006, 2011). These can result in further improvements in the quality and safety of the medical interventions on the patients, in better coordination and cooperation between the various medical departments, and, in general, in improvement in the overall efficiency of the health care units (Menachemi et.al, 2006; Poisant et al, 2005; Millard 2010; Burton, 2004).

On the other hand, costs of EHR are related to the implementation and maintenance of these systems. Major costs are related to the upgrading of the current IT infrastructure in the health care units, in order to enable the adoption of an EHR system, including the necessary costs associated with hardware and software development, as well as the costs for software licenses, and support and maintenance costs. There are also some training costs involved and cost from the drop in productivity due to the disruption process effect from the change. Researchers suggest that this temporary drop in productivity incurs in the first months of the change until the medical staff get used to the new process procedures. They estimate that this productivity drop is 20% for the first month, 10% for the second and 5 % for the third (Menachemi et.al, 2006; Wang et.al, 2003, Miller et. al. 2005). Also we cannot exclude the costs for the malfunctions and failures of these systems that can cause even human casualties. This is a cost that cannot be monetized since any attempt to monetize it is unethical (Menachemi et.al, 2006, 2011).

APPLICATION OF COST-BENEFIT ANALYSIS

Our methodology is based on the theoretical background of Cost Benefit Analysis which is here applied to the context of EHR. Past studies are used to determine the value of costs and benefits, while the paper based health record system is used as reference case in the comparison. The past studies used, estimated the monetary value of cost savings through close observations in a case study setting on various health care units. The data used in this paper relied on the reliability of the sources used. Attempts were made to bring the various values on one case of a hospital with 59 physicians, which is considered to be the average health care unit.

The first step in the application of Cost-Benefit analysis is to identify and attach monetary values to the costs and benefits associated with the use of EHR in health care.

Barlow et.al (2004) examining the cost reduction from the use of EHR in the Central Utah Multi-Specialty Clinic, which had 59 physicians, in the duration of one year they concluded that EHR have the potential to result in the cost reductions presented below:

- **\$103,000** cost reduction due to improved coding in medical forms that result in better compensation of the medical interventions and trials. Many doctors choose less restrictive and less compensated forms for medical interventions while the use of EHR makes coding procedures clearer and easier.
- **\$380,000** cost reduction in transcription costs. Studies suggested that a typical three-physician practice has a cost of about \$0.11 per transcription line (Agrawal 2002; Menachemi et.al, 2006).
- **\$160,000** cost reduction due to the lack in the need to produce new or upgrade existing patient charts (Wang et.al, 2003).
- **\$248,000** savings due to less space requirements, more space for more patients, elimination of storage costs for the traditional paper based records and less personnel due to the extinction of the tangible records.

In the financial benefits, we must also include the savings from the reduction of medical errors. A study in the General Accounting Office Reports (Menachemi et al., 2006) revealed that EHR have the potential to reduce medical errors to such an extent, so that annual savings of the order of \$850,000 can be achieved. Also it is stated that EHR during a 6-year period present the potential to reduce the average length of stay by 32%. This is a reduction around 5.3% per year. The costs per patient per day in the USA in 2005 were estimated to be around \$1,500 (U.S Center for Medicare & Medicaid Services), so the reduction was around \$79.5 per patient. In the table below (Table 1), the savings from the reduction in the length of stay from the use of the EHR are summarized.

Data were retrieved from Center for Disease Control and Prevention, Population Reference Bureau and American Hospital Association and with simple calculations we estimated the number of patients per hospital and the number of patients that stay overnight. There are some discrepancies between those databases since as total number of health units is counted primary health care units, ambulatory units, intensive care units and pediatric practices. Also some data retrieved are from an ambulatory service units setting.

Table 1. Savings from reduction in the length of stay due to the use of EHR

	2005	2006	2007
Discharges per 10000 population¹	2,325	2,312	2,254.7
Discharges on the whole US population (302,000,000²)	70,215,000	69,846,560	68,082,880
Total number of USA registered health care units³	5,795	5,795	5,795
Patients per hospital	12,116.5	12,053	11,748.6
Percent of patient with overnight stay³	8.2%	8.2%	8.2%
Number of patients that stay overnight	993.6	988.3	963.4
Savings per patient	79.5	79.5	79.5
Savings from the reduction in length of stay	78,991.2	78,569.85	76,590.3

Sources: ¹Center for Disease Control and Prevention

²Population Reference Bureau

³American Hospital Association

Furthermore, past studies also state that during a 1-year time period, the use of EHR can result in 9.5% increase in revenue for the health care unit; it is notable that this is directly attributable to the use of EHR (Menachemi et.al, 2006; Barlow et.al, 2004). This percentage can be reformed as an increase of the annual revenues by 1.58%. According to the 2010 Physician Inpatient/Outpatient Revenue Survey, the average annual revenue generated by various medical specialties in 2010 was \$1,496,432 in each USA hospital. Multiplied by 1.58%, that is the annual increase in revenue directly attributable to the EHR system implementation and use, this produces a \$23,643.6 increase in revenue.

Trying to identify and measure costs, various past studies suggest that the cost of implementation of an EHR system is about \$19m for a 7-year long process in an acute care hospital with 400 physicians (Menachemi et.al, 2006, 2011; Wang et.al, 2003). Implementation costs include hardware costs, software licensing, content development, workflow redesign, training, launch support, and project management (Fleming et.al, 2011). This figure can be transformed to \$2,714,286 per year during the implementation process which is around \$6,786 per physician plus \$17,000 per physician for maintenance expenses. So for a 59-phycisian practice the annual cost of implementation should be around \$1,403,374. Finally, the loss of productivity can be estimated around \$11,200 per provider, so for a 59-phycissian clinic, it will be around \$660,800 but this can be treated as a reduction in revenue (Wang et.al, 2003).

In order to sum up and compare all the cost and benefits we estimated their future value, projecting their value in 2010 which will be used as a base year, assuming a 3.5% interest rate (approx. yield of 10yr USA Treasury bond in 2010). The future values of all the above costs and benefits are summarizes in the table (Table 2) below. Applying cost

benefit ratio, excluding costs from temporary loss of productivity since these occur during the first three months and be reflected in the revenue account, we have:

$$\text{Cost-Benefit Ratio} = \frac{\text{Difference in Costs}}{\text{Difference in Benefits}} = \frac{1,848,243.56}{2,291,521} = 0.81$$

CB net benefit approach =
 (Difference in Costs) – (Difference in Benefits) = (1,848,243.56 – 2,291,521) = | 443,277.44 | Net Benefit.

It is clear that EHR present a clear financial benefit that, in the subsequent years following implementation, can become even greater, since there will be less training costs, no productivity losses, and no costs associated with the installation and the launch of the system. Training will be needed only I cases of updates applied on the system but even in this case the costs will be less from the initial training process.

Table 2. Cost and benefits in 2010 values

	2010 Future Value
Benefits	
Improved coding	135,631.3
Reduction in transcription costs	500,460
Cost reduction from chart development	210,720
Savings due to less space requirements	326,616
Potential savings from reduction in medical errors	1,009,533
Savings from the reduction in length of stay	84,917
Revenue increase directly attributable to the EHR	23,643.6
SUM	2,291,521
Costs	
Cost of implementation	1,848,243.56
Temporary loss of productivity	870,273.6
SUM	2,718,517.16

FAILURES OF EHR IMPLEMENTATION: THE NHS CASE

Alongside the financial and broader social benefits that may arise from the implementation of an EHR system, some remarkable examples of their failure must be

taken into consideration. During the application of CBA we had shown that there is great value in adopting an EHR system, but that does not mean that there are not cases of false planning and implementation that can lead to great disaster and monetary loss. These cases are considered as extreme cases that must be presented but we cannot take them into account in the implementation of the analysis. A well-known case is the case of the implementation of the National Electronic Health Record in NHS in UK.

On the 8th of December 2003, the Health Secretary announced that all patients in UK would have their own electronic medical record by the year 2010 and he announced three contracts with IT providers, worth a total of £2,715m. On the 30th of May 2006, the Health Minister announced a delay at least 2-2.5 years to the completion of the project. On the 18th of May 2011, a Financial Times article claimed that the “world’s biggest IT project was facing the failure” after £11bn were spent and the project has not yet been achieved.

According to the National Audit Report (HC 888 2010-2012, 2011), until the 31st of May 2011 only 16% of the systems were delivered in acute trusts, a percentage which is translated in 19 systems while other 103 systems are still outstanding. In community health services, the percentages are better with 93 systems or 73% delivered and 36 systems outstanding. In mental health only 21 out of 56 systems have been delivered and in GP practices only 1,377 out of 4,500 systems have been delivered. Finally, according to the Department of Health (September 2010) “....in line with the broader NHS reforms, the National Programme for IT will no longer be run as a centralised national programme and decision making and responsibility will be localized.” This can only be regarded as a way to decentralize some costs and responsibility for the implementation of the project

FUTURE ASSUMPTIONS ABOUT EHR SYSTEMS AND IMPLICATIONS ON VALUE

This section presents our opinions about what extra information can EHR include and what other databases may be integrated with EHR systems for their efficiency, functionality and usefulness to be enhanced.

Moreover, assumptions are made for the usefulness of EHR in a system that some organizations, such as pharmaceutical and insurance companies, and other companies would have from the use of the information that EHR can provide to them, assuming that the system will provide open access to all these parties in the future, under appropriate restrictions and regulations. Finally we will try to assess the impact that the above assumptions may have on EHR’s costs and benefits.

Until now most of EHR systems are focusing on data from clinical processes and demographic data for the patients, while the incorporation of more types of data could be highly beneficial. EHR can incorporate also behavioral and psychological profiles of the patients that will help doctors to assess better some symptoms that patients may have and can be related to their psychological profile. Moreover some drugs can have negative impact and deteriorate patient’s psychological condition. This would also have

a broader beneficial social perspective for the safety of the individual itself and the broader society.

Furthermore, with regard to the incorporation of further information in HER, it is the authors opinion that there should be implemented a connection between the EHR systems and other databases and records providing various information about e.g. environmental changes or environmental factors that can have a negative impact on human life, databases with data about traffic accidents, alcoholics, drug users etc. The integration of this information into the EHR systems will provide lot of interrelations between the data, providing useful material to the medical providers and researchers to support existing medical knowledge in or to facilitate the development of new norms about the impact of environmental factors and social phenomena may have on human life and health condition.

In addition to the above, the usage of the information that EHR can provide from organizations related to health care can have a catalyzing effect and lead to revolutionary changes in health care systems. Pharmaceutical companies and independent researchers or universities can use the information from the EHR systems to investigate the side effects that some drugs may have, resulting into safer drugs for society and also a major reduction to the costs that hospitals, medical insurance companies, and individuals incur, arising from the need to treat patients that are suffering from the consequences of the side effects. Through EHR they can have access to the total number of patients that take a particular medication and investigate more effectively the causes, the range and the percentage of the side effects and interactions reported. Also extensive use of EHR systems would provide also the ability to the patients and doctors to send reports to the companies about the side effects and interactions of certain medication practices. Although many EHR provide already this ability to the users, as mentioned before in USA only 4% of the registered physicians are using an EHR with all its applications and the ability to send electronic reports (CDC, 2008). Also in the USA only the records from the GP practice are connected to pharmaceutical companies and not the records from hospitals that treat more patients with serious conditions during the year.

Furthermore, pharmaceutical companies and researchers could provide direct feedback to the system about newly discovered drugs, side effects and interactions that could have the form of alerts or notifications to the medical practitioners. In addition to the above researchers, pharmaceuticals and medical practitioners could assess better the efficiency of some drugs on a particular medical situation, compare more efficiently treatments, and even distinguish some particular populations on whom drugs may have not an effect or who may need specific doses or drug cocktails. Finally through the information of EHR systems, the above organizations can identify more suitable groups of patients for testing new drugs and improve in that way the safety of drugs and the research around medical intervention's results.

Finally, through access in EHR, insurance companies could adjust better their functions and ways to estimate individual's costs for an insurance program resulting in better and maybe less costly insurance coverage.

DISCUSSION AND CONCLUDING REMARKS

This research was based on data on application costs and benefits of EHR systems collected in various previous studies. Although the cases examined in these studies were quite different attempts were made to adjust the data so as to reflect the real value of EHR. Many more studies should be done with more data becoming available, in order to be able to identify all the costs and benefits involved with the implementation of EHR in a more generalized framework.

As it was demonstrated above, there are many benefits arising from the use of EHR, which can overcome the existing costs. In the years following the year of implementation, the benefits can be even greater since there will be no training cost, no productivity losses and no costs for the installation and the launch of the system. Moreover, as financial benefits for the health care units in the USA, we can consider also the incentives that will be given through the MEDICARE and MEDICAID incentive programs which will start from a base payment of \$2 million each for the eligible health care units in a 5-year period (Centers for Medicare and Medicaid services: EHR incentive program). Taking into consideration the revenue for the eligible health care units, the benefits from the adaptation and use of an EHR system seem to be much greater. Also many more types of information and assumptions than those presented in this research may be able to be integrated into EHR to improve their future functionality and efficiency and, in general, to help guide the health care sector towards overall efficiency.

All the afore-mentioned assumptions must work under the appropriate law restrictions and ethical implications. First of all, these systems must provide high level security so that the patients are reassured that their medical records will not be accessed by irrelevant or unauthorized persons. This is not only an issue of privacy, but also an issue of safety, since if the medical record of an individual is altered then his/hers own life and safety may be in risk. As society will become more reassured about the safety and access issues, individuals will be keener to provide data of high quality for scientific research. Secondly, it seems that organizations like research institutes, universities, pharmaceutical companies and the insurance sector can have great benefits from accessing and using the information provided by EHR systems while some of these benefits will increase the broader social value of EHR systems, this must be done with great caution and with anonymity, in order to protect individuals in all cases. As it was mentioned above, insurance companies will be able to adjust better their insurance policy but also if anonymity is not protected then they can unfairly discriminate against patients.

To conclude, EHR systems have many benefits to offer towards the transformation of health care, the improvement of patient safety and the quality of the services provided, and the reduction of cost not only for the health care units but also for the broader society. However, these benefits can be only achieved by following the law restrictions and protecting as much as possible the individuals and the society in general.

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BUSINESS STRATEGY FORMATION IN AN INTEGRATED AREA AND HEALTHCARE DELIVERY PROJECT

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ABSTRACT

This study deals with a niche-innovation process that aims at developing a business strategy for an integrated area and healthcare delivery project in the Netherlands. The goal is to explore the critical events and barriers on the strategic level during the niche-innovation process in order to improve business strategy formation in integrated area and healthcare delivery projects. It is a longitudinal study in which the first two authors are engaged as action researchers in order to get an authentic understanding of the niche-innovation processes. The analysis shows that it is all about engaging actors, sharing and exchanging visions and expectations in order to reduce uncertainty and create commitment. The findings can be used by the project members to develop new business strategies while further research can test the propositions in future studies.

KEYWORDS

action research, commitment, niche-innovation processes, strategy formation

INTRODUCTION

Today's fragmented healthcare system is under pressure being challenged by changing external influences such as an aging population (e.g. De Blok, et al., 2009; United Nations, 2010) and increasing healthcare expenditures while simultaneously being confronted with pressures to increase the quality of care and design tailor-made solutions. At the same time, countries with a high population density like the Netherlands need to develop sustainable and coherent areas to assure the long-term usability to its citizens (e.g. de Korte, 2009) which necessitate a sufficient infrastructure including housing and healthcare delivery services.

Consequently, niche-innovation processes are needed that enable the change of systems (e.g. van den Bosch, 2010). A niche is a protected space in which a network of "industries, users, researchers, policy makers and other involved actors" can experiment with new innovations with the goal to change the existing system (Raven, 2005, p.48). For instance, the healthcare delivery system requires a niche-innovation process from supply-driven to demand-driven care to improve the quality of care (Beukema and Valkenburg, 2007; Enthoven, 2009). The area delivery system needs a niche-innovation

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process from fragmented towards integrated developments to ensure the quality of housing and living (e.g. de Korte, 2009).

However, such a niche-innovation process takes time requiring initiatives from organizations and institutions to actively change and facilitate such niche-innovation processes. One of these initiatives is an integrated area and healthcare delivery project in the Netherlands. The project started with the network Twentse aanpak Verzorgd Wonen (TaVW) which received a subsidy from the government to pursue several experiments concerned with welfare, housing and care. Their aim has been to incorporate the lessons learned in the experiments into a business strategy for an integrated area and healthcare delivery project. Thereby, the key question for this study is: *What are the critical events and barriers on the strategic level during the niche-innovation process towards forming a business strategy for an integrated area and healthcare delivery project?* It should be noticed that the strategic level is especially concerned with the visions and expectations of the network actors (e.g. Hamel, 1996; Mintzberg, 1994).

This research is based on a longitudinal study using qualitative data from the project of the TaVW as well as previous research on strategic niche management (SNM) in order to explore the critical events and barriers on the strategic level during the niche-innovation process. According to SNM, the niche-innovation process of the TaVW can be described as a radical innovation process which tries to fundamentally change the area and healthcare delivery systems. Kemp et al. (1998) as well as Raven (2005) provide some insights into niche-innovation processes, but only do so retrospectively. Grin (2008) states that niche-innovation processes could benefit from research that focuses on micro level actors to get a better understanding of the dynamic processes. Subsequently, the theoretical background of SNM will be outlined. Next, it is described how the TaVW project has been studied followed by the analysis of the data. Thereafter, the results are discussed to develop several propositions. Finally, the limitations and recommendations are elaborated and a conclusion is derived.

THEORETICAL BACKGROUND

SNM can be described as an evolutionary theory that tries to change systems through niche-innovation processes (e.g. Geels, 2002, 2004, 2006, 2010; Geels and Schot, 2007; Kemp et al., 1998; Kemp et al., 2007; Raven, 2005; Raven et al., 2010; van den Bosch, 2010). As defined earlier, a niche is a protected space in which a network of “industries, users, researchers, policy makers and other involved actors” can experiment with new innovations with the goal to change the existing system (Raven, 2005, p.48). A system can be described as “a dynamic concept [of] rules (regulative, normative, and cognitive), embedded in human actors [...]” (Raven, 2005, p.31).

An example of a system is the healthcare delivery system (e.g. van den Bosch, 2010), the electricity system (e.g. Raven, 2005) or the automobile system (e.g. Schot et al., 1994). Systems are relatively structured and stable whereas niche-innovation processes are surrounded by high levels of uncertainty resulting in less stability (Geels and Schot, 2007). Government programs can protect niche-innovation processes through subsidies (Caniels and Romijn, 2008a). In the end, niche-innovation processes can stabilize and

might change or replace the existing system (Caniels and Romijn, 2008a; Geels and Schot, 2007; Raven, 2005).

Niche-innovation processes have been studied before (e.g. Kemp et al., 1998; Raven, 2005; Geels and Schot, 2007). Raven identified five building blocks of the niche-innovation process in his study on the use of biomass in the electricity system. These building blocks consist of a vision about the future, the expectations that the stakeholders have about the development of the niche-innovation process, the network formation that is needed to enable the niche-innovation process and conducting the experiments to learn about the niche-innovation process which in turn can alter the visions and expectations of the stakeholders. In so doing, the system will only change if the niche-innovation processes become more structured and stabilized (Geels and Schot, 2007; Raven, 2005).

Nevertheless, as stated in the introduction, Grin (2008) argues that niche-innovation process research would benefit from studies on micro-level actors. Likewise, Hutzschenreuter and Kleindienst (2006) articulate the importance for pursuing longitudinal studies including action research approaches to understand strategic processes.

RESEARCH METHODOLOGY

BUSINESS PROBLEM SOLVING METHOD

This study is an explorative, longitudinal study using qualitative data that is gathered by being engaged in the project of the TaVW in order to discover the critical events and barriers on the strategic level during the niche-innovation process. In order to do so, this research applies the business problem solving method of van Aken et al. (2007), combined with the concept of engaged scholarship (e.g. van de Ven, 2007) and action research (e.g. Kock and Lau, 2001). The concept of engaged scholarship is particularly useful in this context since it provides insights in the perspectives of key stakeholders by closely participating in the project (van de Ven, 2007). Thereby, van de Ven emphasizes that engaged scholarship can be specifically useful in combination with action research. The advantage of action research is the possibility to influence the outcomes of the project while it creates knowledge for practitioners as well as for researchers (Kock and Lau, 2001; Sekaran, 2003). Consequently, the first two authors have been engaged, being part of the project and taking action instead of just observing the TaVW network.

DATA COLLECTION

The data for this study is part of data that has been collected by the first author in an ongoing, longitudinal research on the TaVW. In 2007, the TaVW network was formed. It consists of the following five stakeholders: an elderly-care organization, a mentally-disabled care organization, a project development group, a network firm and a research institute for applied research. The goal of the TaVW was to set up several experiments to learn about area and healthcare delivery innovations that could be used for future integrated area and healthcare delivery projects. The first author started to participate in the network TaVW by becoming a member of the steering committee of the project at

the beginning of 2010. The second author was also a member of the steering committee while the third author was not involved in the project. The data for this study was mainly taken out of the participation on the strategic level of the TaVW since the focus of this study are the critical events and barriers on the strategic level of the niche-innovation process.

During 2010, the first author pursued several semi-structured, open-ended interviews which were recorded and transcribed. Six interviews were conducted with the various members of the steering committee. The steering committee consisted of the elderly care organization’s innovation director who was also the project manager, the CEOs of the mentally-disabled care organization and the project development group, and the consultants of the other two stakeholders. Furthermore, eight interviews were conducted with other organizational members due to their importance for the niche-innovation process. Examples are the CEO of the elderly care organization or the CFO of the mentally-disabled care organization. Furthermore, the first author has been able to get deeper insights and clarify doubts through casual talks during meetings, phone calls and e-mails as well as car pooling talks and getting access to documents. Finally, a workshop with the elderly care and the mentally-disabled care organizations took place at the end of 2010. The workshop was facilitated by the first and second author and dealt with wrapping up the experiments in order to form a business strategy for an integrated area and healthcare delivery project. The workshop was based on the observations, interviews and documents that were gathered throughout 2010. The workshop was videotaped and transcribed for the analysis. The participation and data collection is summarized in Table 1.

Table 1. Participation and data collection

Participation 2010	<i>Team size</i>	<i>Role of first author</i>	<i>Meet-ings joined</i>	<i>Number of inter-views</i>	<i>Time of interview/ workshop</i>	<i>Documents</i>
<i>Steering committee</i>	8	<i>Project member</i>	4/4	6	<i>March-May 2010</i>	50
<i>Other key actors</i>	10	<i>Inter-viewing</i>	/	8	<i>October-November 2010</i>	8
<i>Workshop</i>	10	<i>Workshop facilitator</i>	1/1	/	<i>December 2010</i>	5

DATA ANALYSIS

Based on Boeije’s (2010) qualitative data analysis method the data was analyzed. NVivo, a qualitative data analysis software (e.g. Baezely, 2007) was used to organize and code the data to be able to answer the research question. It has been able to check for inter-observer reliability (e.g. Sekaran, 2003) as the first two authors both participated in the steering committee meetings and in the workshop. Using the interviews, meeting minutes, notes, e-mails, newspapers, and other documents enabled the triangulation of data improving the validity of the analysis (Boeije, 2010; Miles and Huberman, 1994). Previously to this study, owing to the ongoing research on the TaVW, open coding was pursued after a first set of interviews was conducted and

documents were collected. Consequently, various codes evolved which led to numerous categories.

At first, 115 codes have been established during open coding. These codes were identified based on Boeije's (2010) questions such as "What is going on here? What is it about? What is the problem? What is observed here? What is this person trying to tell?" (p.99) as well as "How does the participant act while involved in the process? When, why, and how does the process change? What are the consequences of this process?" (p.105). The codes were named as they occurred in the data. For example, one respondent felt time pressure to go through with the project; hence this was coded under 'time pressure'. Any other data dealing with time pressures were coded into the same code 'time pressure'.

At this point, the general problem situation of the TaVW came to the surface: how to get from the experiments to a business strategy for an integrated area and healthcare delivery project? The problem situation led to the use of SNM since it deals with protected niches in which organizations can experiment in order to derive at new strategies to change the existing systems. The next step was axial coding by gathering additional data and merging codes into categories based on SNM and strategy formation processes. Examples of categories that emerged are for instance 'Visions', 'Expectations', 'Commitment', 'Experiment planning', 'Experiment implementation', 'Learning' etc. Those categories concerned with the strategic level are used for the empirical analysis of this study which is elaborated in the following.

EMPIRICAL ANALYSIS

The overall goal of the TaVW was to pursue and learn from several experiments in order to integrate the lessons learned into future integrated area and healthcare delivery projects. Yet in the beginning the vision of an integrated area and healthcare delivery project was rather vague not knowing what it actually looks like or how to get there which indicates the evolutionary process of the project. This led to the research question that is stated in the introduction: *what are the critical events and barriers on the strategic level during the niche-innovation process towards forming a business strategy for an integrated area and healthcare delivery project?* Based on the data analysis, the participation in the project and the insights of prior research on niche-innovation processes (e.g. Kemp et al., 1998; Raven, 2005) three categories are particularly useful to answer the research question. These are the visions of the stakeholders, their expectations about the project and the commitment for future collaboration.

VISIONS

Working with different stakeholders raises questions about interests and if the steering committee actually shares a common vision. In fact, at the beginning of 2010, the vision was not shared among the steering committee. One member of the steering committee emphasized that they did not have a common vision about the niche-innovation process:

"Maybe it's me who did not get it right. Nevertheless, I have got the feeling that the continuing process becomes more explicit now. Perhaps it was clear to some people, but I sensed that many people did not get hold of [the whole project

idea]. I think that there wasn't a shared vision on; what is the main goal and how do the sub-projects fit into it. Even right now, I think that the overall goal is still vague and that it is still not clear how the sub-projects will add up to the overall goal."

From the quote it seems that the vision has been rather vague, emerging throughout the niche-innovation process instead of being an ex-ante developed shared vision of the steering committee. Another member of the steering committee said that they lost hold of the original vision which should have been scrutinized and taken care of by the steering committee itself:

"I think that we just lost it. Early 2008, we sketched the end-result and made a book of it, the visionary book. Hence, it was really clear. Then we continued with the sub-projects (experiments) and, unfortunately, forgot to encounter the desired end-result. Hence, it somewhat vanishes. I would say you always have to keep that in mind [...] we didn't do that. [...] I think that we as the steering committee as well as the consortium-team should have taken care of it. We simply should have been more attentive to any alteration to the original plan"

Even though the visionary book provides good insights into the experiments it hardly displays any information on the business strategy for the integrated area and healthcare delivery project. In fact, it only states that the experiments should be aligned in an integrated area and healthcare delivery project. Hence, it was anything but clear. A further member of the steering committee highlighted the evolvement of the vision: *"[...] two, three years ago, we did not know where we were heading. Now, we slowly shape the [integrated area]."* Hence, throughout the niche-innovation process the vision became more explicit. In the end, the steering committee has been convinced about the innovativeness of the experiments as well as the importance to design a business strategy around the experiments despite the fact that they did not have a shared vision in the beginning. Throughout the niche-innovation process, the vision about the integrated area was neither completely clear to the steering committee nor did anyone pay much attention to the vision throughout the experiments.

EXPECTATIONS

During the interviews the different interests of the network partners were stressed: *"There are not just one or two [stakeholders], but there are five. You have got five stakeholders who all somewhat have their own ideas in mind"*. Thereby, steering committee members failed to share and exchange their expectations about the future collaboration. This resulted in high uncertainty about the future collaboration of the network:

"One of the biggest problems is that you work with several stakeholders. How do you cooperate with all the stakeholders in the future [by the time the TPLZ program has stopped], despite the fact that it is going fine right now?"

This led to a misperception about the role the different stakeholders occupied and their roles in future collaboration. During the funding by the government, all five organizations have been stakeholders since the risk was with the government program

financing the project. However, during discussions in meetings, car-pooling talks and phone calls it became clear that for future collaborations the network would have to finance the project. In that case, the network firm and the research institute would only be interested in consulting the project, not being a stakeholder anymore. Yet, the management of the project development group perceived themselves as a stakeholder of the project irrespective of the funding. However, the risk in turn would have been with the funding organizations of the integrated area and healthcare delivery project. These would likely have been the healthcare organizations who therefore perceived themselves as the only stakeholders in possible future collaborations. This resulted in a conflict of interests as the project development group acted as a stakeholder and wanted to start as soon as possible with the integrated area and healthcare delivery project. Yet, the healthcare organizations had different interests which resulted in the frustration of both, the project development group as well as the healthcare organizations. This was stressed during the workshop as one participant said:

“And now we are a little bit – and I get nervous by it – we are [pushed] by the [project development] group. [...]. Yet now we cannot tell what we want. That’s really a problem.”

Concurrently, the project development group was frustrated that no decisions have been taken as they were keen on promoting the TaVW as a front runner in the Netherlands. That was the main reason why the healthcare organizations requested a workshop merely for themselves excluding the other network partners of the TaVW.

COMMITMENT

In an interview prior to the workshop it already became obvious that the mentally-disabled care organization has been occupied with other projects so that they prefer to first learn from their existing projects.

“[We are currently working on two small-scaled housing projects at two different locations which] are the only places where we are working in an innovative way. The experiences will be used for the rest of the organization. We limit ourselves to these two places since the management team does not want to take it a step further yet. You don’t know with which situations you will be confronted yet. It could become a financial disaster [at those two locations] because the people in the village think that it is great to get rid of their [parents] to have more time for themselves. If that is the case we will not make it. Then I would be worried about starting other projects [...]. We will not do it like that“.

Several members of the mentally-disabled care organization also indicated that their CEO has great visionary power, but that he often is ahead in time forgetting to engage other organizational members. They argue that time is needed to engage the organizational members while simultaneously taking into account capacity limitations. This was further substantiated during the workshop by a member of the mentally-disabled care organization who first wants to make the project as explicit as possible:

“But we first have to develop a consistent [project plan] on how the project will look like. Otherwise, [you will face major barriers to implementation]. Then you will immediately have a location and problems are already present. [...]. Hence,

we first have to develop a project plan for location x [...], because then you at least have a proper plan that is ready to be used.”

Moreover, the innovation director of the elderly care organization had no decision power to enable projects. It should be noticed that the elderly-care organization has been the biggest organization of the network with the resources to start an integrated area and healthcare delivery project. Therefore, the other organizations have been dependent on the elderly care organization to go through with the project. Throughout the development of a business strategy it appeared that the innovation director was lacking commitment from the board members. Only the board members and the regional directors have been able to take decisions. Yet these members have not been engaged in the TaVW network nor did they know what was going on in the project:

“[Unfortunately, the current TaVW experiments show that] the regional directors sometimes do not really know what is going on within their facilities. Sometimes not even the board knows what is going on. [...] This is not good. It is not good for the representation of the organization.”

“[the project] is represented by one person, [the project manager], whereas the organization does not really know about it.”

As a result, there was high resistance to go through with the project. Hence, the project of an integrated area and healthcare delivery project has been facing a lack of commitment from the board and the regional directors of the elderly care organization. During the workshop the innovation director of the elderly care organization stressed: *“Now I think it is important that there is commitment from the board [to go through with the project].”* He emphasized that the board members have been interested in the integrated area and healthcare delivery project, but that the decisions still would have to be taken. The opposite was true for the mentally-disabled care organization. The CEO was engaged throughout the whole process from starting the niche-innovation process towards the development of a business strategy by being a member of the steering committee. Decisions were taken quickly without slowing down the process.

Finally, the business strategy should have been ready for exploitation at the end of 2010. This was not achieved which can be explained by high levels of uncertainty about the visions, expectations and the commitment for future collaborations.

DISCUSSION & CONCLUSION

VISIONS

The results show that the vision was neither clear nor shared across the steering committee which created a certain level of uncertainty. That the vision was not clear and shared can be explained by literature. In niche-innovation processes, visioning can be described as an evolutionary process that changes over time reliant on the external environment (Caniels and Romijn, 2008a; Kemp et al., 1998; Kemp et al., 2007; Raven, 2005; Raven et al., 2010; Smith et al., 2010). Thereby, visions emerge out of actors who start to share the same expectations about the future which is crucial to the stabilization

of the niche-innovation process (Caniels and Romijn, 2008a, 2008b; Hofman, 2005; Raven et al., 2010; Smith et al., 2010).

However, unlike previous research which demonstrated that experiments do not change the visions of the actors (Raven, 2005) the findings here show that experimenting helped the steering committee to actually sharpen and share the vision. It can be concluded that unlike previous research suggests, experiments can help to not only sharpen actors' visions but also create a united vision. Therefore, the following two propositions are formulated:

Proposition 1: Niche-innovation processes help to make visions about future projects more explicit.

Proposition 2: Niche-innovation processes enable actors to create a shared vision about future projects.

EXPECTATIONS

The formation of the network TaVW resulted in different expectations about the future collaboration ex-post to the government funding. The healthcare organizations perceived the project development group as a contractor while the expectation of the project development group was to be a stakeholder in the integrated area and healthcare delivery project. This led to major disruptions in the niche-innovation process which could have been avoided if the expectations would have been made explicit to be able to adjust them before the network was formed or before they started planning the future collaboration.

In previous research, the significance of managing expectations in niche-innovation processes has been stressed before (e.g. Caniels and Romijn, 2008a, 2008b; Kemp et al., 1998; Hofman, 2005; Raven, 2005). However, they were concerned with the expectations about the experiments. In contrast, during this study the expectations are not only concerned with the experiments, but also with the roles of the different actors within the network. The role of the project development group changes as the funding of the government stops. This is in accordance with previous research which emphasized that networks continuously change dependent on the environmental context while also new networks can emerge (e.g. Gulati et al., 2000; Kash and Rycraft, 2000, 2002; Koch, 2003; Larson, 1991; Rycraft and Kash, 2002). Therefore, the expectations of network organizations need to be continuously managed. Not doing so can end up in the frustration of all network organizations. This is outlined by the following proposition:

Proposition 3: Niche-innovation processes require the continuous management of actor expectations with regard to the experiments as well as to the network configuration in order to enable the formation of a business strategy for an integrated area and healthcare delivery project.

COMMITMENT

Not sharing the vision within the healthcare organizations led to resistance to change. Raven et al., (2010) state that actors embedded in networks are supportive if these actors share the same vision. But what about the support within the organizations as only a few actors of the organizations participate in the network? Hofman (2005) for instance shows that CEO driven niche-innovation processes lead to organizational members' resistance to change and thus results in a lack of commitment. Intriguingly, this study shows that in the elderly care organization commitment is needed from the board members and the regional directors whereas in the mentally-disabled care organization the commitment is needed from the organizational members. Does this mean that all organizational members and CEOs need to be engaged?

This can be partly explained by looking into the strategy formation literature. The importance of commitment in strategic processes has been discussed before (e.g. De Korte, 2009; Dooley et al., 2000; Frentzel et al., 2000; Hamel, 1996). Frentzel et al. (2000) argues that commitment from CEOs is needed during different stages of the process, but that they do not necessarily need to be engaged throughout the whole process. Furthermore, Hamel (1996) amplified that change does not necessarily take place top-down or bottom-up. By this means, he stresses that in top-down approaches CEOs need to engage organizational members to change rather than imposing change whereas bottom-up started changes need to engage CEOs who should provide legitimacy to the change processes. On the other hand, Grant (2003) suggests that business strategy formation can be seen as "planned emergence" (p.513) that can be viewed as a dialog in which strategic direction is provided top-down while strategic planning takes place bottom-up based on the strategic direction. Either way, all stress the significance of engaging the different actors in the organization. Yet it stays ambiguous how and when the different actors need to be engaged. It is proposed that all actors need to be engaged to enable the formation of a business strategy.

Proposition 4: Niche-innovation processes require the commitment of the embedded network actors, the CEOs as well as organizational members to enable the formation of a business strategy for an integrated area and healthcare delivery project.

LIMITATIONS & RECOMMENDATIONS

The first limitation is the possibility of an observer bias owing to the engagement of the first and second author (e.g. Sekaran, 2003). It is acknowledged that the first and second author might have influenced the project due to their engagement. However, this is limited by viewing them as normal participants similar to the consultants. Moreover, the third author was not involved in the project and therefore enabled an unbiased review of the process. Another limitation is the formulation of propositions. Glaser and Strauss (1967) argue that propositions are relatively static not describing the richness of reality. Nevertheless, the choice for propositions can be motivated by the fact that they make the niche-innovation process towards a business strategy more explicit and understandable.

Furthermore, in-depth research on strategic networks in niche-innovation processes is needed. The link between niche-innovation processes and strategic networks offer great potential for business strategy formation. It would be interesting to see how business strategies are formed out of niche-innovation processes that are managed by diverse networks in other industries. Additionally, research should test the propositions and develop more insights in the strategic level dynamics during niche-innovation processes towards business strategies. Moreover, more research is required to explore how and when to engage CEOs and organizational members in order to create commitment in niche-innovation processes. This could also be a goal in the continuation of the project to provide further insights into the niche-innovation process.

CONCLUSION

Analyzing the strategic level of the niche-innovation process to derive at a business strategy for an integrated area and healthcare delivery project demonstrates the importance of engaging actors, sharing and exchanging visions and expectations in order to create commitment. The results can be used for both, future integrated area and healthcare delivery projects and for future research on niche-innovations processes. Particularly, the close engagement of the first author enabled a thorough understanding of the micro-level processes. The results demonstrate that niche-innovation processes enable network actors to create a shared vision as well as to sharpen their vision. Moreover, niche-innovation processes require the continuous management of network actor expectations. Most important however is the engagement of all network actors as well as organizational members to create commitment for the niche-innovation process in order to form a business strategy for an integrated area and healthcare delivery project.

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FLEXIBLE AND ADAPTABLE HOSPITALS – AUSTRALIAN CASE STUDIES

J. Carthey¹ and V. Chow²

ABSTRACT

In 2009, a literature review uncovered different international approaches to achieving flexible and adaptable health facilities and concluded by recommending further research focussing on Australian hospitals to identify key site issues, design features, and major upgrades that have influenced longer term responses to changing modes of service delivery and other demands in local settings. Responding to these recommendations, this second stage research was conducted by reviewing further relevant literature and project documentation for five case studies, visiting and documenting key adaptability features of each case study facility and consulting with health facility personnel where available. Findings include that longer-term flexibility is assisted by: generous site area, lower rise hospital buildings along a horizontal circulation spine ('hospital street'), surplus building services capacity facilitating easy expansion/alteration, and a consistent workable planning grid supporting a range of standardised room sizes. Future investigation should consider the impact of high land values on site utilisation especially in terms of future proofing multi-storey buildings, and how to assist health clients decide when 'enough' flexibility has been provided.

KEYWORDS

adaptability, case study, flexibility, healthcare facilities, hospitals

BACKGROUND

In 2009 a first stage research study was completed for Health Infrastructure NSW that commenced with a literature review looking at how cost-effective flexible and adaptable health facilities could be achieved with an effective life of 50 years or more. A desktop examination of 19 international case study hospitals followed; chosen from the literature review results because each demonstrated one or more definable approaches to future proofing and analysis was possible due to the availability of information. The study concluded that definitions of flexibility and adaptability were inconsistent, recommended standardization of these and concluded that flexibility should be considered as a system applicable at many levels of project design and implementation rather than as a standalone concept or 'motherhood statement'. It also concluded that strategic, managerial, operational and other policy issues impact on flexible performance at least as much as the original design, and need to be considered in terms

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of their positive or negative influence on the desired project outcomes and addressed accordingly.

The first study concluded with the recommendation that a selection of Australian case studies should be investigated in more depth in order to test the extent to which flexibility and adaptability have been successfully applied in the local (NSW) context. It was also anticipated that more detailed findings could be further extrapolated as design principles for use on future projects. This research responds to these recommendations by concentrating on a set of NSW-based case studies that include Westmead, Blacktown, Mt Druitt, Prince of Wales and Royal North Shore Hospitals and examines these in terms of the assessment parameters developed in the first study.

INTRODUCTION

The reasons for flexible and adaptable healthcare facilities were considered in stage one of this research and so have not been repeated here (J. Carthey, Chow, Jung, & Mills, 2009a, 2009b, 2010). In particular, the first study noted that definitions of designing for ‘flexibility’ and ‘adaptability’ are rarely consistent between projects and in agreement with de Neufville, Lee and Scholtes (2008), adopted as a definition: ‘the provision of options for the future use of healthcare buildings, without the obligation to necessarily exercise those options’ (J. Carthey, Chow, Jung, et al., 2010, p. 105). Further, the nature of these options means that their outcomes and effectiveness can rarely be tested or evaluated until some years after project commissioning and as a result, such evaluations rarely occur. To counter this, a matrix of terms and associated concepts was proposed as shown in Table 1 below to enable a more robust discussion and assessment of flexible and adaptable design. The matrix includes both planning scale (short/long term and micro/macro design phases) and planning strategies in terms of managerial, functional or building system requirements.

As the research client is a major Australian State health system (NSW) examples of approaches adopted by other publicly funded health systems were also sought and analysed in the preliminary phases of the research. For example, illustrating many of the points made in the first research study and indeed the definitions and concepts illustrated in Table 1, the US Veterans Affairs Hospital System (VAHBS) developed by a large government agency addresses the longer term issue of providing flexible and adaptable hospitals to resist obsolescence and issues of declining performance over their life cycles. The VAHBS was first developed in 1972 (the ‘Redbook’ Research Report), revised in 1977, applied to major new or replacement hospitals completed between 1977 and 1995, then reviewed in 2005/6 as the Department undertook advance planning for its first new major hospital projects since the mid-1990s (Department of Veterans Affairs, 2006; Dept of Veterans Affairs, 1972). An extensive series of reports and design guidelines continues this work, including the 2006 report that claims in its Foreword that ‘[i]t has been the VA’s experience that VAHBS projects have not cost more than traditional construction bidding, and have cost less on a life cycle basis’ (Department of Veterans Affairs, 2006, pp. 1-1). The VA approach to healthcare facility design can be characterized as ‘systems integration’ defined in this instance as ‘[t]he combination of a groups of relatively independent parts into a coordinated whole to improve performance through controlled interaction...’ (pp. 1-8). Key features of the

system include ‘modular design with integrated service zones for permanent and adaptable buildings subsystems’ (pp. 2-1), both of which are illustrated in the case studies examined in this research.

Table 1. Definitions of Flexibility and Associated Concepts

Focus	Managerial considerations	Functional requirement	Building system
Micro	<u>Operational</u> Easy to reconfigure, low impact on time and cost (e.g. furniture and interior spaces)	<u>Adaptability</u> Ability to adapt existing space to operational changes e.g. workplace practices	<u>Tertiary</u> 5-10 years lifespan, no structural implications e.g. furniture
	<u>Tactical</u> Involves commitment of capital expenditure; changes not easy to undo (e.g. design of operating theatres, provision of interstitial floors)	<u>Convertibility</u> Ability to convert rooms to different functions	<u>Secondary</u> 15-50 years lifespan, e.g. walls and ceilings, building services capacity
Macro	<u>Strategic</u> Substantial increase in the lifetime of the infrastructure (e.g. long term expansion plans, future conversion to other functions)	<u>Expandability</u> Ability to expand (or contract) the building envelope and increase/decrease capacity for specific hospital functions	<u>Primary</u> 50-100 years lifespan, e.g. building shell
Source	(de Neufville, et al., 2008)	(Pati, Harvey, & Cason, 2008)	(Kendall, 2005)

Further driving the need to extend the lives of healthcare facilities, it was also recognized that the movement towards sustainable healthcare development calls for reductions in embedded energy and greenhouse gas emissions, and the leveraging of these in the reuse of existing buildings. This is another major factor driving the need to design healthcare facilities for flexibility and adaptability in order to ensure a longer life rather than more frequent demolition and rebuilding as presently occurs. In terms of sustainable use of energy Sunand Prasad notes that ‘[w]e badly need accurate metrics that factor in embodied as well as operational carbon to help decide between replacement and renewal’. His point is that older buildings often perform poorly in terms of current energy performance requirements but improving zoning and controls can help; he continues by proposing that ‘[s]tripping down a building to its frame is perhaps the most dramatic level of intervention but still recovers 50% of its embodied energy, and in its rebuilding it can deliver equivalent performance to new construction’ (Prasad, 2011, p. 9). Also in this vein are remarks made by Phil Nedin (2011) of Arup in terms of calls to consider whole life rather than first costs. He further challenges the industry to think about how the healthcare buildings designed today could also be used in 20 years despite changes in models of care, reductions in bed numbers, changes in technologies and other dynamic factors.

The case studies that comprise this research represent examples of many of the techniques expounded in the VAHBS model, and in many instances have also performed well in ways that Nedin suggests are essential, in particular accommodating changing health service needs over time. Each has been analysed in terms of the matrix in Table 1 Table with a view to describing some effective approaches to future proofing Australian healthcare buildings which can be extrapolated to the health systems in most

developed countries. The case studies were chosen because they were included as part of the conclusions of the stage one research which suggested comparing them with the mostly international examples considered in that stage of the research. Each is a large urban hospital constructed up to 35 years ago that has undergone at least one major refurbishment or upgrade since first opening. The Royal North Shore Hospital (RNSH) ‘brown building’ was subsequently added to the study due to the coincidence of its opening in 1977 within one year of Westmead Hospital in 1978. Westmead will very likely continue to operate for another 25-30 years whereas the ‘brown building’ will shortly be demolished as part of a major Public Private Partnership (PPP) project on the RNSH site due for completion by 2014.

METHODOLOGY

The hypotheses tested by the research were extrapolated from the first stage research, and as developed with the research partners, are summarised below:

1. Planning healthcare facilities (including site master planning) for change (flexibility and adaptability) will encourage and better support future developments (new and refurbished) that will accommodate both foreseen and unforeseen emerging service delivery needs and other functions over time.
2. If healthcare facilities are not planned to change and adapt they will become obsolescent (or dysfunctional) more quickly than those that are planned for flexibility and adaptability.
3. The strategies adopted for healthcare facility flexibility and adaptability as shown in Table 1 will be tested and validated by this research as inclusive and accurate.

For each case study facility, a literature search was conducted which included sourcing documents from design and other consultants known to have been involved with either the original hospital development or with major upgrade projects over its life. In addition, where possible, site facility managers were interviewed informally or consulted using email or telephone, followed up by site visits to each of the facilities. Due to political sensitivities surrounding the current redevelopment project for the site, the RNSH ‘brown building’ was not visited and reviewed only as a desktop exercise. Project personnel or facility management were also not available at the Prince of Wales Hospital. For these two case studies, literature from the search plus website information were analysed and then compared to the other three case studies of Westmead, Blacktown and Mt Druitt Hospitals.

A timeline for the development of each hospital was prepared from the available information with major upgrades noted. Finally, the development of each hospital was reviewed in terms of its manifestation of longer flexibility and adaptability according to the definitions of the stage one study.

The data for each hospital were collated and organised using an analytical framework that included determination of the principle characteristics of the site such as overall master planning, the built form of the hospital (tower, hospital ‘street’, site coverage)

and where articulated from project documentation or other sources, strategies incorporated for anticipated future growth or change. Major upgrades (renovations, additions, alterations) were identified and compared in terms of reasons for these and the strategies subsequently adopted with those anticipated at the time of opening of the major hospital buildings. Conclusions were drawn and a report written for the research client - Health Infrastructure NSW- which included recommendations for future proofing NSW healthcare facilities and for future research (J. Carthey, Chow, & Wong, 2010).

RESULTS

WESTMEAD HOSPITAL

Westmead Hospital was the first major project developed following publication in 1974 of the Sax Report: 'A Report on Hospitals in Australia' (Australia Hospitals & Health Services Commission & Sax, 1974) which was seminal in recommending a new philosophy for Australian healthcare delivery including benchmarks for needs assessment and sizing of hospitals. Westmead opened in 1978 with approximately 1000 beds which by 2011, due to changes in the delivery of care, had been reduced by about 200 beds rather than expanding as first anticipated. It was designed by the English architects Llewellyn-Davies Weekes in collaboration with Australian partners, Forrestier-Walker and Borr, and the NSW Government Architect. Drawing from UK hospital planning models such as the Best Buy and Harness systems, Westmead was designed using a strategy of 'indeterminacy' so that it could change in unpredictable ways to cope with different care practices and future advances in technology (Nield, 2008). Because it was expected to be completed in only four years (1974-78) Westmead was built using fast track construction and is one of the earliest examples of this form of contract in Australia. This affected the sequence of construction and various decisions regarding detailing of the facades and floor slabs. The hospital was designed to be modular and building services were zoned to enable easy upgrade or alteration in the future. In the mid 1990s the Royal Alexandra Hospital for Children was relocated to the site from Camperdown to become the 350-bed Children's Hospital at Westmead, and like Westmead Hospital this was also designed to be readily changed and expanded (Constructional Review, 1992). In addition to many smaller developments, in 2008 a major development on the site implemented components of the Western Integrated Network (WIN) Strategy for the Western Sydney Area Health Service. This redeveloped several departments including intensive care units, allied health areas, women's health and newborn care, cancer treatment services and the renal unit. Extensive upgrades of the hospital's engineering plant and services were also undertaken (Leighton Holdings, 2010b).

According to Lawrence Nield the design of Westmead Hospital was 'radical for its time' demonstrating relatively revolutionary planning strategies that included the organization of individual hospital units and the need to anticipate and plan for future growth and change (Nield, 2008, pp. 225-226). Six-storey inpatient buildings and three-storey service blocks were arranged around major movement routes or 'streets' designed with the capability to be extended in response to future growth and change. Almost every main block was designed with a free end to enable future extension or alteration

without incurring excessive capital cost or disruptions to hospital functioning. This centralised plan form with a potentially linear pattern of growth allowed the more determinate elements of the hospital to be located centrally along the spine to form a core set of departments and functions. Less determinate elements were then attached to this core and spread outwards along the secondary circulation routes to ensure that they could be expanded independently in terms of the strategy described above. It was anticipated that new elements could be added to the complex along the spine or core to meet future needs (Architecture Australia 1977). Other features included strict zoning of functions and services at strategic and tactical levels with planning based on a 7.2m grid north to south and multiples of this from east to west (Burgmann, 1982). Structure, services and finishes were zoned to minimize clashes, non-load bearing partitions were used so that design and construction could proceed independently of final room layouts and floor screeds were used throughout all major blocks which enabled the resolution of final bathroom layouts to be deferred until late in the project. In terms of building services, a system was devised comprising standard floor penetrations and double columns to accommodate services thus enabling future alterations to these without disrupting operation of the building.

In 2004-2008 the major works undertaken for the WIN strategy included construction of a building (Block E) across the north-eastern end of the current Westmead hospital buildings across the ends of blocks D and C. Refurbishment and additions to existing building blocks in that vicinity were also made including to the University Clinics building at the end of the Diagnostic and Treatment Block. This development effectively closed off the hospital street or core circulation spine, thus preventing any future expansion of the hospital in that direction. Given the reduction in bed numbers since completion of the original hospital and likely continuation of that trend into the future, the expansion of wards (related to increased inpatient bed numbers) seems to no longer be a priority for the Health Service. Alternative reasons for expansion, for example the need for new services such as rehabilitation or increased diagnostic and treatment capacity, appear to have driven this particular project.

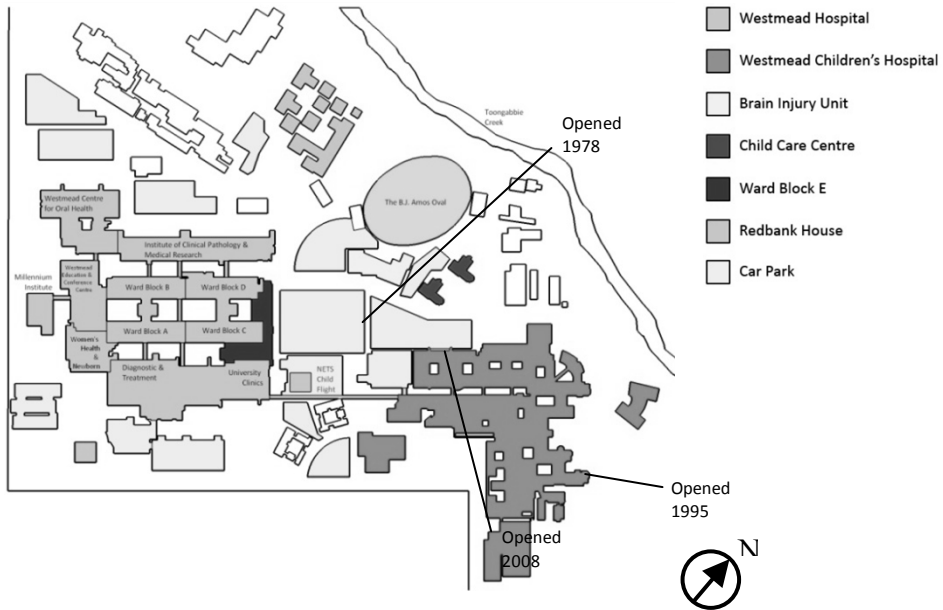


Fig. 1. Westmead Hospital Campus

The Children’s Hospital at Westmead was also built around a naturally lit double height internal street. This complex has four levels and is constructed of reinforced concrete with 7.2m x 7.2m column grid with flat slab floors and dropped panels (Constructional Review, 1992). Infill and cladding materials include rendered blockwork and powder-coated metal. Areas requiring heavy servicing are provided with a full height undercroft allowing for easy replacement and upgrading of mechanical and electrical systems (Wislocki, 1996, p. 64). The future of the Westmead site includes options for expansion/ replacement/ decanting/ demolition of the hospital plus zones for other uses such as a biomedical hub precinct. At the present time, the Millenium Institute on the site is being upgraded and expanded along with other smaller scale refurbishment works in various parts of the facility. See Figure 1 above.

BLACKTOWN HOSPITAL

First opened in 1965 Blacktown Hospital has expanded from an original 160 beds to about 365 beds in 1987. In the 1990s the hospital underwent a major redevelopment that was finally commissioned in 2000 (NSW Health, 2010). The planning phase for another major redevelopment is currently underway that will respond to the health service needs and planning principles outlined in the Concept Master Plan Report for the site prepared in 2007 (R. Carthey, Ryan, Cameron, & Driscoll, 2007). Over the years several buildings have been added to the site; however the largest change was the construction of the new main hospital building that opened in 2000. According to Lawrence Nield, the main public hospital building is now a ‘linked pavilions form’ that is often used for smaller country hospitals and for upgrades of suburban hospitals. The site topography determined the location of the main entry at level three with visitor access to the fourth level inpatient facilities by stairs. The building sections are long, narrow and broken up

by courtyards which express the circulation patterns and act as a way finding device. The general inpatient units are laid out in a double-loaded single corridor form (rooms to both sides of the corridor) with the units laid end to end (Nield, 2008, pp. 231-232). The location of the main hospital buildings on Blacktown Road offers good access from the main road and leaves most of the remaining site available for future development.

The redevelopment was planned to be flexible, adaptable and expandable with features that included the use of non-structural walls, weight bearing slabs, and easy access to hydraulics and electrical/mechanical services to enable straightforward reconfiguration, extension or upgrade in the future (Project Planning Team - Blacktown/Mt Druitt Hospitals Redevelopment, 1996a, 1996b). The 2007 masterplan report included concept plans for a future redevelopment scheme that demonstrated that the building envelope could be extended quite easily through the addition of simple extensions to each end of the hospital and in adjacent locations either side of the main east-west axis. This would provide up to 20,000m² of additional floor area to meet the defined service needs.

Although Blacktown and Mt Druitt Hospitals effectively function as one hospital, and are within 10 minutes' drive of each other, their campuses are distinct and each has its particular focus. For example, the Blacktown campus provides high level inpatient and outpatient services and has the capacity to manage complex patients who require specialist acute care. Mt Druitt provides services to its local community and surrounding region in a complementary manner and these include 24-hour emergency care, cardiology including outpatient cardiac rehabilitation, consultation liaison psychiatry services, a comprehensive paediatric service, aged care rehabilitation, outpatient pulmonary rehabilitation, palliative care and planned surgery including orthopaedics with an Area-wide role in provision of major joint replacement surgery (Health Services Development Unit, 2010).

MT DRUITT HOSPITAL

Mt Druitt Hospital opened in 1983 with 200 beds and although various refurbishments, additions and alterations have occurred the main fabric of the building has not been extensively changed. Various additional buildings have been added to the site either located in close proximity to the main circulation spine or more remotely on the site. See Figure 2 below.

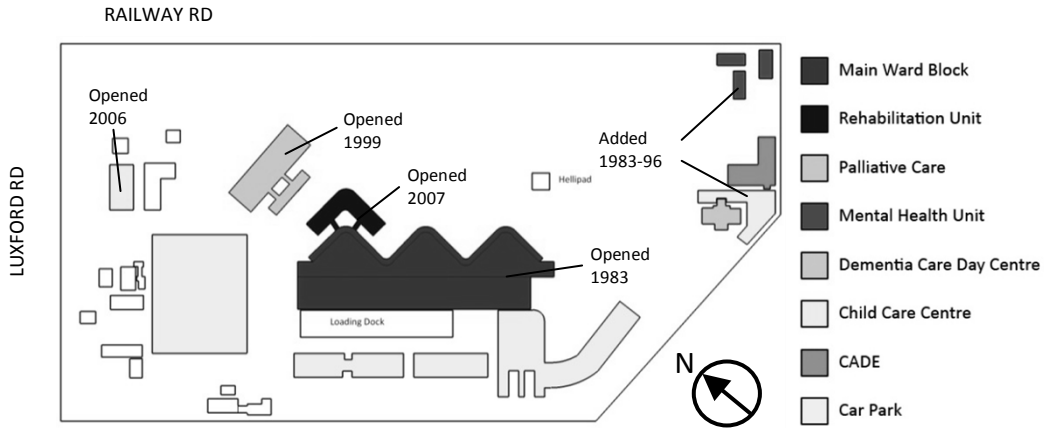


Fig. 2. Mt Druitt Hospital Site

According to Lawrence Nield (2008), architect for the hospital, Mt Druitt Hospital was planned using a computer program called TOPAZ – Technique of Placing Activities in Zones, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), to maximize efficient layout and location of the hospital departments. Studies of internal traffic in similar hospitals informed the arrangement of spaces, and in this case determined the two-storey layout that relies on a hospital street for major circulation that also becomes an organizing principle for future growth and change. The hospital street and the plant rooms act as a spine for the development that was ‘simple to construct, easy to expand or change internally, and had a minimum of external wall area’. Airconditioning and air handling and distribution are placed on a special floor above the upper level, allowing adjustment and maintenance to be carried out without intrusion into clinical areas (Builder NSW, 1984; Nield, 2008). Nield classifies the hospital as an ‘unbundled’ typology in that its form was determined by site and care delivery model.

Triangular shaped nursing units (inpatient wards) are placed on one side of the street on both levels. The triangular wards were designed to ensure that patients were undisturbed by passing traffic, had good outlooks to pleasant views and their environment was tranquil. At the same time they could still be easily observed, and could also readily see the nursing staff to ensure that they felt secure and cared for at all times. Paediatric wards are placed at ground level and have access to a courtyard play area. They were designed with ‘care-by-parents’ units so that parents could be closely involved with the care of their children. On the other side are located clinical and non-clinical units with treatment and diagnostic services and an entry on the upper floor, and kitchen, dining, pathology, plant and maintenance services on the lower floor. Car parking is also located on this side of the street so that patients would not have to look out at masses of parked cars. Instead they have a view across the surrounding landscape that links to the Mount Druitt Town Centre (Nield 2008).

The hospital street is a way finding device and visitors can walk along it to the appropriate ward, using the stairs to access lower levels for example to access the children’s ward. The stairs were designed to be open and inviting to assist in convincing

visitors to use them and not the lifts. The hospital was intended to be easy to operate and administer with good connections between wards and service functions such as the kitchen for delivery of food to wards, dining rooms, etc. According to Builder NSW (1984) significant passive and active energy conservation measures were included in the building. Future expansion can be dealt with by extension of the hospital street at either end while modification of clinical and support facilities can be achieved by extension to the south (Heath, 1984). At present, the Mt Druitt camps focuses on planned surgery, sub-acute rehabilitation and palliative care services and it is likely that future expansion will increase capacity in these areas and also in emergency, mental health, oral health and outpatient clinics for children and adults.

PRINCE OF WALES HOSPITAL (POWH)

The POWH site has been used for healthcare and related purposes since 1858. Initially used as an asylum for destitute children, it first became a hospital during the First World War and has subsequently been through several incarnations as a repatriation hospital and teaching hospital. From the mid 1990s onwards, a major redevelopment on the site added the Royal Hospital for Women (relocated from Paddington), a new acute care services building including 19 operation theatres, three-level private hospital, research facilities, mental health, an upgraded children's hospital and various other services and facilities.

The site is very heavily utilized and accommodates three heritage buildings that cannot be demolished. Land values are high and the site has been built up to leverage this value with several multi-storey buildings that are deep-planned, reliant on airconditioning and artificial lighting. A recent local council precinct study anticipates future expansion of the campus into surrounding areas in the future that would require possible land rezoning, plus reorganization of site entry points and connections to the local community (Randwick City Council, 2010).

ROYAL NORTH SHORE HOSPITAL (RNSH) 'BROWN BUILDING'

The RNSH 'brown building' which opened in March 1977 was included in this study as a comparator to Westmead Hospital which opened in late 1978. The RNSH building known as the 'Main Block' will shortly be replaced by a new PPP hospital due to open in 2014 (Leighton Holdings, 2010a). It was constructed with the capacity to hold 650 beds over seven levels (6-12) above a six-level diagnostic and administrative podium below. On top of the ward levels are two floors of plant forming levels 13 and 14. The tower is 'H'-shaped with the ward areas occupying the 'limbs' of the 'H' with administrative areas, the transport core and service areas in the centre of each floor. Each 25-bed ward was designed on the 'racetrack' principle with a double corridor with patient rooms on the outside walls and staff working areas in the middle. Although the design was standardized to enable future flexibility, each ward is allocated to a single specialty although some specialties use more than one ward. Special needs have been accommodated through the use of local modifications such as radiation shielding or by the use of mobile equipment.

The difficulties in modifying this building to support new models of care have clearly been a factor in the decision to demolish it subsequent to construction of the new hospital. Modifying it while parts of it remain operational on a functioning hospital campus would be especially difficult given limited access and the need to contain dust, noise and rubbish without disturbing or endangering patients and staff working in the hospital.

DISCUSSION

FEATURES THAT ASSIST WITH LONGER TERM FLEXIBILITY AND ADAPTABILITY

Each case study was assessed in accordance with the principles of the stage one study matrix (see Table 1). The planning strategies adopted were mostly focused on enabling long term changes to the building envelope (mostly extension or expansion) to accommodate new healthcare services or alternatively changes of use that required internal remodelling - rather than simply using spaces unmodified for these new purposes. One of the limitations of this research was that largely due to time constraints, it did not examine in detail the use of this last strategy on the projects and as described in the top row of Table 1. Although this approach was validated anecdotally by several of the facilities it should be examined in further depth in future research to understand exactly what features supported it (e.g. room size, shape, etc) or alternatively, worked against it.

Features that do appear to have assisted the case study buildings to change and adapt were identified from the project data and are noted below. Clearly, these were considered desirable because they supported expansion and alteration of the facilities rather than constraining or preventing it.

1. A large site with appropriate healthcare-related zoning (evidence derived from Westmead, Blacktown and Mount Druitt). Maintaining sufficient site area for future expansion or even replacement of some or all of the existing hospital while the existing facility continues to operate is a useful metric for determining appropriate site area. It could also guide master planning approaches to the hospital campus e.g. the 'empty chair' or 'four quadrant' approach demonstrated by the Martini Hospital at Groningen (J. Carthey, et al., 2009b, p. 22).
2. Design around a hospital 'street' or spine with three to six-storey buildings along it. This allows expansion at either end or to various units along the spine - outward or upward (evidence derived from Westmead, Blacktown and Mount Druitt). This strategy also facilitates the refurbishment or upgrade of various parts of the hospital without negatively impacting on the remaining parts in terms of noise or other disruptions.
3. Capacity to upgrade building services on a zone by zone basis (evidence derived from Westmead, Blacktown). A service tunnel can also assist with this as can the double column building services arrangement used at Westmead.
4. Use of a modular grid that supports a range of functions e.g. the 7.2m x 7.2m grid used at Westmead has proved beneficial in reconfiguration of spaces for other purposes. This is also supported by Diamond (2006) in his report for the NHS, and more recently in the latest version of the UK Health Building Notes which proposes a small range of room sizes (12, 16 and 32m²) that fit with standard planning grids

for clinical and clinical support functions (Department of Health Gateway Reviews Estates & Facilities Division, 2010).

ISSUES FOR FURTHER INVESTIGATION

The following issues may be worthy of further investigation and discussion with reference to these and other case studies:

1. At Westmead the strategic provision of courtyards formed a redundancy strategy that later offered the opportunity to turn these courtyards into utility and clinical spaces at a later date. This results in a lesser amount of outdoor space (and possibly reduces the entry of natural light) for the hospital. Does this have a detrimental effect on patients, staff and the quality of the environment?
2. Westmead, Blacktown and Mount Druitt were all built on large, outer urban 'brownfields' or 'greenfields' sites whereas POWH and RNSH are both built on inner urban high land level sites. This has an impact on land values and the need to use the site much more efficiently to leverage that value. The downside is that on the POWH and RNSH it would be much more difficult to justify holding on to vacant land for future expansion than it is for the hospital sites located further west in Sydney where land is less expensive. The other question becomes 'how much land is enough to ensure flexibility over time?'
3. Further investigation of modular grid sizes could prove useful in planning future adaptive strategies. A comparison between Westmead, Blacktown and Mount Druitt suggests that the irregular design of Mt Druitt may have limited its potential to flex over time.
4. Although the findings of this study have shown that the types of flexibility measures that appear to be most useful largely conform to the literature search from stage 1, review of further detail regarding the changes accommodated at Westmead and Blacktown may highlight further questions. For example - how much can a facility designed for one clinical function change to accommodate other functions? The functions accommodated in areas that have undergone alteration need to be compatible with the original function - in terms of spatial requirements, building services and access arrangements. In particular, 'hot floor' operating and similar functional spaces seem to be the most resistant or difficult to change without a major building project. Perhaps because of this most of the changes seen are in secondary clinical spaces e.g. outpatients, clinics, inpatient units, etc. For this reason grouping similar functions together as suggested by Bjorberg and Verweij (2009) and accepting a change or downgrading of function over time could be considered a useful strategy.
5. Maintaining service delivery during a renovation or upgrade is often very important or even essential. There seem to be a number of ways to achieve this, including the provision of interstitial spaces or service tunnels as examples of planning options. In terms of master planning the hospital, long, low, stretched out planning around hospital streets as occurred at Westmead, Blacktown and Mount Druitt all seem to better support service delivery during an upgrade or to minimise the impact of construction on an operating hospital. Podium and tower block approaches (RNSH and possibly POWH) appear to make this more difficult due to disruption from noise, dust, etc.

CONCLUSIONS

The research results largely support the hypotheses tested in that those facilities with actively articulated and designed-in flexibility and adaptability strategies have better supported upgrades and developments over time without requiring extensive demolition and re-building of key hospital buildings. However, although the strategies outlined in Table 1 are largely confirmed by this research they are not yet claimed to be fully definitive or inclusive, especially given the lack of testing of the short term ('no modification') strategies on any of the project due to time and data constraints. Similarly, although not often specifically mentioned as a tactic for encouraging healthcare facility flexibility and adaptability in Table 1, appropriate and sensitive site master planning appears to be a precursor for encouraging and supporting many of the initiatives undertaken, in particular at Westmead, Blacktown and Mt Druitt Hospitals, and inappropriately done, may constrain the effective life of other inner urban hospitals. As a result, future revisions to Table 1 will incorporate site master planning as another primary strategy for ensuring longer life for the building shell and the future expandability of a hospital.

Thus, the extent to which features that promote flexibility and adaptability can be implemented on health projects is not yet fully defined and is the subject of ongoing research. As Olssen and Hansen (2010) point out in discussing approaches to flexibility during the construction stage of a project, there are likely to be at least two views on flexibility on every project – one held by those who will use or run the building (client/users) and one by those responsible for financing and procuring the project. Also as health service and facility managers, and other key personnel change over the effective life of a facility, an early focus on facility-related flexibility initiatives may be lost as a result of poor knowledge transference, or alternatively, result in an emphasis on other priorities over time. Given these competing demands, for flexibility to be incorporated into the planning of a facility, built in to the finished facility and then used to future proof the facility during subsequent upgrades and refits, suggests that there has to be strong and unwavering organisational commitment to flexibility initiatives especially when faced with other competing project needs, and indeed changing personnel over time. The US Veterans Affairs Hospital Building System has demonstrated such commitment for nearly 40 years. Similarly the Westmead Hospital case study also shows the value derived from built in flexibility initiatives some of which have been utilized in ways perhaps not originally envisioned by those designing the building.

Lessons for other countries and settings include an overview of the difficulties associated with assessing the longer term flexibility and adaptability of health facilities. The primary focus of all health buildings is to support the delivery of health services; they are a 'tool' not a product in themselves. Similar drivers in most developed countries require changes in service delivery associated with new technology, evolving demographics, etc, to be accommodated. This research found that the assumptions behind the original case study flexibility strategies have been quite often superseded by emerging trends and events such as the move away from providing inpatient beds towards care in the community. However although such facilities were called on to

change and adapt for different reasons than those previously foreseen, they were still often up to this challenge.

Where future proofing features were documented and valued by the facility and other management, then the subsequent modification and upgrade of such buildings was more effective and efficient – and led to a longer effective life for the facility. Where these features were not appreciated or the relevant knowledge was not effectively transferred, facilities were more likely to become obsolescent. In particular, multi-storey or tower and podium type facilities appear to be least flexible and as a result, further research could be targeted at looking at how much flexibility is indeed enough or how to design multi-storey hospital buildings (such as POWH and RNSH) to flex and adapt over time. Given the cost and relative shortage of inner urban land, this may be a useful exercise to ensure that these buildings in particular may have a longer life than they have at present and would contribute to a more sustainable built environment in terms of future carbon and energy costs.

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A LEAN WAY OF DESIGN AND PRODUCTION FOR HEALTHCARE CONSTRUCTION PROJECTS

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ABSTRACT

As a consequence of the lack of solid conceptual foundation, the project management concepts and techniques usually applied within the construction sector are fragmented and have proved to be incapable of solving the complex problems of design management. As a result, healthcare providers have become frustrated with the outcomes such as cost and schedule overruns, accidents, less than expected quality and inadequate functionality. However, an investigation of successful healthcare projects reveals that new approaches have been developed to tackle such problems. This study uses recent data based on six construction projects. The idea is demonstrate how successful projects are dealing with the integration between design, production, and operations, through an appropriate approach to the management of production systems. The paper aims to assist the different parties of the AEC industry to better understand how practices applied into design phase could support the efficiency in the management of production systems.

KEYWORDS

design management, implementation, lean philosophy

INTRODUCTION

It is largely acknowledged that it is within the design phase that the best opportunities for improving production efficiency, customer value as well as sustainability occur. It is within the design phase that product, service specifications are determined, the execution process established, and consequently costs are set. However, as argued by Ballard and Koskela (1998), architectural, engineering and construction (AEC) developments present complex management problems. For instance, there are conflicting needs and requirements that lead to complex trade-offs and an inherent high degree of uncertainty. In the specific context of healthcare projects, Reed (2008) states that owners, mainly large healthcare providers, have become frustrated with the outcomes provided by the conventional project delivery, such as cost and schedule overruns, accidents, less than expected quality and inadequate functionality.

The problems of managing the design and production are well investigated and myriad ideas have been developed as a way to solve such problems. However, many of these ideas fail due to the fragmentation of the AEC industry as stated by Mauck et al. (2009).

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For these authors, the fragmentation has been a cause of a considerable negative impact on the productivity of the sector over the last 40 years. These issues were evidenced by Feng and Tommelein (2009) whilst carrying out research in healthcare projects. These authors analyzed the causes of rework in the design and permitting phases and identified over 150 instances of relevant process waste. They argue that these wastes are on its vast majority related to design and can be reduced by improving its management. Researchers have been investigating how lean production principles can minimize these problems (Koskela et al, 1997, Ballard and Koskela, 1998; Howell and Ballard, 1999, Ballard et al., 2001, Koskela et al., 2002, Ballard, 2008). For these authors, Lean provides the foundation for project managing complex projects.

Successful cases exist and lessons can be learnt in order to improve the management of large and complex projects (Khemlani, 2009; AIA, 2010a; AIA, 2011). Project management initiatives such as changes in commercial relationships and the use of managerial tools for managing production systems are being fruitfully used (Tiwari et al, 2009; AIA, 2010b; Lichtig, 2010). In this article, successful cases of healthcare projects are investigated with the aim of amalgamating the existing and fragmented knowledge and better understanding commonalities and differences amongst the identified initiatives that have supported the increase of efficiency of design and construction processes.

The investigation was based on the thorough analysis of rich secondary data of six cases. Given that lean construction provides the appropriate basis for managing complex projects, this study sought to identify practical examples that follow this line of thought in order to investigate the initiatives implemented and also the outcomes achieved. Thus, the criterion used to select the case studies was the relation between the initiatives implemented in those cases and the lean construction approach to the management and execution of design advocated in the literature review (Ballard and Zabelle, 2000b; Ballard, 2008). The unit of analysis of this study was the implications of having an integrated process from a systemic point of view. The theoretical foundation of this research is based on lean construction principles. The limitation in terms of reliability, accuracy generated by the use of secondary data is here acknowledged.

ON INTEGRATED DESIGN AND PRODUCTION

In construction projects the management of design and engineering is one of the most ignored areas (Koskela et al, 1997). According Ballard and Koskela (1998) the separation of design and construction has long been presented as the root problem of construction. The same authors also reveal that the project management concepts and techniques have demonstrated incapable for solving the complex problems of design management. They argue that the primary reason for the poor level of design management has been the absence of solid conceptual foundation. That the traditional conceptualization of engineering looks the engineering just as a conversion. And, that it is necessary to move from a conception of production solely based on the transformation of inputs into outputs to the TFV (Transformation / Flow / Value) model of production (Koskela, 2000).

Following that line of thought, Ballard and Zabelle (2000) argue that it was in order to structure the work in pursuit of the lean ideals that the Lean Project Delivery System (LPDS) was conceived. The LPDS is described as “a new and better way to design and build capital facilities” (Ballard, 2000). Ballard et al (2001) considers that the production system design tackles the three main goals of lean production systems: do the job, maximize value, and minimize waste. Fig 1. presents the LPDS model.

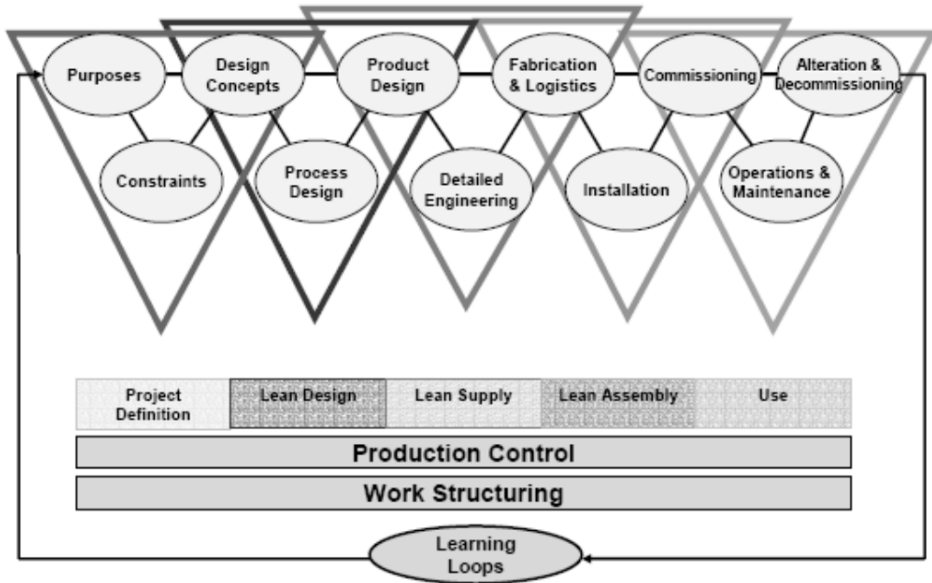


Fig. 1. Lean Project Delivery System (Ballard, 2008).

The lean approach to the management and execution of design embedded in the LPDS model include steps such as: a) cross-functional teams organization; b) the pursue of a set-based strategy; c) the structuring of the design around a lean processes; d) the minimization of negative iteration; e) the use the Last Planner System™ for design and production planning and control; and f) the use IT that facilitate lean design (Ballard and Zabelle, 2000b). Two aspects come into view from this model that represents relevant contemporary additions (Ballard, 2008). First, the importance of managing the production systems from a life cycle perspective is evident. Within the model, management starts at the beginning of the project and follow throughout the product developed been in use. Second, the project definition and design phases, which are more often explored than the other triads, have their scope of work expanded. Particularly to the design phase, the early engagement of key members along with the implementation of practices such as target costing and set-based design are practices that have been explored with successful results. Moreover, the collaborative work between project participants, ranging from designers to subcontractors, in conjunction with the use of technologies that enables this integrated work efficiently have been tested.

There are many initiatives for managing design and production processes. Examples of these include the adoption of the Last Planner System™, Integrated Project Delivery, Target Costing, Set-Based Design, Building Information Modelling, Value Stream Mapping, Cross-functional teaming, Co-location (“Big Room”), and Early Involvement of Participants. The literature on these methods and tools is abundant and assumed to be well known and for this reason not covered within this section. Less known and relevant are the issues related to the design of production systems in construction.

Production system design in construction is a topic that uses concepts and ideas that emerged in manufacturing. Slack et al. (2007) argues that, in general, the design of product and services and the design of the processes, which make them, are considered as separate activities. Despite product and process design are clearly interrelated and should be treated together, practitioners from downstream phases are not involved in early phases and do not participate in making key decisions that impact positively on efficiency. Gaither and Frazier (2001) emphasize that decisions regarding technological process, connections among its parts, equipment’s choice, installation layout, and human resources are made. Askin and Goldberg (2002) argue that it within the design of the production system that a manner to manage the resources and information to produce the products is defined. In addition, Meredith and Shafer (2002) contend that alternatives for production organization and strategy that influence target results are set. Fig 2. illustrates the interconnection between product and process design.

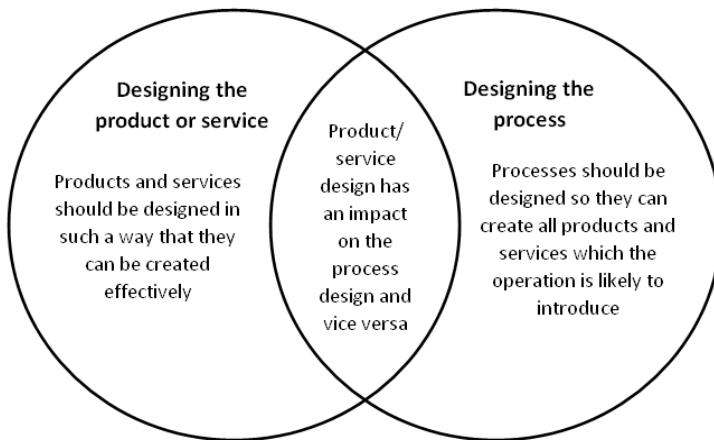


Fig. 2. The relation between products and processes design (Slack et al., 2007)

It is evident from the manufacturing and construction literature that better integration of design and production have been sought and achieved through the adoption of the tools and methods above mentioned. However, less discussed are the implications of having an integrated process from a systemic viewpoint. Also the impact that adopting lean principles have on the project environment. Therefore, the cases presented in the next sections illustrate how successful projects have been considering the lean philosophy in the design phase through the implementation of managerial practices.

CASE ANALYSIS

Six reported success cases (Table 1) have been included in the analysis of the implications of having an integrated process within construction projects. In spite of the fact that six cases were used, only three cases are presented in detail due to space constraints. However the source of information is given. Table 2 lists the practices implemented throughout the investigated cases.

Table 1. Case projects

	Case Projects	Location	Construction Type
1	<i>Sutter Health Fairfield Medical Office Building (AIA, 2010a)</i>	<i>Fairfield, California, US</i>	<i>New building</i>
2	<i>Sutter Medical Centre (Khemlani, 2009; Tiwari et al., 2009; Lichtig, 2010 and AIA, 2010b)</i>	<i>Castro Valley, California, US</i>	<i>New building</i>
3	<i>The California Pacific Medical Centre's (CPMC) Cathedral Hill (Parrish et al., 2008; Yoders, 2010 and AIA, 2011)</i>	<i>San Francisco, California, US</i>	<i>New building</i>
4	<i>Cardinal Glennon Children's Hospital (AIA, 2010a)</i>	<i>St. Louis, Missouri, US</i>	<i>Expansion</i>
5	<i>St. Clare Health Centre (AIA, 2010a)</i>	<i>St. Louis, Missouri, US</i>	<i>Replacement</i>
6	<i>Encircle Health Ambulatory Care Centre (AIA, 2010a)</i>	<i>Appleton, Wisconsin, US</i>	<i>New building</i>

Table 2. Practices presented in the cases

Practices implemented	Cases					
	1	2	3	4	5	6
<i>Last Planner System™</i>	<i>X</i>	<i>X</i>	<i>X</i>		<i>X</i>	
<i>Integrated Project Delivery</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>
<i>Relational Contracting</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>
<i>Target Costing</i>		<i>X</i>	<i>X</i>			<i>X</i>
<i>Set-based Design</i>			<i>X</i>			
<i>Building Information Modelling</i>	<i>X</i>	<i>X</i>	<i>X</i>		<i>X</i>	<i>X</i>
<i>Value Stream Mapping</i>		<i>X</i>				
<i>Co-location ("Big Room")</i>	<i>X</i>	<i>X</i>	<i>X</i>		<i>X</i>	

CASE 1 – SUTTER HEALTH FAIRFIELD MEDICAL OFFICE BUILDING

All the information about this project was gathered from AIA (2010a). This project was the first of a series of building projects to be developed by Sutter Health (SH), a healthcare organization in California. In order to comply with the legislative framework for seismic safety in California as well as to support the growing healthcare needs of the communities Sutter Health has set a \$6.5 billion building program. The hospital seismic safety law from California came up as the main driver for Sutter Health improves its hospitals. According to that, healthcare facilities must be upgraded to meet the safety requirements in order to enable those hospitals to continue in service after an earthquake. In addition to this major requirement, Sutter Health has also taken this opportunity to experiment an innovative way to design and build its hospitals as well as the delivery of healthcare through innovative ways.

The Sutter Health Fairfield Medical Office Building comprises a three-story, 70,000sf medical office building housing primary care medical practices and laboratories, with pediatrics, oncology, rheumatology, and cardiology departments and administrative offices. The construction project has achieved positive results according to project managers. Despite a considerable amount of owner scope additions (\$836,528), the final construction cost remained below the contracted cost. Furthermore, the completion date was achieved even though there was three months delay for reprogramming and the extra services caused for the scope additions.

In order to promote conceptual alignment among team members, participants were made aware of the project vision and its practical implications through their involvement in a three-day event. This event aimed at promoting transparency in terms of project goals and aspirations and it was delivered through a partnership between Sutter Health and the Lean Construction Institute (LCI). Whilst SH provided project context, the LCI provided the theoretical guidance for project management.

Integrate Project Delivery (IPD) was used the project method delivery. Consequently, an intensive up-front work was needed and collaborative work ranged from strategic to operational areas. Collaborative practices included the **early involvement of project participants**. For instance, client representatives were engaged from the fuzzy front-end of design to the end of the construction in order to speed up the decisions and foremen participated in up-front group scheduling meetings. This up-front attitude led to reduction of the rework in the building site. The subcontractors were responsible for the main sub-systems (mechanical, electrical and plumbing/fire protection) and their participation was vital in the pre-construction design phase. According to the builder, further improvements could have been achieved if other specialties (e.g. exterior glazing and skin) were also involved earlier in the design process. Besides, at the end of this project the builder concluded that foremen from all subcontractors must participate in group scheduling meetings. Collaboration was also observed through **cross-functional teamwork**. For example, the project team did the management of contingency funds jointly. Architect and builder adjusted their contingencies as per demand. They were also equally responsible for construction errors and design omissions.

The work environment for project development, management and delivery was considered as a key for integration. In this regards, a space named “Big Room” (BR) was created to facilitate integration. The BR consisted of a common space configured to allow meetings with more than 30 people to work. Within this space, facilities such as a big wall for planning the process, a space for planning the design (wall sized maker board) used for both planning and sketching design ideas, smartboards to project 3D models, plans, schedule and to make possible the remote communication among team members, planning tables to the teams refine plans and small meeting rooms were provided.

IT was perceived as an enabler of better integration between design and production. The use of Building Information Modelling (BIM) in conjunction with Big Room (BR) assisted the project team to achieve better efficiency outcomes. In this respect, more than 400 systems clashes were identified prior construction. According to builder representatives the combination of BIM and BR “provided significant cost savings due

to increased field productivity, tighter schedule, more prefabricated work, and less redesign”. Additionally, the use of BIM as a GPS (Global Positioning System) allowed a shorter time to accomplish the placement of hangers (from 2-3 weeks to 2-3 days). It created conditions for much larger sections of shop pre-fabricated ductwork and less field labour.

Key project participants, when interviewed, expressed their opinion about features of this project that had positive, negative, or neutral impacts on better integration. For the builder representative the cost of the work should be disconnected from the profit - “*the key is the alignment of commercial interests*”. For the architect, the incentive pool did not necessarily led to a collaboratively environment. He argued that to keep control of his own is a better approach - “*a lump-sum fee is a leaner approach*”. Finally, according the project participants the IPD was considered suitable for complex and large-scale projects whereas not so much for smaller and simpler projects.

CASE 2 – SUTTER MEDICAL CENTRE

The information for this case was gathered from Khemlani (2009), Tiwari et al. (2009), Lichtig (2010) and AIA (2010b). The project comprised of a new 130-bed, US\$320 million hospital project for Sutter Health. Project aims included the development of a facility that supports the recognition of this corporation as a state-of-the art advanced technology and quality medical centre. Requirements included hard goals, such as design and deliver a facility of the highest quality, at least 30% faster, and far no more than the target cost.

According Lichtig (2010) Sutter Health used an Integrated Form of Agreement (IFOA) model that combine ‘Lean Project Delivery’ and a new contractual model. This new contractual model sought to balance the commercial interests of the major project participants and govern the delivery process as a collective enterprise. For Lichtig (2010), the adoption of the IFOA had a significant influence in the implementation of management practices on reasonable terms. The feature of the IFOA contract that was key to incentive collaborative work was the definition of rules for sharing gains and pains amongst all project participants. Tiwari et al. (2009) stress that the IFOA contract was the major incentive for the architects and structural engineers getting involved in the model-based cost estimating process.

The effort and money invested to plan and coordinate the design process by using those innovative practices had significant impact on carrying out a design process that resulted in higher quality outputs, at a faster design and construction pace, and with no relevant additional costs An illustration of that is the reduction of the expected time for structural design from fifteen to eight months with substantial improvement in the design quality (Khemlani, 2009).

Better integration was perceived as the result of many initiatives been used concomitantly. Primary to this was the **early involvement of a cross-functional** team approach along with the use of **incentives** (financial) for motivating project participants to collaborate and optimize the whole project rather than the parts. The Big Room

concept was essential to create conditions for people, geographically distant, working together (AIA, 2010b).

The use of Value Stream Mapping (VSM) was instrumental in the provision of a better understanding of the improved design process as well as for streamlining workflows. The implementation of Last Planner System™ (LPS) was perceived as equally important in dealing with uncertainty in the course of design development. Team members understood the flow of value by the use of VSM and made commitments to each other applying the LPS principles (AIA, 2010b).

BIM was used as a support to design coordination and sharing of information. Cross-functional teams periodically reviewed 3D models in order to get better solutions. Design issues were identified and corrected earlier through the use of fully integrated BIM models. Moreover, BIM increased the reliability of the design information allowing it to be directly used for fabrication and pre-assembly. Gains in terms of reduced changes and schedule delays were perceived (Khemlani, 2009).

CASE 3 – CALIFORNIA PACIFIC MEDICAL CENTRE’S CATHEDRAL HILL

Information for this case was gathered from Parrish et al. (2008), Yoders (2010) and AIA (2011). The California Pacific Medical Centre’s (CPMC) Cathedral Hill comprises a new 555 beds, 858,000sf, US\$ 1,028 billion hospital development for Sutter Health in San Francisco, California (AIA, 2011). Design and construction schedule were planned for 55 and 48 months respectively and it is an ongoing project to be completed in 2015. Moreover, the project is aiming a LEED-Gold rating from the U.S. Green Building Council and is expected to be completed below the target cost (Yoders, 2010).

According to Yoders (2010), Sutter Health project team adopted a traditional design process initially that led to a considerable cost overrun as a result of the 1.2 million sf design. Consequently, the entire process of design and delivery of CPMC Cathedral Hill had to be re-thought. For the program manager of the Cathedral Hill Project and the senior program manager at Sutter Health *“it was 400,000sf too big and the finishes were out of step with the needs. We had a recognition that we had to do something different. We needed an approach that streamlines the entire planning and design process by applying lean management techniques and focusing on drastically reducing waste while increasing value”* (Yoders, 2010).

This project is arguably remarkable in terms of innovations implemented to the management of production system. Besides the adoption of Integrated Project Delivery (IPD) as project delivery method, the CPMC has used several practices to improve the efficiency of design and construction, such as Target Costing, Set-based design, Last Planner System™, Building Information Modeling, among others.

Yoders (2010) argues that better integration (though collaboration) is an inherent feature of IPD and Lean Construction that leads to improved efficiency outcomes. In terms of architectural layout, for instance, the current proposal delivers 90% of the original’s briefing in 70% of the space. The LPS has been fundamental in promoting stability within the design process. The statistical approach of the planning process reliability

enabled by the LPS facilitated the improvement of project participants own efficiency (AIA, 2011). Moreover, the learning curve of the project participants is high as they can assess the root cause of the tasks non-accomplished.

It is worth mentioning that as long as IPD and lean construction has become fundamental to project outcomes, training and study are required to enable team members to deal with this innovative way of work. In this sense, the involvement of the client and the general contractor (GC) with research should be pointed out. For instance, both companies have a strong relationship with the Lean Construction Institute, who is partnering with UC Berkeley. According to AIA (2011) the client and the GC have been studying lean construction and IPD over seven years. Experience in IPD and lean construction as well as the motivation to collaborate and learning were considered as characteristics highly desirable in the selection process of project stakeholders.

Early involvement of a cross-functional team has been crucial in terms of financial savings. Return on investment (ROI) has been already made up-front. According AIA (2011), “the initial target cost developed by the team early in the project was approximately 14% (i.e. \$80 million) below market average. At the time of this report, the team estimated that an additional \$22 million dollars will be saved under the national market average. The team is continuing to track ROI throughout the development process. These significant savings have been primarily attributed to the Target Cost process”.

The financial scheme agreed in the Integrated Form of Agreement (IFOA) is believe to support integration. According Parrish et al. (2008) “*this pay structure supports collaboration and innovation, as there is an incentive for the entire team, not just one team member. The IFOA mandated that all project participants collaborate and use set-based design as soon as they are brought onto the team*”. The set-based design was used as a way to consider multiple design alternatives jointly, avoiding rework due to early commitment to a specific design, and to develop a more satisfactory design decision.

BIM has been used to support design coordination and production planning. In respect to production planning, the proposed construction process was simulated as well as optimal production method alternatives assessed. The use of BIM was required of all IPD team members, including trade partners. A BIM cluster group was created consisted of a BIM champion from each company of the IPD team. A management protocol was set in order to promote transparency in terms of the procedures that should be adopted as well as roles and responsibilities.

DISCUSSION AND FINAL CONSIDERATIONS

It has been argued throughout this article that AEC developments present complex management problems that lead to low levels of satisfaction with project performance and delivery from clients and professionals within this industry. Lean, it has been claimed, provides the appropriate foundation to cope with those complex management problems inherent to construction projects. In this respect, initiatives based on the lean approach to the management and execution of design (Ballard and Zabelle, 2000b;

Ballard, 2008) that have been developed and implemented to mitigate these problems were identified. These include the Last Planner System™, Integrated Project Delivery, Target Costing, Set-Based Design, Building Information Modeling, Value Stream Mapping, Cross-functional teaming, Co-location (“Big Room”), and Early Involvement of Participants.

This research aimed at investigating the implications of adopting such practices from a holistic point of view. This was done through the thorough analysis of rich secondary data of healthcare project developments. The unit of analysis was the investigation of the implications of having an integrated process from a systemic point of view. Six cases were selected for the analysis and three are described in detail. The key principles identified throughout this research as well as their similarities with the lean features embedded in the LPDS model are presented below.

- **Early involvement of the cross-functional team:** all the studies stressed the importance of recognising the necessary movement of people from downstream to upstream in the project process as a way to increase value as well as reduce waste. Although it sounds simple, it implies the generation of a considerable amount of extra information at an early stage that must have contractual support. In the investigated cases, IPD provided such support by a) establishing the agreement of purposes between stakeholders; b) by providing incentives to achieve better performance, c) by fostering a learning environment that leads to innovations, hence higher performance levels; and d) by setting clear rules for shared pains and gains. Optimizing the whole rather than the part was the primary message for IPD projects members. Six out of six projects analyzed have implemented this principle, thus supporting the lean approach featured in the LPDS.

- **Transparency of goals, process, rules and responsibilities:** transparency is a principle that emerged in varied ways throughout the case studies presented. For instance, the clear definition of customers’ values and expectations, the open budgets to enable designers to understand the impact of their changes in the overall budget, the 3D models used for design coordination, the maps created to make people aware of the design process and its constraints, and also the meetings to share performance indicators. In this respect, the identified practices that embed this principle include Target Costing, Building Information Modelling, Value Stream Mapping, and Last Planner System. For example, the use of Last Planner System has a specific objective, which is deal with the uncertainty and complexity inherent to building projects by managing commitments in order to achieve a stable and smooth process. This stability means a project running with less variability, which is considered into the lean systems a type of waste. Therefore, it is possible to identify a coherent relationship between theory and practice. In other words, it is the adoption of the right practice for the correct purpose. Corroborating with Santos (1999), Liker (2004), and Tezel (2011) arguments, transparency plays a key role in the management of production systems, therefore its consideration within design phase must be more explicit and systematic.

- **Supportive collaborative environment:** collaboration amongst the involved parts is essential for the integration of design and production. This principle, it was observed, is intrinsically related to all the management practices identified. This result corroborates with what is suggested in the literature of lean production. A collaborative environment relates to the physical and virtual environment where the project team develops their work as well as the psychological environment created. In respect to the later, the transparency regarding the goals to be achieved, the rules and responsibilities of each member, the clarity of the status of the development as it evolves and the level of commitment of each team member are fundamental for a supportive environment.
- **Investment up-front:** the “extra” and necessary effort and investment made up-front to plan and coordinate design and production is arguably worthwhile. Perceived positive impacts of up-front investments included the increase of predictability in terms of cost and schedule, the promotion of a stable and smoother design and production process with less rework, the incorporation of innovations and improvements, and increased clients’ satisfaction. To this end, two factors should be noted as facilitators. At first, the willingness to change. Based on the case studies, it is clear that the best way to assess the efficacy of this approach is experimenting. It is by practicing and experimenting that the necessary awareness to achieve a continuous improvement is developed. However, there are risks of experimenting new practices that can be managed by, for instance, integrating industry and academy. The cases have presented this connection as a starting point for a solid journey towards excellence in performance and innovation. As long as new ways to manage the production systems have been brought to the project environment, support are required to enable people to deal with this innovative way of work.

From the research, lessons could be learnt that are indicative of success in project management. For example, any path to improve the way that healthcare facilities are designed, built and operated must consider the integration of design, construction and operations as a relevant factor. This integrated approach constitutes a change in the way that projects have been developed and delivered. In order to embrace this change, AEC project members must base their practices in appropriate theory for managing production systems. In this respect, Lean philosophy has been proved as a strong conceptual foundation to guide the implementation of the practices for the management of production systems purposes. Each construction project is characteristically different from each other, thus the main idea is developing a prescriptive way that help users to understand and decide what is suitable for their specific purposes in relation to managing production systems, rather than creating a solution that fit all projects. Continuous learning is intrinsic to all projects and the most important outcome of this is developing a continuous capacity to learn and improve. The whole picture is more important than the isolated results, and the opportunity to create a better project environment that improves the construction sector as well as the healthcare infrastructure must be taken into account.

Due to the limitations of using secondary data in this research, it is recommended as further research an extended and through testing of the identified principles with a basis on empirical and direct observation. Such research is also necessary to clarify the intrinsic interconnection that was perceived amongst the proposed principles.

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EVIDENCE-BASED DESIGN AT A TIME OF AUSTERITY: DO BUILDING STANDARDS AND TOOLS REFLECT THE REALITY OF DESIGNING FOR DEMENTIA, THE ELDERLY, CHILDREN AND REFURBISHMENT OR RECONFIGURATION?

M. Phiri¹, G.R. Mills², C-L. Chang³, A.D.F. Price⁴, and S.A. Austin⁵

ABSTRACT

The 2007-10 financial crisis and subsequent economic downturn, triggered by a USA banking system liquidity shortfall, has not only affected negatively the funding arrangements and development of healthcare building standards/norms and tools but has also brought them under scrutiny, questioning their relevance especially in underpinning quality and safety in environments where care is provided. This paper reports on findings from three focus groups conducted to elicit views of architectural and engineering design practice across the UK. Findings indicate the need for continued rationalisation of published material to create core standards that facilitate frequent updates and reduce development costs, to offer opportunities for design quality improvements, creativity and innovation. Strengthening and building on key guiding principles for the development of a best-practice framework that addresses the challenges of quality, innovation, productivity and prevention and producing a road map to guide healthcare decision-makers are also essential.

KEYWORDS

evidence-based design, standards, design tools, care pathways, design practice

INTRODUCTION

UK healthcare organisations are facing huge challenges to provide and maintain the quality of the healthcare estate in order for it to keep pace with rapid changes in organisational structures, improvements to accommodation such as increasing percentages of single bedrooms and eliminating mixed sex wards, new technologies, and contractual arrangements, and with increasing demands for all types of health services coupled with dwindling budgets. The challenge of designing to accommodate new information, improvements to accommodation, communication and tele-medicine technologies is nothing new. From the earliest periods of architecture and building, actions by designers and builders have been heavily influenced by rules, regulations, standards, and governance practices. What's new is the rising expectations of the role of the physical environment in improving the quality and safety of care. As a consequence there are unanswered questions on how best to develop and maintain future building standards and tools to ensure these continue to play a vital role in defining and

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underpinning the baseline quality of the healthcare estate. There are fears that the introduction of new monitoring regimes within a reconfigured regulatory framework, and the creation of new commissioning General Practice Consortia or Units together with the abolishment of key strategic healthcare organisations in England will impact negatively on the any gains achieved thorough initiatives of 2000s decade of enhancing design quality or under the recent hospital building (including the Private Finance Initiative hospital building programme (Barlow *et al* 2009)). The 1990/2000s hospital programme yielded much guidance and tools e.g. ADVICE (NHS Estates 2002), AEDET⁶, ASPECT⁷, NEAT⁸, DART⁹, IDEAs¹⁰, SHAPE¹¹, etc. whose development was centrally-funded by Department of Health. The evidence-base approach adopted to enable standards and tools support health policy that is responsive to new knowledge, novel technologies and greater staff and patient expectations may be compromised by these changes.

To increase our understanding of the role played by healthcare guidance/tools in practice and to examine possible consequences of the organisational changes we investigated the challenges of improving design quality and safety of the healthcare estate using three focus groups. Findings report a proliferation of published material on healthcare planning and the need for continued rationalisation to create core standards that facilitate frequent updates and reduce development costs offering opportunities for quality improvements, creativity and innovation (Moss et al 2001). Imrie & Street 2011 survey of 798 UK design practices found a broader escalation of regulation stemming from an increased use of external government agencies and fragmentation of works tasks which then require assurance for risk free projects complying with health and safety legislation. “Where before you had 5 British Standards, you’ve now got 55”.

One vital role for the Department of Health is to create an affordable system of quality assurance that is able to respond to changing policy and organisational structures. Costs of developing and updating standards and tools have been increasing being affected by both the way they are developed, the impact of electronic media, the durations of the updates and by whom. Aspirations by the NHS review to reduce the regulatory burden emphasising clarity and manageable ensemble of standards may be understandable aims to ensure better compliance. Recommendations to the Department of Health include improving standards/tools where there is new knowledge; up-to-dating them within a centralised system that incorporates mechanisms for dealing with comments classifying these into three main categories:

1. Items that can be actioned straight away such as text and grammatical errors.
2. Aspects that can be actioned quickly but need expert/ peer review/discussion to reach agreement.

⁶ Achieving Design Excellence Evaluation Toolkit

⁷ A Staff and Patient Environment Calibration Tool

⁸ NHS Environmental Assessment Tool

⁹ Design And Risk Tool

¹⁰ Inspiring Design Excellence Achievements

¹¹ Strategic Health Asset Planning and Evaluation

3. Items that need more time to resolve (such as those needing research studies to obtain answers) and those changes that could affect a few parts of the documents in ways that need more comprehensive changes. These changes could be made periodically depending on the urgency and political aims.

Findings also strengthen Fröst *et al* 2010 five key guiding principles for the development of an international best-practice framework that addresses providing for quality, innovation, productivity and prevention in the healthcare estate.

Principle 1: Guidance and mandatory standards that support outcomes such as sustainability; auditability; measurable benefits; sharing of best practice; patient safety values; revenue consequences; utilisation of space; inspirational guidance etc. (Lawson & Phiri 2000).

Principle 2: Appropriate evidence-base underpinning standards and tools showing how the designed healthcare estate can impact on length of stay, reduction of falls, mixed sex infringements, consumption of medication, etc. including very detailed results such as heart rates, sleep patterns, staff absenteeism and so on (Lawson & Phiri 2003).

Principle 3: Guidance and tools to aid the design process giving them authority especially when challenged by clinicians whose background is in pure science.

Principle 4: Strategic planning role that includes research and development, information and future forecasts similar role to that provided by a Development Control Plan for organising a site.

Principle 5: Learning environment incorporating feedback from completed construction projects to ensure that successes and failures are not overlooked and innovations do not miss their targets.

METHODOLOGY

Three focus groups and a literature review were conducted to collect data under the **Health and Care Infrastructure Research and Innovation Centre (HaCIRIC)** project “Nurturing an **Evidence-Based Learning Environment** which supports the Innovative Design of Healthcare Facilities or similar (Acronym **EBLE**)” a Sheffield and Loughborough Universities collaboration with partners including Department of Health Estates & Facilities for England, Welsh NHS Estates, Health Facilities Scotland, Northern Ireland Healthcare Estates and others.

The focus groups involved some of UK’s leading healthcare architectural and engineering designers i.e. Medical Architecture, WSP Group, Llewellyn Davies Yeang and Nightingale Associates. Selected because of their willingness to be involved in the EBLE project and their commitment in disseminating and sharing knowledge and innovations, these practices relate to 3 core themes:

Theme 1: Dementia and mental health highlights many problems of the modern world all of which merit further consideration and the need for systematic research to identify

the key features of the physical environment which contribute most effectively to optimising health outcomes and minimising harm for dementia patients and people suffering mental health illnesses.

Theme 2: The delivery of Children's healthcare facilities indicates many problems which require solutions such as ensuring any hospital building programme is accompanied by appropriate standards which are not merely transferred from those used in adult accommodation.

Theme 3: Refurbishment and reconfiguration is about addressing the large amount of existing NHS premises 95% of which is need of modernisation. The new realities are people are living longer and associated with this is a dramatic rise of incidence of chronic diseases accounting for up to 80% of the total UK healthcare spending due to declining numbers of economically active people contributing to health and social care finances. The pressing need to accommodate treat and move a growing population of bariatric patients alone has profound issues in terms of space standards, equipment provision, operation of healthcare facilities and staffing with significant physical and cost consequences for capital projects.

Furthermore, considerable advantages accrue from engaging with such a body of expert opinion and good practice in a systematic and explicit way, extracting conclusions and recommended design features for analysis and synthesis.

Each focus group session followed a standardised format (presentations of schemes, questions/answer sessions and discussions), consisted of 10-20 invited participants or well-known experts throughout the UK, was held in a neutral venue to enhance objectivity and facilitated by Sheffield and Loughborough Universities. The architectural and engineering practices used case studies of proposed healthcare projects as well as healthcare schemes from their commissions. Healthcare standards, which relate to above themes and tools were reviewed through retrospective and comparative analysis of the case studies. All the focus group sessions were recorded, transcribed and analysed within an integrating framework to identify common themes, issues of concern to the UK NHS and what actions are needed addressing.

DEMENTIA, MENTAL HEALTH AND FACILITY DESIGN

The Medical Architecture focus group used Wandsworth Recovery Centre, Bamburgh Clinic, Rosebury Park and Glenside, Australia to evaluate the options and issues of meeting the challenges of the changing needs or requirements for Dementia and Mental Health through the provision of efficient and therapeutic healthcare environment.

Completed in January 2006 procured under Procure21, the 41-bed adult forensic Bamburgh Clinic not only adopts several innovations challenging interpretations of existing healthcare design guidance on Mental Health Units but also employs many design strategies tried and tested in previous projects. Zonal spatial organisation was used to match a servicing strategy of 24-hour living zone and 12-hour office, administration and support spaces. Safety and security measures incorporated a secure

perimeter boundary with fixed windows in patient areas, good observation and relational security optimising natural daylight.



Fig.1. Bamburgh Clinic, Northumberland, (Medical Architecture) A reaction to poor 1970s buildings with the then draft HBN35 squeezed into a nucleus hospital template

Courtyards and gardens were provided as safe and fence-free external spaces in which existing trees were retained supplemented by new planting. The Sports Barn was built as a multi-purpose therapy space for shared sports and activities. Generic room sizing together with swing and expansion zones were implemented to facilitate flexibility, growth and change. A new combined heat and power site-wide strategy was adopted to reduce hospital peak loads targeting 38 GJ/100cu m for energy consumption and incorporating a sealed inpatient building with naturally ventilated offices; ligature free under floor heating with local controls and zoning; installation of efficient movement sensitive lighting controls; rainwater harvesting and permeable surfaces to facilitate drainage; and provision of a maintenance walkway to avoid entering patient areas. Construction reused demolished material and involved land remodelling, renewables of the structure, windows, screens and doors and cladding; off-site manufacture of kit of parts and panellised timber cassettes; local sourcing of materials; waste management based on a clean and safe site and engagement in commissioning.

Comprising of an 18 bed-acute ward, a 10-bed psychiatric intensive care unit together with community bases and outpatients facilities Wandsworth Recovery Centre at Springfield University Hospital London learns from the Bamburgh Clinic. Completed April 2009 as a mixed gender inpatient facility for adults with acute mental illness, Wandsworth Recovery Centre exemplifies Principle 5 (learning from completed projects). Similarly, Roseberry Park, Middlesbrough, for Tees Esk and Wear Valley NHS Trust draws from the design experience of another mental health unit, Highcroft, Birmingham completed in 2002. In this case facilities are located on the periphery to create a public open space for outlook, recreation, and good staff supervision with supervised circulation areas that allow easy access by residents to contained external areas. The resulting space encourages outdoor activities and quiet contemplation for the benefit of patients' treatment and rehabilitation.



Fig. 2. Reservoir Court Old Adult Mental Health Unit (below) learns from Highcroft Birmingham 2002 Scheme above (Medical Architecture)

Comprising of inpatient facilities for adults and older people with Learning Disability and Forensic services, Roseberry Park is a 312-bed new build mental health village built to focus on individual patient experience conveniently sited adjacent the existing St Luke’s Hospital. Accommodation is in a number of ‘houses’ arranged around large activity courtyard gardens to create ‘architecture without fences’ that helps remove stigma associated with mental health units.

Principle 5 is taken to another level of knowledge transfer in the new 129-bed Glenside Campus Development Adelaide Australia by Medical Architecture and local practice Swanbury Penglase to bring together acute, rehabilitation, drug alcohol withdrawal, and peri-natal inpatient units alongside outpatient, front-of-house, and office and support accommodation. The master plan locates these facilities adjacent to new retail, commercial, and residential precincts while creatively re-using the existing heritage “Victorian” asylum building to become an independent film centre. The design objectives are creating modern facilities for Glenside as a place of refuge, safety, security and healing through demystification, destigmatisation, autonomy and integration with flexibility and adaptability, ecological sustainability and accommodation of diversity. Based on the client’s desire for integration within the community, the design concept is for a high standard of aesthetic quality in a park-like setting with courtyard buildings arranged around a shared central “healing garden” accessible to both patients and the public de-stigmatising the existing site. The facilities

are configured for flexibility with a continuous gradient or hierarchy from privacy and security for patients to fostering autonomy and supported recovery-focused care.



Fig. 3. Glenside Campus Redevelopment Adelaide Australia (Medical Architecture/Swanbury Penglase): a new AUD\$130m 129-bed health facility providing specialist services for mental health, drug and alcohol care aims to de-stigmatise the existing Victorian asylum.

In all these case studies hospital design guidance and planning documents are reviewed against their evolution in response to changing legislation, policy and care practice. For example, HBN 37 In-patient Facilities for Older People 2005 replaced the 1981 version, after recommendations in the National Service Framework for Older People, and the need for buildings to comply with the Disability Discrimination Act 1995. Clearly, evidence-based design guidance and practice offer opportunities for improving the quality of the healthcare estate to meet the changing demands of both an ageing population and of working with vulnerable people, older and those afflicted by dementia.

DESIGN FOR CHILDREN'S HEALTHCARE SERVICES

The Llewellyn Davies Yeang/WSP Group focus group used Great Ormond Street Hospital for Children Redevelopment to examine issues in providing carbon neutral environments for the treatment of sick children while integrating visual arts, acoustic requirements, poetry and kinetics in therapeutic settings for children, families and staff. The development is an exemplar that shows lessons learnt from completed phases can feed forward into future phases based on a 2005 Development Control Plan strategy that seeks to unlock the site potential to enable all clinical services to be provided in modern accommodation by the end of Phases 3 & 4 (Principle 4). The wide ranging audience; children and young people from new born to 18 years of age, parents/carers, siblings, staff, visitors, donors, the general public and others is a challenge.

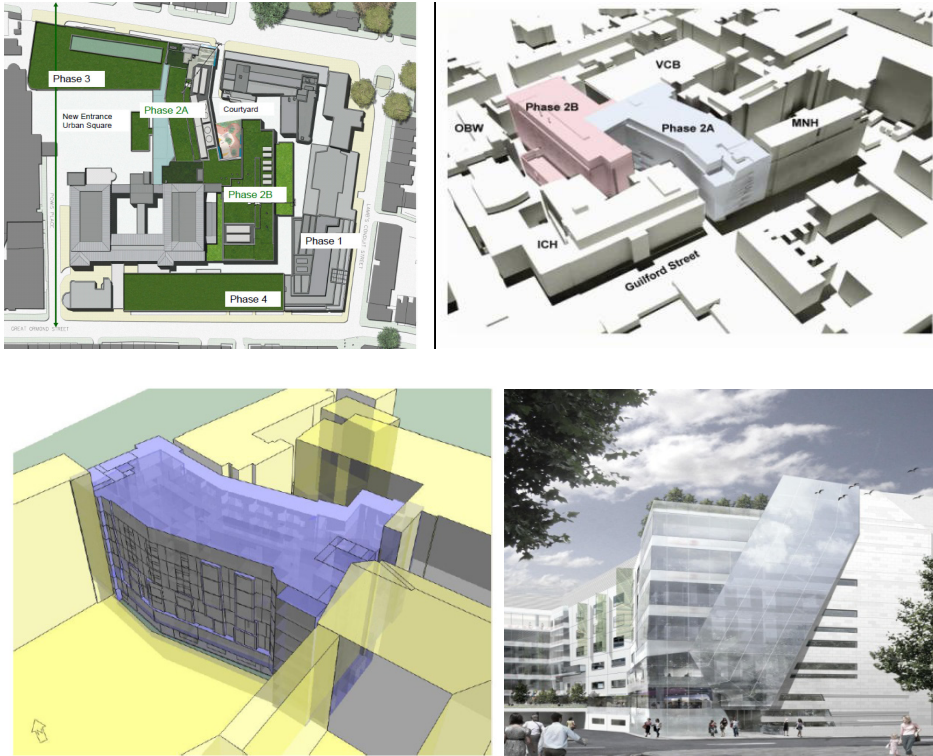


Fig. 4. Great Ormond Street Hospital for Children (Llewelyn Davis Yeang, WSP Group) – 2005 Development
 Control Plan shows Phase 2A Morgan Stanley Building which drew lessons from the 2005 Octav Botnar Building (Anshen & Allen) and in turn will inform Phase 2B

Phase 2A Morgan Stanley Building integrates the island site with horizontal connectivity, aspects that have increased pressure on building services due restricted floor-to-floor levels to achieve a modern environment containing 3 bed-pool ward floors, a cardiac intensive care unit, 3 operating theatres and a hybrid-angio theatre, a restaurant, which can be used for functions and events for the patients, families and staff. Phase 2B is to follow 2A once decants are complete. The layout separates public, clinical, staff and facilities management movements via separate vertical cores located at the north and south ends of the building leaving the clinical floor plate clear minimising disruption to the adjacent floors during any future reconfiguration/ refurbishment thus achieving a ‘long-life loose fit’ objective (Principle 3).

Table 1. Great Ormond Street Children’s Hospital –A long list of guidance for Phase 2A

LIST OF GUIDANCE		
LEVEL 7 IP Bedpool	4 Inpatient Accommodation 1997/ 4.1 Isolation Facilities 2005/ 18 Office Accommodation 1991/23 Accommodation for Children & Young People 2004/ 40.1&2 Common Activity Spaces 1995/ 53 –Renal 1996	DESIGN GUIDES * The Art of Good Health 2002- Design for Health 2004; * Wayfinding: Guidance for Healthcare Facilities 1999 * Friendly Healthcare Environments for Children & Young People 2004 * Ward Layouts with Single Rooms& Space for Flexibility
LEVEL 6 IP Bedpool	4 Inpatient Accommodation 1997/ 4.1 Isolation Facilities 2005/ 18 Office Accommodation 1991/23 Accommodation for Children & Young People 2004/ 40.1&2 Common Activity Spaces 1995/ 53 –Renal 1996	
LEVEL5 IP Bedpool	4 Inpatient Accommodation 1997/ 4.1 Isolation Facilities 2005/ 18 Office Accommodation 1991/23 Accommodation for Children & Young People 2004/ 40.1&2 Common Activity Spaces 1995/ 53 –Renal 1996	
LEVEL4 Cardiac Critical Care	57 –Clinical Care 2003/4 Inpatient Accommodation 1997/ 18 Office Accommodation 1991/23 Accommodation for Children & Young People 2004/ 40.1&2 Common Activity Spaces 1995/	
LEVEL3 Theatres & Interventional Procedures	6- Diag. Imaging & Intervention Radiology Vol. 1& 2 2001 &3/ 18 Office Accommodation 1991/23 Accommodation for Children & Young People 2004/ 26-Facilities for Surgical Procedures 2004/28- Cardiac Services 2006/CAS 1,2,4	
LEVEL2 Staff/Visitor Dining	10 – Catering Department 1997/18 Office Accommodation 1991/40.1,2,3,4 Common Activity Spaces 1995	
LEVEL1 Cardiac Day Care/ Echo & ECG/ Lung Function	28- Cardiac Services 2006/18 Office Accommodation 1991/23 Accommodation for Children & Young People 2004/ 40.1&2 Common Activity Spaces 1995/ CAS 40, 4 1995/12-OPD 1990	
Level 0 Staff Change/ Catering	10- Catering Department 1997/18 Office Accommodation 1991/40.3 Common Activity Spaces 1992/CAS 40.4 1995/ 41- Staff Changing and Storage of Uniforms 1984	

The Clinical Plan shows all the public activities located at the southern end of the building connecting into the existing hospital street (the main artery of the island site). The floor plan has a hierarchy which denotes movement from public to private with the public areas featuring a large light and airy reception, waiting area adjacent a parent sitting room on all ward floors, followed by a ward entrance and adjacent play/recreation/dining areas. The wards have over 60% single bedrooms and 2 four-bed high dependency bays a practical response to the original strategy of providing 100% single rooms. Informed by evidence from both research and a mock-up on the site, the typical bedroom has a calm domestic feel with enhanced visual links to nursing staff and patient observation points (Principle 2). The bed-head unit design introduces a relaxing feature colour, integrates lighting/medical services to minimise any institutional feel. Parents have a private area within the bedroom adjacent an external window and an integrated wardrobe provides within the room storage space for personal belongings. All bedrooms and intensive care units have openable windows.

The high acuity activity flow progresses around the floor, from the clinical entrance at the high dependency bays to the isolation rooms then on to single bedrooms and low dependency rooms before going home. All clinical support facilities are in the centre of the floor plate for easy access from both sides. At the most northern end of the building staff activities occur with the staff rest area conveniently located with tranquil park

views away from clinical and public areas. Theatres are internal with a clinical corridor on one side supported by a service corridor on the other but with visual screens to the green roof bringing staff inside the external environment via a live web link. An artist has been commissioned to create a distraction during the patient's journey to theatres, a nature trail through which a patient travels as a sequence of abstract animal images in a woodland setting leading to the anaesthetic room and theatre.

Natural daylight penetration has been maximised in key areas of the building with full height glazing at the 'cranked' building foot print. Mixed mode ventilation is provided to all ward bedrooms giving patients and parents control of their environment when the external conditions allow. Mixed mode natural ventilation to the level 2 public and staff restaurants is achieved with cross-ventilation and a glazed thermal flue integrated into the Guilford Street façade. The thermal flue, expressed on the only public façade makes a statement about the building and the trust's aspirations towards sustainability. Extensive, semi-intensive and intensive green roofs have been specified to increase biodiversity on a dense urban site to reduce both storm water run-off and the heat island effect at the hospital by increasing thermal performance. A post-tension concrete floor slab minimises the structural zone and concrete content in the building and where possible its thermal mass is used to stabilise peak temperatures with all finishes selected to reduce embodied energy and to enhance the internal healing environment.

As at Evelina Children's hospital London, wayfinding uses a Natural World theme with Phase 2 floor as a habitat, each ward named after an animal from that habitat. Graphics are strategically positioned throughout the building to aid wayfinding and provide informative and educational positive distractions. The graphics also enhance legibility of place providing visitors with familiarisation, orientation and a sense of identity. The hospital's active arts and humanities programme uses creative residences and workshops for patients and staff.

The development aspires to be one of the greenest hospitals in the UK, achieving a 20% reduction in carbon emissions through renewable sources (BREEAM¹² rating 77%) while meeting the targets set for the City of London. The Development Control Plan's aims relate to the initial Plan for a GSHP - Ground Source Heat Pumps (hot water supplement and thermal plan for heat rejection in summer months); PV- Photovoltaics (Electrical generation and improved fabric insulation); and Solar Thermal (supplement LTHW - Low Temperature Hot Water – 80/70°C).

¹² BRE Environmental Assessment Method

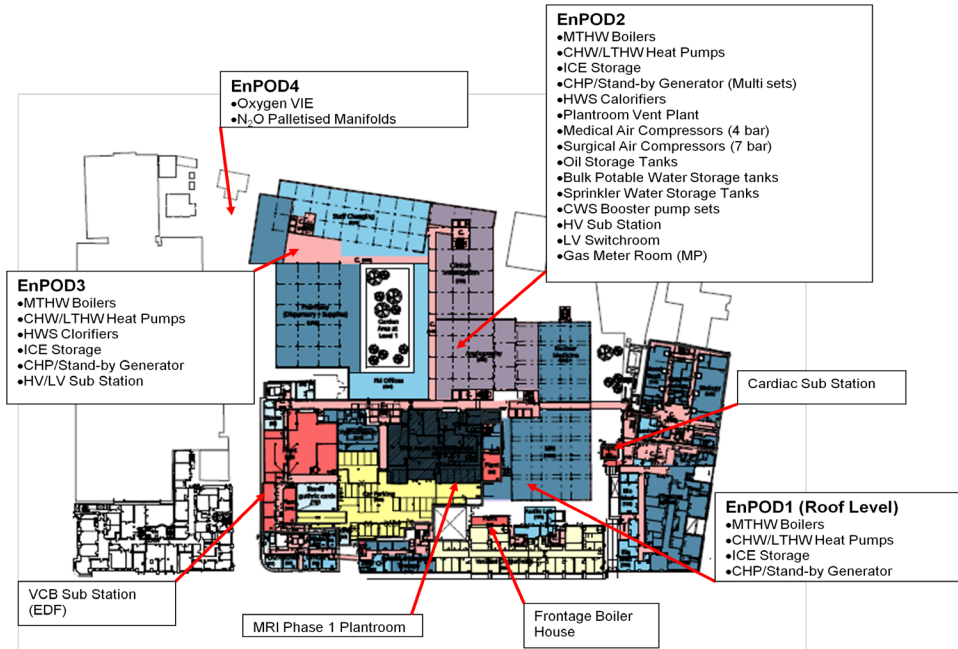


Fig. 6. Great Ormond Street Children’s Hospital Redevelopment (WSP Group) 2005 Development Control Plan aims to reduce both carbon emissions and distribution temperature for the system while de-centralising the boiler plant.

With GSHP not recognised under the London Plan the development’s focus is complying with the 2004 mayor’s energy strategy for: a reduction of energy usage (i.e. Be Lean!); increased use of renewable energy sources (i.e. Be Green!) and achieving efficiency of energy usage (i.e. Be Clean!) while acknowledging that a separate drive to include CHP negates gains from solar thermal collectors. Also the strategy incorporates HV electrical generation with exports to the local electricity grid; MTHW (Medium Temperature Hot Water – 95/71⁰C) heat generation and formation of Centralised Energy Centre (EnPOD 2); tri-generation (CCHP- Combined Cooling Heating and Power) with CHW linkages to adjacent buildings and energy efficiency plus decentralisation with priority over renewables). The carbon story, which was informed by the zero carbon hierarchy (measures allowing for reductions of emissions that are difficult to achieve on site - on-site energy generation - good building fabric performance), highlights primarily gas-fired system based on future bio-gas/bio-oil fuels; a reduction in circulating temperature (i.e. 156 – 95⁰C); provision of a mixed-mode ventilation to in-patient & canteen areas; installation of LED lighting and lighting control systems; with energy efficiency and CCHP that exceed targets for carbon dioxide emissions by 20%.

In general, the development highlights several legislative challenges usefully summarized in Table 1& 2. These challenges involve satisfying both clinical demands and operational requirements while complying with Building Regulations, City of London targets on sustainability, HTMs for example HTM 03-01, 07, and 08-01,

HBN23 Hospital accommodation for children & young people (revised edition) 26th January 2005 previously revised in 2004.

Table 2. Great Ormond Street Children’s Hospital Redevelopment- Legislative challenges

Health Technical Memorandum (HTM) Compliance	
<i>Clinical Requirements</i>	
<i>Operational requirements</i>	
<i>Phase 2</i>	<i>HTM 03-01 Requires greater airflows</i>
	<i>HTM 04-Inpatient Accommodation Great Ormond Street Hospital reduced temperature and copper silver ionisation</i>
	<i>HTM 07 series</i>
	<i>HTM 08-01 Acoustics</i>
Part L Building Regulations Compliance	
<i>L2B 2010 reduces specific fan powers to 1.8 W/l/sec</i>	
<i>CCHP lower rating in calculation.</i>	

REFURBISHMENT AND RECONFIGURATION OF THE HEALTHCARE ESTATE

The Nightingale Associates focus group used eight hospital schemes (Rotherham, Liverpool Heart & Chest, Royal Liverpool University, Stepping Hill, Arrowse Park, Maidstone, Rampton and Prince Charles, Gurnos Merthyr Tydfil and the “bedpod” innovation to examine refurbishing NHS healthcare buildings.

In all these schemes, addressing the existing structure and external envelope, the limited external façade walls due to the form and shape of the building, the location of existing windows, the provision of en-suite facilities, nurse stations, views, existing services risers and structural columns are key considerations to complying with standards on the number and size of single rooms. Rotherham District Hospital Ward B2 reconfigured an existing 35-bed Ward (5x6 bed rooms & 5 single bed rooms with 1 en-suite) to provide a 20-bed Ward with 8 single rooms and four 3-bedded rooms. A tight programme prevented a Town Planning Application to change the external walls. The floor area of 12.95m² (3.7x3.6) for the single room (and 4.5 m² for the en-suite) is less than the recommended 16m² for a single room (and 4.5m² for en-suite) in HBN 04. The Liverpool Heart & Chest Hospital Ward C scheme is procured under Procure21 and completed in 2007 as a £2.4m reconfiguration of the Ground Floor of a ‘Nucleus’ template (housing a former SICU) providing a 20-bed Ward with 8 single rooms and 2 six-bed Wards. The floor area of 16.56m² (3.96x4.2) for the single room and 6.03m² for the en-suite are above the recommended 16m² for a single bedroom and 4.5m² for en-suite in HBN 04. This is the same as what was achieved for Royal Liverpool University Hospital Ward 3X project despite extra challenges of existing main circulation routes adjacent ‘live’ accommodation and an existing ‘racetrack’ fire evacuation strategy. Completed in 2009 under a £1.3m traditional tender, Royal Liverpool University Hospital Ward 3X reconfigures an existing 25-bed Ward (5 singles with 2 en-suites) to provide 8 lobbied isolation rooms and 5 single rooms with en-suites.

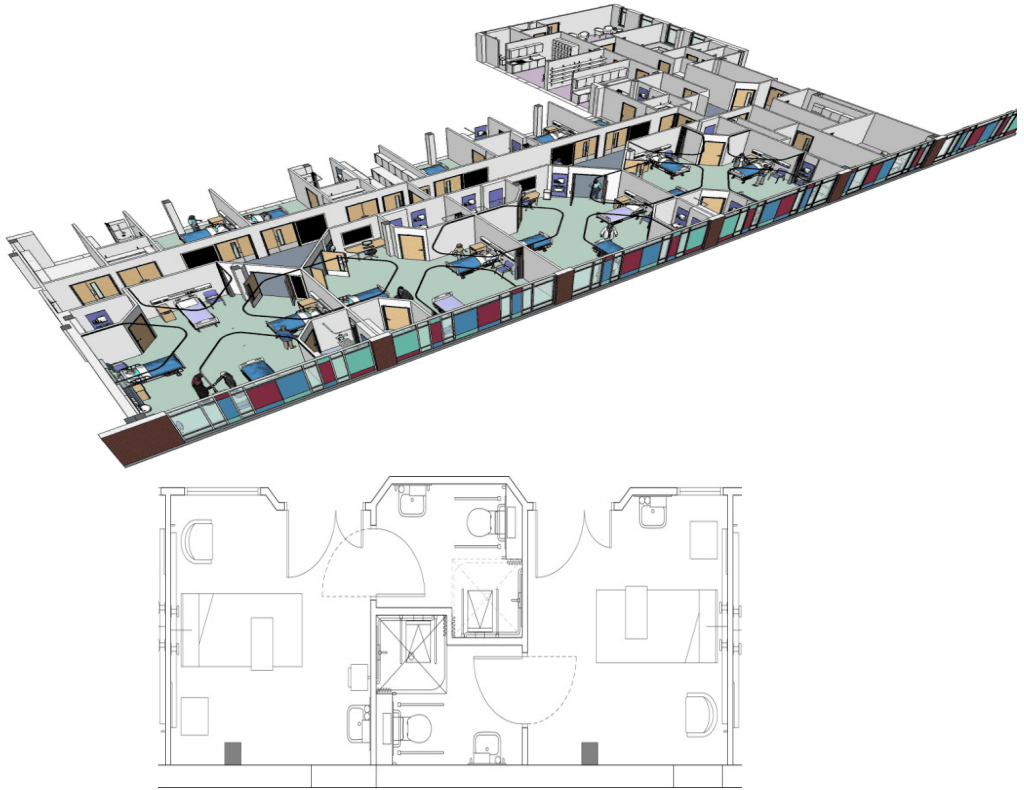


Fig. 7. Rotherham District Hospital Ward B2, (Nightingale Associates) Reconfiguration of the existing 35-bed ward with 5 single bedrooms-floor area of 12.95m^2 (3.7×3.6) is below 16m^2 recommended in HBN 04

The Stepping Hill Hospital 4th Floor Maternity Block, Stockport is a £1m traditionally procured scheme due for completion in 2011 reconfiguring a former Ward (9 single rooms with no en-suites and 5 four-bed bays) to provide 4 single rooms with en-suites and 6 four-bed bays. Extra reconfiguration challenges were a very limited budget, a pre-determined client layout, and asbestos in the ceiling void of a 'live' Maternity Ward below. Although 4.8m^2 is above the 4.5m^2 for en-suite in the HBN 04, the floor area of 10.96m^2 (3.07×3.57) for the single room is significantly less than 16m^2 for single bedroom, 58.0m^2 for 4-bed room in HBN 04. Another traditionally procured £900k scheme completed March 2011, Arrowe Park Hospital Ward11, Wirral reconfigures 17 existing Paediatric single rooms (8 with en-suites) to form a reduced number of 14 single rooms with en-suites and 4 three-bed bays (26 beds in total). Additional design considerations were replacing existing continuous glazing to external walls as part of the project and working below 'live' facilities. The floor areas of 14.0m^2 (3.32×4.49) for the single room and 4.25m^2 for the en-suite are less than 16m^2 for single room and 4.5m^2 for en-suite in HBN 04.

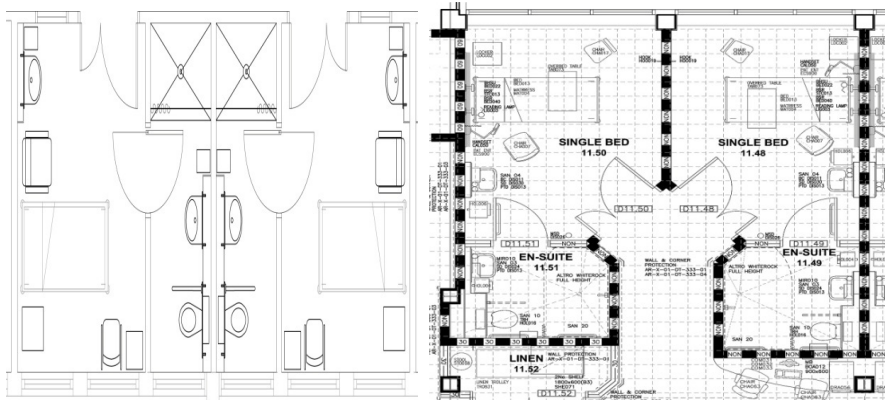


Fig. 8. Stepping Hill Hospital, 4th Floor Maternity Ward (right) and Arrowe Park Hospital Ward 11 (left)
 Reconfigurations provided respectively 4 single rooms: floor area of 10.96m² (3.07x3.57) and 14
 bedrooms: floor area of 14.0m² (3.32x4.49) less than 16m² in HBN 04.

Another case study, the 380-bed Maidstone District General Hospital examines the challenges of reconfiguring a variety of buildings from different periods 1983, 1992 and 2003-2006 responding to evolving standards. With full A&E services, a Kent Oncology Centre, the core Maidstone Nucleus hospital has 1983 Ward blocks that do not meet modern standards due to draughty single-glazed windows, poor air tightness, a lack of insulation and solar shading as well as mechanical and electrical services that do not work properly. Many options to provide 50%, 75% and 100% single rooms were considered. Typically, the existing bed count of 407 was reduced to about 250 beds at 75-100% single rooms. However, none of the ward refurbishments or any of the upgrading of the external fabric was undertaken as funding became restricted in 2006 due efforts being diverted to the all single bedrooms Pembury PFI Hospital.

As with the Maidstone project, the Prince Charles Hospital, Gurnos Merthyr Tydfil is about reconfiguring and upgrading outdated facilities in this case a typical 1978 tower and podium hospital typology. Commissioned in 2006 the brief was to upgrade at an overall cost of £33m the ward accommodation to comply with current guidance. Construction which started in 2008 with completion date of 2012 adopts a suitable decant strategy; phases demolitions incorporating removal of asbestos in accordance with health and safety regulations, installs fire protection to the existing structural steelwork and underside of concrete floor slabs with external envelope alterations that include replacing windows with low emissivity double-glazed units with integral blinds to reduce solar gain; installation of louvre panels to assist in the ventilation system. Solar shading without curtains assists with infection control.



Fig. 9. Maidstone District General Hospital (Nightingale Associates): A survey highlighted the non-compliant conditions of the estate with the 1983 Nucleus System buildings in red in need of extensive maintenance and reconstruction to comply with modern standards.

External envelope refurbishment re-designed the window frame arrangement to minimise transoms and mullions and maximize views, adopting modules to glazing and panels that facilitate flexible layouts while incorporating assisted mechanical ventilation to remove warm air from the deep plan wards. Interior blinds, anti-sun glazing and external shading with maximum user control for variable ventilation requirements are provided as an integrated system. Design solutions include a 24-bed ward option with 33% single rooms; a 28-bed ward option with 28% single rooms and a 30-bed ward with 20% single rooms yielding a final layout of 24 beds, 4-four bed wards, 7 single bed with ensuites and one isolation suite with a lobby.

Yet another case study, Rampton secure Hospital shows a typical NHS estate layout with many old buildings (villas, old wards etc.) in need of reconfiguring and modernising. A Charter Mark, a government scheme designed to both reward excellence and encourage constant quality improvement but focusing on the quality of service

provided to users (patients, visitors and the public) was awarded to Rampton Hospital in February 2000.



Fig. 10. Prince Charles Hospital (Nightingale Associates): “Existing 30-bed wards did not meet guidance HBN04 Inpatient Accommodation Options for Choice 1997, Revised Schedules of Accommodation (Consumerism), HFN 30 Infection Control in the Built Environment”



Fig. 11. Rampton high security psychiatric Hospital near Woodbeck (Nightingale Associates): Opened in 1912 as an overflow of Broadmoor Hospital shows the challenges of refurbishing an old estate to comply with modern standards.

The "special hospitals" of Broadmoor, Rampton and Ashworth were formerly administered directly by the UK Home Office outside the NHS. However, in April 2001, Rampton Hospital became part of the Nottinghamshire Healthcare NHS Trust providing care under five areas: Mental Health, Women’s Services, Learning Disability, Personality Disorder and Dangerous and Service Personality Disorder. “The regime is

different from that in a mainstream prison. A typical day could involve art therapy or a session with a psychiatrist.” However, of interest *“Maintaining the 75000m² hospital and its 77 ha site presents a significant challenge, with many of the complexities of an acute hospital combined with the security measures found in a prison”*. As part of the brief to refurbish the hospital a Development Control Plan was therefore produced.

This focus group also considered the “Bed Pod” prototype for application in both new build and refurbishment schemes to raise standards and quality of the environment. It was a response to the Design Council and the Department of Health competition under the “Design for Patient Dignity” 2010. *“We realised that the necessary components which make up a complete bed environment, from medical gases and drip rails to lighting and a bedside locker could all be integrated into one product substantially simplifying procurement and installation”*. The innovation features a personalised modesty screen as a curved, perforated metal bed head and ceiling canopy that redirects sound waves down on to the bed rather than across the room, so that the volume of conversations between clinician and the patient are reduced by as much as 20dB. The structure incorporates medical gases, power supplies, bedside grab rails and mountings for entertainment systems and offers the patient control of the environment for ambient lighting and for increased privacy. Low-level LED lighting gives patients enough light to safely navigate around the ward at night, when general lighting levels are reduced to promote sleep. High-level storage utilises previously unused space and a fold-down chair or bed for visitors can be incorporated. Also, the materials used have been chosen to make cleaning easier.



Fig. 12. “Bed Pod” Design innovation (Nightingale Associates): offers a temporary or permanent measure in hospitals, creating a private space even within a multi-bed ward environment giving Trusts more control and the flexibility to release space within their estate.

RESULTS AND ANALYSIS

Participants from all the focus groups were in agreement over several key issues. There was unanimous acknowledgement that the evidence-based approach is vital in underpinning standards and tools based on the same rationale as that provided for Evidence-Based Medicine - *“The conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients”* (Sackett *et al* 1996, Dopson *et al* 2003). Warnings were raised against “short-term” mentality of cost-cutting under the austerity measures being implemented across Europe including the

UK. This is being seen as too risky and could affect the quality of the standards and tools as subsequently the healthcare estate which these are meant to safeguard. Design quality initiatives are feeling the squeeze as programmes for quality improvement are either scaled back, put on hold indefinitely or only focus on minimum requirements such as patient safety.

Participants of the focus groups acknowledged that individual healthcare regions (Scotland, Wales and Northern Ireland) are not necessarily taking the approach England may be adopting to reduce healthcare spending. The value of the website (<http://www.spaceforhealth.nhs.uk/>) was accepted as a vehicle for sharing data on standards and tools previously disseminated via the Department of Health Knowledge Information Portal (KIP). Also the current situation may be an opportunity for development of standards/ tools by the private sector endorsed by the Department of Health. However, *“While it is preferable that the Department of Health produce and coordinate healthcare guidance, for reasons such as costs and to avoid duplication, guidance on some specific topics e.g. disability design might be best produced by others, particularly where it is applicable across other sectors.”* This recognises the learning from other sectors. Projects become a series of interconnected projects for knowledge transfer with design solutions tried and tested and successful applications repeated time and time again. Learning from precedents embodies experiences with regards building standards/ norms for example the extent of compliance and in some cases the nature of derogation. *“Standards provide a useful baseline and a common target from which to derogate”*. Without inferring that derogation is the norm, a developer may do so for other reasons e.g. simply to reduce capital costs. Whatever the case derogation lists provide useful information about areas of guidance where gaps are and where new knowledge is required.

Participants from the individual focus groups reflected specific issues. The Medical Architecture focus group showed the need for feedback from evaluations of completed projects with researchers disseminating findings and *“measures we are expecting to improve which become overarching aims in the design”* clearly setting out the agenda at onset of a new project. Understanding that buildings last a long time but have to accommodate changes in both healthcare services and in the building fabric (60-120 years), building services (10-15 years) and furniture and fittings (5-7 years) is essential to recognise the different life spans and keep pace with the evolution of ideas. *“Wandsworth scheme is an inversion of the asylum concept (1860s asylum idealised as a hospital in parkland outside town)”*.

Great Ormond Street Hospital for Children refers to the importance of *“learning from what we did before engaging staff and families for example via ‘Acute Bedpools Group’, interfacing with fundraising, linking with peers such as Boston Children’s Hospital US, establishing status of vital guidance including HBNs, HTMs etc. and National Service Frameworks.”* In practice this means investigating specific issues for instance Decentralised or Dispersed Clinical Workstations which are supported by evidence from scientific studies (Fable Hospital innovations - Berry et al 2004) as enabling nursing staff to be in close proximity to patients, reducing travel distance to PCs, while improving observation or increasing assistance for patients and families.

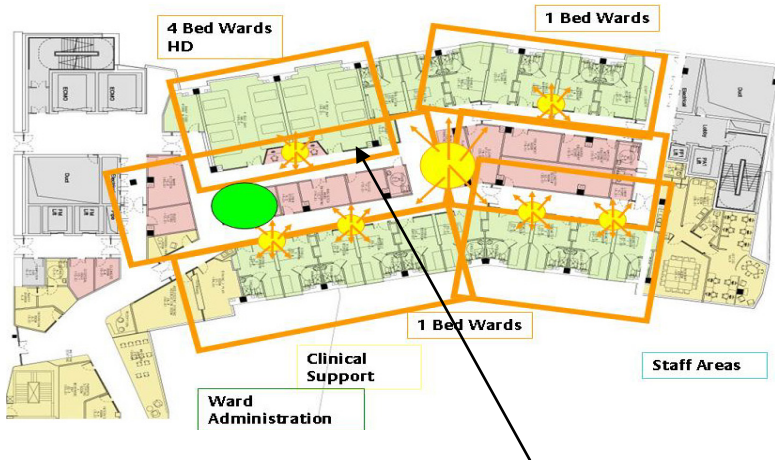


Fig. 13. Great Ormond Street Hospital for Children (Llewellyn Davies Yeang) shows application of a decentralised or dispersed clinical workstation

The Llewellyn Davies Yeang/WSP Group focus group shows how the pressures to maintain a reputation as a world leading centre of excellence influence compliance with standards and encourages adopting innovations. Great Ormond Street Hospital is not a typical NHS project and because of having benefactors who contribute some 70% non-healthcare private funding towards capital projects expectations are high for state-of-the-art quality facilities with a vision and robust Estates Strategy. Hence the reason for developing a Development Control Plan “*produced in 1999 the DCP has been a means to test the Care Model on this very tight urban site in central London providing a vision to control development over a 25-year timescale. To date the DCP has facilitated over 68 enabling works while allowing day-to-day operational functions of the hospital.*” In support of this vision is reflected in efforts not only to identify the standards to clarify the extent of compliance but also to examine their evidence-base.

Table 3. Great Ormond Street Children’s Hospital Redevelopment –Example indicating extent of compliance with NACHRI 2008 standards

National Association of Children’s Hospitals + Related Institutions (NACHRI) 2008	Evidence-Based Design and extent of compliance in Great Ormond Street Children’s Hospital Phase 2
Increase visual access and accessibility to patients.	All patient bedrooms are provided with glazed walls to the internal corridor, dispersed clinical work stations (1 to each 4 bed HDU/CICU bay, 1 to every 2 single bedrooms increase access and visibility of patient and staff.
Optimise natural light in staff and patient areas.	All patient bedrooms/bed spaces, play/recreation areas, waiting areas, staff rest rooms have natural daylight Theatre and Angio corridors have natural light, with glazing panels in doors of inner rooms of the floor to allow natural light penetration into inner core of ‘work’ rooms
Install HEPA filters in all areas accommodating immune-compromised patients.	HEPA filters are provided to the CICU floor with each lobbied isolation room on all floors
Install high performance sound absorbing ceiling tiles.	Great Ormond Street Hospital Project has used high performance acoustic tiles in Enabling Works for Phase 2
Conduct a noise audit and develop a noise reduction plan.	An acoustics study of the Octav Botnar Wing is being conducted by a PhD student. Findings will be incorporated into Operational Policy development and future schemes. Anti-vibration pads are to be installed for equipment where noise generated. Also Plant rooms will be acoustically protected where located in Ward areas.
Use music interventions as a positive distraction during medical procedures.	Inclusion of facility to play music in all treatment rooms on Ward areas and in each bedroom/bed space. I-pod docking station installed in all theatres and angio- laboratories

The Nightingale Associates focus group suggested the likely shift in emphasis from a focus on new build to that of upgrading existing assets to improve standards, reduce running costs and reconfiguring existing buildings to meet new Care models. Significant dilemmas were highlighted *“One of the key drivers for increasing the numbers of single rooms and dedicated en-suites is the need to comply with demands for gender separation or segregation. Breaches of these requirements are punished by fines which are then levied on the Trusts”* Reconfigurations which reduce the trust’s total number of beds are therefore seen as bad design solutions. Also when wards are closed due to refurbishments and bed spaces are lost e.g. for a standard 30 bed ward this could mean up to 9,500 bed days in a 40 week period impacting on costs and disrupting services.

Focus groups also highlighted issues regarding the application of design tools such as costs, sharing of knowledge, in-house practices etc. for example *“Improvements in sustainability and the use of BREEAM Healthcare at the higher ratings levels (such as Excellent and Outstanding) usually increases capital costs, but will also reduce life running costs.”* *“We develop in-house design tools to evaluate energy consumption, application of renewable energy technologies, etc. to complement those by CIBSE, BSRIA and others.”*

CONCLUSIONS

Results from all this work validate the five key guiding principles for the establishment of an international best practice framework identified by Fröst et al 2010 when designing facilities for healthcare services. These principles are the main focus of this paper and relate to the main issues of continuously:

- Raising awareness in healthcare design of the importance of the evidence-based approach to underpin the development of rigorous standards and tools to improve quality and safety via processes, products and their performance.
- Recognising in health design the relevance of learning and feedback from
 - Previous projects internally within organisations or externally - via new knowledge, best or better practice, innovations, value creation etc.
 - Other sectors e.g. residential, manufacturing etc.
 - Other countries USA, EU, Australia and so on e.g. Fable Hospital and Pebble Project etc.
 - Research studies that build on evaluation of completed projects.
- Optimising the possibilities of reuse/ renovation of existing accommodation before opting for new build as strategy to providing improving health and social care accommodation. However, dangers are that the existing accommodation constrains the development of innovative personalised care perpetuating outdated medical practices. A scarcity of resources suggests adopting a “Make-do and mend” healthcare architecture (after the wartime Ministry of Information slogan) as a practical and sensible response to tighter budgets and lower expectations.
- Increasing our understanding of forces of centralisation (defined by an increased role of the Department of Health and other central government agencies both historically and in the future) vs. decentralisation (by local authority and private sector) generating and maintaining standards/tools.
- Recognising that changes in organisational structures and associated health policies play a vital role in developing suitable evidence-based guidance.

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DEVELOPING ACCURATE COSTING SYSTEMS

C.Chapman¹ and A. Kern²

ABSTRACT

Producing accurate product costs remains in many contexts a challenge for cost system designers (Noreen and Soderstrom 1994, 1997; Foster and Gupta 1990). Not only do they face technical challenges such as errors (Christensen 2010; Labro and Vanhoucke 2007), but they also face the organizational challenge of involving non-accountants in cost system design (Eldenburg et al. 2010; Wouters and Wilderom 2008; Wouters and Roijmans 2010). Whilst there is empirical evidence that shows that participation of non-accountants in cost system design enhances accuracy, usability of costs and financial performance, we know very little about this process of making cost systems more accurate.

Based on a field study undertaken in a UK Health Trust we analyze the process of making costs systems more accurate. Our study makes two main contributions. Firstly, we extend the literature on costing system errors (Christensen 2010). We suggest that reducing the total error through trade-off or off-setting effects misses an essential point even if it may reduce the total error (Labro and Vanhoucke 2007). Errors are not only sources to improve accurateness of costs but also to manage efficiency. Secondly, we find that there is a recursive process of making cost systems more accurate. We identify two dynamics of this process linking participation non-accountants in cost system design, alignment of cost system design and organizational processes and usability of cost data for decision-making. The process is on-going without converging to an optimal state. This understanding has significant implications for designers and users of costing systems alike.

KEYWORDS

costing healthcare, cost system design, decision-making, quality of cost information, clinical engagement

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HELPING DECISION MAKERS NAVIGATE THE EVIDENCE AROUND HEALTH FINANCING

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ABSTRACT

There are calls for low and middle income countries to develop robust health financing policies to increase service coverage. However, the existing research evidence around health financing mechanisms is complex and difficult for policy makers to access. We developed a web-based tool to help decision makers navigate this evidence.

We considered five potential goals of a health financing policy in relation to seven health financing mechanisms. After reviewing the literature, we summarised the impact of the health financing mechanism discussed in each paper on each of the goals.

Eleven country indicators considered relevant to health financing were used to provide information of the significance of each study to the user's context.

The web-based tool provides graphical summaries that allow a user to assess in a single graphic: the number of relevant studies, the heterogeneity of evidence, where key evidence is lacking and how closely the evidence matches their own context.

KEYWORDS

health financing, evidence review, web tool

BACKGROUND

There is an established need for low and middle income countries to increase health service provision but it is not clear how countries should or can increase health expenditure to fund such increased provision. Against a background of calls for robust domestic health financing to 'attain and sustain' increased service coverage (Evans & Etienne 2010), domestic financing choices are more complex than they have ever been. The gradual removal of user fees (Borghi et al. 2006; Gilson & McIntyre 2005; James et al. 2006) is leaving a policy and funding vacuum. At the same time, low-income and

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middle-income countries continue to struggle with ongoing or emerging conflicts, stagnant economic growth and a recent global recession, the effects of climate change, persistent HIV and the increasing prevalence of chronic diseases. Community based health insurance (CBHI) and social health insurance (SHI) have both been hailed as the ‘new solution’ for financing healthcare, but increasing evidence suggests that these are meeting with limited success (Basaza et al. 2008; Logie et al. 2008; Smith & Sulzbach 2008; Mladovsky & Mossialos 2008).

The system of health financing used by a country underpins its health infrastructure and indeed may directly influence the design of that infrastructure. It is possible that the ideal health financing approach is a carefully chosen mix of methods appropriate to a given economic, social, political and epidemiological context and designed to best meet the most urgent health system priorities, without significant negative consequences (Palmer et al. 2004, Kutzin et al. 2009, Normand and Thomas 2008). However, the pragmatic reality is that striving to define and achieve this difficult balance may create confusion and policy paralysis. This paralysis may be further exacerbated by the breadth of a relatively fast-growing body of evidence.

The last comprehensive review of the evidence on domestic health financing was conducted more than six years ago by Palmer et al. (2004), with Lagarde & Palmer (2008) more recently reviewing the evidence on user-fees. While Palmer et al. (2004) considered the impact of health financing methods on service use and health outcomes, Lagarde & Palmer (2008) focused on the impact of user-fees on health service use, equity outcomes, health expenditure and health outcomes. In work to be published elsewhere, we have extended this valuable evidence base by updating the evidence on a wide range of health financing methods to reflect the most current learning. In the context of this updated review, a health financing mechanism is defined as a mechanism intended to raise domestic revenue for health including national/government/social health insurance, taxation, community-based insurance, private insurance, user fees, equity funds and discount cards.

Despite being valuable in its own right, this updated review is nonetheless still a complex source of evidence covering numerous studies; the health financing mechanisms considered, and the countries in which they have been implemented, are many and the evidence of impact is heterogeneous. Such reviews are generally not tailored to the needs of policy makers and there is a need to make the evidence more accessible to policy makers (Rosenbaum et al. 2011). Being able to navigate this heterogeneous evidence around health financing choices would be of considerable help to decision makers in low and middle income countries.

In this paper we report on our development of a web-based tool that can be used by decision makers to summarise the available evidence quickly and easily, but with the ability to access information on the underlying evidence from anywhere within the tool.

THE EVIDENCE AND PERSPECTIVES UNDERLYING THE TOOL

We used country classifications from the World Bank (World Bank website, 2011) to determine the list of low- and middle-income countries. We approached the problem

from the perspective of what a potential decision maker would find helpful in summarising the available evidence for these countries.

GOALS OF A HEALTH FINANCING SYSTEM

Each potential health financing mechanism was considered in relation to its potential impact on each of five possible goals of a health financing policy (Table 1).

Table 1. Five possible goals of a health financing policy

<i>Goal</i>	<i>Brief Description</i>
<i>Promote equity</i>	<i>Equity here incorporates references to poverty reduction, equity, the distribution of disease burden (e.g. DALYS), the distribution of the financial burden (e.g. the incidence of catastrophic health spending), and risk pooling.</i>
<i>Reduce poverty</i>	<i>This refers to changes in absolute poverty.</i>
<i>Improve quality</i>	<i>Quality refers to service quality and to changes in health outcomes that may be a consequence or indicator of improved quality of care.</i>
<i>Generate revenue</i>	<i>Revenue refers to either absolute or relative revenue generation at any tier of health service delivery. The assumption here is that increased revenue generation or retention is the desired outcome.</i>
<i>Increase use</i>	<i>'Use' refers to the quantity of health services demanded, access to care and the utilisation of health services.</i>

EVIDENCE ON HEALTH FINANCING POLICY DECISIONS

A rapid literature review was performed using methods adapted from EPPI-Centre (EPPI-Centre 2007) and Greenhalgh et al. (2005). The details of this literature review have been submitted elsewhere and are not described in this paper. Seven possible health financing mechanisms were considered:

Taxation: A tax-financed system is one where the government raises revenues through various forms of compulsory taxation to finance government healthcare expenditures.

User fee maintenance / increase / implementation: Payment at the point of delivery made by the patient. Here we consider the implementation, increase or maintenance of user fees.

User fee reduction / elimination: Payment at the point of delivery made by the patient. Here we consider the removal or reduction of user fees.

Community-based health insurance (CBHI): These schemes generally have three characteristics: they are voluntary, not for profit and community-based.

National or government-run health insurance: Social health insurance is an insurance programme which meets at least one of the following three conditions:

- Participation in the programme is compulsory either by law or by the conditions of employment.
- The programme is operated on behalf of a group and restricted to group members.

- An employer makes a contribution to the programme on behalf of an employee.

Private health insurance: Private health insurance is insurance that individuals or their employers purchase to cover their healthcare expenses.

Equity funds or prepayment schemes: These involve a third party identifying the poor and paying user fees on their behalf by reimbursing the service provider.

The evidence available was qualitative, descriptive and heterogeneous. To make it accessible to policy makers, for each article we summarised the impact of the health financing mechanism discussed on each of the goals given in Table 1 by assigning one of five impact scores: "Evidence against", "Some evidence against", "No evidence of impact", "Some evidence for" and "Evidence for". We also explicitly recorded if a goal was not considered as part of the study, since we thought it important to capture where evidence was lacking as well as where it existed. To assign impact, GK and JSW first summarised each study found in the literature review. CP, JSW and APB then independently assigned an impact summary to each goal and health financing mechanism for each study. Any discrepancies were resolved in a group discussion.

CONTEXT MATCHING OF STUDIES

The available evidence would not be of equal relevance to all users. We sought to provide information to the user on how closely the countries considered in each study were 'matched' to the user's own country. JSW and CP produced an initial long list of country indicators that were considered relevant to health financing policy and on which countries could be 'matched' to each other. It was also considered important that indicators be easily available for most countries and transparent to users. JSW, CP, NB and MU reduced the long list to a final set of eleven indicators that were considered to provide independent information relevant to health financing policy. These indicators, along with the source used to populate them, are given in Table 2.

We transformed the value of each indicator, I , into a value, $T(I)$, between 0 and 1 according to:

$$T(I) = \frac{I - \min(I)}{\max(I) - \min(I)}$$
, where the maxima and minima were taken across all middle and low-income countries.

Each country is thus characterised by a set of 11 values between 0 and 1, $\{T(I)_j\}$ where j runs from 1 to 11. These values can be thought of as a single point on an 11-dimensional graph, and we use the 11-dimensional 'distance', d_{YZ} , between two points as an estimate of how closely two countries Y and Z are matched, where:

$$d_{YZ} = \sqrt{\sum_{j=1}^{11} (T(I_Z)_j - T(I_Y)_j)^2} .$$

Table 2. Country indicators used for context matching

<i>Indicator</i>	<i>Source (2008 data)</i>
<i>Health expenditure per capita (\$)</i>	<i>World Bank</i>
<i>Maternal Mortality Ratio</i>	<i>World Bank</i>
<i>Under 5 Mortality Rate</i>	<i>World Bank</i>
<i>HIV prevalence</i>	<i>World Bank</i>
<i>Malaria Incidence</i>	<i>UN</i>
<i>Education Index</i>	<i>UNDP</i>
<i>GDP (\$)</i>	<i>World Bank</i>
<i>Life expectancy at birth</i>	<i>UNDP</i>
<i>Proportion of the population living in an urban environment</i>	<i>World Bank</i>
<i>Proportion of the population living on less than \$1.25 a day at 2005 international prices</i>	<i>World Bank</i>
<i>Population (log, base 10)</i>	<i>World Bank</i>

BUILDING THE TOOL

THE CORE GRAPHICAL DISPLAY

A key part of the project was to develop a means of displaying the available evidence to the user in an intuitive and informative way. With input from all the authors, we developed a 'scattar' plot, which has elements of both scatter and radar charts. Each such display focuses on one goal of a health financing policy and shows the evidence available for all seven health financing mechanisms in the context of the (user-specified) country of interest (see Figure 1).

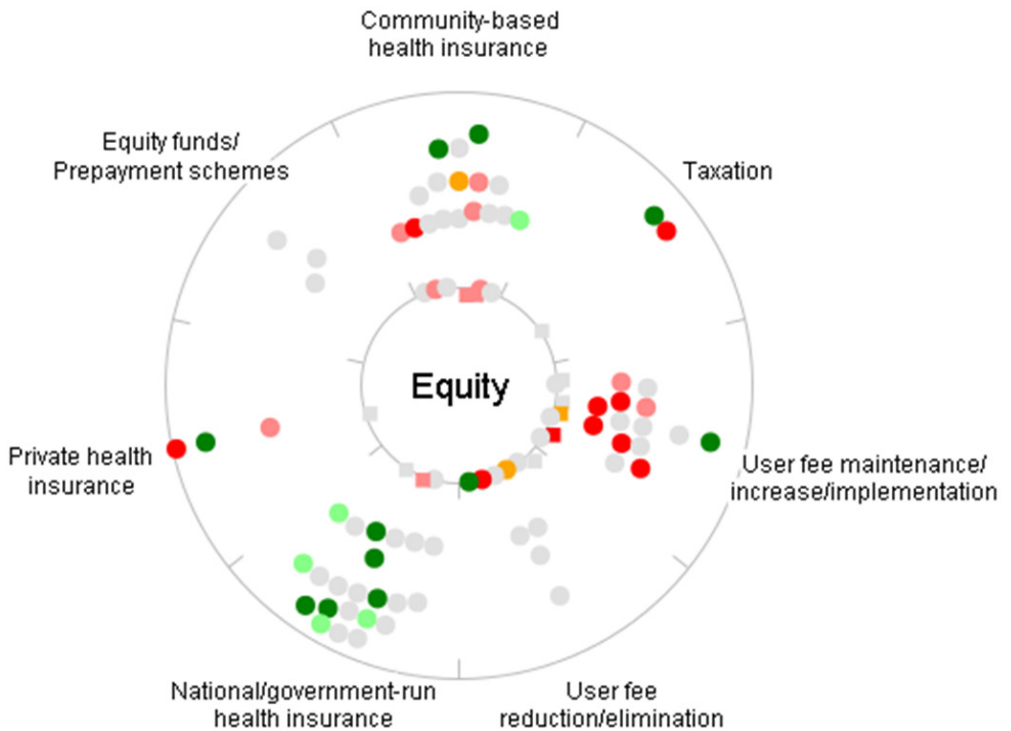


Fig.1. Example of a 'scattar' plot. This example shows the available evidence of the impact of each health financing tool on promoting equity in relation to Uganda. Each dot represents a single study and its colour represents our interpretation of the impact reported in the study on the specified goal (where red is a negative impact and green a positive impact).

Review studies are shown in square dots on the inside ring while all other circles are round dots. The distance of the dots from the inner ring within the 'scattar' plot indicates how closely the countries considered within each study 'match' the country under consideration. Round dots on the inner circle correspond to studies that consider the country chosen by the user (in the case of the example shown in Figure 1, this is Uganda). The diameter of the outer ring is fixed to the largest 'distance' between countries regardless of the country chosen by the user, so that comparing the graphical displays between countries will give consistent information on context matching.

The colour of the dots indicates our summary of the impact on the chosen goal (in the case of Figure 1, promoting equity) reported in the given study. These colours range from green for positive impact to red for negative impact, with orange indicating that there was evidence of no impact. Dots coloured in gray correspond to studies that considered a given health financing tool but did not consider the impact on the particular goal under consideration. We felt it was important to include these on the graphical display as they give an indication of where evidence is lacking as well as where it exists.

All possible plots would always have the same number of dots (since all studies are shown on every plot). The position of the dots within the ring will change according to the user-specified country (but remain the same within a country) and the colour of the dots will change according to the (user-specified) goal.

In the example shown in Figure 1, the user can quickly see that there is most evidence around national and community health insurance and the implementation of user fees. There is some evidence directly related to Uganda (round dots on the inner circle). The large number of gray dots shows that many studies did not consider the impact on equity. Looking at the colours of the dots, the evidence suggests that national health insurance schemes have a positive impact on equity, user fee implementation a negative impact and that the evidence on community based health insurance is mixed. The two studies where community based health insurance had a positive impact on equity are least well matched to Uganda's context (the dots are close to the outer ring), but two community based health insurance studies directly related to Uganda show some evidence of a negative impact.

THE WEBSITE

We decided that the most accessible platform for the tool would be a website, where users could navigate easily between different countries and goals. The website (www.equitablehealthfinancing.org) was registered under Save the Children branding, since they funded and commissioned this work. The website itself was built by XD with content and structure decided by all authors.

The user begins by choosing the country and health financing goal they are interested in, before being taken to a page (Figure 2) showing the relevant 'scatter' plot as shown in Figure 1. In addition to the main display, there is an explanation on the right hand side on how to interpret the display and thumbnails of all five goals are given at the bottom of the main plot allowing the user to switch easily between goals by clicking on the relevant thumbnail. The thumbnails also allow a quick visual impression of where most data exists (increasing use of health services) and where least exists (increasing revenue and quality).

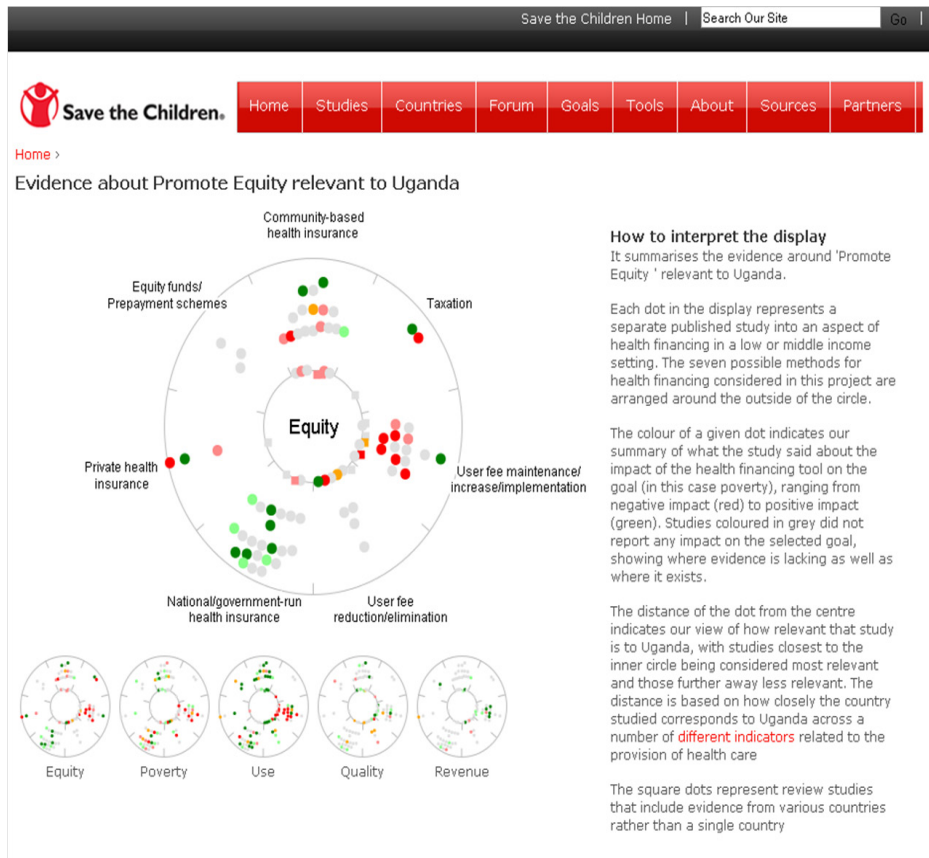


Fig. 2. A screenshot of the graphical summary from the website. As for Figure 1, the chosen country is Uganda and the chosen goal is "Promote Equity"

We felt it was important that the user always has access to the basic evidence and information that the summaries are based on. On the graphical summary page, the user can hover over any dot in the display with the mouse to display the authors and title of the study as well as the country the study considered. Using the mouse to click on any dot will bring the user to a separate page (in a new tab) with the full reference, a link to the publisher of the study, the published abstract of the study and our summary of the evidence from the article of impact for all five goals.

Additionally, there are separate webpages within the site that provide a searchable and sortable list of all the studies used, with summaries of impact (Figure 3) and the indicator values (and source) for each country, which were used for the context matching.

Title	Country	Health Financing Tool	Equity	Poverty	Quality	Quantity	Revenue
Basaza 2008	Uganda	Community-based health insurance	Some evidence against	Not considered	Not considered	Not considered	Not considered
Blanchard-Horan 2007	Uganda	Community-based health insurance	Not considered	Some evidence for	Some evidence for	Some evidence for	Not considered
Dekker 2010	Uganda	Community-based health insurance	Not considered	Evidence for	Evidence for	Not considered	Not considered
Basaza 2007	Uganda	National/government-run health insurance	Not considered	Some evidence against	Not considered	Not considered	Not considered
Kipp 2001	Uganda	User fee maintenance/increase/implementation	Not considered	Not considered	Not considered	Some evidence against	Some evidence for
Xu 2007	Uganda	User fee maintenance/increase/implementation	Not considered	Evidence against	Not considered	Not considered	Not considered
Amone 2005	Uganda	User fee reduction/elimination	Evidence against	Evidence against	Not considered	Evidence for	Evidence for
Nabyonga 2005	Uganda	User fee reduction/elimination	Some evidence for	Some evidence for	Some evidence for	Evidence for	Not considered
Nabyonga-Orem 2008	Uganda	User fee reduction/elimination	Not considered	Some evidence for	No evidence of impact	Some evidence against	Not considered
Xu 2006	Uganda	User fee reduction/elimination	No evidence of impact	No evidence of impact	Not considered	Some evidence for	Some evidence against
Yates 2006	Uganda	User fee reduction/elimination	Not considered	Evidence for	Not considered	Evidence for	Not considered

Showing 1 to 11 of 11 entries (filtered from 90 total entries)

Fig.3. Screenshot of the list of studies shown under a search for Uganda. Any search term could be used, or the gray arrows at the top of each column used to sort the entire list. The text in red represents links to the extended information on the given studies and country.

CONCLUSION

We have developed a powerful tool that can be used by policy makers to explore the available evidence on health financing. The graphical display contains a great deal of information but remains easy to interpret and provides a quick visual guide to what evidence exists and what it says.

There was inevitably a level of subjectivity in the assignment of simple measures of impact to complex and qualitative studies and also in the choice and use of indicators for context matching between countries. We wanted these choices to be transparent to the user and at every stage in the tool provided links to the studies which form the evidence base, the indicators used for each country along with their values and source. Thus, should a user be particularly interested in a particular health financing mechanism or study, it is easy for them to go directly to the underlying evidence. We have also included information on how we defined each health financing mechanism and goal of a health financing policy.

The website is due to be launched by Save the Children in August 2011. We hope that it will be useful not just for health ministries but also for NGOs and international agencies and over the following months we will be able to assess how it is used and who is using it.

This project, along with insights generated on its use following the public launch, could provide a new way to make learning available in academic peer-reviewed papers accessible to policy makers. The implementation of our tool on a public website ensures that it is accessible as well as easy to disseminate. Given a clear need for better ways in which to summarise evidence for policy makers (Rosenbaum et al. 2011), this work

provides not only a useful tool specific to health financing but also a template for future evidence summaries on other, equally important, issues.

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THE BENEFITS QUANTIFICATION METHOD: A PRACTICAL APPROACH TO ENGAGING STAKEHOLDERS IN THE JUDGEMENT OF BENEFITS REALISATION

D. Thomson¹, A. Kaka², L. Pronk³, C. Alalouch⁴

ABSTRACT

The Benefits Quantification Method (BQM) is a practical approach to engaging stakeholders in the definition and judgement of benefits sought from investments in healthcare infrastructure; most notably buildings. As many of these benefits are intangible and cannot be directly measured, the extent of their realisation must be judged by the stakeholders to whom they will accrue. This requires a participatory approach to defining investment project intent and monitoring performance in realising same.

The BQM addresses this problem by operationalising utility theory to quantify the benefit realisation performance of an investment project. These quantifications, which represent stakeholders' perceptions of the worth of benefits realisation are intended to inform a Benefits Realisation Management Process (BRMP) such as HaCIRIC's BeReal.

This paper summarises the theoretical underpinnings of the BQM and presents a hypothetical example of its use derived from insights gained during its development. The role of a BQM Facilitator in engaging stakeholders in the translation of programme-level, strategic benefits into the project-level, tactical benefits they seek is explained. The practicalities of translating abstract definitions of benefits into practical explanations of what stakeholders expect benefits realisation to "look like" when achieved are addressed. The need for rigour in eliciting the judgements of benefit worth that underpin the BQM's ability to translate stakeholder observations of benefit-generating investment qualities into meaningful quantifications of benefit worth is identified.

KEYWORDS

benefits realisation, design evaluation judgement, stakeholder engagement, utility theory

INTRODUCTION

This paper briefly illustrates the quantification of benefits realisation by the "Benefits Quantification Method." Use of its insights to inform a Benefits Realisation

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Management Process (BRMP) is summarised. To be successful, investments in healthcare infrastructure must “realise” changes desired by stakeholders: “benefits” (Thomson et al., 2010). A BRMP requires an accurate definition of these benefits and accurate quantifications of project performance in their realisation. This paper summarises use of the BQM to balance analytical rigour with the need for a practical approach for use in projects settings to address these needs.

By structuring stakeholder engagement, the BQM informs the definition of investment intent, decision making, and through-life outcome appraisal. This paper briefly summarises selected BQM features and presents an abridged worked example.

THE NEED FOR BENEFITS QUANTIFICATION

HM Treasury’s ‘Green Book’ focuses public sector investments on demonstrably delivering stakeholders’ sought benefits. Associated guidance (Office of Government Commerce, 2004), supported by ‘Managing Successful Programmes’ (MSP & Office of Government Commerce, 2007), introduces benefits realisation to investment governance. This policy is reflected in National Health Service (NHS) procurement practice (see, for example, Scottish Government Health Directorates, 2009).

Intangible benefits often result from investment (Office of Government Commerce, 2009; Office of the Third Sector, 2009), requiring their quantification to characterise investment success. Several non-monetary measurement techniques can be used (Pearce and Özdemiroglu, 2002), including stated preference valuation techniques such as willingness to pay and revealed preference valuation techniques such as hedonic pricing. To ensure workability in project contexts, the BQM informs quantification using sense-making and consensus building techniques with project stakeholders.

THE PRINCIPLES OF BENEFITS QUANTIFICATION

The BQM addresses the intangible nature of many healthcare investment benefits by eliciting judgements of their realisation from those to whom they accrue. Stakeholders observe the investment outcome qualities they associate with benefits. When creating a healthcare building, for example, these “benefit generating qualities” are physical, functional, or financial building attributes. A “reduced infection risk” benefit might be evidenced by internal finishes, space cleanliness, and facilities available to staff and visitor to ensure their cleanliness. Stakeholders judge benefit realisation by observing the presence of these qualities. The BQM translated these observations into meaningful quantifications of benefit worth.

As benefits realisation is judged, perception of benefits and - specifically - the notion that “more is not necessarily better” must be acknowledged. The BQM distinguishes between the presence of benefit generating qualities and stakeholder perceptions of benefit magnitude. This distinction acknowledges that each unitary increase in benefit generating qualities provision adds a diminishing increase in benefit realisation. In short, acknowledging that benefit perception exhibits diminishing marginal utility allows realisation to be meaningfully quantified. Measuring the evidence of benefit

presence (i.e. benefit generating qualities) does not appropriately characterise benefits realisation.

THE VALUATION OF BENEFIT WORTH

The valuation of benefit worth, as perceived by stakeholders, must inform the quantification of benefits realisation. The BQM adopts the ‘willingness to pay’ stated preference valuation method to ask stakeholders what varying magnitudes of benefit realisation (indicated by the presence of benefit generating qualities) are ‘worth’ to them. This approach is used to quantify intangible benefits in non-healthcare sectors (Johannesson, 1996; Smith and Richardson, 2005). To apply it to healthcare, the BQM distinguishes between benefit magnitude and benefit worth. Magnitude represents the presence of benefit generating qualities associated with a given benefit in the investment outcome. These are perceived by stakeholders through observation.

Informed by these observations, judgements are anchored to a prescribed benchmark (quantity and definition) definition of notional worth and elicited as multiples of this datum. Stakeholders interpret the investment outcome from documentation during delivery or experience once in use (Office of Government Commerce, 2007a; Sapountzis et al., 2007).

“Benefit functions” model the relationship of benefit realisation magnitude to benefit worth. These functions typically demonstrate diminishing marginal returns as discussed above and are illustrated by Fig. 1.

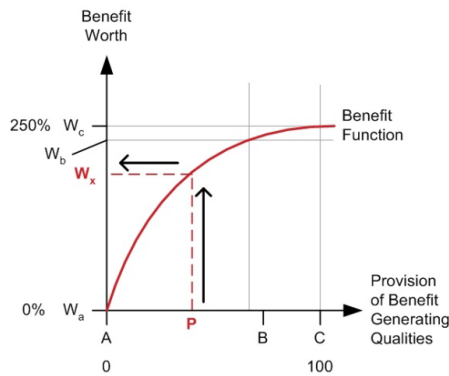


Fig. 1. Quantification of benefit worth using a benefit function

OPERATIONALISING THE EVALUATION OF BENEFIT WORTH

OPERATIONALISATION REQUIREMENTS

The BQM’s distinction between benefit magnitude and benefit worth, together with its premise that stakeholder judgement must inform benefits quantification, require appropriate operationalisation to ensure its quantifications will appropriately inform a BRMP.

Operationalisation must also be appropriate to stakeholders’ context. The BQM must be aligned with existing investment project processes. It must not introduce undue management overhead or impose additional participation burden beyond that currently experienced by stakeholders in their roles as healthcare commissioners, healthcare providers, construction consultants (or other specialised consultants if the investment outcome sought is not a building), and lay-people.

The methods used to elicit stakeholders’ perceptions must further be appropriate to stakeholders’ expertise and experience of engaging in investment projects. They must be compatible with stakeholder engagement workshops pre-existing in investment delivery projects so that they can be inserted into same where possible. Issues of: stakeholder motivation and reward; workshop format and facilitator; and workshop fatigue during the life of the investment project all require address. Some compromises in analytical integrity must be accepted to satisfy these requirements.

DEPLOYMENT FORMAT

The salient features adopted by the BQM to facilitate its operationalisation, particularly within the construction projects enacted to realise benefits from the creation of buildings are as follows.

The BQM comprises initialisation and quantification activities. The former facilitate quantification by defining project benefits and eliciting perceptions of their worth so that benefit functions can be compiled. The latter capture stakeholder perceptions of benefit magnitude (evidenced by investment outcome qualities) and translate them into quantifications of benefit realisation.

These activities align with project inception, delivery and use (Fig. 2). Initialisation and quantification activities performed during investment delivery are informed by stakeholders’ anticipation of investment outcome use. Quantification activities performed after the outcome is in use are informed by stakeholders' experiences.

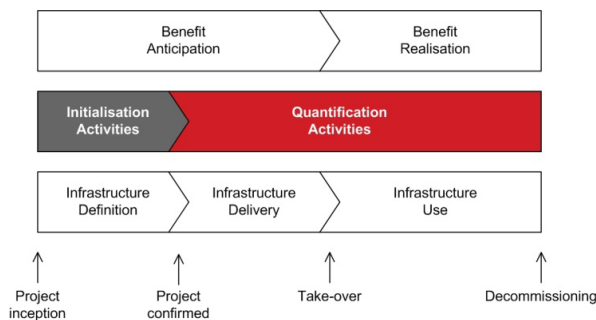


Fig. 2. BQM application contexts

Current investment guidance only acknowledges benefits realisation upon outcome use. The BQM differs in that it elicits anticipations of future benefits realisation during

delivery so that investment project performance can be characterised while opportunities for correct action remain.

To minimise management burden the BQM links with existing workshops wherever possible. The BQM's focus on buildings causes these workshops to typically be associated with value management or architectural briefing. In pre-project activity, the BQM integrates with the stakeholder engagement informing business case formation.

Despite this, a one-day workshop specific to the BQM is suggested for initialisation, whereas quantification activities are more opportunistic and much shorter. Eliciting stakeholder judgements typically requires around 20 minutes and can be performed collectively or by each stakeholder independently. The former can be implemented in design or performance review meetings. The latter can use email or telephone conversations.

Workshops require facilitation. The MSP Senior Responsible Owner (SRO) must carefully choose a BQM facilitator familiar with the activities, their principles and supporting tools. The value management practitioners often engaged in construction projects are ideally suited to this role. They are proficient in stakeholder engagement, possess construction expertise, and could rapidly learn the BQM itself. Alternatively, the Project Directors employed in the OGC Project Sponsor role (Office of Government Commerce, 2007b) could substitute their typical understanding of ether clinical or nursing needs for construction expertise.

INITIALISATION REQUIREMENTS

BQM initialisation activities must: be quick; minimise management burden; and engage stakeholders effectively. They must also synthesise reliable benefit functions to accurately inform BRMP use. Necessary compromises in analytical rigour are offset with the facilitation of socially-constructed understanding. Participation and negotiation complement the analytical derivation of insight. Individual (Thiry, 2001) and organisational (Maitlis, 2005) sense-making is essential. This requires cross-stakeholder dialogue, negotiation and the careful facilitation of both to form a participatory process.

INITIALISATION ACTIVITIES

BQM initialisation activities synthesise the benefit functions that model stakeholder perceptions of benefit worth associated with varying magnitudes of benefit generating qualities present in the investment outcome. Performing these activities diligently ensures accurate benefit functions and, thus, meaningful quantifications of benefits realisation performance in following stages.

The synthesis of a benefit function is a multi-step process (Fig. 3). As a practical compromise, it is performed once on investment commencement even though stakeholder perception or composition might change over time. Indeed, stakeholder agreement of sought benefits may also change in a project of sufficient duration of unstable context.

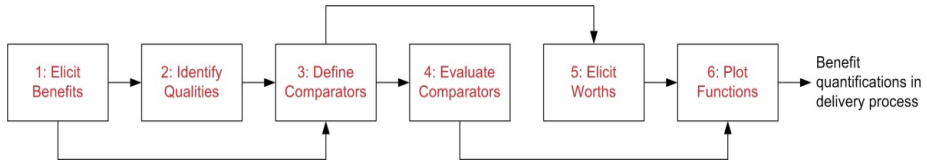


Fig. 3. BQM initialisation activities

The ‘Elicit Benefits’ activity captures stakeholder perceptions of project benefits. This group activity builds consensus regarding the benefits that all stakeholders collectively seek from the investment. The facilitator’s ability to lead stakeholders through the negotiation and social construction of a common set of project benefits is pivotal to BQM effectiveness. If effective, a satisficing set of project benefits will result. Individual brainstorming elicits possible project benefits followed by facilitated collective card sorting and affinity diagramming to stimulate the sense-making from which stakeholder agreement regarding satisficing project benefits results.

The ‘Identify Qualities’ activity replicates the method of the previous activity although this time stakeholder perceptions of the benefit generating qualities they expect the investment outcome to exhibit as evidence of the realisation of each project benefit are gathered. The same facilitated approach to the social construction of common understanding ensures every stakeholder understands the perceptions of the others and any conflicts therein.

The ‘Define Comparators’ activity engages stakeholders in the definition of three ‘comparator’ scenarios for each project benefit to illustrate their collective understanding of how benefit generating qualities might become evident in practical situations. By representing stakeholders’ collective perception of “loss of benefit,” “general satisfaction,” and “excellence,” these comparators anchor stakeholders’ quantification evaluations and define the three magnitudes of benefits realisation from which benefit functions are elicited.

The ‘Evaluate Comparators’ activity establishes, for each benefit in turn, the magnitude of benefits realisation that the stakeholders associate with each comparator. Note that these magnitudes are not quantifications. They define the scales on which subsequent stakeholder evaluations of benefits realisation will be made.

The ‘Elicit Worths’ activity uses ‘willingness to pay’ to determine the worth the stakeholders collectively place on each of the three magnitudes of benefits realisation represented by the three comparators describing each project benefit.

Finally, the ‘Plot Functions’ activity fits a single curve to each set of three data points provided by the preceding two activities. Each of these curves is a single benefit function, allowing any perceived magnitude of benefit generating qualities to be translated into a perception of benefit worth at any point by subsequent quantification activities.

QUANTIFICATION REQUIREMENTS

After initialisation, BQM quantification activities must elicit meaningful quantifications of benefits realisation performance from stakeholders. In addition to being simple and reliable, these quantification activities must, for each assessed benefit, use the corresponding benefit function to translate stakeholder observations of benefit generating qualities into quantifications of benefit realisation. Sufficient rigour is required to adequately inform a superordinate BRMP (such as BeReal) that will, in turn, direct project progression. Placing the benefits function at the core of ongoing benefits quantification during project progression embodies the principle that “more is not necessarily better.” The quantifications resulting can help BRMP users and investors to understand when an optimal, rather than maximal, realisation of each project benefit has been achieved. Quantification activities must, therefore, be sufficiently accurate. This is achieved by a combination of the proficiency with which initiation activities were formed as this determines the accuracy of each benefit function. It also depends on the rigour with which quantification activities are used.

Quantification Activities

To reliably assign meaningful quantifications to the current state of benefit realisation, BQM quantification activities must: elicit each stakeholder’s judgements of the presence of benefit generating qualities in the investment outcome; combine these views through a weighting and scoring system; and translate the collective view into a single, overall characterisation of project performance in realising the benefit concerned.

The quantification of benefits realisation performance is an ad hoc sequential process intended to be performed as and when necessary. In addition to responding to spontaneous investor requirements during the project phase of investment, typical instances of benefits quantification would include: regular performance evaluations such as design reviews and site meetings; client change request review meetings; risk register review meetings; and so forth. During the operation of the investment, the quantification of ongoing benefits realisation would likely be more ad hoc, however periodic reviews may be linked to annual performance evaluations and condition surveys (wherein social obsolescence may be addressed).

Three quantification activities (Fig. 4) are performed in quick succession to provide each quantification of benefit realisation quickly. It is ideally performed in a workshop setting as this will afford stakeholders the opportunity to discuss emergent quantifications, thereby sustaining a common understanding of project performance and assisting in the management of insight into the causes of that performance. Evaluations can alternatively be gathered from stakeholders in isolation by telephone conversation, email, website form completion, and so forth. Each instance of the quantification process progresses as follows.

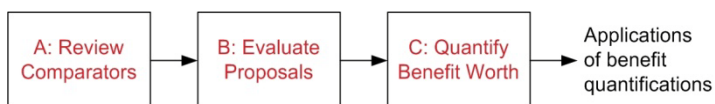


Fig. 4. BQM quantification activities

Stakeholders are first asked to ‘Review [the] Comparators’ defined for each project benefit to remind them of the illustrative scenarios painted of the possible realisation of each. This ensures consistency between quantifications by establishing consent anchors to stakeholders evaluations which may be performed some time apart (e.g. annually once the investment outcome is available and in use). After this, they ‘Evaluate [the] Proposals’ available to them by searching for evidence of the presence of the benefit generating qualities associated with each project benefit and potential embedded into the outcome in the manner described by the comparators. During initialisation and delivery, these observations may only be informed by available project documentation or design details. They are thus anticipations of future benefits realisation. Once the outcome is in use, they are informed by stakeholders’ experience of the investment outcome. Once stakeholders have been primed (‘Review Comparators’) and have observed the presence of project benefits via their benefit generating qualities (‘Evaluate Proposals’), the BQM Facilitator then uses the benefit functions to translate observations into quantifications. This process is explained in the illustrative example below.

BRMP FACILITATION

As discussed above, most benefits sought from buildings are intangible (Abdul-Samad and Macmillan, 2005). HM Treasury (2003) addresses this stating “... benefits for which there is no market price also need to be brought into any assessment. They will often be more difficult to assess but are often important and should not ignored simply because they cannot be easily costed.” The BQM therefore requires disciplined application of initialisation and quantification activities to reliably inform a BRMP.

The provision of such information to a BRMP largely follows an investment through the Gateway Review process (Fig. 5). Further spontaneous quantification can characterise tactical project performance (Gateways 3 to 5) and, once the investment outcome is in use, ongoing operational performance (up to and after Gateway 5).

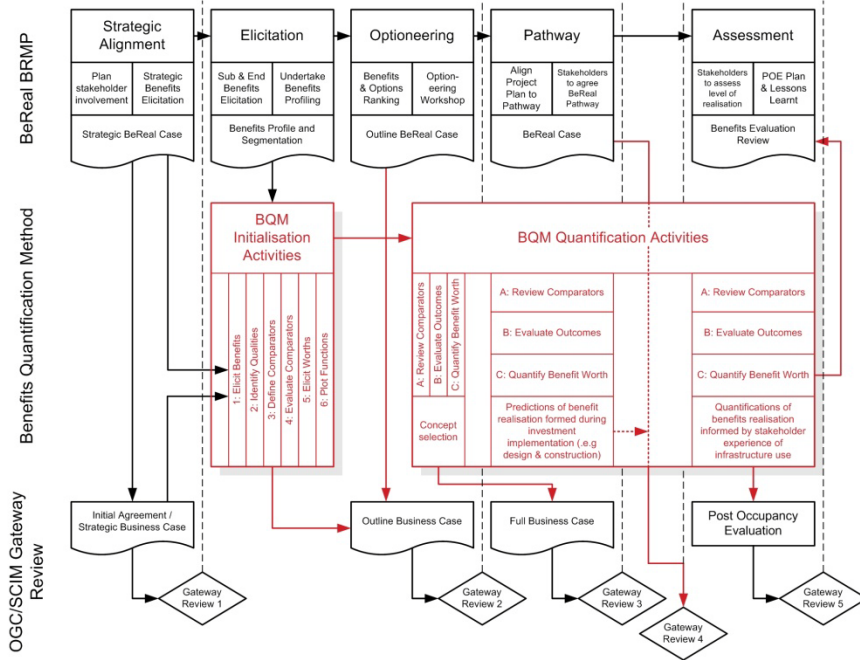


Fig. 5. Association of the BQM with the BeReal BRMP

ILLUSTRATIVE EXAMPLE

The following presents vignettes of a hypothetical BQM application. They are drawn from experiences of developing and validating the BQM’s activities with several NHSScottish Health Boards and stakeholders on ‘live’ investment projects at varying stages of business case approval, construction and early stages of use.

The stakeholder roles illustrated below are typical of those with whom the BQM will engage. Although stereotypes are presented, the attitudes and opinions summarised are similarly drawn from the authors’ encounters during BQM development.

The BQM considers all stakeholders equally important and gives all equal voice. In ‘live’ applications this may not be the case. If so, the power, legitimacy and urgency (Mitchell et al., 1997) of each stakeholder can be reflected by weighting their engagement with the BQM. Although this can be achieved numerically for many initialisation activities, their participative elements (such as the pilesorting and social negotiation used by the ‘Elicit Benefits’ and ‘Identify Qualities’ activities) cannot incorporate weightings and must engage all stakeholders fully.

EXAMPLE SCENARIO

NHS Somewhere serves an ageing population. Demographic change is placing a strain on the existing Somewhere Acute Hospital, which is beginning to struggle to maintain service levels and to provide the range of services required by the changing populace.

NHS Somewhere identified their infrastructure as the main restraint on service quality at Somewhere Hospital, which consists of several buildings scattered over a large site. These buildings are in varying states of repair, physically incapable of housing the latest technologies and, as a whole, are too small to support required patient throughput.

A strategic plan was developed to promote the delivery of acute care through a single, rationalised campus housing all departments: the new Acme Acute Hospital. NHS Somewhere managed benefits realisation in addition to traditional project metrics, and used the BQM to monitor project performance in realising the benefits sought by stakeholders.

EXAMPLE STAKEHOLDERS

Three healthcare stakeholder representatives were engaged in the Acme Acute Hospital investment. The BQM considered their views representative although some self-selection bias was noted. Around ten stakeholders would typically engage with the BQM. Only three stakeholders are presented below for clarity.

Dr. Reid, a House Doctor for NHS Somewhere, represented the oncology staff. She expected a notable improvement in the quality of the existing buildings. She required buildings that could accommodate the latest healthcare developments throughout their life. Although she appreciated the psychological influence of buildings on patients, she typified NHS Somewhere's medical staff in believing that buildings are less important than medical technologies and treatments.

Mrs. Reyes represented the patient body. Like most of NHS Somewhere's patients, Mrs. Reyes was satisfied with care quality but was generally disappointed with the age, state of repair, and general "atmosphere" of NHS Somewhere's buildings.

Mr. Turk, a Clinical Director, was typical of the clinical staff. Recently attracted to NHS Somewhere with the promise of the latest equipment, he found that the buildings could not support it. He had specific concerns about infection control and also considered the theatre space outdated in its arrangement and facilities. He considered healthcare buildings to be factories for delivering low-risk, repetitive care. He wanted to treat as many patients as possible on an outpatient basis.

Although not a stakeholder himself, 'Bob' worked alongside the above to apply the BQM itself. As Project Director for Acme Acute Hospital, he was the BQM facilitator. Bob sourced the 'BQM Manual' and 'BQM Spreadsheet' from www.benefitsquantification.com to let him do this. Bob also operated a BRMP informed by the BQM's quantifications of benefits realisation performance. The BRMP is not described here.

ILLUSTRATIVE VIGNETTES

The following vignettes illustrate application of the BQM to the hypothetical, yet realistic Acme Acute Hospital project.

Defining the Benefits

Bob used the ‘Elicit Benefits,’ ‘Identify Qualities,’ and ‘Define Comparators’ initialisation activities to engage stakeholders in the definition of project benefits. This was done in the first half of a single day BQM-specific workshop.

Bob performed the ‘Elicit Benefits’ activity as follows. Stakeholders were given cards and asked to note one possible project benefit on each. After exhausting their suggestions (Table 1), Bob led a group pilesorting activity to produce an affinity diagram that clustered ‘like’ benefits. When moving cards into clusters, Bob asked the stakeholders to verbalise their thinking. This group sense-making facilitated the social construction of consensus. Five clusters resulted (Fig. 6). Bob asked stakeholders to name each by its thematic content. The clusters were adopted as the project benefits, with each defined by its constituent suggestions and the discussion that ascribed meaning. Typically, between six and ten project benefits are found to balance the need to sufficiently inform a BRMP with the need for manageable stakeholder engagement.

Table 1. Suggested project benefits, by stakeholder

<i>Stakeholder</i>	<i>Suggested Project Benefits</i>
<i>Dr. Reid (Oncologist)</i>	<i>adopting latest technologies - attract high-quality staff to the hospital - avoid an "institution" - avoid corridors - easy access to beneficial care - good working conditions - homely atmosphere - innovative delivery paths - provide artwork - put patients at ease - well-resources - lots of modern equipment</i>
<i>Mrs. Reyes (Patient Representative)</i>	<i>clean environment - easy to find your way around - easy to reach buildings - friendly staff - good quality care - low risk - individual care for each patient - nice, pleasant bedrooms - not left by yourself - socialisation - well-maintained buildings</i>
<i>Mr. Turk (Clinical Director)</i>	<i>effective theatre space with the latest equipment - high-throughput theatre space - space that reflects the esteem of the profession - excellent support staff - "cleanliness is next to Godliness" - high-quality consultancy rooms - accommodation of private practice</i>

Bob moved the workshop onto the ‘Identify Qualities’ activity which also used brainstorming and pilesorting to consider each benefit in turn, identifying the physical, functional, and/or financial investment outcome qualities that evidence its realisation. Typically, four or five of these “benefit generating qualities” were found for each project benefit. Stakeholders then considered the contribution made by each quality to the realisation of the associated project benefit and agreed an appropriate weighting. These allowed the importance of qualities to be considered when evaluating their presence (or otherwise) when quantifying benefits realisation in subsequent stages.



Fig. 6. Adopted project benefits

Bob next guided the negotiation of “comparators” that described stakeholders’ collective understanding of examples of the realisation of each project benefit. For each benefit in turn, Bob asked the stakeholders to consider a hypothetical ‘ideal’ project, a current ‘best of class’ project, and a further project representing an undesired (i.e. ‘loss of benefit’) outcome. The agreed “comparators” and the way in which they illustrate the presence of benefit generating qualities (to varying extents) were recorded descriptively in a “comparator grid.” These grids were used to anchor subsequent stakeholder judgements of benefit realisation against a common definition of what that realisation would ‘look like.’

Modelling the Benefits

To implement the second aspect of initialisation, Bob directed the stakeholders to model their perceptions of benefit worth to structure the meaningful quantification of benefit realisation. He performed the ‘Evaluate Comparators,’ ‘Elicit Worths,’ and ‘Plot Functions’ activities in the afternoon of the day-long BQM initialisation workshop.

The ‘Evaluate Comparators’ activity defined scales for stakeholders’ evaluation of benefit generating quality presence. Considering each project benefit in turn, Bob produced a continuous evaluation scale of 100 notional units for each benefit generating quality on which 0 units represented “not present” and 100 units represented “fully

present.” He asked the stakeholders to consider each comparator and agree its position each scale. The definitions of the three comparators associated with each benefit (‘loss,’ ‘satisfaction,’ and ‘sector excellence’) caused them to be distributed over their evaluation scale, assigning meaning. Bob recorded these scales in the BQM Spreadsheet (Fig. 7).

Comparator Evaluations:

Project Benefit	Benefit Generating Qualities	Weight (%)	"Loss of Benefit"	Comparators		Weighted Comparators		
				"General Satisfaction"	"Excellence"	"Loss of Benefit"	"General Satisfaction"	"Excellence"
1. Clinical Effectiveness	1.1 Adoption of Relevant Technologies	30%	0	50	90	0	15	27
	1.2 Control of Risk	50%	0	55	86	0	27.5	43
	1.3 Achievement of Throughput	20%	0	35	73	0	7	14.6
	1.4 Not defined	0%	0			0	0	0
	Comparator Scores:						0	49.5
Normalised Comparator Scores:						0	58.51	100
2. Sustainability	2.1 Source of Energy	20%	0	50	95	0	10	19
	2.2 Recycling Facilities	40%	0	60	92	0	24	36.8
	2.3 Building Envelope	40%	0	35	82	0	14	32.8
	2.4 Not defined	0%	0			0	0	0
	Comparator Scores:						0	48
Normalised Comparator Scores:						0	54.18	100
3. Patient and Staff Environment	3.1 Public Transport	50%	0	45	75	0	22.5	37.5
	3.2 Location	30%	0	55	89	0	16.5	26.7
	3.3 Public Access	20%	0	64	99	0	12.8	19.8
	3.4 Not defined	0%	0			0	0	0
	Comparator Scores:						0	51.8
Normalised Comparator Scores:						0	61.67	100

Fig. 7. Definition of evaluation scales within the BQM spreadsheet

Bob performed the ‘Elicit Worths’ initialisation activity by asking the stakeholders to consider each project benefit in turn. Following standard willingness to pay practice, he instructed the stakeholders with an appropriate version of the following prompt, asking each to respond individually:

“Assume that the realisation of “Clinical Effectiveness” offered by the “Loss of Benefit” Comparator is worth 100 tokens. How many tokens would you assign the realisation of this Benefit by the “General Satisfaction” Comparator; and how many would you assign to the “Excellence” Comparator?”

This elicited each stakeholder’s judgement of the worth of varying magnitudes of benefits realisation anchored to a common datum. Although academic comprises associated with the meaning assigned to these datums exist, they were accepted in light of the need for a workable process that could aggregate individual stakeholder views into collective ones. The judgements were recorded by Bob in the BQM Spreadsheet.

Bob performed the last initialisation activity (‘Plot Functions’) in front of the stakeholders even though their input was not required. He did this show how benefit functions were produced and to explain their role in subsequent quantifications. The activity was automated by the BQM Spreadsheet. For each benefit, considering

stakeholders individually and collectively, it fitted a degree 2 polynomial function to the data points using the scales from ‘Evaluate Comparators’ as the independent variable and judgements of worth from ‘Elicit Worths’ as the dependent variable of each function (Fig. 8).

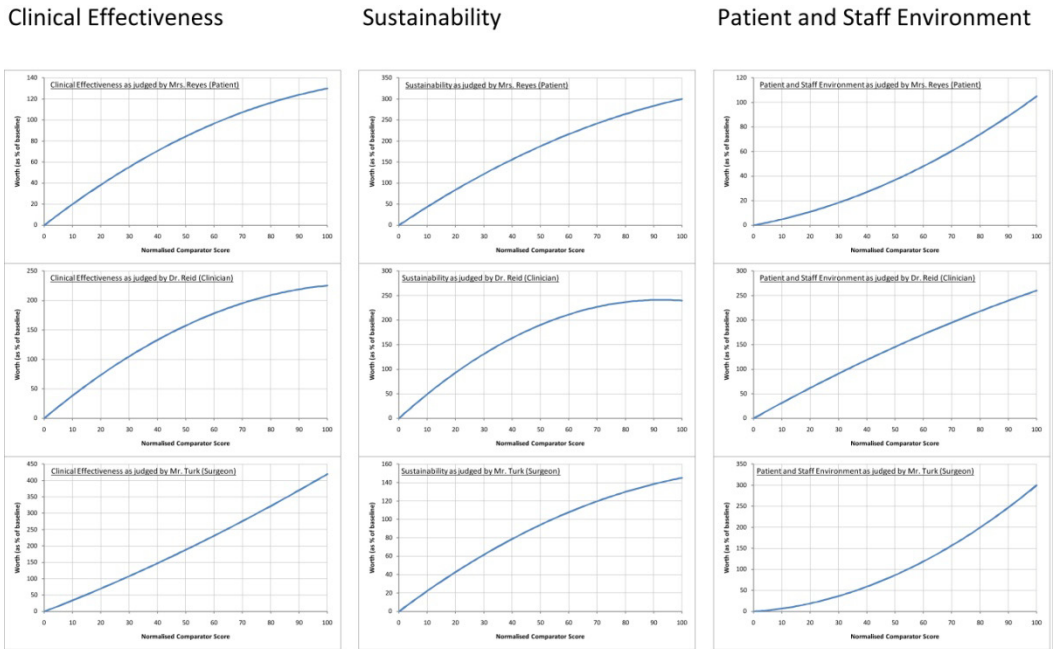


Fig. 8. Example Individual Stakeholder Benefit Functions Resulting from Initialisation Activities (note: not specific to the example; actual data)

This activity highlighted a notable compromise made by the BQM to promote usability over academic integrity: the BQM assumes that all benefit functions pass through the origin, following the principles of Kahneman and Tversky’s (2000) Prospect Theory. Economic theory suggests that this is not the case. The absence of benefit generating qualities may actually be desired to some extent by stakeholders, in which case they would judge some worth to arise out of no provision of those qualities. The opposite could also be true in certain situations.

Quantifying the Benefits

As soon as the initialisation workshop was finished, the BQM was able to provide quantifications of benefits realisation. The benefit functions were available for use to translate these perceptions into meaningful quantifications of benefits realisation, based on the worth of that magnitude of realisation to the stakeholders. Quantifications were gathered in this way on the Acme Acute Hospital project as follows.

Bob used the three quantification activities to inform business case formation, gateway reviews, concept design selection, periodic design reviews, and post-occupancy reviews.

A typical example arose upon production of the initial concept design for the hospital building, when stakeholders' reactions were sought. Bob requested some time in the concept design review workshop to address its performance in terms of benefits realisation using the 'Review Comparators' quantification activity. He asked the stakeholders to review the previously-agreed comparators that defined what the realisation of that benefit might 'look like' in terms of the presence of its benefit generating qualities in a possible investment outcome.

Bob then implemented the following 'Evaluate Proposals' activity by asking each stakeholder to review the concept design (i.e. the information available describing the current state of the investment outcome). Focusing on the "Clinical Effectiveness" benefit as an example, Dr. Reid stated she would prefer two departments to be more closely located to minimise the travel time for patients. She provided a moderate evaluation of benefit realisation as she did not consider the benefit generating qualities associated with "Clinical Effectiveness" to be present in the concept design in the manner suggested by the 'excellence' comparator. Mrs. Reyes could not offer a medical perspective but she had some understanding of the benefit (from preceding business cases) and considered all its benefit generating qualities to be reasonably well represented. She accordingly gave a moderate evaluation of their presence. Mr. Turk firmly opined that the two departments identified by Dr. Reid must be adjacent to each other and, upon not seeing this, did not consider the benefit generating qualities associated with the "Clinical Effectiveness" benefit to be present. He reflected this view in his evaluation.

After hearing these divergent views, Bob helped the stakeholders negotiate a collective evaluation representing all their views. On asking the stakeholders to explain to each other how they interpreted the concept design to reach their individual view, Bob found that the negotiation process was eased by the examples of that benefit's realisation previously agreed in the comparators. The stakeholders used the three anchors to help them agree a single evaluation of benefit generating quality presence. This was repeated for all benefit generating qualities associated with each project benefit. Bob recorded the evaluations in the BQM spreadsheet (Fig. 9).

Comparator Evaluations:

Project Benefit	Benefit Generating Qualities	Weight (%)	Current Evaluation Score (0 - 100)	Contribution to Benefit Realisation
1. Clinical effectiveness	1.1 Clinical adjacencies	20%	80	16
	1.2 Noise	40%	30	12
	1.3 Equipment	40%	55	22
	1.4 Not defined.	0%		0
			Current Evaluation =	50
2. Sustainability	2.1 Energy source	10%	50	5
	2.2 Recycling	15%	25	4
	2.3 Building envelope	75%	65	49
	2.4 Not defined.	0%		0
			Current Evaluation =	58
3. Patient and staff environment	3.1 Lighting	50%	45	23
	3.2 Noise	40%	65	26
	3.3 External environment	10%	85	9

Fig. 9. Example Evaluations of Benefit Generating Quality Presence

As the final step in the quantification process, Bob recalled the benefit function for each benefit and implemented the ‘Quantify Benefit Worth’ activity. In the same manner as the last initialisation activity, he elected to perform this activity in the presence of the stakeholders. Even though this was not required, it helped achieve stakeholder support for the quantifications resulting as stakeholders could see how they were produced.

Bob used the BQM spreadsheet to recall the relevant benefit function (Fig. 10). The production of a meaningful quantification of benefits realisation was a simple matter of plotting the current (collective, in this case) evaluation of the extent to which the associated benefit generating qualities were represented in the concept design proposals on the evaluation scales (1). These were simply translated into the function to calculate the current quantification of benefit worth (2), expressed as a multiple of the original notional quantification (recall the ‘Elicit Worths’ initialisation activity). As an alternative, Bob could have performed this translation graphically or could have asked the stakeholders to do it themselves.

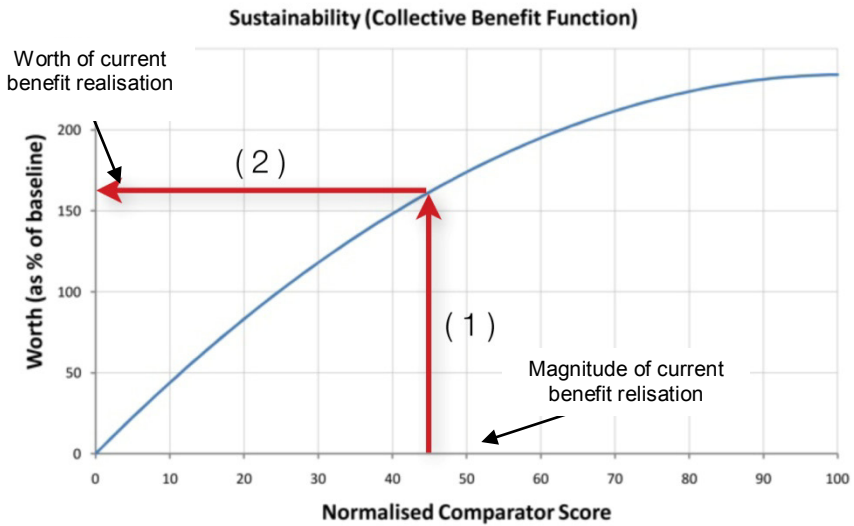


Fig. 10. Use of a benefit function to translate an evaluation of benefit presence into a meaningful quantification of the worth of that presence

CONCLUSION AND FURTHER WORK

This paper has briefly summarised content and typical approach to application of the Benefits Quantification Method. Its role in informing a BRMP has been introduced and the salient points of an illustrative example presented. It is apparent from this review that the BQM can provide meaningful quantifications of the benefits realised by investments in healthcare infrastructure, as perceived by stakeholders. Its operationalisation of utility theory complies entirely with axiomatic economic theory and is not contentious. Despite this, some synthesised benefit functions did not exhibit diminishing marginal utility (recall Fig. 8). Whether this is a trait of the stakeholders from whom the data was gathered or a consequence of the methods used to gather it requires further investigation. Further work is also required to test the validity of its additional concepts (notably benefit generating qualities and the notion of benefit worth) in a wider range of situations and stakeholder types to those already explored by the understanding research study.

The underlying research has established the viability of the component parts of the BQM by working with stakeholders on several NHSScotland Health Board capital investment projects. Subject to funding, the BQM as a whole will be tested in subsequent work, where the opportunity to engage with an ongoing capital investment project arises. This future work will seek to confirm the appropriateness of the academic and analytical compromises identified in the preceding discussion as being considered necessary to ensure stakeholder engagement and practicality of the BQM “in the field.” Although the method implements a heavily operationalised form of many of its key components, the advantages of using the method over the ad hoc and, as Thomson et al. (2010) have established in the case of project benefits definition, superficial treatments of these issues in current practice contribute a marked advance.

A full description of the Benefits Quantification Method, including free access to the BQM Manual and access to the BQM Spreadsheet that guides and supports the facilitator is available at www.benefitsquantification.com or from the authors.

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INTEGRATED DECISION SUPPORT: A NEW APPROACH TO THE DESIGN OF HOSPITAL FACILITIES TO OPTIMISE LOW CARBON PERFORMANCE

M. Bacon¹, D. Passman² and K. Hicks³

ABSTRACT

The all too common disparity between planned carbon performance and actual achieved performance in buildings has been receiving increased attention in recent years. In 2006, the National Audit office expressed concern that 80% of the HM government estate was failing to perform to the required standards. In 2009 a follow up study was carried out which showed little improvement.

With the continuing failure of a large proportion of buildings to deliver low carbon performance, which is a particular challenge for the NHS Estate, the Governments targets for a low carbon economy will be jeopardised.

This paper discusses the present knowledge concerning this situation and places that knowledge in the context of low carbon design for hospital facilities. The paper then describes a new approach to low carbon design being undertaken by the authors on the project known as '3T's for the Brighton and Sussex University Hospitals NHS Trust. The work is developing a fundamentally new approach to low carbon design for hospital facilities.

KEYWORDS

building performance, innovation, in-use, low carbon, sustainable design

1. BACKGROUND CONTEXT

The consistent failure of buildings to perform In-Use according to the aspirations of the project team is being increasingly commented upon. This failure affects refurbished and new buildings alike in both the public and private sectors.

In 2006 the National Audit Office (NAO, 2006) carried out a study to understand how well the Government estate was achieving its sustainable agenda. It concluded that it was substantially under performing with over 80% of buildings failing to comply with modern standards.

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'The government has set sustainability standards for the construction and refurbishment of buildings on the government estate, but these are not being met. Departments are failing to carry out environmental assessments and achieve the target ratings. In the sample of projects we examined, 80 per cent would not have attained the required standards'.

Three years later, the Public Accounts Committee observed that no demonstrable improvements had been made and that operational performance assessments (post-occupancy evaluation) were carried out in only a small proportion of the government estate (HCCPA, 2008). Bordass (Bordass et al, 2004) advocates:

'To achieve genuine step-change improvements, procuring clients, design and building teams, users and managers will all need to engage much more closely with achieved performance. Better transparency between intentions and outcomes will release drivers towards better assumptions, better predictions, better design, better implementation, and better management of both the procurement and the product.'

The Royal Academy of Engineers in their report published last year (RAE, 2010) titled: *'Engineering a Low Carbon Built Environment*, made the same point in different terms:

'In order to create new buildings, and adapt existing ones, to be fit for the 21st Century, rigorous performance analysis and energy prediction needs to gain widespread acceptance as the replacement for experimental development....without integrating the rigorous performance analysis brought by building engineering physics with the architectural design and with the empirical construction knowledge embodied in the industry, we will continue to construct inefficient buildings whose energy performance falls far below that which we need to achieve.'

The report goes on to advocate the need for a new process, one that is founded in an integrated approach and which recognises that facilities are complex systems each part of which must contribute to an holistic solution. Yet even here, where the writers advocate for integration within the design team, there is no recognition of the need to engage with the users and to engage with them in the process.

Should any further evidence be required as to how critical the need for a new approach to low carbon has become, the report from the NHS Sustainable Development Unit clearly illustrates the failure of the estate to drive down carbon emissions. (NHS SDU, 2011) Please refer to Figure 1 below:

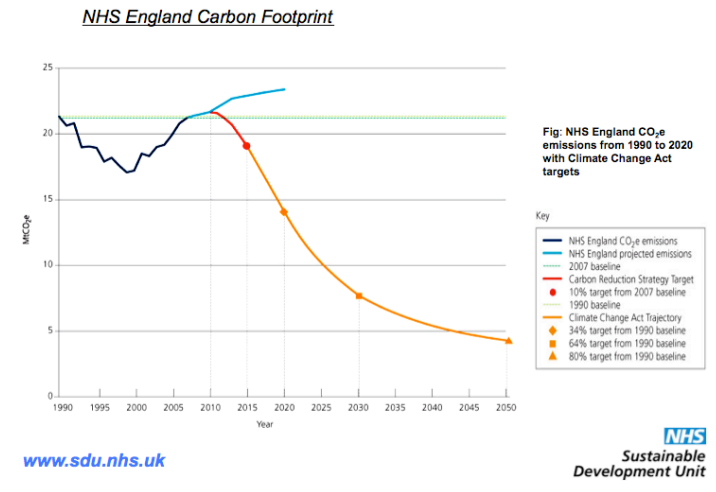


Fig. 1. NHS Carbon Update 2010

Figure 1 illustrates a trend of carbon performance that is opposite to that which the government aspires. The NHS is currently unable to normalise any of its data in terms of carbon emissions relative to each patient care episode for example, because it does not collect the data to enable this. Lack of In-Use data clearly affects the users as well as the policy makers.

THE NEED FOR A NEW APPROACH

We can draw much from this discussion, and unpublished research by Bacon, has identified what he considers to be the fundamental reasons for this disparity, in what others have referred to as the ‘Bridging the Great Divide’.

- Process. A fragmented process, that often fails to create a holistic solution aimed at driving towards aggressive In-Use performance targets. There is currently little alignment between the way in which buildings are designed and the way in which they need to be operated.
- Briefing. In-Use requirements inadequately communicated to the design team. Implications of design proposals not effectively communicated to the users. Users inadequately engaged in the design process.
- Basis of Design. The over-design of systems based on major assumptions concerning how the building would be occupied and operated. Engineering codes based on data that is decades old. Insufficient In-Use data to challenge established codes, and so drive towards improvements in low carbon performance.
- Controls. Lack of sub-metering and zonal controls (although this improving – however, collection and assimilation of In-Use data is rarely achieved).

Inadequate specification of building automation systems, so that In-Use data can be harvested for In-Use analysis.

- In-Use data. Insufficient In-Use data to inform design strategies, such that sustainable design strategies can be measured and evaluated. The industry lacks a comprehensive database that aligns design, procurement and operational strategies with actual performance. Without such data realistic outcome-based targets cannot be established.

It is now becoming clear that another set of drivers for change will impact on the NHS Estate: Firstly, the Carbon Reduction Commitment, and the associated Carbon Tax being formally introduced in 2013 will significantly impact on hospital trusts. As energy costs increase these too will increasingly influence the need to reduce In-Use energy consumption. Secondly, ‘peak-load’ pricing tariffs will become the norm for non-residential premises. Some Trusts are already witnessing such pricing demands. Consequently, Trusts will need to become effective managers of peak energy loads in their estate. Assimilation of In-Use data becomes even more critical to facility owners as they seek to manage peak-loads for the facilities under their control.

FORGING THE RELATIONSHIP – BACON –PASSMAN - HICKS

It was against this background that Bacon conceived the In-Use Energy Management strategy – one that addresses each of the needs identified above. It is a strategy that correlates the way in which a facility is occupied and operated with the resulting energy consumption, based on how energy-consuming resources are used; the strategic objective being to drive down carbon emissions.

The three authors came to share the vision, where Passman as Programme Director (the Client role) foresaw the opportunity to drive the strategy into the 3T’s project through the Principle Supply Chain Partner, under the leadership of Hicks (the Supply Chain Integrator and Construction roles).

The incentive to engage in a fundamentally new process as advocated by Bacon, was appealing to the Trust. Passman in his Client role had witnessed first hand the Brighton and Sussex Children’s hospital performing with a DEC rating of ‘F’, and yet a few years previously it had been awarded a BREEAM rating of Excellent.

The Client perspective

From the Client perspective, the initial starting point was the desire to understand how the building would perform from an operational perspective: how patients, staff and visitors would move around the building. Major new NHS capital developments are based on the Department of Health’s “Health Building Note” series, which provides good practice to client organisations on the planning of departments within a health care facility. These guidance notes also provide metrics for the size of each department based on the proposed levels of patient activity (usually) that are expected.

It is up to each individual NHS Trust how this guidance is applied which is appropriate to the local operation. The Trust usually produces a Client Brief for the Design Team and this includes a Schedule of Accommodation (list of rooms, quantities of each room and the requisite area to provide clinical functionality) and an Operational Policy. The latter document defines how patients, staff, visitors will move through that department – the operational processes. These policies also define the way in which facilities management activities (maintenance, supplies deliveries, cleaning etc) will also operate within that department and within the building as a whole.

The Design Team then use these documents to put forward designs for each area for discussion with the clinical users (and sometimes patient groups) to ensure that the operational processes set out are being delivered by the design.

However it was apparent to Passman, from over 20 years experience of undertaking the Client role that although some studies (particularly for lifts) were undertaken, there was little clear assurance that the design of the building was being optimised. It is usually unclear what peaks and troughs in activity mean for the operation of the building: is the space around lifts sufficient for the traffic that will use them? Are there bottlenecks in departments caused by inefficient processes or assumptions made by the Client and which feed into the design?

Although there is some modeling of this nature which is undertaken in Europe and North America, it did not seem to be undertaken as a matter of course in the design of healthcare facilities in the UK.

The synergy between Passman's need to understand the occupancy characteristics of the proposed facilities with the opportunity presented by Bacon to use occupancy data to inform the basis of design was immediately obvious to both of them. As will be explained later understanding occupancy is central to understanding how to optimise the facilities for In-Use. Bacon had been developing a new science, which he refers to as 'Occupancy Analytics' and this provides the basis for what he refers to as the 'Enhanced Brief.'

It was a short leap of logic to being able to use this to the occupancy data to inform the potential energy performance of the building during the In-use phase: of increasing importance in the context of national energy policy and the costs associated with energy in major healthcare facilities.

The Contractors perspective

From a Contractors perspective the strategy was appealing because it promised a new form of engagement with the users that is often missing on complex projects such as hospitals. As already mentioned, a major innovation in the strategy was the development of the new science of Occupancy Analytics. It was though this work that Hicks could foresee how early stage briefing process could be fundamentally improved through the new Enhanced Briefing Process.

Hicks could foresee the benefits of harnessing the facility's projected throughput and

providing a model of the hospital's activity along a time line, so that the use of the building could be visualised and understood in ways not possible before. This approach allows the professional team to view the operational building in its concept stage and allows decision-making to have a meaningful context. The model allows designers to refine design criteria to eradicate bottlenecks alongside users who are able to contemplate changing operational practices to smooth them out, to make the building more effective and efficient over the course of its operational day. Achieving this perception of the building's operational phase this early in the design phase provide the timescale for planning organisational change, as well as predicting life cycle impact.

Another major benefit to the Contractor role is that design decisions are better informed, and life cycle issues better planned. All too often information concerning how a facility is to be used is not available to the team until much later in the process (at best) or never at all (worst).

The key decisions where an understanding of the how the facility is to be occupied and operated impacts the design process are:

- Space planning
- Internal heat gains analysis, informing the design of major plant capacity
- Controls and monitoring strategy
- Vertical circulation design
- Equipment selection and procurement

The decision-making process is one where outcomes are evaluated with the team, and decisions integrated into the existing design process as the design progresses. The process is designed to challenge assumptions and make these visible in the decision-making process.

It will be explained later that where assumptions in these areas are made that these often lead to a sub-optimal design, and which also lead to over-sizing of HVAC plant. Such over-sizing leads not only to unnecessary capital cost but also the inefficient operation of the plant, where motors are drawing larger currents than would otherwise be required. This translates directly into unnecessary energy consumption and consequently carbon performance.

A VISION FOR LOW CARBON DESIGN IN HOSPITAL FACILITIES.

The vision is for an integrated design and operational strategy shaped through a new scientific basis for energy efficient hospital design. It is one where users understand the carbon impact of different operational processes and where design and operational strategies mutually inform each other. It is one where outcome-based performance targets are informed by In-Use performance data assimilated at functional level, and aggregated at facility level. It is one where the facility is continuously optimised for low carbon performance, and where simulation technologies support skilled facility engineers in arriving at informed decisions concerning system optimisation and so

continuously drive to improved low carbon performance.

To achieve this vision the In-Use Energy Management strategy evolved into seven work-streams. These were identified as:

- Target setting and benchmarking
- Basis of Design
- Energy modelling
- Occupancy Analytics
- Controls and Monitoring
- Equipment management and procurement
- Research

As outlined earlier, these work streams are integrated into a new process that is ‘woven’ into the existing briefing, procurement and operational processes. The objectives of the new process are to ensure that decisions made by the leadership team are informed by the impacts on the outcome-based energy performance target. At all stages there is engagement with the users to ensure that user requirements are effectively managed.

This paper discusses the current work, and the research that informs it, in the first four of these work-streams. Future papers will elaborate on the remaining work-streams.

PROCESS

TARGET SETTING AND BENCHMARKING

This work stream was conceived because there is currently very poor In-Use performance data for hospital facilities. As explained earlier, the essential need at an early stage of the briefing process is to inform the design team of an outcome-based performance measure that is both realistic and measurable.

Research (un-published) conducted by Bacon identified that:

- There is no publically available In-Use data for hospital facilities in the UK that has been collected at departmental level and so able to inform accurate outcome-based benchmark targets for the proposed new facilities.
- In-Use data for hospital facilities has been collected for some years in the Finnish hospital sector. Data has been collected at departmental level.
- Studies of hospitals conducted by the private sector consultancy firm: Olof Granlund has identified key design strategies that lead to low carbon performance in Finnish hospital design.

An analysis of Finnish hospitals was carried out in terms of carbon performance. A peer group of facilities with similar functions was established. Data was collected and

normalised for the UK and from this analysis departmental targets could be established. These targets were then aggregated into a whole facility target.

A review of Encode 07-02 was carried out. This is the standard by which UK designers are required to establish an outcome-based performance measure for new facilities. Encode is only able to establish facility performance at a facility level and then only in terms of facility types such as ‘General hospital’ or ‘Acute hospital’. Given that functions within hospitals can significantly vary then these can be considered to be very coarse measures, a view that is shared by the NHS Sustainability Development Unit. Using data as a basis for establishing an outcome-based performance measure is clearly unrealistic. It was for these reasons that hospital data from Southern Finland was chosen because this could be normalised for the UK, and would thus provide comparable benchmark data.

The Client perspective: The challenges of setting meaningful outcome-based performance measures.

As noted above, there is no publicly available In-Use data for hospital facilities at a departmental level. This combined with a plethora of guidance on healthcare facility design, plus the energy targets set for the NHS in developing new healthcare facilities means that it is difficult for clients to produce meaningful outcome-based performance measures that are actually capable of being delivered. For example, outcome-based measures are standard in the procurement of healthcare facilities under Public Private Partnerships. A major acute hospital development is required to have an energy consumption figure of between 33 and 55 Giga Joules per 100 cubic metres per annum. This is usually agreed at the top end of the range. As well as this, the building is also required to be BREEAM “Excellent”.

However, despite the thermal modeling undertaken during the design process, the end result, as identified earlier, is a poor In-Use performance. In a time when NHS budgets are expected to make challenging cost improvements year-on-year, the issue of energy performance gains increasing importance and the issue of energy costs an increasingly difficult challenge to manage without detriment to patient care.

Passman therefore considers it vital in the design of the new facility that there is a robust methodology in place that will deliver greater predictability about the In-Use energy consumption, and therefore meaningful outcome-based performance measures in addition to the cost of the new facility.

BASIS OF DESIGN

Following extensive discussions with the Chartered Institute of Building Services Engineers as well as number of semi-structured interviews with leading Mechanical Electrical Plumbing (MEP) designers, Bacon concluded that poor carbon performance emanating from plant over-sizing through the following factors:

- That a number of important design standards lead to significant over-sizing of engineering solutions. A notable example concerns ventilation rates. A systematic

literature review of research in ventilation health care facilities (Whitehead, 2008) has demonstrated that there is very little scientific evidence to support higher ventilation rates in hospital design as a means of reducing spread of infections. Higher than necessary ventilation rates lead to plant capacity that is larger than it needs to be. Other examples concern ‘rules of thumb’ and formulaic guidance that is based on data that is decades old. Evidence from MEP engineering consultants clearly demonstrates that the Plumbing Services Engineering Design Guide (IoP, 2007) is one example of this guidance that grossly over-estimate water storage requirements.

- Designers are obliged to make significant assumptions concerning how a building will be occupied and operated. They will assume for example, that spaces are fully occupied and will design accordingly. This is another reason for over-sizing of plant. Health Facilities Note 27 provides many other examples of the reasons that lead to oversizing. Importantly it states that over-sizing accounts for between 10-15% of HVAC energy consumption. (NHS Estates, 1998)
- The paucity of In-Use data presents a significant barrier to learning how to optimise designs that would lead to low carbon performance. Conversely designers remain largely ignorant of the design decisions that they make which lead to oversizing of plant.

An example of the significance of over-sizing of plant is the study by Crozier (Crozier, 2000) and which concluded the following:

Fifty HVAC systems in the UK have been monitored and analysed using the methodology set out in this guidance and the extent of oversizing established. It was found that 80% of the heating plant, 88% of the ventilation plant and 100% of the chiller plant incorporated capacity above that necessary to meet design requirements.

Oversizing of MEP systems leads to unnecessary expenditure in both CAPEX and OPEX. Clearly the reasons for oversizing need to be addressed. Research studies by Bacon and Olof Granlund OY have concluded that between 3-5% of CAPEX could be saved by pursuing a strategy to address the reasons for oversizing.

Within the overall strategy proposed by Bacon is a two-fold approach:

1. To address the fundamental reasons for poor carbon performance by removing major assumptions that designers are usually obliged to make, through what Bacon refers to as an ‘Enhanced Briefing Process’. This process introduces a new science developed by Bacon referred to as ‘Occupancy Analytics’, where the functional processes of the hospital are modelled in a database and drive a simulation of all clinical processes. The outcome of this work is an analysis of the clinical pathways that lead to occupancy densities. From this work a model of the sensible heat gains derived from the occupancy within any part of the facility at any time of the day is produced. It is this data that is provided in the Enhanced Briefing Process outlined earlier. Please refer to section 2.4 for an explanation of this work.

2. An analysis of the engineering strategies that lead to the benchmark performance targets was explained earlier in this paper. From this analysis a candidate list of Energy Reduction Measures (ERM's) was identified. The ERM's are presently being evaluated in terms of:
 - The potential of each measure to reduce energy consumption.
 - A holistic analysis in terms of the impact that one measure would have on another.
 - Design, Construction, Facility operations and Life-Cycle costs.
 - Risk assessment.

The process itself leads to some significant challenges. Not least of which concerns the contractual obligations of the team to design in accordance with prescribed standards and reluctance to be exposed to potential Professional Indemnity liabilities in seeking to vary (derogate) from them. For these reasons the team is planning to work with the Department of Health to discussing alternative strategies that would achieve the same performance outcomes but with a lower carbon impact.

In response to these challenges, Passman has invited the team to submit a business case for each standard that the team would wish to derogate from. Based on the evidence presented (which will also include risk and whole life costs assessments) he will consider each business case. It is constructive approaches such as this that will enable the team to remove the factors from the design process that contribute to carbon emissions.

The Contractors perspective: The barriers to establishing meaningful outcome-based performance measures.

In attempting to establish meaningful outcome-based performance measures there are contradictory constraints that bear on the professional team. The contractor has design constraints imposed through the plethora of guidance and standards that contractually they are obliged to apply. It is now understood that these requirements probably impact on energy performance, but there is little In-Use data available to prove this. Unless there is an environment created where the basis of design is open to challenge, then it is inevitable that the underlying factors that lead to excessive energy consumption will remain unchallenged.

On the 3T's redevelopment is a Client that has the vision to allow the professional team the opportunity for such challenge. But the traditional tools available to the team constrain the team's ability to assimilate conflicting requirements. In the case of the 3T's redevelopment it has been the use of sophisticated technology along with the specialists able to use it, that has enabled the team to understand the holistic impact of design constraints and conflicting standards on the outcome energy performance.

With the approach taken on 3T's informed decisions can be made by the client and the contractor in respect of building design in order to maximise in-use performance.

This approach does challenge current thinking in key areas of the design and provides a foundation to inform future developments in setting meaningful outcome-based performance measures as well as the standards that drive them.

ENERGY MODELLING

We have already seen how the significant disparity between the project team's aspiration of energy performance as inferred by a BREEAM rating and the resultant performance as measured through the Display Energy Certificate lead to facility owners being dismayed by the poor performance of the facility In-Use.

In our view the current Building Regulations lead to this confusion. Part L of the regulations oblige the project team to calculate performance based on very strict criteria that do not reflect what is actually achieved in an operational facility. Of course it would be argued that it is not the purpose of regulations to do this. However, our argument is that they create a misleading situation, not least because 80% of carbon emissions arise for In-Use (IGT, 2010). The BREEAM In-Use assessment has attempted to address this need, but we argue that this is too late in the process and that predictable forecasts are essential at the design stage, so that clients are able to arrive at informed decisions at each stage of the process.

It is the direct correlation between the way in which a facility is operated and the carbon outcomes that is essential to be modelled. It is in this process that the Occupancy Analytics studies (please refer to next section for a definition of Occupancy Analytics) and a Whole Facility Energy Model (WFEM) are integrated, to provide decision support for the project leadership team.

The purpose of the WFEM is to simulate energy loads based on the occupancy requirements. This in-turn provides the data to inform discussions with Service managers as to the most efficient practices that balance operational needs and constraints with the associated energy use.

Both *Regulated and Unregulated energy* are modelled to forecast the energy consumption, albeit with certain qualifications. Due to obvious uncontrollable and unpredictable variances in the way a building will actually be used the forecast is defined in terms of a performance range, as distinct from a finite value. The performance range is derived from a confidence analysis.

A peer review group has been established with Laing O'Rourke (including their Authorising Engineer), their principal MEP designers, and IBM Smart Buildings Group to consider the evidence arising from these studies and to discuss the impact of this work on the way in which healthcare facilities should be planned and designed in the future.

The WFEM during the In-Use Phase of the facility life-cycle

The WFEM will be connected into the In-Use database, where the In-Use database will be receiving data streamed from the Building Automation System. By this means there

will be a direct correlation between the engineering design strategies and the performance outcomes as measured by the Building Automation System.

The In-Use database design will be discussed in later papers.

OCCUPANCY ANALYTICS

Definition: Occupancy Analytics is the systematic analysis of the In-Use processes carried out within a facility in conjunction with the people and equipment resources required to enable those processes. The analysis creates the following knowledge:

- Occupancy at any time of the day based on the consequences of the processes that lead to the movement or dwell time of people within a part of a facility.
- The type of occupancy. In the case of a hospital the ‘occupancy types’ comprise: Staff, Visitors and Patients.
- The demand on equipment usage as a function of occupancy.

The analysis is driven from a Facility Activity Model, where process logic and occupancy data are managed in a sophisticated database.

Why Occupancy Analytics?

It has previously been highlighted in this paper that the most significant assumptions that are most usually made in the design of Heating, Ventilating and Air Conditioning Systems HVAC system concern the internal heat gains from people and equipment. Together these constitute the largest internal heat gains that must be managed by the system. The common method of calculating the gains from people is to refer to CIBSE Guide A Section 6: Internal heat gains (or as coded in environmental design software). The guides estimates gains from people relative to certain generic activities. However, it is well understood amongst engineers that the total sensible heat gains are very much dependent on the number of people, duration of occupancy and the activity level. The Guide states the following:

“In the design of air conditioning systems, the internal heat gain may contribute a significant part of the total cooling load and it is therefore important that all such gains be included. However, the plant must also be capable of operating satisfactorily at part load. Over-estimating internal heat gains may result in over-sizing of plant leading to higher capital costs of plant, poor part load performance and increased running costs.”

Designers are obliged to make assumptions concerning the occupancy and the equipment loads. They do so, because there is usually no other data available to them other than guidance such as that produced by CIBSE. For example, they will often assume that a room of a certain type will be fully occupied and on this basis that they

will develop assumptions based on different room types. Consequently the aggregated occupancy will not necessarily correlate to how the building will be occupied In-Use.

Designers will also be obliged to make assumptions concerning equipment energy consumption and cooling loads. They argue that when they are required to carry out their design work that the data that they require for this analysis is rarely available to them.

Inevitably the assumptions concerning both occupancy and equipment loads lead to estimates that err on the side of caution. These assumptions directly impact the sizing of major plant and for these reasons can lead to substantial over-sizing, as described earlier. The issue is compounded because the assumptions lead to peak-load calculations based on worse case criteria. The peak conditions may never arise, because substantial tolerances have been engineered into the calculations. Because the sizing of main plant is based on peak loads it can be appreciated how errors in the sizing of main plant can arise.

The RAE report cited earlier expressed this concern in this way:

“Construction clients are increasingly specifying performance standards for buildings, such as a target energy performance rating, a specific rating under the Building Research Establishment Environmental Assessment Method (BREEAM) or other international standard such as Leadership in Energy and Environmental Design (LEED). However, the industry lacks sufficient information, guidance and mechanisms to design and construct buildings to achieve such targets.”

Clearly there is a need for new knowledge and information to inform the HVAC design process. It is for these reasons that Bacon developed the science of Occupancy Analytics and it is this science that is being implemented on the 3T’s redevelopment in Brighton.

The science was inspired by a theoretical approach developed by Augenbroe and his team at Georgia Tech for an analysis of post Katrina trauma departments (Augenbroe et al, 2009). Augenbroe explored the concept of a correlation between HVAC design and Occupancy and the potential for simulation to provide the knowledge for that design. Occupancy Analytics substantially develops the work by providing a foundation of a data driven model derived from an XPDL schema.

The instantiation of a database uses datasets derived from clinical information systems, operational policy and interview. The model defines process logic and through this logic inter-departmental flows are modelled. In the 3T’s analysis we have developed the logic from a departmental-centric position. In some respects it would be preferable to develop the logic from a person-centric position. This is because the resources associated with a person type (patient type/ staff type etc) could in theory also be modeled. However experience from the post-Katrina study referred to earlier identified that deeper analysis (particularly intra-departmental process logic) becomes very

complex to assimilate. The department-centric model describes the processes relative to patient flows from one department to another. Our objective is to understand dwell time of patients within a department as much as the logic for the flow of patients out of one department to another.

As with any simulation the forecast can only be as good as the data that informs it. It is the process logic, and specifically the variances and constraints that operate dynamically on it, that render a patient-centric position too complex to model at present. Confidence in the results is gained through consultation with a Reference Group of experts, who are able to comment on the results and identify any obvious inconsistencies. Nevertheless there are ad hoc (for example, human behavioural variability's) that could potentially impact the results, and currently these in modelled through a random distribution applied in the post-processing stage.

CIS Ward

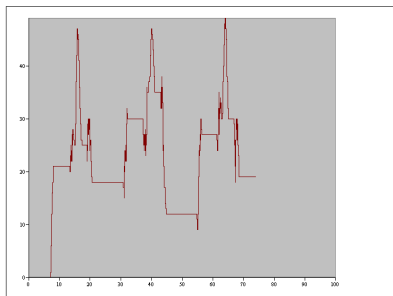


Fig. 2. Simulation result showing how occupancy varies over time in a specific department

However, despite these qualifications, the analysis leads to an understanding of occupancy in the design process that has never, to our knowledge been developed before.

The process creates another opportunity, that whilst not central to the strategy for achieving a low carbon solution, it does potentially offer substantial added value. In considering the potential of a data-driven Occupancy Analytics model, the opportunities of structured briefing data can also be realised (Bacon, 2009). In this regard the Facility Activity Model database enables the dynamic creation of an adjacency model, as illustrated in Figure 3. The potential of this work is to simplify the extrapolation of adjacency logic from the brief, which is most usually unstructured information. The potential also exists to reference this data into a Building Information Model.

The Client perspective: Occupancy Analytics.

As set out above, from a Client perspective, Passman believes that the simulations undertaken will provide a crucial tool in understanding how the facility will work in operation. This will allow the Trust to understand:

- Where the potential inefficiencies in operation lie – is the facility being used as intensively as possible thereby providing a good return on investment?
- The potential for further rationalization of the Trust’s estate if there are inefficiencies;
- The potential to re-engineer care processes to more evenly spread occupancy over the working day – thereby reducing energy consumption in peak periods.

The Contractors perspective: Occupancy Analytics.

Being involved in this approach to designing a modern hospital facility, the Contractor has been able to explore the planning of a building which looks forward to its future, and not simply one that is a concept conceived within today’s thinking. The combination of Operational policy development, (which is very much focused on how the building is to be designed and managed for future operation) embedded in the Facility Activity Model database and simulated using sophisticated technology provides a new basis for future practice.

Whilst the science of Occupancy Analytics is emerging, we believe that it has significant potential to transform the conventional briefing process, because for the first time, both the Client and the professional team together are able to explore the impact of briefing decisions on a simulated forecast of how the facility would function In-use.

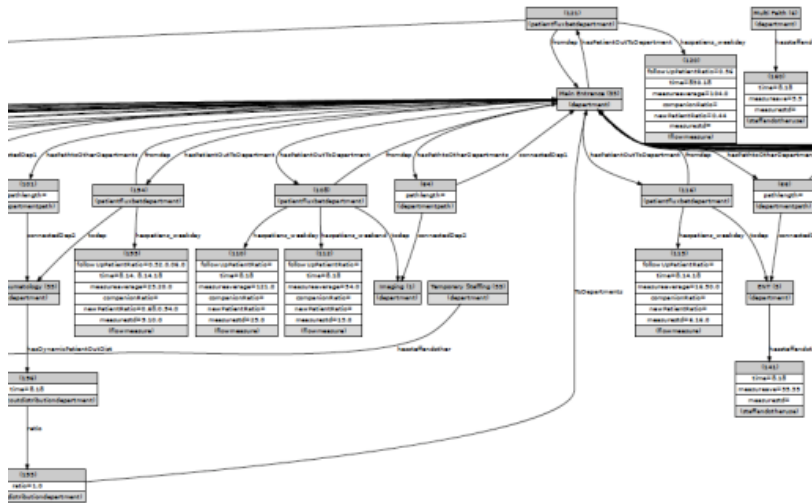


Fig.3. Automated adjacency model, published directly from the Occupancy Analytics database

A MODEL FOR FUTURE DESIGN OF HOSPITAL FACILITIES

If hospital trusts and their professional teams are to base their planning and design decisions on modelling and evidence, rather than theory and supposition based on what

has been done in the past (Passman, 2011), then the aspiration of the authors is that more efficient, sustainable developments will result.

The outcome that we seek is an aggressive reduction in energy consumption. We argue that we need to embrace the In-Use perspective because, as has been observed by others (IGT, 2010), 80% of all carbon emissions on the built environment emanate from In-Use. Absolute Carbon emissions from the NHS are increasing each year, not decreasing (Figure 1). Carbon efficiency must be achieved through the greater efficiency in the use of hospital facilities. This means that the carbon emission per patient care episodes must also decline.

In order to normalise data so that meaningful measures can be assimilated, then trusts will need to gather performance data at a more granular level. An In-Use database is the logical means for achieving this.

The NAO report cited earlier advocate that Government needs to:

‘Develop outcome-based performance targets for individual buildings (for example in terms of energy and water use) which departments can include in specifications for construction and refurbishment projects’.

Until the Built Environment sector has access to verifiable, and accurate In-Use data this aspiration will be difficult to achieve. Outcome-based targets can never be realistic until the Built Environment sector understands In-Use energy performance. In our opinion it is the lack of In-Use energy data and specifically that which reflects *whole facility use*, which is the major hurdle in establishing meaningful outcome-based performance targets.

Without accurate, verifiable In-Use data, new models for design and planning will also be slow to emerge. We also contend that hospital trusts do have access to data that provides a valuable In-Use perspective, but could exploit the value of it more effectively in the manner described in this paper. An example of this concerns the data used in Occupancy Analytics studies, where the input data is derived from clinical information systems (CIS) and the output data can be leveraged to inform design and planning of hospital facilities. The work on 3T’s clearly demonstrates that this is the case. We argue that the natural ‘home’ for this data is in the ‘Enhanced Brief’. But to leverage this data requires experts able to traverse the traditional boundaries of design and In-Use. It also requires experts able to assimilate CIS data and to process it so that knowledge of facility processes can be used to inform the Facility Activity Model.

The strategy developed by Bacon for the 3T’s project takes this thinking a stage further. It is the correlation between the design strategy *and* the resulting carbon performance that must be understood. Without this knowledge we argue that design strategies for hospital facilities will remain ill informed.

THE CLIENT'S PERSPECTIVE

From the client perspective, this collaboration between Trust and Professor Bacon and his team is of crucial importance and wider applicability not only to the NHS but to the rest of the public sector and to private sector developers as well. It potentially delivers a way in which the building can be tested and evaluated before it is built. The opportunity remains through the rest of the design process to fully optimise the human processes within the building and the design processes which wrap around those: for the first time.

THE CONTRACTOR'S PERSPECTIVE

From the contractor's perspective having a team able to challenge conventional thinking and to address fundamental challenges by bring an empirically based approach is a refreshing experience. Typically project processes do not afford the luxury of this level of analysis and challenging of the process. This is partially because project team workloads are usually very intense, but also because the challenging process requires disciplines not usually found in conventional practice, such as: clinical information system experts, business analysts, database management experts, simulation experts and statisticians. But more than this is the need for a vision for a 'step change' in sustainable design and a united team able to realise that vision.

CONCLUDING REMARKS

In our view the need for a step-change in the sustainable design of hospitals is of fundamental importance. The seemingly inexorable rise in energy consumption from the NHS Estate is not sustainable. The current design codes have made little impact on energy efficiency within the NHS Estate. The authors of these codes implicitly acknowledge in them that the lack of In-Use data is a major constraint to improvement. Lack of In-Use data means that new approaches to the design of MEP systems is unable to be effectively evaluated. Clearly change is required, and it is hoped that this paper provides an insight into how this could be achieved. It is one based on evidence and the development of new science.

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MODELLING INNOVATIVE DIAGNOSTIC TOOLS FOR TUBERCULOSIS IN DEVELOPING COUNTRIES TO FACILITATE EFFECTIVE UPTAKE

I. Langley¹, B. Doulla², H. Lin³, K. Millington⁴, and S. B. Squire⁵

ABSTRACT

The introduction and scale-up of new tools for the diagnosis of Tuberculosis (TB) in developing countries has the potential to make a huge difference to the lives of millions of people living in poverty. To achieve this, policy makers need the information to make the right decisions about which new tools to implement and where in the health infrastructure to apply them most effectively. These decisions are difficult as new and expensive tools are developed and the health system and patient impacts are uncertain particularly in poor and rural settings. The authors demonstrate that a discrete-event simulation linked to transmission models can play a significant part in improving and informing these decisions. Results are presented for a diagnostic facility in Tanzania and are used to evaluate alternative tools to provide policy makers with valuable information on health systems costs, and patient outcomes.

KEYWORDS

developing countries, diagnosis, health infrastructure, modelling, tuberculosis

INTRODUCTION

According to the World Health Organization (WHO, 2010) there were 9.4 million new cases and 1.7 million deaths resulting from Tuberculosis (TB) in 2009. TB is the archetypal disease of poverty and most TB cases are amongst the poor in South-East Asia, Africa and the Western Pacific regions. The highest incidence rates are in the countries of sub-Saharan Africa where TB incidence is greater than 300 per 100,000 people. It is estimated 11–13% of TB cases are Human Immunodeficiency Virus (HIV)-positive with Africa accounting for approximately 80% of these cases. Despite the availability of highly cost-effective antibiotic treatment, these figures show that TB remains a major threat to public health, particularly in the developing world. A substantial proportion of TB cases are either not diagnosed and treated promptly or never detected by the health system (Stop TB Partnership, 2009). Delays in diagnosis result in poor treatment outcomes at the individual level and a longer infectious period and sustained transmission at the community level.

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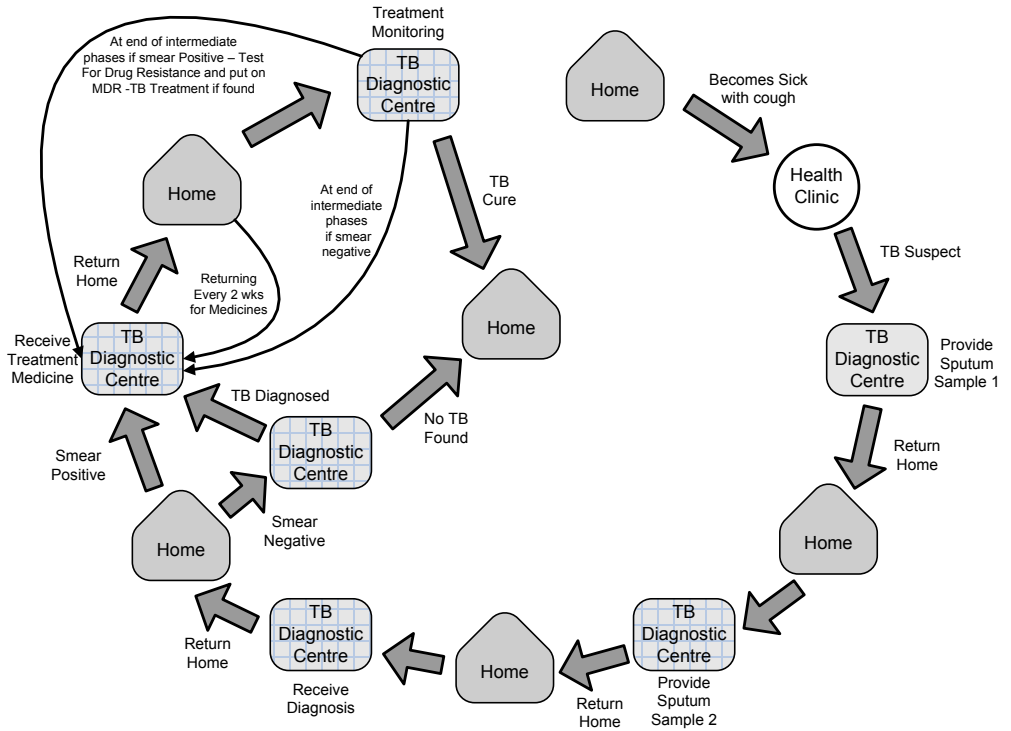


Fig 1. TB Diagnosis and Treatment Flow Diagram

The process that a typical individual showing symptoms of TB would need to follow in order to access diagnosis and treatment is illustrated in a simplified flow diagram in Figure 1. In the developing world this process presents a number of barriers that can limit its effectiveness. In particular the distances that individuals need to travel; the number of visits required to the diagnostic centre (typically a minimum of 4); the duration of standard and multiple drug resistant TB (MDR-TB) treatment (6 and 24 months respectively); the patient time involved in both diagnosis and treatment; and as a result the high cost relative to income incurred by the poor, even when the diagnosis and treatment itself is provided free of charge (Kemp, Mann, et al, 2007; Liu, Thomson, et al 2007; Squire et al 2005).

Efforts to stimulate innovation in the processes and technology of TB diagnosis have resulted in the development of several novel diagnostic tools and improved algorithms (Boehme et al, 2010; Marais et al, 2008; Morgan et al, 2005; Ramsay et al, 2009, Small et al, 2010). The introduction and scale-up of these new tools in the healthcare infrastructure for the rapid diagnosis of TB and related drug resistance has the potential to save many lives in low and middle income countries where there is a high burden of TB. Any new tool or combinations of tools endorsed by the WHO (e.g. WHO, 2011) for implementation requires evidence to inform the formulation of guidelines and recommendations. In 2009, the WHO adopted the GRADE (Grading of

Recommendations Assessment, Development and Evaluation) approach (GRADE Working Group). The evidence is generally presented in the form of systematic reviews of accuracy or efficacy based on test or demonstration studies. Generally these will summarise the quality of evidence about whether innovations can work, but not whether they will work or the impacts in a given context (Squire et al, 2011). Successful adoption of new diagnostic tools for TB relies on policy makers within the Ministry of Health of countries having the information to make the right decisions about which tools to implement and where in the healthcare infrastructure to apply them most cost effectively. These decisions can be difficult as many of the new tools require significant investment, have substantially increased running costs, and the impacts on the health system and patient outcomes are uncertain and interconnected.

Many of the impacts that policy makers need to understand are categorised by the Impact Assessment Framework (IAF) proposed by Mann et al (2010). Table 1 uses the IAF to categorise some of the questions that need to be considered before scale-up of new TB diagnostic tools in a particular context. The challenge is to answer these questions in a timely manner, in support of implementation trials and scale-up, in order that the benefits of new innovations can be delivered as quickly as possible with predictable impacts on patients, the health system, and the community.

Here we expand and build on previous work by using an innovative application of discrete event simulation to model the healthcare infrastructure for TB diagnosis and treatment in developing countries (Lin, Langley et al, 2011). The models are used to demonstrate how the approach can provide understanding of the impacts and answer key questions proposed by policy makers in developing countries that inform and improve decisions including assessments of cost effectiveness. The approach uses, as an example, the potential implementation of automated nucleic acid amplification test machines - Xpert MTB/RIF (Boehme et al, 2010) in a district TB laboratory in Tanzania to show that a flexible and informative model can be developed. We also discuss how the approach can be linked into transmission modelling.

Table 1. Impact Assessment Framework (Mann, 2010)

Layer of Assessment	Questions that need to be considered for rollout of new tool(s) and algorithms for TB diagnosis
Layer 1: EFFICACY ANALYSIS	<ul style="list-style-type: none"> • How many additional cases will be identified who would otherwise not have been identified? • How many additional cases will actually start and complete treatment?
Layer 2: EQUITY ANALYSIS	<ul style="list-style-type: none"> • Which patients benefit? (e.g. HIV+, the poor) • Why do these benefits accrue?
Layer 3: HEALTH SYSTEM ANALYSIS	<ul style="list-style-type: none"> • What are the human resource implications? (e.g. staff numbers and skills) • What are the infrastructure implications? (equipment, lab organisation, bottlenecks) • What are the procurement implications? (e.g. reagents, consumables)
Layer 4: SCALE UP ANALYSIS	<p>What are the projected impacts of going to scale? e.g.</p> <ul style="list-style-type: none"> • cost savings to patients in relation to income • costs to health providers • effects on transmission
Layer 5: POLICY ANALYSIS	<ul style="list-style-type: none"> • How do other existing or emerging technologies compare in their projected performance and cost effectiveness?

METHODS

A variety of modelling tools could potentially address many of the questions posed in Table 1 (Dowdy et al, 2008; Giroi et al, 2005), however in modelling a situation like that of TB diagnostics in Tanzania it is recognised there are additional features that would greatly improve the utility of the models across a variety of context in the developing world. These features are shown in Table 2. A successful modelling approach that these features suggest is a visual and interactive discrete-event simulation model using readily available software for a powerful laptop computer. Such an approach is widely used in many industrial and commercial settings as well as in health systems in the developed world (Katsaliaki and Mustafee, 2010; Günal and Pidd, 2010). The approach enables decision makers to understand and visualise the impacts of alternative decisions whether they relate to manufacturing facilities in the automotive industry, till layouts in retail, or accident and emergency facilities in hospitals. Such tools are very flexible, portable, and easily linked into standard databases like Excel for input and output. For these reasons we chose the WITNESS simulation tool (Lanner, 2011) for the health system modelling of TB diagnostics and treatment.

Table 2. Features of high utility models for TB diagnostics in developing countries

FEATURE	REQUIREMENT
Core Data Driven	With a limited set of core data available for diagnostic centres in the developing world the models need to be able to run on this limited data with key assumptions discussed with experts and tested through sensitivity analysis. The data must be linked in through an easily updated database.
Flexible	So that models can be used to understand a variety of diagnostic approaches and across a wide range of different settings in the developing world they must be easily and quickly reconfigurable.
Visual	In order to provide policy makers with confidence in the model accuracy, its outputs, and to assist in validation the model must be visual and present a simple but realistic schematic image of the health system being modelled (Kapsali, 2010).
Powerful	In order to link to longer term transmission modelling and to speed model runs there must be sufficient processing power to simulate up to 10 years within 1 hour of modelling time.
Stochastic	To model variables such as patient arrivals, power outages, and default probabilities the modelling tool must have the ability to model uncertainty based on user defined and statistical probability distributions.
Interactive	'What-If' scenarios must be quickly and interactively testable
Portable	In order to demonstrate and validate the model on location in remote rural diagnostic centres the model must be portable.
Transferable	In order to give personnel within National TB Programmes (NTP) the opportunity to experiment and evaluate appropriate tools and impacts for themselves in individual diagnostic centres it must be possible to transfer executable versions of the model for ongoing evaluation within the NTP

MODEL BUILDING

A flexible and generic model was developed which included modules for health clinics, individual TB diagnostic centres, the diagnostic centre laboratory, and the central TB reference laboratory (CTRL). The CTRL is where testing for drug sensitivity takes place and is essential for the diagnosis of MDR-TB. These modules could be reconfigured for different diagnostic tools and locations. It was decided to model at a detailed level including each activity within a diagnostic centre in order to provide insight on important factors such as specialist staffing requirements and to identify bottlenecks. It was recognised that this could add significantly to the complexity of the model and the time for simulation runs, however the valuable insight it could provide outweighed these disadvantages. If the detail proved unnecessary following experimentation the model could easily be simplified to speed simulation runs.

Variable parameters were read from Excel data files and included staffing levels, patient numbers, positive test probabilities, timings for diagnosis, and the number and capacity of diagnostic tools such as microscopes and automated nucleic acid amplification test machines (i.e. Xpert MTB/RIF). The minimum level input data required from the records at each diagnostic centre to run the model is shown in Table 3 with example inputs for a diagnostic centre in Tanzania. This data was validated by records kept centrally at the CTRL.

Table 3. Example minimum level input data

Parameter	Example Data from Tanzania	
Current Diagnostic Tools	ZN Microscopy & X-ray	
Laboratory Staff	2 lab technicians	
TB cases per year	New TB Smear +ve	560
	New TB Smear -ve	450
	Retreatment	93
HIV+ rate in TB Cases	42.0%	
Smear +ve Rate - New Suspects	11.4%	

Key assumptions for other parameters such as the sensitivity and specificity of the tests, the false positive rate of the tests, the time a patient was willing to wait for results, and the likelihood a suspect would not return following an initial visit to the health facilities were researched through published papers and agreed with experts in the field. They could then be subject to sensitivity analysis particularly if there was a high degree of uncertainty about the values. To evaluate the cost effectiveness of the implementation of a particular TB diagnostic tool the output of the model was linked to an Excel spreadsheet containing all cost information.

The model was run using the dynamic graphical interface to validate it was performing as expected using the current TB diagnostic tools and algorithms. An example of the WITNESS screen layout for a diagnostic centre is shown in Figure 2. The validation process involved working with local experts with knowledge of how the existing process operates.

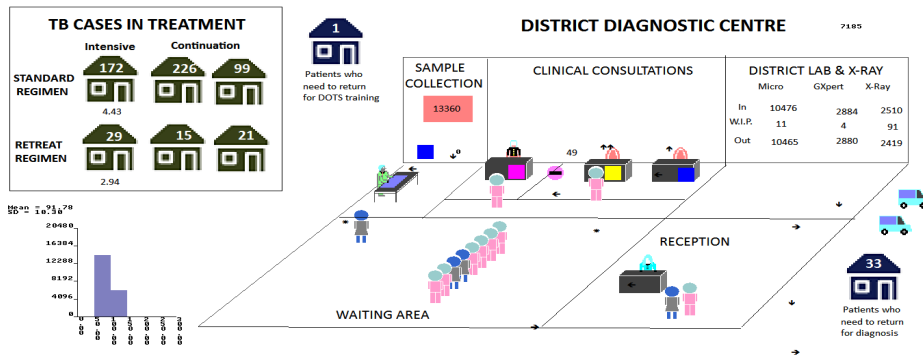


Fig. 2. WITNESS module for Diagnostic Centre

Four options for TB diagnosis were considered for a large diagnostic centre in Tanzania – Table 4. All options included the possibility of using chest X-ray and clinical diagnosis if the primary TB diagnostic tool was negative yet TB symptoms persisted.

Table 4. TB Diagnostic Process Evaluated

Option	Name	Primary Diagnostic Tool	Secondary Diagnostic Tools	Drug Susceptibility Testing (DST)	Treatment Monitoring Tool
Base case	ZN	ZN Microscopy 2 samples	Chest X-Ray and Clinical Diagnosis	Solid Culture & DST at CTRL	ZN Microscopy
A	LED	LED Microscopy 2 samples	Chest X-Ray and Clinical Diagnosis	Solid Culture & DST at CTRL	LED Fluorescence Microscopy
B	Xpert Full	Xpert MTB/RIF 1 sample	Chest X-Ray and Clinical Diagnosis	Xpert MTB/RIF in Diagnostic Centre & Culture /DST at CTRL	LED Fluorescence Microscopy
C	Xpert Part	Xpert MTB/RIF for HIV+/ retreat. 1 sample & LED Micro. for HIV- 2 samples	Chest X-Ray and Clinical Diagnosis	Xpert MTB/RIF in Diagnostic Centre & Culture/ DST at CTRL	LED Fluorescence Microscopy

Once validated the model was run for up to 10 years of simulated time for each TB diagnostic process being investigated. The results were downloaded to an Excel spreadsheet for consolidation, comparison, plotting, and further statistical analysis including the calculation of confidence limits. The ‘Disability Adjusted Life Years’ (DALY) averted was calculated from the comparison of the number of TB patients cured and the difference in the speed to successful completion of appropriate TB treatment.

RESULTS

Results based on 10 year simulation runs of the model are shown in Table 5. The cost figures used within this analysis are in US dollars. They are based on figures provided by the National Tuberculosis and Leprosy Programme (NTLP) of Tanzania and use costs for Xpert MTB/RIF hardware and tests as negotiated by the Foundation for Innovative Diagnostics (FIND, 2010). The cost per test for Xpert MTB/RIF are based on the most optimistic values associated with the highest volumes being achieved (i.e. \$10.72 per test). For this reason the results presented here should be treated as indicative of what the modelling approach can deliver rather than definitive forecasts of future absolute costs. The models are configured in such a way that alternative costs for interventions can be evaluated.

Table 5 includes a ‘patient success rate’ which is defined as the proportion of individuals with TB disease that seek diagnosis and are cured. This factor takes into account not only whether patients are put on treatment, but whether they successfully complete treatment and whether they were correctly diagnosed in the first place. The

denominator is the number of all individuals seeking diagnosis that have TB disease including those that are missed by the diagnostic process.

Comparing the performance demonstrates that switching to LED Fluorescence Microscopy (Option A) from ZN Microscopy (Base Case) for this example diagnostic centre would reduce the time to diagnosis (-9%) leading to a positive affect on reducing the proportion of defaults during diagnosis (-1.7% points). An increase in the number of smear positive cases detected (+108 per year) is partly offset by a reduction in the number of smear negative cases (- 91 per year) which leads to a reduction in the false positive rate (-2.8% points). This is because the proportion of suspects incorrectly put on TB treatment as a result of clinical diagnosis following a negative smear test is much higher than if the smear test is positive (Hargreaves et al, 2001). The combination of these effects leads to an increase in the number of patients cured by around 5% and takes the patient success rate to nearly 70%. This is achieved with no significant increase in running costs for an investment of around \$2,300.

Table 5. Results from Health System Model

	Performance – 10year run				Difference to Base case		
	Base Case ZN	A LED Micro.	B Xpert Full	C Xpert Part	A LED Micro	B Xpert Full	C Xpert Part
Diagnosis							
Mean Time (days)	25	22	15	19	-9%	-39%	-25%
Mean Patient Visits	6.0	4.5	3.7	3.8	-25%	-38%	-37%
Smear Test Positive /yr	562	670	1060	898	+108	+499	+337
Smear Test Neg. TB cases /yr	446	355	53	188	-91	-393	-258
MDR-TB Cases /yr	4	4	7	5	0	+3	+1
Samples /year	17,327	17,288	12,386	15,322	0%	-29%	-12%
% default during diagnosis	15.6%	13.9%	10.7%	10.7%	-1.7%	-4.9%	-4.8%
Treatment	*Patients cured excludes false positives who received treatment but had no TB disease						
Mean Cure Time (days)	218	208	203	204	-5%	-7%	-7%
Patients Cured p.a.* (95% C.I.)	842 (827-858)	884 (866-902)	975 (955-995)	933 (917-948)	+5%	+16%	+11%
False + Rate for TB	14.3%	11.5%	8.7%	9.3%	-2.8%	-5.6%	-5.0%
Staffing							
Lab techs	2	2	2	2	0	0	0
Costs							
Incremental Cost/yr \$k (95% C.I.)	95.2 (90.2-100.3)	95.3 (90.3-100.2)	142.0 (137.6-147.3)	120.8 (115.4-126.2)	+0.0	+46.8	+25.6
Investment Cost \$k	0.0	2.3	34.7	19.3	+2.3	+34.7	+19.3
Summary	+Patient success is the % of individuals with TB that seek diagnosis and are cured						
Patient Success +	66.6% (65.3-67.8)	69.5% (68.0-70.9)	77.2% (75.6-78.8)	73.6% (72.4-74.9)	+2.9%	+10.6%	+7.1%

A full rollout of Xpert MTB/RIF (Option B) for diagnosis has a greater impact. Comparing full Xpert MTB/RIF rollout with ZN Microscopy shows a reduction in the time to diagnosis from a mean of 25 days to 15 days (-39%) and mean patient visits required from 6.0 to 3.7. These improvements result in a positive affect on reducing the proportion of defaults during diagnosis (-4.9% points). An increase in the number of test positive cases detected (+499 per year) partly offset by a reduction in the number of test negative cases put on TB treatment (-393 per year) increases overall TB diagnosis rates

and reduces the false positive rate (-5.6% points). This leads to an increase in the number of patients cured by around 16% and takes the patient success rate to over 77%. In addition because Xpert MTB/RIF detects Rifampicin resistance at initial diagnosis there is an increase in MDR-TB cases detected (+3 per year) which means these cases will also be put on effective treatment earlier. To achieve these results requires significant investment (\$34,700) and increases running costs by around \$46,800 per year for this one diagnostic centre.

The fourth option (Option C) modelled looks at a lower cost implementation of Xpert MTB/RIF by targeting the new technology only at HIV+ cases where it is known the incremental effect of Xpert MTB/RIF is more significant (Boehme et al, 2011). This reduces the impact, but still delivers significant improvements. A reduction in the time to diagnosis from a mean of 25 days to 19 days (-25%) and mean patient visits required from 6.0 to 3.8 results in a positive affect on reducing the proportion of defaults during diagnosis (-4.8% points). An increase in the number of test positive cases detected (+337 per year) partly offset by a reduction in the number of test negative cases put on TB treatment (-258 per year) increases overall TB diagnosis rates and reduces the false positive rate (-5.0% points). This leads to an increase in the number of patients cured by around 11% and takes the patient success rate to 73.6%. To achieve this requires investment of \$19,300 (\$15,400 less than full Xpert MTB/RIF rollout) and increased running costs of \$25,600 per year (\$21,200 per year less than full Xpert MTB/RIF rollout).

For this example diagnostic centre the results in Table 5 show that all of the options can be delivered with no change in laboratory staffing levels.

In order for policy makers to decide which of the available options to choose they need to understand the costs verses benefits of each option and to be able to compare these to other potential demands on resources. This is true throughout the world, but particularly in the developing world where resources are so scarce. In table 6 an assessment including Incremental Cost Effectiveness Ratios (ICER) is presented based on cost per patient cured and cost per 'Disability adjusted life year' (DALY) averted for each option compared to the base case. These values can be compared to other interventions and sensitivity analysis conducted to determine which intervention should have priority relative to other investments.

Table 6. Summary Incremental Cost Effectiveness Ratios

Difference to Base Case	A	B	C
	LED Micro.	Xpert Full	Xpert Part
Incremental DALY averted/ yr (95% Confidence Intervals)	399 (259-539)	1,220 (1011-1429)	843 (655-1032)
Incremental costs/ Additional Cure (95% Confidence Intervals)	\$0.8 (0.4-1.1)	\$353 (299-406)	\$282 (233-331)
Incremental costs/ DALY averted (95% Confidence Intervals)	\$0.08 (0.05-0.11)	\$38.3 (31.8-44.9)	\$30.3 (23.5-37.1)
Sensitivity of Incremental costs/ DALY averted to Xpert cost per test \$16.9 (max) rather than \$10.7 (min)	\$0.08 (0.05-0.11)	\$67.8 (56.3-79.4) +77%	\$48.4 (37.5-59.2) +60%

DISCUSSION

The results from the modelling of an example diagnostic centre in Tanzania provide a projection of the increased effectiveness of new technologies in that centre. The results project the impact of effectively optimising existing microscopy technologies (Option A verses the Base Case) as compared to the investment in Xpert MTB/RIF (Option B). In this example the improvement in patient cures from optimising microscopy was 5% compared to 16% for full rollout of Xpert MTB/RIF. In addition the patient success rate increased to 77% compared to around 70%. The results also project the level of investment that is required and the impact on ongoing health system costs which would be incurred and these are substantial. With these results it is possible to look at alternatives that may still improve impacts at potentially lower cost. Option C which involves partial roll-out of Xpert MTB/RIF is an example where the results from the modelling demonstrate the level of cost savings achievable and a projection of the reduced patient outcomes. Policy makers can make other suggestions and sensitivity analysis on key variables such as cost per test can be completed using this modelling approach. The utility of the modelling approach has been recognised by policy makers in Tanzania who are now considering specific sites for implementation of the new TB diagnostic technology. The modelling approach will be used to assist in these implementations and to project impacts.

The results of the simulations demonstrate that the developed models can provide useful projections of effects on the operation of the health system, running costs, and patient outcomes of alternative TB diagnostic tools. These projections can be converted into incremental cost effectiveness ratios (ICER) like cost per DALY averted, and therefore used by policy makers to understand impacts and make appropriate decisions. Policy makers can compare the ICER of the proposed intervention with other interventions in other areas, or the same intervention in different locations, to assist in making the right decision for each implementation and to understand priorities. The ICER could also be compared to a country specific willingness to pay threshold such as Gross Domestic Product (GDP) per capita (Kim, 2007), to test whether the intervention meets this

benchmark. For example in Tanzania \$503 is the GDP per capita (World Bank Data, 2009) which can be compared to the projected incremental running cost per DALY averted of full Xpert MTB/RIF of \$38 for this example diagnostic centre with the cost assumptions used. This can be a helpful guide, but many other factors will also need to be considered.

An additional impact to the health system that can affect both the future diagnostic process and ultimately the success of the intervention is the impact on future incidence of TB disease through transmission. In order to provide a comprehensive solution an innovative approach of linking transmission modelling to the health system model has been proposed and demonstrated by Lin, Langley et al (2011). The approach on transmission modelling uses a differential equation model that captures the most important features of the natural history of TB (Blower et al, 1995). To incorporate the health system context where the diagnostic tool will be employed, the model also includes details of the pathway from disease onset to TB diagnosis and initiation of treatment. Berkeley Madonna (Berkeley Madonna 8.3.18) is used as the numerical solver for this differential equation model. The transmission model is linked to the operational model through data feeds that affect the inputs and outputs of each model. So for example, the demand for TB diagnosis in the health system model is fed by the output from the transmission model which models TB incidence. Similarly the time to diagnosis is an output from the health system model which feeds into the transmission model as this affects the infectious period and therefore transmission.

The development of these models does take longer than some other approaches such as Decision Analysis (Dowdy et al, 2008; Girosi et al, 2005), however now that the core models are available adaptation to other contexts can be completed quickly. The modelling approach provides a level of detail that other approaches like Decision Analysis are unable to provide. For example the approach enables staffing requirements at individual centres to be determined, can identify bottlenecks, and takes account of interactions within a health system that effect performance. The simple visual nature of the modelling approach enables non-modellers to view the model and identify errors and opportunities to improve system performance. Through a link to transmission models the approach also allows macro-effects to be included such as the impact on TB incidence that an improved diagnostic tool may deliver. This impact can then be modelled to understand how it affects future health system costs and patient outcomes.

There are a number of areas where further investigation using this modelling approach is to be progressed which will demonstrate its full utility. Firstly, in the Tanzanian context an implementation trial site will be chosen for the new diagnostic technology and modelled using the tools described in this paper. The results of the modelling will feed into this implementation trial. The results from the trial will help validate the model and improve its effectiveness for future implementations. In addition, the models will be used to make an overall assessment of the impacts of full scale up of the new technologies across the country including linking into transmission impacts. Secondly, the approach will be assessed in a number of different country contexts including Brazil, and high MDR-TB settings which as yet have not been modelled. Thirdly, transfer of the model to personnel within national TB programs for their own use is an objective that will first be piloted in Tanzania.

CONCLUSION

A health system modelling approach using a visual and interactive discrete-event simulation tool linked to transmission modelling is practical and provides information that helps policy makers understand impacts and make decisions on TB diagnostic tools. It is easy for TB specialists to understand and has been welcomed by officials from the National TB Program (NTP) in Tanzania who will be engaged in using the tool in the future to evaluate new TB diagnostic tools. Further research needs to continue to prove the approach across many contexts in the developing world and to actively use the approach to assist in making the important decisions that the leaders of NTP's are currently considering. These decisions are urgent and important and relate to the new technologies for TB diagnosis such as Xpert MTB/RIF that have the potential to make a huge impact on worldwide TB control in the coming years.

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THE MATERIALIZATION OF SIMULATION: A BOUNDARY OBJECT IN THE MAKING

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ABSTRACT

Research on boundary objects focuses on interpretive flexibility neglecting the process and the organization of materialization. This means that research has mainly investigated how boundary objects support collaborative and communicative processes amongst communities of experts, neglecting the transformation of specialized technology objects and their materialization into simulation models, which is not arbitrary but the result of their relations, practices and perceptions.

This paper discusses findings from research on how simulation models transform and materialize during the process of collaborative model building projects by answering this question: *How does simulation transform in collaborative modelling projects?*

Our findings show first, that the materialization of simulation models depends on group learning processes, and second, that the model structure creates a cognitive challenge for participants, which affects the transition of simulation between different roles throughout the project phases. Group composition and professional practice was salient in understanding and materializing simulation.

KEYWORDS

simulation, materialization, boundary object

INTRODUCTION

This paper is a follow up of research on the potential importance of modelling in healthcare planning and in particular about the usefulness of simulation as a social object within group modelling projects which deliver simulation products for healthcare planning. The focus in this paper is the social roles of simulation within interdisciplinary collaborative groups and the effects of these roles upon the process of transformation and materialization of simulation to a final technological model. The opportunities to use simulation as a social object can also reveal the barriers for modelling to reach its full potential in healthcare planning, therefore to satisfy the need to understand modelling processes better and use of modelling tools more effectively.

We draw on the literature of materialization of technology through its social dimension and we discuss its behaviour within these particular groups. Of particular interest is to investigate the transformation of social roles and final materialization of the model

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within 'loose' groups; looseness defined as the level of professional diversity and cognitive distance between the members of the groups. Looser groups provide us with the opportunity to observe how the social transformation of the model changes and the effects this has on its final materialization. Learning and cognitive challenges within the groups are of particular importance.

THEORETICAL BACKGROUND

THE QUESTION OF THE MATERIALIZATION OF SIMULATION OBJECTS

As Star (2010) claims research in boundary objects has focused on interpretive flexibility neglecting the work processes and the organization of materialization. The forms of boundary objects are not arbitrary but are the result of the relations of the people whose practices transform them. The process of transformation of the objects is not taken into account since research focused on how physical artefacts support cognitive processes as repositories of knowledge, representations of cognition and expressions of culture and the ways these artefacts affect social processes between communities to facilitate knowledge integration (Wilson et al., 2007; Nemeth et al., 2006; Becky, 2003; Carlile, 2002; Norman, 1991), how artefacts support future-oriented sense making, or otherwise cognitive sculpting (Doyle and Sims, 2002), the interpretation of tasks (Ewenstein and Whyte, 2009) and expressions of personal interpretations (Heracleous and Jacobs, 2008).

The role of generic boundary objects such as maps, diagrams, plans etc, has been investigated in project management as a means of promoting learning between diverse groups (Brown and Duguid 2001; Yakura 2002). Findings in the literature at the moment claim that the use of boundary objects is marginal as it cannot replace personal interaction but rather plays the role of a complementary coordination mechanism (Sapsed and Salter, 2004). This happens especially in projects where interdependencies are weak, reflecting a negotiation of power. Engwall and Westling (2004) observe that objects are as much the result of project control processes as they are the result of social construction and cognitive convergence. Scarbrough et al. (2004) argue that professional diversity creates the conditions in which members create new project practices. Other studies look at the role of the objects that mediate between the project with the host organization and the roles of boundary spanners (Garrety et al., 2004), their use in contracts and other boundary collaborations (Koskinen and Makinen, 2009; Ruuska and Teigland, 2009), the organization of a project to enhance individual creativity for solving problems (Henderson, 1991), as well as the role of client objectives and negotiation, conflict and discontinuities in the alignment of perceptions (Alderman et al., 2005; Jensen et al., 2006).

However, scarce studies focus on the process of objectification of generic boundary objects, the evolution of their content from ideals to discourses and their materialization whilst they are being codified (Papadimitriou and Pellegrin, 2007). In addition, little research has been done on the boundary roles of specialized objects like simulation models. In this regard, there are two perspectives on the use of models as artifacts (Knuuttila and Voutilainen, 2003): the syntactic, which sees models as steady and ready-made entities and the semantic, which emphasizes why and how models are used,

their diversity and the modelling process. The former argument implies that the models are more or less static, relying on data categories (Boumans, 1999). The latter perspective sees models functioning as mediators, investigative instruments dependent on their 'partial' representation (Morrison and Morgan, 1999), which means that we learn more from models when building them than just by using them. Apart from knowledge representation, Dowling (1999) claims that simulation models also have an epistemic role as a virtual laboratory creating experimental conditions. In addition, simulation models can be used to make predictions and allow experimentation in a safe, quick and low-cost way as a technical object and they can also help to shape the conversation as a boundary object (Dodgson et al., 2007). Despite incorporating agency Knuuttila and Voutilainen (2003) claim that models are not open to all interpretations because their properties may be a constraint for certain boundary roles. These models are purposefully constrained structures, fabricated in a more orderly way than generic types of boundary objects which antagonizes their ability to objectify various kinds of knowledge originating from different fields. For this reason their representation role should be critical and it is *relational*, despite of their independent constitution.

This stream of research is fragmented and therefore we are left to question how simulation models materialize, transiting through different boundary roles during the modelling lifecycle and how they are affected by group relations. *What are the forms that models take during the process of materialization?* As Orlikowski (2007) points that organizational literature has discussed materiality of technology in a fragmented way, considering it as an occasional issue, instead, this paper proposes that in order to study the materialization process of simulation not as pre-formed but as an outcome of performed relations, it is best to study it within diverse project groups and within the modelling process.

This study fills in this gap by studying the materialization process of simulation objects through the modelling stages, within tightly and loosely related project groups. This paper discusses findings from research on how simulation materializes through a process of transformation into different types of object roles through the modelling stages within two different relationally structured project groups (loose and tight relations), contributing to the work on the materialization of simulation and its social roles (Papadimitriou and Pellegrin, 2007; Zagonel, 2002). Drawing from evidence from two comparative cases of model development groups (with different levels of tightness or looseness), our findings show first, that simulation creates a cognitive challenge that affects the way participants related to the model and the point of collective understanding which is crucial within the process of materialization; second, how the various boundary roles of simulation change and recombine according to project stages; third, that the representation role of simulation was salient through the stages for the loose project affecting their relating to the object; and fourth, that there was dependency between the transition of the object roles with the point of learning closure, participation levels and the organization of the perceptions and expectations of the participants during the stages. All these phenomena are affected by the type of 'looseness' (as defined in the introduction) within the project groups.

METHOD AND ANALYSIS FRAMEWORK

In our study we collected evidence from two projects which aimed at developing system dynamics models with expert-client groups for use in healthcare commissioning. We did this by first observing a series of modelling workshops (typically 4-6 sessions per project) and by conducting interviews with clients, consultants and expert group members afterwards (typically 8-10 interviews per project). We have chosen a case study approach (Eisenhardt, 1989; Yin, 1994) in order to combine ethnography with in-depth secondary and interview data.

Our case studies have a number of common elements which allow our research design to be replicated; however they also have some differences in group composition which help compare the effects of the model roles on management methods.

Our analysis framework (depicted in table 1) builds on Zagonel’s (2002) social use of simulation as well as on the work of Ewenstein and Whyte (2009) on object roles. In our framework, simulation models can take up to four object roles: it can be either a boundary or a representation object (depict the service system structure) and it can also be an epistemic or a technical object (table 1). Representation objects can be used in two different ways: either to learn or to predict. These four roles are ideal types – in practice the roles of simulation might not always clearly fit into one of these roles, but instead be a mixture of them and transit from one to another at different points during the phases of the project.

Table 1. A framework to classify the social roles of simulation models (the authors)

	Epistemic Object (create knowledge)	Technical Object (make knowledge available)
Boundary Object (facilitate communication across boundaries)	Learn as group	Experiment and express
Representative Object (represent reality)	Explore	Predict

In order to enrich our discussion in the analysis we use this framework as an introduction to a concept map which depicts the combination of the social roles of simulation as a social object with the transition of the simulation through the phases of its different ‘shapes’: 1. Initial structure (where decisions were made to define the purpose and the parts of the structure of the model); 2. Skeleton (where the basic structure has been established and is fed with data to see how representative it is and define the model boundary and identify key variables); 3. Initial runs (experimenting with this structure and data to describe the behaviour or draw the reference modes of the key variables); 4. Modifications (through testing scenarios and finalize the mechanisms and the feedback loops) and 5. The final completed simulation model.

CASE STUDIES

THE MATERIALIZATION OF TWO SIMULATION MODELS

The two project groups differed in regards to their composition. In case 1 the participants were nationally recognised experts who had knowledge of each other and the system that was modelled. Even though they came from different disciplines, they had an understanding of the other participants' knowledge and had developed a shared language from their repeated encounters. Case 2 was a local group of professionals involved in implementing the policy on a local level and had larger cognitive distance and less holistic understanding of the healthcare service system and the modelling approach.

In both projects, the 'clients' (public healthcare actors) were part within those expert group building processes. This did impact on the objects' transformation as the processes have had a more technical object focus. The priority in both cases was to provide an accurate technical tool that describes the behaviour of the service system and allowed for experimentation of policy options. The learning was primarily about the model such that participants could feed the appropriate system interactions and data into the building processes, rather than learning about the system, which would more likely be the case in other contexts.

Initial analysis has considered the transformation in the four object roles of the model in both cases was under the influence of many factors. This transformation was found to change and recombine according to the stage of the built structure of the model (figure 1) but in slightly different ways in each project. This is because there is a mixture of factors like the level of understanding of the simulation objective, the system and the data that was necessary to feed in the model, the cognitive distance and professional interests which gave way to several types of disputes (areas of negotiation).

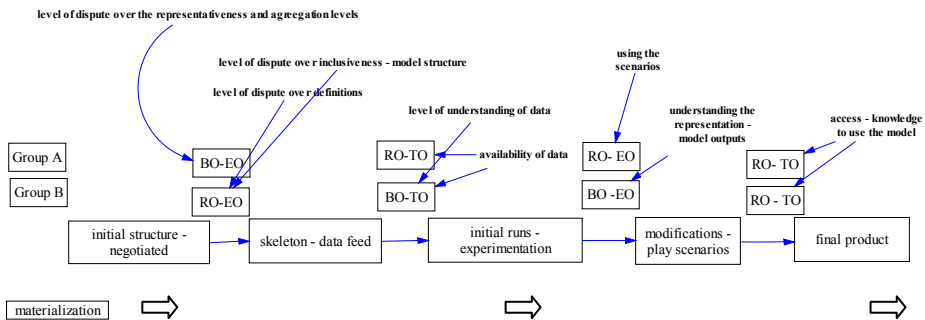


Fig 1. The materialization of a simulation model and the social use of simulation for the two project groups (the authors)

We found that the group composition had two consequences. First on the use of the roles. In case 1, the model was conceptualized as a decision-making tool. The familiarity of the group with the simulation and its parameters in case 1 resulted in less use of the model as a boundary or an epistemic object. In case 2 the model was more of

a boundary object and an epistemic object than in case 1: it was used in bridging the gaps in the knowledge of the participants and in supporting the production of new knowledge. In case 2, the ability of the model to serve as a representative object was limited by the perceived complexity of the visual representation of the simulation. The representation role of the model could be understood as serving a catalyst function to enable the social roles of the model as an epistemic or boundary object. In case 2, where there was a need for knowledge of the system or roles of the other participants to be shared, there was relatively high level of learning in the first two meetings which reached a plateau and declined during the last three meetings in the last phase. The model as an epistemic object succeeded in developing a general impression but not deep understanding of the system and its relations. In the follow-up interviews concerns were raised by the participants included the rapid pace of the meetings, how the model was introduced to them and the way they did or did not engage with it. Therefore the models can to some extent function as epistemic objects to facilitate participants' learning and as boundary objects to facilitate understanding of the whole system, their own place in the system and their relation with other parts of the system.

The roles of simulation can recombine in four ways (as in table 1) listed in abbreviation as BO-EO, RO-EO, BO-TO and RO-TO in any phase of materialization (as in figure 1). We found that the second consequence of the difference in the composition of the groups is that the roles combined differently within the building transformation of the model. In particular in stages 1 and 3 of the materialization process, we find that the groups have used opposite combinations (BO-EO and RO-EO). It seems that the difference in tightness-looseness affected the type of social roles within the same stages. There is also more emphasis on the Boundary role in group 2 since the participants used it more to define, negotiate and debate about model structure and representation.

There also seems to be a relation of dependence between these combinations of roles. It seems that the representation role is important to the successful function of the boundary role that leads to the function as an epistemic object that eventually will lead to a reified technical object. This however will have to be corroborated in future case studies. The evidence so far from the case studies shows that the representative role of the object is a catalyst for its success in a loose project group.

SUMMARY AND CONCLUSIONS

This paper shows the transformation of four key social roles that simulation can play whilst it is being materialized as depicted in figure 1. In case 1 the more cohesive group used combinations with more technical roles while in case 2 the looser group used the boundary roles more for sense-making and communication. The result is that role-taking depends on the group's feeling of familiarity (3 types, group, model and system) and participation levels. Furthermore the extent to which participants could understand and work with the model determined what roles they picked for it. There is a cognitive challenge for the loose group, where the participants get more engaged in the boundary role of the model, only to plateau and wither if the group does not in the end trust and familiarize with the function of the model. It is the cognitive boundary and the representative role that are at this time found as most significant in looser project groups.

Therefore, there did seem to be a relationship between the materialization stages and the social roles of simulation. Initially, the more fluid boundary object and epistemic roles are most prominent. As the model solidifies into a technical simulation product and the group develops a more established understanding of themselves and the system, the more fixed the project group is on the representative and technical object roles. Therefore we see a development of boundary roles according to stages, conditioned by the group's use of boundary and representation roles in the first and third stages and their level of confidence in their understanding of the model function in the second phase. This was conditioned on the level of familiarity of participants with the data that the model used-therefore the method used by the model.

Finally we observed several conditions upon which the groups emotively chose the roles the simulation performed, that is the conditions that make these roles more practical or not for a loose group to use. These are related to the link between simulation planning and type of roles.

Narrowly systemic analyses of the materialization process focus on barriers stemming from professional cultures and identities. Learning is often not examined. Boundary practices are too often equated with tools, boundary crossing does not deal with tensions and horizontal development of expertise is not considered. Therefore, it is not enough to know that simulation functions as boundary, epistemic, representative or technical, but how a model within the project process can provoke the generation of new ideas and mediate between different professional worlds.

Through the process of model development the designers have to create a form of standardization that supports participants to use simulation during group processes, by abstracting in the model the work processes that are subjectively considered to be essential and by visualizing this knowledge at the "right" level of abstraction which is ultimately going to lead to the final product (Whyte et al., 2008; Kristiansen, 2005). Despite incorporating agency, simulations are not open to all interpretations: they have purposefully constrained structures, fabricated in an orderly way to structure people's perceptions and collaboration, which constraints their ability to represent different kinds of knowledge.

Whether, and the extent, to which there is an observable transition in their development and use over the phases of the model building is to be corroborated over a series of follow-up case studies, in different groups and simulation practices.

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OVERVIEW OF BUILDING INFORMATION MODELLING IN HEALTHCARE PROJECTS

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ABSTRACT

In this paper we explore how Building Information Modelling (BIM) functionalities together with novel management concepts and methods have been utilized in 13 hospital projects in the United States and the United Kingdom. These projects were covered in twelve case reports, articles, and papers because two healthcare projects in United Kingdom, *Saint Bartholomew* and *Royal London Hospital* projects, were considered together in one case report. This paper addresses the following questions: What are the strategic reasons for deploying BIM in healthcare projects? Who should take the initiative to implement BIM? What are the expected challenges and benefits? Secondary data collection and analysis were used as the method. More specifically, quotations, grouping, and summarizing accounts techniques were used. Initial findings indicate that the utilization of BIM enables a holistic view of project delivery and helps to integrate project parties into a collaborative process. The initiative to implement BIM must come from the top down to enable early involvement of all key stakeholders. It seems that resistance from people to adapt to the new way of working and thinking rather than immaturity of technology hinders the utilization of BIM.

KEYWORDS

Building Information Modelling (BIM), Integrated Project Delivery (IPD), building model, information, design and construction

INTRODUCTION

Delivery of healthcare projects is complex and dynamic process, which requires balancing political, policy, design, and human choice and preferences (Passman, 2010). BIM as a collaboration platform has a profound impact on how healthcare projects are managed and delivered as shown by the findings of this paper. BIM enables early contribution of all the key stakeholders to support evidence-based decision making for planning, designing, constructing and managing facilities. This paper explores how BIM functionalities together with novel management concepts and methods have been utilized in thirteen hospital projects in the United States and United Kingdom. The structure of this paper, inspired by literature review and analyses of hospital projects, first defines the notion of BIM and addresses the major aspects that are necessary to understand the significance of this topic. This is followed by introducing 12 case studies and their general characteristics to better understand when and where BIM can be used.

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The last part of this paper discusses the findings from the case study projects regarding the BIM enabled project delivery.

BUILDING INFORMATION MODELLING (BIM): DEFINITION AND KEY CONSIDERATIONS

Implementation of BIM into practice can be challenging, especially if one lacks any previous experience and necessary knowledge. It is a strategic decision requiring many changes in all levels of project delivery (Kymmell, 2009). Against this backdrop, a definition of BIM is provided and key aspects to be considered are listed.

BIM - what does this three-letter acronym actually mean? The glossary of the BIM Handbook (Eastman et al. 2008), one of the best-known publications in this field, defines BIM as a verb or adjective phrase to describe tools, processes and technologies that are facilitated by digital, machine-readable documentation about a building and its performance, design, construction, and operation. BIM is a process which results in a building information model – (visual) information repository (Kymmell, 2009). A ‘building information model’ or simply ‘building model’ is a digital database of a particular building that contains information of its objects. BIM software tools are characterized by the ability to compile virtual models of buildings by using machine-readable parametric objects (Sacks et al. 2004).

Some of the major aspects that one must consider when embarking on a BIM journey: choosing proper project delivery and contracting methods to enable holistic BIM approach (Eastman et al. 2008); developing a BIM execution plan to identify needed high value uses/functionalities, design workflow, intermediate deliverables, and develop infrastructure in forms of contracts, communication procedures, etc. (buildingSMART alliance™, 2009); understanding of interoperability to develop BIM program in a project or company; and understanding of the legal aspects of implementing BIM in project context in terms of model ownership and responsibility for model accuracy (level of detail/development), as well as about concerns about the responsibility for the cost of producing and managing the model (Kymmell, 2009).

ANALYSIS OF BIM HOSPITAL PROJECTS

This analysis of BIM in healthcare projects is based on the information obtained from twelve case study reports, magazines and journal articles. This approach has its advantages and disadvantages, where one of the greatest disadvantages was information availability in each of these sources differing in matter of quality and quantity. Most of the case studies and articles covered design and construction stages of project delivery and also included information about other project stages like facilities management.

Table 1. Overview of the hospital projects examined

No	Project	Location	Project time
1	<i>Camino Group Medical Building</i>	<i>Mountain View, California, US</i>	<i>2003 - 2007</i>
2	<i>Sutter Medical Castro Valley</i>	<i>Castro Valley, California, US</i>	<i>2007 - 2012</i>
3	<i>Phoenix Children's Hospital</i>	<i>Phoenix, Arizona, US</i>	<i>Construction 2008 - 2012</i>
4	<i>Maryland General Hospital</i>	<i>Baltimore, Maryland, US</i>	<i>2010</i>
5	<i>The Kaiser Permanente Oakland Medical Centre</i>	<i>Oakland, California, US</i>	-
6	<i>Saint Bartholomew's and Royal London Hospital</i>	<i>West Smithfield and Whitechapel, London, UK</i>	<i>Construction 2006 - 2016</i>
7	<i>Ann & Robert H. Lurie Children's Hospital</i>	<i>Chicago, Illinois, US</i>	<i>2004 - 2012</i>
8	<i>Good Samaritan Hospital</i>	<i>Puyallup, Washington, US</i>	<i>2007 - 2011</i>
9	<i>Sherman Replacement Hospital</i>	<i>Chicago, Illinois, US</i>	<i>Construction completed 2010</i>
10	<i>Middle Tennessee Medical Centre</i>	<i>Murfreesboro, Tennessee, US</i>	<i>Construction completed 2010</i>
11	<i>Las Vegas Hospital & Community Living Centre</i>	<i>North Las Vegas, Nevada, US</i>	<i>2006 - 2011</i>
12	<i>Maple Grove Hospital</i>	<i>Maple Grove, Minnesota, US</i>	<i>Construction completed 2009</i>

Eleven projects explored were from the United States, and two others, the *Saint Bartholomew* and *Royal London Hospital* projects, were from the United Kingdom. Table 1 presents general information about these projects. Table 2 includes information about strategic properties of projects: type, project delivery and contracting methods, sustainability, and implementation of lean. BIM can be implemented not only in new building projects but also in all kinds of projects as illustrated by the projects chosen for the purpose of this paper. It can also be used for refurbishment, expansion and replacement projects while still remaining beneficial due to its nature. Clients have also understood the necessity of using project delivery and contracting methods that enable early collaboration and the emergence of problem solving teams (Thomson et al, 2009). In all of these hospital projects, the general contractors have been involved early to let them contribute their knowledge to design regarding construction 'means and methods'. Hospitals are energy intensive facilities, and this is what has made owners to focus on sustainable goals to drive down the operating and maintenance costs (Autodesk, 2008 a, and Autodesk 2008 b). Frequently, clients impose the requirement to deliver healthcare projects in accordance to the LEED (Leadership in Energy and Environmental Design) specifications, a certificate developed by U.S. Green Building Council.

Table 2. Strategic characteristics of hospital projects

No	Project type	Project delivery and contracting methods	Sustainability	Use of lean
1	<i>New Build</i>	<i>Started Design-Bid-Build; later evolved to IPD</i>	<i>N/A</i>	<i>Lean</i>
2	<i>New Build</i>	<i>Integrated Form of Agreements (IFOA)</i>	<i>LEED</i>	<i>Lean</i>
3	<i>Expansion</i>	<i>Construction Manager at Risk; construction portion Guaranteed Maximum Price</i>	<i>Yes</i>	<i>N/A</i>
4	<i>Expansion</i>	<i>Construction Manager at Risk with Guaranteed Maximum Price</i>	<i>N/A</i>	<i>N/A</i>
5	<i>Replacement</i>	<i>Integrated approach (not specified)</i>	<i>N/A</i>	<i>Lean</i>
6	<i>Refurbishment and new build</i>	<i>Private Finance Initiative (PFI)</i>	<i>Yes</i>	<i>N/A</i>
7	<i>New Build</i>	<i>Hybrid of Design-Build and Conventional Design-Bid-Build (client integrating processes and stakeholders)</i>	<i>N/A</i>	<i>Lean</i>
8	<i>Expansion</i>	<i>Joint-Venture (Guaranteed Maximum Price)</i>	<i>LEED</i>	<i>N/A</i>
9	<i>Replacement</i>	<i>Joint-Venture (Guaranteed Maximum Price)</i>	<i>Environmentally friendly hospital</i>	<i>N/A</i>
10	<i>Replacement</i>	<i>Early involvement of key contractors and trades</i>	<i>N/A</i>	<i>Lean</i>
11	<i>New Build</i>	<i>Joint-Venture (contract not specified)</i>	<i>Yes</i>	<i>N/A</i>
12	<i>New Build</i>	<i>N/A</i>	<i>Yes</i>	<i>N/A</i>

In five of the hospital projects, lean principles and methods were applied. *Camino Group Medical Building* project team believes that the use of a shared 3D model linked to lean construction techniques led to reduced project cost, time, and helped to increase productivity on site (Eastman et al. 2008). Lean refers to the application and adaptation of the underlying concepts and principles of the Toyota Production System (TPS) to construction. Like in the TPS, the focus of lean construction is on reduction of waste, increased value to the customer, and continuous improvement (Sacks et al. 2009).

Table 3 lists BIM functionalities by project and its stage of use. This list is not exhaustive. Functionalities described are from Sacks' et al (2010) research, where, due to the nature of their work, they focused on exhibited functionality, rather than the core technology. It must be also noted that these functionalities are overlapping and are extending throughout the project delivery stages. For example, visualization can be used in all stages of facility lifecycle, even during exploitation of facility for facilities management. In the projects observed here, BIM has been mainly used for design rather than construction and other phases. Still, the *Saint Bartholomew's* and *Royal London Hospital* projects show that general contractors are starting to pay attention to using BIM during execution.

Table 3. Use of BIM functionalities by project and its stage

Stage/Functionality	Project											
	1	2	3	4	5	6	7	8	9	10	11	12
Design												
Visualization of form	x	x	x	x	x	x	x	x	x	x	x	x
Model changes tracking		x										
Predictive analysis of performance		x	x					x		x		x
Automated generation of drawings and documents	x	x	x			x	x	x				x
Modelling temporary structures (scaffolding) and existing structures			x									
Automated clash checking	x	x	x	x	x	x	x	x	x	x		x
Online communication of product and process information	x	x	x	x		x						
Online meeting sessions		x						x				
Reuse of model information		x			x	x	x	x				
Site planning			x						x			
4D and 5D scheduling			x		x			x				
Construction												
Information for survey and scanning systems			x				x					x
Project status tracking						x						
As-built model				x		x			x			

BIM ENABLED PROJECT DELIVERY

This section focuses on the main findings from the 13 case projects; these findings are also related to insights from literature review. More importantly, the link between BIM functionalities and novel management methods in different project stages is examined.

FEASIBILITY STUDY

The first step always is to identify, determine, and understand the project scope. BIM enables rapid visual creation, consideration, and assessment of project alternatives (Sacks et al 2010) as the outcome of modelling process is a virtual repository of building information with its object parameters and properties. From that database, it is possible to extract information for various purposes: links between building information to energy, structural, MEP (mechanical, electrical and plumbing) analyses in the matter of dimensioning, conformance to requirements, and sustainability goals can be created. In *Maple Grove Hospital*, Dunham engineers extracted space and room information from the architect’s model within the MEP specific software environment and then imported that information via green building extensible mark-up (gbXML) into third-party software for load calculations. Airflow and load calculations for each room were posted back to the MEP specific software model as room attributes to begin equipment and ductwork sizing. This streamlined the load analysis process, and helped Dunham optimize the building systems for maximum performance and efficiency (Autodesk, 2008 b). Another example is *Good Samaritan Hospital* where the project team included light shelves into the BIM model, which made it very easy for the mechanical engineers

to understand them and include the effects in the HVAC cooling load calculations (Bovey, 2008). In *Phoenix Children's Hospital*, structural analysis performed early in the design resulted in identification of unique, high-grade steel material and bracing requirements allowing to identify a unique steel supplier and pre-purchase (prior to a period of steel price escalation) steel resulting in a \$2 million total savings (MacKenzie, 2009).

BIM models (visualization) can also help project team members to develop shared understanding and to provide a common language for design conversations. This complements the use of the lean method called Set-Based Design (SBD), originating from Toyota Motor Company (Wong et al. 2009). SBD, also implemented in *Sutter Medical Castro Valley* project (Chambers, 2010), is a methodology whereby a designer (or team) considers a set of design alternatives (rather than a single 'point' design) and postpones commitment to a specific design to the last responsible moment (Parrish et al. 2007). Visualizing the differences offers project teams an opportunity to discuss value trade-offs between alternatives (Wong et al. 2009). This approach is beneficial in early project stages but can be used in following phases as well. Thus, implementing SBD together with BIM can provide assurance to find the sustainable design solution and add greater value for client (Wong et al. 2009).

DESIGN

The core idea of IPD is to create a collaborative environment by aligning stakeholders' objectives with project objectives, thereby developing a culture for pain/gain share (Khemlani, 2009). IPD can be implemented separately from BIM but BIM is used as a collaboration platform. This has created opportunity for another management method called Target Value Design (TVD) to emerge. TVD – lean management practice that drives design to deliver customer values and develops design within project constraints (Ballard 2008). Traditionally, design solution is the basis for cost estimation, and value engineering is used when necessary to cut project costs. Implementation of BIM facilitates the TVD process as quantities can be extracted automatically and directly from model and linked with estimating applications to get automated cost feedback. *Sutter Medical Castro Valley* project team gained a better understanding of how design decisions and changes influenced the cost of the project, thereby emphasizing learning by doing (Tiwari et al. 2009).

Contractors can contribute their knowledge such as construction specific information (also including information about temporary structures and site conditions) to design processes, which results in a model they can use for their own purposes; e.g. estimating, detailing for fabrication, site planning, production planning (4D – 3D model linked with construction schedule) and resources planning (5D – linking 4D with budget) (Eastman et al. 2008). BIM process gives project teams the opportunity to virtually plan and build construction projects before any bigger commitments to money and time are made; i.e. enhanced constructability analysis (Kala et al. 2010). In the *Kaiser Permanente Oakland Medical Centre* replacement project, the 3D modelling process was implemented in parallel with traditional project delivery method. Constructability reviews, through modelling the design documents, found more than 200 issues at each stage that were not

found by the parallel traditional constructability process (Kala et al. 2010). This resulted in reduction of errors occurring in the execution stage.

In implementing new methods and achieving targeted outcomes, project teams are using iterative modelling coordination meetings to reduce clashes, errors and omissions in the design; e.g. clashes between MEP systems and structures. *Maple Grove Hospital* project team said: “The software’s 3D modelling environment helped our engineers visualize the design and fit all the piping, ductwork, and equipment into tight spaces” (Autodesk, 2008 b). It is not only important for gaining flawless building information model but also to enhance common understanding and knowledge of project team by virtually building a project (Kymmell, 2009). These meetings can be tracked by using BIM-based applications that have capability to compare older and new versions of models by means of colour coding. In the *Sutter Medical Castro Valley* project, this helped prevent a major issue emerging by comparing what had changed since the last model coordination meeting; and, it turned out that in addition to the new beams that had been added, the depths of some of the existing beams had also been changed causing collisions (Tiwari et al. 2009 and Khemlani, 2009).

In the hospital projects studied here, the site planning capability of BIM was not extensively used. In *Phoenix Children's Hospital* project, some site planning was done in terms of a site logistics plan based on the building model (MacKenzie, 2009). This included how to organize construction site concerning laying materials, site offices, fences, existing utilities, etc. However, there are also other possibilities for using modelling for site planning.

BIM-based applications provide for the extraction of accurate and consistent drawings of any set of objects or specified view of the project (Eastman et al. 2008). This should significantly reduce the time needed and errors associated with generating construction drawings. In the *Sutter Medical Castro Valley* project, the approach was to produce a multi-disciplinary, fully coordinated 3D model first, delay the production of paper documents until the last responsible moment, and then produce them with as little rework as possible (Khemlani, 2009). The same tactic was used in *Phoenix Children's Hospital* project: HKS (architect) use of BIM enabled them to work in a truly integrated fashion with contractors and their clients, allowing more time for designing rather than producing construction documentation (MacKenzie, 2009). Beyond the traditional drawings, Dunham (sub-contractor on *Maple Grove Hospital* project) used the software to automatically create 3D isometric drawings and shaded images of highly congested areas which were incorporated into construction documents - to more clearly communicate the engineering design to the system installation contractors and the owner (Autodesk, 2008 b). Studies have shown that incomplete project documentation is the main reason for obstacles, problems, and rework on site (Kala et al, 2010; Pikas, 2010). A solution is provided by BIM-based clash detection, providing many advantages over traditional 2D coordination methods (Eastman et al, 2008). It allows automatic geometry-based clash detection to be combined with semantic and rule-based clash analysis for identifying qualified and structured clashes. “BIM Handbook” distinguishes two different clashes: hard clash, objects occupying the same space; and soft clash/clearance clash, objects are so close that there is insufficient space for access (Eastman et al. 2008).

CONSTRUCTION

A general contractor's main responsibility is to plan the realisation of the project, coordinate the execution, and manage the conformance of outcomes. Harnessing BIM capabilities and using IPD have enabled contractors to do a major part of planning prior to the construction phase. As contended by Walsh Group, the contractor from *Sherman Replacement Hospital* project, the success of the preconstruction phase will determine the project's overall success (Libby, 2009). However, this does not mean that no planning is needed during construction, most often, detailed planning is required; e.g. in *Phoenix Children's Hospital* project modelling, including temporary structures, and 4D sequencing allowed an expedited erection plan and lean process (as needed) delivery of steel which helped them to better comprehend the tight site conditions (MacKenzie, 2009). This planning and modelling information can be used also for coordinating execution and conformance control.

The objects in a building model have attributes, and one of the attributes is location. The location of each component is established according to the coordinate system. It is an important factor that the model is placed into a coordinate system and it is usually done by architect, who has to consider all the aspects that the orientation of the building affects. A model in a coordinate system offers another dimension to coordinate and control work. Information about coordinates (xyz) can be extracted from model and may be used for survey and scanning systems for various purposes (Eastman et al. 2008, Tudor, 2010 and MacKenzie, 2009). The projects examined here reveal that survey and scanning systems and methods can be used for three general purposes:

1. Surveying and scanning existing structures and systems; results can be used as a reference for BIM modelling process (Raphael, 2010).
2. Extracting information about coordinates from model enables using it in survey and scanning systems for layout and installation works (Tudor, 2010 and MacKenzie, 2009).
3. Quality control by surveying and scanning new structures and systems; results can be used to compare reality with planned BIM model (Tudor, 2010).

During construction, monitoring the progress of construction process to compare planned activities with work completed is important for tracking the progress of the project and the performance of the stakeholders to focus on tasks that have fallen behind schedule (Harty et al. 2010). This is often complicated in traditional project delivery processes as communication is based on 2D drawings. In the *Saint Bartholomew's and Royal London Hospital* project, hand-held devices were used to record the information about the actual start and completion of work on site. This information was fed back to the BIM application and was used to produce a comparative animated model (4D model) showing actual activity on the site over time along with planned activity (Harty et al. 2010). These two models were then run side-by-side to compare actual against planned activity and therefore allow better communication between project parties. Monitoring can also be used to track material delivery, handovers from design to and

from construction to client, resources flow, etc., as different kind of information can be attached to objects in the model (Eastman et al. 2008).

A new emerging trend is the use of Radio Frequency Identification (RFID) technology to link the physical building components with digital information (Eastman et al. 2008). It is useful for on-site inspection of work and documentation, real-time project progress management, and quality assurance, which are important aspects of implementing lean in construction projects (Pedersen, 2010). There are case studies and experiments of using RFID, but as this capability was not used in hospital projects studied here, it is beyond this work to go into more detail. Conceptually, a similar but perhaps less expensive approach is to use bar codes. This was done in *Maryland General Hospital* project which focused on facilities management purposes. Each piece of equipment was tagged with a unique barcode in an accessible location that enabled seamless information exchange from field to database and from database directly to field into handheld devices (Dave, 2010).

FACILITIES MANAGEMENT

The workflow of BIM process enables to record and deliver as-built information which can be linked with the facilities management system and processes. However, the nature of the model and information may need to be adjusted for this purpose (Kymmell, 2009). In the *Maryland General Hospital* project, the main objective in implementing BIM for closeout and facility maintenance was to create a central database containing closeout documentation and maintenance of information that can be both easily accessed in the field and easily maintained and linked to a 3D model for better visualization (Dave, 2010). This helped to better visualise the facilities management processes, and improve the response times in case of maintenance calls (Dave, 2010). This can make maintenance and management of facilities more efficient and provide improvements across the lifecycle of the building.

BIM IN REFURBISHMENT AND/OR EXPANSION PROJECTS

Many hospital projects are about expanding and/or refurbishing old facilities, such as in the case of *Phoenix Children's Hospital* (MacKenzie, 2009). During construction, hospital services were not allowed to be disrupted, which made sequencing and phasing of work a key issue. The 3D graphic nature of BIM allowed the project team for *Phoenix Children's Hospital* to comprehend the complexity of this project in a much shorter period of time and to develop more creative options (MacKenzie, 2009). According to a member of the *Sherman Replacement Hospital* project team, "Rather than out on the field, where a conflict can potentially stop construction and ultimately affect cost and schedule, we will do real-time problem solving in the 3D model prior to construction without affecting the project schedule." (Libby, 2009).

These projects can be even more complex than new build projects because of the task of fitting new structures and systems with existing ones. Findings of this study show that BIM can be used in these types of projects and can benefit project team. In general, projects must pass the same stages of delivery as usual but a bit different approach is needed due to the nature of these projects. Existing structures must be mapped and

transformed into a 3D object-based model which enables more accurately assess, communicate and fit new systems with existing ones. For mapping existing structures and systems, laser survey and scanning methods can be used. This was done in *Las Vegas Hospital & Community Living Center* project.

DISCUSSION

Throughout this paper, many benefits and challenges have been described based on the findings of analysing the 12 cases. The findings clearly show that BIM can and does have a profound impact on how healthcare projects are delivered. Using BIM together with complementing management practises and methods, like lean construction methods, can help project teams to tackle the complexity, dynamics, and challenging target goals of hospital projects. The BIM capability of enabling virtual construction and a high degree of project visualization helps to develop a common understanding among project partners and solve major problems earlier. Such problems, for example errors and omissions in construction documentation, usually become visible during the construction phase, where making changes and stopping work is very costly. That said it is also important to emphasize that BIM enables a holistic view of projects when used together with project delivery and contracting methods that enable early participation of key stakeholders.

Findings of this paper show that the use of BIM has been limited mostly to design and, to some extent, to construction phase. This suggests that all of the current benefits and achievements delivered by using BIM are merely a scratch on the surface, and major benefits are yet to come. For example, extended use of RFID technology will bridge the gap between the physical world and the digital environment. Furthermore, BIM has been beneficially implemented in various refurbishment projects, not only in new build projects.

Case projects also reflect that healthcare projects have complex building services systems that cause many obstacles for the project teams to successfully deliver project outcomes. These kinds of systems in hospital projects can account for 40-60% of the project value (Khazode 2010). Not only are these systems expensive, their designs often contain clashes as a result of traditional design processes where communication is based on 2D paper based modes (Eastman et al. 2008). The use of 3D intelligent parametric objects for modelling results in a virtual model (prototype) of facility. The visual and intelligent nature of the model makes it possible to automatically identify the hard clashes, and the soft clashes can be identified by working together on the model in weekly design coordination meetings (Tiwari et al. 2009). This helps to reduce uncertainty for contractor to deliver the product.

The implementation of BIM is not without its challenges. Some of the challenges have been discussed above, such as project delivery and contracting methods, BIM execution planning, etc. There are also some challenges that have not been explicitly mentioned yet which are probably the most complicated to overcome. *Camino Group Medical Building* project team said (Eastman et al, 2008): "Not every participant has the skills, resources and experience to fully participate in the project goals. Also it is taking time of teams to learn how to collaborate effectively." There are more examples like that

from other projects. This reflects that hesitancy from people rather than immature technology has opposed the use of BIM, which requires project teams to adapt to new methods, as a way of organizing and managing information. Therefore, someone has to take leadership to guide a project team and motivate others to come along. In the various hospital projects studied here, usually the architect, engineer, contractor or sub-contractor has been the one who has understood the benefits of BIM implementation. In *Camino Group Medical Building* and *Sutter Medical Castro Valley*, it has been a client who has taken an initiative to require BIM implementation. This has many benefits over one project party taking responsibility as it enables a more holistic BIM approach.

CONCLUSIONS

Hospitals are capital intensive projects with their unique characteristics; e.g. building services systems in hospital projects are commonly highly complex and create a great share of the project's budget. Implementation of BIM with complementing management practices and methods has been shown to have profound impact on how healthcare projects are and can be developed and delivered. It is highly recommended to use collaborative project delivery and contracting methods to maximize the benefits provided by BIM. Strong leadership is required to lead the project and the people involved. BIM can be utilised in all kinds of projects, and only the reluctance of people hinders BIM from achieving its full potential. BIM is no longer a new trend, and there are stakeholders who have understood the benefits that BIM implementation promises - value maximization and waste reduction. Findings of this study show that the current achievements of BIM reflect a deeper prospect for increasing gains because the situation is dynamic, new software and new features in existing software emerge, and people learn to better utilize BIM opportunities by aligning both existing and new processes. Those already on the learning curve will be among the first ones materializing the benefits from BIM implementation. Thus, it is important to start now in any hospital project.

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