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REVIEW

Lean thinking in a healthcare system – innovative roles

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Abstract: This review article is based on an extensive literature search incorporating aspects of lean thinking in a healthcare setting. The rationale of the problem considered is seeking ways to minimise waste, improve efficiency, and create a harmonious working environment within a health care setting. Five hospital specialities were utilised to emphasise the importance of cost-effectiveness of function. Healthcare organizations, through its doctors, nurses, radiographers, pharmacists and other allied professions, the need to be placed in the driving seat by applying equally powerful vectors of change, including choice or commissioning leading to improved patient care. Lean adds value to patient needs, identifies the value stream for every patient group, ensures a continuous patient journey flow; pulls in response to the rate of demand of patients, manages toward perfection, and follows clearly defined steps for assessing patients via assessment, investigation, treatment and discharge. Just in Time, pull production, mistake proofing and six sigma are useful elements. Lean thinking, as a tool, is important strategically to effect a reduction in costs and achieve a high turnaround using the same staff and processes, but in a more effective manner. It requires strong, determined leadership to drive its successful implementation.

Key words: healthcare, lean, policy, review, strategy

INTRODUCTION

Lean thinking is a process-based method that considers the interactions across the whole supply chain. A lean approach requires departments to consider from the start their positions in the supply chain and any impact their changes will make holistically. Support services, including health records, pathology, and secretarial services, should work together in a cohesive manner to ensure that the processes meet the requirements of 'getting it right first time'. Doctors, nurses, radiographers, pharmacists and other allied professions should be motivated to work within a system that encourages unity of effort, promotes team working, and puts the patient first. Lean has been successful in decreasing the length of in-patient stay. This change involves looking at the whole value stream as the patient travels along his/her unique care journey. The rationale of the problem entails finding ways to minimise waste, improve efficiency and create a harmonious working environment within a healthcare setting. The National Health Service (NHS) in the UK is currently beset by inefficiencies, wastage and massive expenses. There is clear evidence that the management style is inappropriate and inefficient. People lack empowerment and the paper work is phenomenal. In the USA, the tight-fisted medical insurance companies are unwilling to render their serves to the less fortunate and many of the low-income groups, leaving many people without health and dental treatment and care. There is certainly a need for a revamping of the global healthcare systems, although the practicality and ease of their implementation might not always work. We therefore explored ways – based on cogent information obtained from relevant literature sources – of improving this ineffectual system, while providing actual examples and supporting the notions by presenting real data.

Value is defined in this context as a process leading to elimination of waste, and adding value to each step along the patient's care pathway, enabling staff responsible for analysing what they do and how they can improve. A long-term strategic focus is essential if an organisation operating in the highly complex and versatile world of health care is to achieve the best service for all its stakeholders, and achieve value for money. The strategic objectives of lean thinking include identifying customer value, management of a value stream, developing capability for flow production, use of pull mechanisms to support material flow, and the pursuance of perfection through reducing all forms of waste inherent in the system [1]. There is certainly a need for strategic thinkers and innovators in a health care setting to propose new solutions to major issues facing local health authorities. Lean thinking encourages synthesis of direction among various activities within an organisation, and as such facilitates the smooth flow of procedures and reduces wastage [2]. When used to redesign care and emergency department procedures it can produce long-term benefits for the patient, including enhanced safety and reduced waiting times [3]. The streaming of patients into groups cared for by specific teams of medical practitioners and reducing long waiting times, greatly improves functionality [4].

In order to achieve competitive advantage within a global marketplace, health care organisations require increases in the national health service capacity to meet demand and reduce waiting times [5]. Hospitals need to be geared towards

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applying equally powerful vectors of change, including choice or commissioning leading to a more patient-focused strategy [6]. Financial incentives would provide powerful dynamics that under the direction of far-sighted leadership will provide means of greatly improving patient care. The strengthening of primary and secondary care partnerships via collaborative opportunities will reduce wastage of resources [6]. The British NHS is being subjected to a rigorous review of operations, including financial constrains, health and safety concerns, and skill shortages. In the long-term, lean thinking will help resolve these issues [5]. It is essential to remove obstacles throughout the patient's journey, to understand the scale and the causes of variability of demand, and to smooth it out where possible [5].

The flow of patients through an accident and emergency department may involve redesigning activities, such as managing medical and surgical patients throughout a hospital, and revamping support services 'getting the knowledge', 'stabilising high-volume flows', and 'standardising and sustaining' [7]. For instance, the length of stay for medical patients admitted as emergency cases, attenuated by a day following the introduction of the Redesigning Care programme, resulting in a saving of 15,000 bed-days [7]. In a fast-track system, dedicated staff and the quarantining of clinical resources are needed, and waiting times reduced via the triaging of patients into separate streams [8]. A business approach may reduce waiting times, facilitate patient flow and increase bed usage efficiency [9]. Following the benchmarking of a chemotherapy day unit (CDU) against two separate CDUs, an integrated set of interventions, including a new planning system, resulted in a 24% increase of treatments and bed utilisation, 12% increase of staff member productivity, and an 81% attenuation of overtime [9]. Methodological developments associated with value include the operational, the clinical and the experimental [10]. Lean strategy helps accelerate a patient's journey through the practice. A technological approach by adding 'smart' room technology that projects images and scenes and plays stress-relieving music may lessen the boredom of waiting. The advantages of care allow the patient to be pulled gently through the practice systems [11]. Other technologically innovative solutions include the Department of Health directive to NHS primary care trusts to allow patients with back pain free treatment from NHS physiotherapists without having to go through a General Practitioner (GP) [12]. Rigorous application of technology assessment is an important means for protecting patients from interventions that either do not work, or have low frequency, high-consequent side-effects [13].

The aim of the current review was to discuss aspects based on an extensive literature review, and apply this to actual examples and strategic objectives of applying lean thinking principles to a health care organisation undergoing change.

METHODS

The criteria used in the current review for selecting articles to be included were both theoretically and practically motivated, and adopted from proposed criteria. These included:

- Articles chosen had internationally recognised impact factors.
- Criteria for selection of literature used included 'yes-no' responses to: the appropriateness of methodology; adequacy of subject numbers, specificity of gender and/or age of subjects, and statistically significant response rates to survey questionnaires.
- The time frame used was limited to 1990-2009, inclusive.
- It was presumed that collective articles detailing known factors of the use of lean principles were not necessarily correlated with functionality and health.
- Compilation of materials for the review started with published literature, or easily accessible academic research.
- The articles were accessible from on-line sources, including PubMed, Medline, Embase, Cinahl, Database of Abstracts of Reviews of Effects (DARE), and the NHS Economic Evaluation Database (NHS EED).
- Each sub-chapter was designed to emphasise the weak points of currently available health care systems, possible reasons and specific proposals for eliminating errors.
- Where applicable, statistical data and economic analyses were presented to support the argument that lean thinking benefits an organization, staff and patients.
- Clear examples of pre-clinical and clinical research were given throughout.

IS LEAN NECESSARY?

Lean is beneficial to an organisation, hospital or practice as it incorporates at least three levels of implementation that focus on the patient's journey, the reorganisation of tasks, and the implementation of strategic plans.

During a patient's journey, all the care process can be connected, from admission to diagnosis and treatment, and thence to discharge. This requires that every step of patient care, and every support process, is channelled through the value stream, mapping processes and redesign. Lean approaches can be used to reorganise the way in which a particular task is completed or a department/unit functions. Lean principles can be used to guide strategic decisions, such as investment in future capacity, and to redesign the way the system itself operates.

Lean thinking may be defined as a continuous improvement through the elimination of waste by people who perform the work; that is, performing the work in the least wasteful way. Lean thinking reduces waste and improves the quality of operations [14]. Health care lean thinking may be linked to the Toyota production system, focusing on excellent hospital and doctor practices [15]. Lean production has also been studied in garment manufacturers where positive and negative effects of lean production team working depend on management choices implicit in work design [16]. Lean has been described as a tactic to accomplish or achieve a strategy [17]. The philosophy of lean thinking, based on the ideas developed by Womack and Jones [18], is best applied in health care as a long term method within the overall strategic policy of the organisation. The lean thinker will find that error in the execution of a process is an absolute waste [19]. It is often regarded that the collation of incidents, solutions and fixes would enhance safety; thus, if healthcare incident reports are to be of real value, they should be considered by doctors who can identify relevant human factors and organisational issues [20]. Sometimes, medical errors occur through faulty systems and processes that leads people making mistakes [21].

Lean thinking considers the holistic picture, not merely the steps, and in the process streamlines activities and reduces

waiting times [22]. Managing and synchronising different processes can improve productivity while reducing delays and errors. Lean thinking helps accelerate a patient's journey and cuts waste by reworking routine procedures [23].

Lean thinking realises the importance of patient needs and concerns; drastically minimises wastage, creates a safe, hygienic and calm environment, repairs disjointed processes, and empowers staff to solve problems [5]. Digital technology may be a part of lean to provide an up-to-date medical photographic service in teaching hospitals [24]. Laboratory efficiency may be greatly improved by simplification of processes, improving laboratory support of patient care services; reducing turnaround time; improving productivity, reducing costs, saving space, standardising work practices, reducing errors and error potentials, continuously measuring performance, eliminating excess unused inventory and visual noise, and cross-training all staff [18]. Enhanced turnaround times and elimination of errors in laboratories will improve their pre-analytical, analytical and post-analytical phases [26]. If the heath care organisation streamlines its systems and makes it easier for patients to utilise products and services, costs can be lowered and time saved [27].

CERTAIN WEAKNESSES AND POSSIBLE REASONS FOR ADOPTING LEAN

Hospitals are currently in debt and underfunded by government. There are too many procedures and the paper work massive, staff over-worked and stressed. When one enters a typical hospital following a letter-request for an appointment, one may find that the reception is understaffed and the process of entering patient details into the computerized database lengthy. More significant, however, is when one is directed to wait in a seated area until called for the specialist's assessment. The latter is usually very short, of about 10 minutes duration, but the wait may supposedly be considerable, e.g. 4 hours in the renal unit at the Good Hope Hospital in Birmingham, UK, and up to 6 hours in the eye clinic at the City Hospital, also in Birmingham, UK. Amazingly, these delays also include follow-up appointments. Transfer between units in a hospital may take the whole day. On presenting to accident and emergency departments one is made to lie in a cubicle for a long time before a doctor is able to conduct an examination. This waste of time necessitates the use of lean strategy, possibly via the use of virtual links that allow an assessment and effectively follow-up patient needs.

SOME SPECIFIC PROPOSALS TO ELIMINATE ERRORS

During a patient's journey, all care processes must be linked, from admission to the clinic, thence to diagnosis and prescription, and finally, follow-up. Perhaps an NHS card scanned on entry to a clinic will speed up the data entry. The card will hold data via finger-print identification of the patient and their records, and will be designed so that only designated hospital sensors can read the magnetic strip. Rather than posting the cards, they will be issued at the point of entry, with a fee payable for replacements. Entering the reference number on the card in a password-protected database will allow patients access to results at home. If the patient had previously undergone testing and the results were negative, a print-out to the patient at a designated point of entry (including at chemists) would denote this as well as the suggested negation of follow-up appointments. Pervasive wireless technology could be programmed to prompt one on a PC at home to view results, with explanations on-line. The necessity for a follow-up appointment can be eliminated by texting a messages to mobile telephones. For example, Whittall Street Genito-Urinary Tract Clinic in Birmingham, UK, texts an all-clear message to patients, 'Your results are normal. If you have a future appointment please keep it'. In order to establish specific systems there would be need for considerable change in the ways of thinking among health care workers, so that employees are encouraged and valued for challenging existing work processes, and supporting services that ensure ward efficiency [11].

IMPROVEMENTS IN HEALTHCARE EFFICIENCY

The most important directions to improve healthcare efficiency by incorporating currently functioning solutions include: Adoption and implementation of a 9-C paradigm shift to ensure that the efficiency and strategic direction of healthcare decisions and processes are fulfilled, and the functionality of a unit becomes more patient-focused and friendly. This is appropriate for a surgical assessment unit for an elderly patient suffering from renal complications arising from diabetes.

Another tool would include the concentric ring and patient flow paradigm incorporating a gap analysis that analyses the current functionalities and the patient flow paradigm, and matches it with the desired level of attainment. A strategy of lean could be implemented into the functioning of a surgical unit, with emphasis on a renal unit. This uses a unique model of whole-system thinking of the principal operations in surgical assessment units and the desired innovative care parameters.

An investment in lean thinking development may be used that specifically includes the apportioning of funds to conducting surveys for identifying the needs of individual practitioners, by using a spider-web model that indicates the resources. For example, liaison between nephrologists and urologists, and potential risks, such as loss of income from a primary care trust - a GP who has made a referral.

The establishment of a centralised, computerised, visual communication software approach that allows two-way communication between the specialist/doctor and the patient in a follow-up appointment. This can be used free of charge over a high-security wireless LAN network. For example, upon discharge, the follow-up can involve the revelation of results and instructions for treatment based on the most up-to-date medical information available. The option of home-delivery of medication following payment will be facilitated. This method would have to consider the cultural needs of the patient and aspects of confidentiality during the transmission. The benefits derived from this innovation would include reduction in waiting time, lessening of anxiety, and being responsive to questions.

WARD SPECIALITIES

Functionality. Specific specialities in a hospital may incorporate strategic direction incorporated within lean thinking, and may include the following: neurology, haematology, infectious diseases, diabetes, orthopaedics, respiratory medicine, renal medicine and urology, cardiology, gastroenterology, hepatology, endocrinology, geriatric medicine, and surgical assessment. Of these, we shall focus on five specialities. Lean thinking propositions are creating a safety culture by eliminating errors.

Orthopaedics. An 81-year-old man who lives in a care home has presented with complications due to a suspected fall. Lean thinking would prioritise the integration of specialist responses. If the patient is suffering from a septicaemia-infection as a consequence of a complex fracture of the femur, a blood and urine test needs to be completed within 5-10 min after physical examination, the results of which will be analysed whilst he is being X-rayed. The significant reduction in waiting time will alleviate shock as a consequence of confusion and pain.

Respiratory medicine. A 46-year-old woman presents with chronic dyspnoea and phlegm cough who has smoked for 23 years, currently on six cigarettes per day. Lean thinking principles will allow prioritisation of diagnosis by sending a productive sputum sample for analysis whilst lung-function tests (e.g. vital capacity and forced expiratory flow) are performed. If there is evidence of severe air-way obstruction (e.g. cyanotic lips) the alleviation of this should be prioritised. If inhaled steroid medications are prescribed, due consideration of side-effects should be considered.

Diabetes. A 28-year-old man presented with altered urine content, confusion and dizziness, with a blood pressure of 160/82 mmHg. The blood test should be completed initially to determine hyperglycaemia. Any cardio-vascular, renal and neurological associations should follow. The use of ACE-inhibitor medication to combat the proteinuria may need an increase in the dosage, although consideration of the immediate side-effects would be more important.

Cardiology. A man aged 67 who had a sudden onset of chest pain and shortness of breath may require an aortic dissection. However, oxygen therapy is a priority, followed by pain relief with diamorphine. Later, a chest X-ray will determine if there is enlargement of the mediastinum. Lean will eliminate waste by enforcing the use of chest computed tomography, which is more reliable diagnostic tool. Clearly though, because of the threat of death, urgent surgical intervention of aortic dissection would be required.

Renal medicine. A 64 year-old man presented at accident and emergency with diarrhoea, vomiting and renal impairment. Intravenous access should be performed immediately, for example, to allow urea and electrolyte determinations. There may be a need for salt supplementation. Measurement of blood pressure, pulse and urine output will be monitored hourly. If the hyponatraemia is <20 mmol/L a diagnosis of pre-renal failure would be easily reversed.

Cost categories in health care include visits to the practitioner (GPs, specialists or pain clinics), diagnostic tests (e.g. computed tomography scan, ultrasound or electromyography) and other services (e.g. acupuncture, transcutaneous electrical nerve stimulation). The cost of the training programmes for GPs is also important [28]. For instance, the increase in costs due to the higher number of visits by GPs was more than offset by the reduction in specialists' visits and visits to pain clinics [28]. Cost-savings were particularly sensitive to variations in unit costs, use of tests or services at each visit, the proportion of patients achieving pain control and the proportion of patients receiving pharmacotherapy [28]. The shift from specialists to GPs remained less costly in all scenarios [28].

ECONOMIC ANALYSES

Direct costs would include those for the interventions, blood products, treatment of wound infections, and treatment of transfusion-related disease and complications [29]. A comprehensive analysis would include the costs of surgery (identical for all patients) and hospitalisation (length of stay data were not available for all groups) [29]. If a breakdown of cost items is given, the unit costs and the resource quantities should be clearly denigrated. Discounting may be relevant for long-term costs per annum [29].

In *orthopaedics*, the cost-effectiveness of alternative bearings for total hip arthroplasty (THA) was highly dependent on the age of the patient at the time of surgery, the cost of the implant, and the associated reduction in the probability of revision relative to that associated with conventional bearings [30]. Hard-on-hard bearing surfaces such as ceramic-ceramic and metal-metal couples could be cost-saving for patients under the age of 63 years, while less costly bearing surfaces, such as highly cross-linked polyethylene, could be cost-saving for patients up to 70 years of age [30].

In *respiratory medicine*, the actual costs of acquisition of surfactant if annual expenditure is used instead of hospital charges, removal of pharmacy and nursing costs will be excluded [31]. The costs of a paediatric intensive care unit (PICU), bed/day and hospitalization are related to the group diagnosed, the average length of stay parameters, and estimated average wage-adjusted cost [31]. Costs of transfer between specialist units need to be predicted; the speed at which this occurs depends upon availability of an intermediate care unit, level of acuity manageable in the general wards, and unique paradigms [31]. If baseline risks are computed on the basis of acute hypoxemic respiratory failure alone, then stratification of risks based upon improved oxygenation at entry, will allow estimates of costs and outcomes related to baseline severity of oxygenation defects [31].

Another study argues that kinetic therapy is useful for preventing lower respiratory tract infections (LRTI), and is cost-effective if there is an attenuated incidence of nosocomial pneumonia and other disease [32]. In the USA, the average cost saving was $6,695/patient pa in comparison with an average intensive care unit bed. One can calculate the savings on incremental cost to avoid infection per 1,000 patients by dividing the total cost by the number of reduced infections [32]. It is also useful to calculate the costs of particular therapies specifically as: the cost per gram (hospital acquisition) x prescribed daily dose by weight of injection [33]. One would need to add the costs of personnel and disposable resources.

The authors found that ceftriaxone was the most cost-effective for treating patients with LRTIs [33].

In *diabetes*, the treatment of type 2 incorporates a computed costing that related to input parameters that altered the total costs by at least 10% following their change up to 90% of original input values [34]. In-patient cost parameters that were greatly affected, included annual admission rates, average length of stay, and the unit costs per bed day [34]. Outcome input parameters with the most significant impacts at diagnosis included the mortality non-cardiovascular disease rate, and the coronary heart disease complication rate [34]. In-patient costs may include the computed admissions per year/1,000, the average length of stay, the unit costs of admitting a patient, and the cost per bed day. Out-patient costs may include attendances/1,000 for 4 years, and the cost per attendance of different specialities. GP consultation costs may include the average cost per consultation and the average number of consultations per annum. The prescription costs include the average number of prescriptions per year and the average cost per prescription [34]. Within defined percentage alterations, new total costs can be computed against which real costs incurred may be compared [34], for instance:

	% alteration of initial in-patient admission rates value					
	90% decrease	60% decrease	30% decrease	30% increase	60% increase	90% increase
New total costs (£m)	25.13	28.43	31.74	38.34	41.64	44.95
% change from initial UK total costs	-28	-19	-9	9	19	28

Significant alterations in outputs occur as a consequence of further adjustments to the in-patient length of stay, out-patient attendances, and the average number of annual prescriptions [34], as shown below:

Input	New upper % increase of initial UK parameter value presented on charts	% change of total costs
In-patient length of stay	237	74
Out-patient attendances	185	27
Prescriptions per annum	249	33

In children suffering from type 1 diabetes mellitus, out-patient or home-based management may avoid the stress associated with a hospital stay, could provide a more natural learning environment for the family, and may reduce costs to the health care system and family [35].

In diabetic patients, the optometric costs of retinopathic screening are important. In established retinopathic screening centres, the staff need to comply with specifically-agreed protocols. Patients should be encouraged to attend screening clinics which provide second grading, quality assurance and results reporting. The optometrist must inform the patient's GP of any results [36]. An assessment of short-acting insulin analogues forms part of a comprehensive cost-assessment of a clinic specialising in diabetes treatment [37]. One would need to assess the impacts of health care costs during treatment regimes beyond 12 months. Long-acting insulin analogues (LAIAs) do not show clinically important differences in glycated haemoglobin, a widely-used marker of blood sugar control in diabetes [38]. Substantial investment is needed to publically fund LAIAs. Economic arguments for this investment, however, are limited as they are based on unproven assumptions concerning the long-term benefit of therapy [38].

The direct costs inherent in the post-partum screening for diabetes include those relating to screening tests, doctor visits, administrative costs for scheduling a visit, laboratory costs and patient time [39]. Screening every three years with oral glucose tolerance tests results in the smallest costs per case of detected diabetes.

Relating to cost-effectiveness are key assumptions in the quality of life utility from inhaling rather than injecting insulin, the effect of the inhaled option on the willingness to begin insulin treatment in patients with a poor diabetic control of oral medication, and the effectiveness of glycaemic control [40]. During inhalation, a larger amount of the drug is needed, and the cost per dosage ranges from £600->ä1,000/patient/pa. [40].

In *cardiology*, management of hypercholesterolemia may include direct costs of a doctor's visit, the laboratory analyses and the costs of lipid-attenuating medication [41]. Specific costs incurred to prevent one death from hypertension was €6,230.71 with chlorthalidone, €70,369.96 with propranolol, €105,596.72 with amlodipine, €75,301.40 with enalapril, and €158,659.35 with losartan [42]. Following the consideration of other costs (laboratory tests, clinical visits, side effects, and switch to other therapies), the costs of chlorthalidone and losartan were reduced to less than three-fold [42]. It is important to determine the effects of medication in attenuating the incidence of disease in order to justify cost expenditure. One study revealed that ACE inhibitors were associated with a reduction in cardiovascular mortality (RR 0.851, 95% CI: 0.741, 0.977; 4 studies; p=0.022), fatal and non-fatal myocardial infarction (RR 0.792, 95% CI: 0.685, 0.916; 3 studies; p=0.002), and the need for invasive coronary revascularisation (RR 0.860, 95% CI: 0.762, 0.971; 2 studies; p=0.015) [43].

In *renal medicine*, it is important to estimate the clinical- and cost-effectiveness of machine perfusion (MP) *vs.* cold storage (CS) to determine the preservation of prior-transplanted kidneys [44]. The relative risk of delayed graft function (DGF) is also important. The authors suggest that the economic assessment is difficult in UK due to difficulties in obtaining complete cost recovery from a reduction in DGF [44]. Randomised controlled trials (RCT) may be used to compare the different treatments for kidney transplant recipients, which may suggest that treatment with a bisphosphonate, vitamin D sterol or calcitonin following renal transplantation may protect against immunosuppressant-induced attenuation in bone mineral density, and avoid fractures [45].

THE PULL STRATEGY

A pull strategy at work results in the pulling of people and skills, materials and information towards its functional entities when required. Within a healthcare perspective this includes the processes of admission, diagnosis, treatment, discharge, support processes, pathology, radiology, pharmacology, central sterile supplies department (CSSD), laundry, etc. [5].

In the lean ideal, patients are 'pulled' through the system at a rate that keeps pace with demand. Discharge pulls patients from wards, which in turn pulls patients from surgeries and admissions, whilst pulling aligns with processes from support departments, all attenuating wasted time or effort [5]. Organisational resistance and deeply entrenched ways of thinking among employees need to be addressed to find the right balance between innovation and complexity [46].

STAFF ROLES

Lean uses value to determine the effectiveness delivered, value streams, flow by improving the value stream, pull via triggering every flow from actual demand, perfection through continuous regular improvement, understanding the difference between work and waste, considering the human resources as valuable, innovative and powerful, realising and deciding what is wrong with current operations, and embedding improvements in organisational culture [5]. For example, to speed up the process in a queue of patients, nurses might approach the next in line while somebody in front is still being served. Nurses form an integral part of the process as they are directly involved with patients and their families [47]. This is particularly important in the care of the elderly and children. For example, in a renal dialysis unit, parents should be trained in how to set up the dialysis facility, empty urine trays and adjust seating. Parents can entertain their children with toys and games during the procedure. The more helpful the nursing staff, the better impression created of a health care facility. However, the hospital needs to ensure that staff are not over-worked and tired as this can lead to irritability, giving the impression of rudeness. One study showed that appointing a full-time staff support coordinator in a community trust reduced absence, offered confidential interviews, necessitated the attendance of no more than two sessions, and acting as a mediator in situations of staff conflict [48]. We propose that the outcome of this process is to minimise conflict, strengthen inter-professional partnership working, and foster collegiate relationships with doctors. If there are problems, these should be brought to light and dealt with professionally. British staff should be trained in cultural awareness, especially because many doctors come from abroad and may speak with a heavy accent, e.g. Poland, Pakistan, India and Russia. In this regard, there should be a flattening of hierarchy and a shared vision in which each member's contribution is valued and acknowledged. Each one should be mutually supportive of the others, and together they can increase efficiency and accuracy in the workplace. In a neuropathic pain management unit, for example, at Russell's Hall in Dudley, UK, the use of a spinal morphine-injecting pump is sometimes essential. In the diagnostic area, support for the patient may be via musculo-skeletal testing by a medical-laboratory technician. These roles will lessen the pressure on the consultant during ward rounds. In order to allocate nursing staff to the patients efficiently, one nurse should assist the consultant to re-fill the spinal pump via abdominal injection once the insertion pad is located. Staff in all roles should be cognisant of the need for medical research, and should support PhD students and academics.

TOOLS ASSISTING THE ATTENUATION OF WASTE

The logic of lean thinking includes identifying and eliminating waste, the involvement people at all levels, and the annual application of efficiency and effectiveness improvements [5]. Within the context of healthcare, a lean six sigma approach has been recommended, using a systematic innovation effort to remain competitive, cost efficient and up-to-date [49]. The authors advocate that this approach places a better control on rising healthcare costs, improves quality and provides better service to patients. It should, however, be noted that although an overview of healthcare applications have been proposed [50], the six sigma approach is still in its infancy [51]. In ensuring management success and a smooth transition into the arena of lean thinking, the processes of overall coordination through regular meeting, linked processes (admission/discharge); establishing small batch sites (reduction in number of ward rounds), and solving the space issue via use of prediction and escalation concepts [5].

Tools commonly prescribed to encourage and monitor the lean thinking process include Just in Time (JIT), pull production and mistake proofing [50, 52]. Additionally, a six sigma control system may be adapted for better control of increases in healthcare costs, improved quality, and providing better healthcare [53]. Lean and six sigma are certainly quality and process improvement techniques with significant applications in diagnostic laboratories. Ultimately, they are employed to eliminate waste in the operational functions of an organisation.

In a study comparing the cost and benefit outcomes achieved from a health care JIT implementation with those realised by manufacturing, service and retail industries, it was found that it is necessary for a restructuring of the health service market in order to encourage greater price competition among priorities, and the elimination of duplication of products, thereby achieving substantial savings [54]. Hospitals have been slow to adopt JIT, continuous replenishment and supporting technology, such as like bar coding and radio frequency. This has resulted in the negation of significant cost advantages [55]. Just in Time ensures continuous improvement via the encapsulation of constantly changing objectives and removal of rigid procedures [56]. Just in Time therefore ensures enhanced utilisation of resources (employee involvement, reduction of waste) and long-term success (customer focus, vendor partnerships) [56]. JIT focuses on simplifying the total business operation and execution of business processes [57]. If a pull strategy is also applied to healthcare, it should ensure that patients are rapidly and efficiently treated [5].

Excessively complicated procedures within a healthcare organisation contribute to variation and unnecessary mistakes. Mistake proofing utilises the best methods for controlling variation, mistakes and complexity, which ultimately significantly reduces costs [58]. Mistake proofing principles facilitate improvement in product quality and reliability, via six sigma conceptualization [59].

CONCLUSION

Lean thinking provides one important way for resolving, in the long-term, the qualms experienced by health care organisation. As a tool it is important strategically for effecting a reduction in costs, and achieving a high turnaround using

the same staff and processes, but in a more effective manner. Although the UK healthcare system is in need of change, the principles of lean could easily be applied globally.

The benefits of using lean thinking include increasing productivity, reducing waiting times, lowering costs, and improving safety and experiences of patients and staff [5]. Lean thinking provides an overall philosophy and a way of setting priorities, has a body of evidence-based tools and techniques, encompasses a vibrant lean and quality community willing to share experiences and expertise, and focuses on safety and quality from the patient's perspective. Ultimately, lean strategy enables these functions to be delivered at low cost. It also focuses on the design of patient-focused care. In the context of national health provision, embedded lean theory is an opportunity to achieve progress within an organisation via a try and test approach, which itself takes time to embed. Indeed, it will not provide a 'quick fix' for all ills, but it promises to deliver significant improvements over the medium to long term. The potential for continuous improvement is therefore genuinely very great.

Lean provides careful and rigorous ways of arguments for changes in practice. It is unlikely to be easy due to barriers and walls created, respectively, by resistance to change and laggards, and requires a strong, determined leader to drive it forward to success. An organisation should not fall into the trap of rearranging its function simply in order to give the impression of active change. Rigidity of management in the lean process should be avoided as this only results in the creation of a negative working atmosphere in the workplace.

CONFLICT OF INTEREST

None recorded.

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REFERENCES

1. Boaden R: Quality improvement in healthcare. In: Walshe K, Smith J (eds.). 'Healthcare Management', Berkshire, *Open University Press* 2006, 454-478.
2. Ben-Tovim DI, Bassham JE, Bolch D, Martin MA, Dougherty M, Szwarcbord M: Lean thinking across a hospital: redesigning care at the Flinders Medical Centre. *Aust Health Rev* 2007, **31**, 10-15.
3. Kelly AM, Bryant M, Cox L, Jolley D: Improving emergency department efficiency by patient streaming to outcomes-based teams. *Aust Health Rev* 2007, **31**, 16-21.
4. King DL, Ben-Tovim DI, Bassham J: Redesigning emergency department patient flows: application of Lean Thinking to health care. *Emerg Med Australas* 2006, **18**, 391-397.
5. Jones D, Mitchell A: Lean thinking for the NHS. *NHS Confederation,* London 2006.
6. Cowper A: In the driving seat. *Health Manag* 2006 (July/Aug), 20-21.
7. Ben-Tovim DI, Bassham JE, Bennett DM, Dougherty ML, Martin MA, O'Neill SJ, Sincock JL, Szwarcbord MG**:** Redesigning care at the Flinders Medical Centre: clinical process redesign using 'lean thinking'. *Med J Aust* 2008, **188(6 Suppl),** 27-31.
8. Ieraci S, Digiusto E, Sonntag P, Dann L, Fox D: Streaming by case complexity: evaluation of a model for emergency department Fast Track. *Emerg Med Australas* 2008, **20(3),** 241-249.
9. van Lent WA, Goedbloed N, van Harten WH: Improving the efficiency of a chemotherapy day unit: Applying a business approach to oncology. *Eur J Cancer* 2009, **45(5)**, 800-806.
10. Young TP, McClean SI: A critical look at Lean Thinking in healthcare. *Qual Safe Health Care* 2008, **17(5),** 382-386.
11. Cooper RG, Mohabeersingh C: Lean thinking for medical practices. *JPCCR* 2008, **2(1),** 1-10.
12. Carvel J: Straight to the specialist: Johnson cuts GP referrals. *The Guardian* 2008, 21 Oct. Available at: http://www.guardian.co.uk/society/2008/oct/21/health-health/print
13. Lau EWL, Leung GM: Is the Hospital Authority's drug formulary equitable and efficient? *Hong Kong Med J* 2008, **14**(5), 416-417.
14. Anonymous: Five principles can encourage organisations to 'think lean'. *Perform Improv Advis* 2004, **8**, 94-95.
15. Long JC: Healthcare Lean. *Mich Health Hosp* 2003, **39**, 54-55.
16. Jackson PR, Mullarkey S: Lean production teams and health in garment manufacture. *J Occup Health Psychol* 2000, **5**, 231-245.
17. Goree M: Thinking strategically. *Mich Health Hosp* 2002, **38**, 8-11.
18. Womack JP, Jones DT: Lean consumption. *Harvard Bus Rev* 2005, **83**, 58-68.
19. Ben-Tovim D: Seeing the picture through 'lean thinking'. *BMJ* 2007, **334**, 169.
20. Vincent C: Incident reporting and patient safety. *BMJ* 2007, **334**, 51.
21. To Err is Human: building a safer health system. *National Academy of Sciences,* Washington 2000, 8 pp.
22. Jones DT, Filochowski J: Lean healthcare. Think yourself thin. *Health Serv J* 2006, **116 (Suppl. 6-7).**
23. Mathieson S: Lean healthcare. Wait watchers. *Health Serv J* 2006, **116(**Suppl. 4-5), 7, 9.
24. Crompton P: Modernizing medical photography, part 2. *J Vis Commun Med* 2005, **28**, 6-12.
25. Panning R: Using data to make decisions and drive results: a LEAN implantation strategy. *Clin Leader Manag Rev* 2005, **19**, E4.
26. Hill B: Lean and mean. 2007. Available at: http://www.labnews.co.uk/laboratory_article.php/1551/5/lean-and-mean. Accessed 27 Jan 2009.
27. Womack JP, Jones DT: Lean Thinking. *Simon & Schuster,* New York 1996.
28. Berger A, Kramarz P, Kopperud G S, Edelsberg J, Oster G: Economic impact of shifting the locus of care for neuropathic pain from specialists to general practitioners. *Eur J Health Econ* 2007, **8**, 245-251.
29. Vitale MG, Roye BD, Ruchelsman DE, Roye DP: Preoperative use of recombinant human erythropoietin in pediatric orthopedics: a decision model for long-term outcomes. *Spine J* 2007, **7(3),** 292-300.
30. Bozic KJ, Morshed S, Silverstein M, Rubash HE, Kahn JG: Use of cost-effectiveness analysis to evaluate new technologies in orthopaedics: the case of alternative bearing surfaces in total hip arthroplasty. *J Bone Joint Surgery* 2006, **88(4**), 706-714.
31. Thomas NJ, Hollenbeak CS, Lucking SE, Willson DF: Cost-effectiveness of exogenous surfactant therapy in pediatric patients with acute hypoxemic respiratory failure. *Pediatr Crit Care Med* 2005, **6(2**), 160-165.
32. Mullins CD, Philbeck TE, Schroeder WJ, Thomas SK: Cost effectiveness of kinetic therapy in preventing nosocomial lower respiratory tract infections in patients suffering from trauma. *Managed Care Interface* 2002, **15(8),** 35-40.
33. Lucioni C, Ravasio R, Concia E: Cost-effectiveness of various antibacterial therapies in hospitalised patients with lower respiratory tract infections. *Pharmacoeconomics – Italian Res Articles* 2001, **3(1),** 37-47.
34. Thomas M: Sensitivity analysis of the DiDACT cost-effectiveness model. M.Sc. Student Placement, Lancaster University. *York Health Economics Consortium*, York 2006, pp. 32, appendices i-xiv.
35. Clar C, Waugh N, Thomas S: Routine hospital admission versus out-patient or home care in children at diagnosis of type 1 diabetes mellitus. *Cochrane Database Systemic Reviews* 2007, **2**, CD004099. DOI: 10.1002/14651858. CD004099.pub2.
36. 'The College of Optometrists Member's Handbook', revised April, amended August, *NHS*, UK 2008, 02.17.1-02.17.2.
37. Banerjee S, Tran K, Li H, et al.: Short-acting insulin analogues for diabetes mellitus: meta-analysis of clinical outcomes and assessment of cost-effectiveness. *Canadian Agency for Drugs and Technologies in Health,* Ottawa 2007, 67.
38. Tran K, Banerjee S, Li H, et al.: Long-acting insulin analogues for diabetes mellitus: meta-analysis of clinical outcomes and assessment of cost effectiveness. *Canadian Agency for Drugs and Technologies in Health,* Ottawa 2007, 62.

39. Kim C, Herman WH, Vijan S: Efficacy and cost of postpartum screening strategies for diabetes among women with histories of gestational diabetes mellitus. *Diabetes Care* 2007, **30(5),** 1102-1106.
40. Black C, Cummins E, Royle P, Philip S, Waugh N: The clinical effectiveness and cost-effectiveness of inhaled insulin in diabetes mellitus: a systematic review and economic evaluation. *Health Technol Assess* 2007, **11(33),** pp. 2.
41. Cobos A, Vilaseca J, Asenjo C, et al.: Cost effectiveness of a clinical decision support system based on the recommendation of the European Society of Cardiology and other societies for the management of hypercholesterolemia: report of a cluster-randomized trial. *Dis Manag Health Outcomes* 2005, **13(6),** 421-432.
42. Stafilas PC, Sarafidis PA, Lasaridis AN, Aletras VH, Niakas DA: An economic evaluation of the 2003 European Society of Hypertension-European Society of Cardiology guidelines for the management of mild-to-moderate hypertension in Greece. *Amer J Hypertension* 2005, **18**(**9),** 1233-1240.
43. Saha SA, Molnar J, Arora RR: Tissue angiotensin-converting enzyme inhibitors for the prevention of cardiovascular disease in patients with diabetes mellitus without left ventricular systolic dysfunction or clinical evidence of heart failure: a pooled meta-analysis of randomized placebo-controlled clinical trials. *Diabetes Obesity Met* 2008, **10(1),** 41-52.
44. Wight J, Chilcott J, Holmes M, Brewer N: The clinical and cost-effectiveness of pulsatile machine perfusion versus cold storage of kidneys for transplantation retrieved from heart-beating and non-heart beating donors. *Health Technol Assess* 2003, **7(25),** pp. 2.
45. Palmer SC, McGregor DO, Strippoli GF: Interventions for preventing bone disease in kidney transplant recipients. *Cochrane Database Systemic Reviews* 2007, **3**, CD005015. DOI: 10.1002/14651858. CD005015. pub3.
46. Gottfredson M, Aspinall K: Innovation versus complexity: what is too much of a good thing? *Harvard Bus Rev* 2005, **83**, 62-71.
47. Jenkins J: Survivorship: finding a new balance. *Semin Oncol Nurs* 2006, **22**, 117-125.
48. Allen C: Human resources. Lean on me. *Health Serv J* 2001, **111**, 32-33.
49. de Koning H, Verver JP, van den Heuvel J, Bisgaard S, Does RJ: Lean six sigma in healthcare. *J Healthc Qual* 2006, **28**, 4-11.
50. Sehwail L, De Yong C: Six sigma in health care. *Int J Health Care Qual Assur* 2003, **16**, 1.
51. Revere L, Black K, Huq A: Integrating six sigma and CQI for improving patient care. *TQM Mag* 2004, **16**, 105-113.
52. Hines P, Holweg M, Rich N: Learning to evolve: A review of contemporary lean thinking. *Int J Oper Prod Manag* 2004, **24**, 994-1011.
53. de Koning H, Verver JP, van den Heuvel J, Bisgaard S, Does RJ: Lean six sigma in healthcare. *J Healthc Qual* 2006, **28**, 4-11.
54. Jarrett PG: An analysis of international health care logistics: the benefits and implications of implementing just-in-time systems in the health care industry. *Int J Health Care Qual Assur Inc Leadersh Health Serv* 2006, **19**, i-x.
55. Scanlin T: A case for 'just in time:' could it be right for your hospital, too? *J Healthc Resour Manag* 1997, **15**, 10-14.
56. Guarriello ML: Just-in-time in the infrastructure. *Hosp Mater Manage Q* 1997, **19**, 68-72.
57. Jacobi MA: How to unlock the benefits of MRP (materiel requirements planning) II and Just-in-Time. *Hosp Mater Manage Q* 1994, **15**, 12-22.
58. Hinckley CM: Make no mistake - errors can be controlled. *Qual Saf Health Care* 2003, **12**, 359-365.
59. Crow K: Mistake-Proofing by Design. *DRM Associates*, California 2007.