Using industrial processes to improve patient care

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Might industrial processes improve quality, reduce waiting times, and enhance the working environment?

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Radical thinking about the design of industrial processes over the last century has greatly improved the quality and efficiency of manufacturing and services. Similar methods to deliver higher quality health care at lower cost would be extremely valuable. In health care, however, we must also consider how patients feel about the processes and the extent to which they are able to exercise meaningful, informed choice.

Although the potential of using industrial methods in health care has been discussed,[1 2] their value is hotly debated. Some doubt that there is a valid analogue between industry and health care, while others see it as an excuse to force an overworked community to work even harder.[3 4] We describe three established industrial approaches—lean thinking,[5 6] theory of constraints,[7] and six sigma,[8 9]—and explore how the concepts underlying each might relate to health care.

Lean health care

Lean thinking started with Toyota in the 1950s and was developed by Womack and Jones.[6] It seeks to provide what the customer wants, quickly, efficiently, and with little waste (box 1). An obvious application to health care lies in minimising or eliminating (within a framework of clinical excellence) delay, repeated encounters, errors, and inappropriate procedures. Some conceptual issues that arise in relating lean thinking to health care include the extent to which patients, service providers, or even taxpayers equate to customers in the commercial setting and the way in which health outcomes, patient satisfaction, or even cost can be legitimately used to define value. Furthermore, although the routes followed by items in a manufacturing process are clearly defined, those followed by individual patients depend on clinical judgments at various stages, which may complicate a rigorous analysis.

STEVEN POETZER/PHOTONICA

The NHS could learn from methods to improve industrial processes

Box 1: Five key concepts for lean thinking[5 6]

Value—Products should be designed for and with customers, should suit the purpose, and be set at the right price

Value stream—Each step in production must produce "value" for the customer, eliminating all sources of waste. The concept of waste is far reaching and may include waiting, travel, mistakes, or inappropriate processing

Flow—The system must flow efficiently, ideally without intermediate storage. Among other things, flow depends on materials being delivered, as and when they are needed, to the quality required

Pull—The process must be flexible and be geared to individual demands—producing what customers need when they need it

Perfection—The aim is perfection. Lean thinking creates an environment of constant review, emphasising suggestions from the "floor" and learning from previous mistakes

Although lean thinking in industry often results in staff reductions, it first creates extra capacity by identifying and eliminating wasted resource. Indeed, one of the key problems Womack and Jones[6] discuss is how to maintain the morale of a workforce that has just been reduced because the product can be made with fewer people. A lean environment will thus have sufficient capacity to handle variations without introducing queues.

Maternity care, notable for the absence of waiting lists, already exhibits some lean characteristics. These include a strong focus on the pathways of mother and child and responsiveness to their needs. Although it is probably better funded than other parts of the system, delivering care without queues is still an important achievement.

A practical challenge is to disentangle actual patient pathways and obtain a clear picture of journeys that loop back on themselves and bounce across boundaries between primary and secondary care. The different types of record kept by each sector make it difficult to piece whole trajectories together so complete data on patient flows are sparse.

A second challenge is to deliver care under a truly lean model. Although it might be possible to identify a better pathway, it may not be clear how to resource it. For instance, rigorous elimination of all waiting in accident and emergency departments would free up the waiting room and triage staff and release time spent interacting with waiting patients and their friends. However, it is less clear how this extra resource could be deployed to ensure that queues would not develop. A way to clarify this is to use computer simulation to describe the sequential activities and interactions of patients and evaluate the effects of different interventions. Graphical output makes these models seem more realistic, and systems could be developed to allow staff to interact with the simulations through role play. We call this interactive, or gaming, approach scenario simulation (see below).

Theory of constraints

The theory of constraints began with a simple concept about production lines, similar to the idea that a chain is only as strong as its weakest link.[7] Later, this developed into a set of thinking tools to tackle problems in business, politics, and even marital breakdown. The methodology targets bottlenecks (box 2) or constraints; it is an appealing theory because it is easy to see that queues go with bottlenecks and that removing one bottleneck may well create another.

The location of healthcare bottlenecks is not obvious, and a rigorous analysis would make an important contribution. Wolstenholme developed a model to test alternatives for relieving pressure on health services at the interface between primary and secondary care.[10] He showed that providing additional intermediate care enabled hospitals to discharge patients more quickly and was more effective at increasing overall throughput than providing extra hospital beds. The National Audit Office, however, identified hospitals themselves as blocking some discharges,[11] and a study by Feachem et al suggested access to primary care might be a bottleneck.[12]

An interesting strategic perspective is that there will always be a bottleneck; the decision is where you want it. The idea of designing a system with the bottleneck placed where it can best be managed or responded to is powerful. Another perspective is that anything that increases throughput at the bottleneck, almost without regard to cost, adds value to the system so long as it is safe. Away from the bottleneck, idleness of a resource (such as unused equipment) costs nothing. Take the example of a ward associated with an operating theatre, in which the operating theatre is the bottleneck. A traditional view might encourage filling the ward. However, nothing would be gained (and indeed operational losses would be made) by putting more patients on the ward than the theatre could process. Thus, the theory of constraints solution is to lower ward occupancy to match the theatre's throughput, even if a proportion of the resources (heating, lighting, fixed staff costs, etc) seems to be wasted in consequence.

Box 2: Five steps of theory of constraints[7]

Identify the system constraint. Although a system will have many processes, few will represent a constraint to the overall system. The more complex the system, the more likely it is that there will be a single, overall bottleneck

Get the most out of the constraint since it determines system throughput. The entire value of the system is represented by what flows through the bottleneck. For instance, you would want to keep the bottleneck working all the time, since your whole system is idle if the bottleneck is idle

Support the constraint by making it only do work that cannot be done elsewhere

Elevate it within the system so that all other parts work to help it

Return to step 1 because a different process may have become the constraint

Box 3: Six sigma[8 9]

Six sigma begins with a detailed survey of critical customer requirements by senior management, whose visible leadership is vital. Expert leaders identify critical activities, and a cross functional team implements a four phase methodology (access to automated information is important to making six sigma work)

Measure—Identify process defects that influence critical customer requirements and collect defect data

Analyse—Analyse these data to identify opportunities for defects, and the variables that cause them

Improve—Quantify the impact of these variables and determine acceptable ranges—one sigma, two sigma, etc (most companies are at the three or four sigma level). Identify and make the changes necessary

Control—Monitor process performance using statistical process control tools

Six sigma

Six sigma was developed by Motorola in the late 1970s as a universal system to assess quality, produce quantifiable results, and establish quality goals (box 3).[8 9] Sigma represents the statistical standard deviation from the mean in a normal distribution, and six sigma is usually defined as 3.4 defects per million.

Six sigma requires good data, clearly defined critical outcomes, and agreement on what constitutes a defect—a real challenge in health care. In health care the model must also include the clinicians' and other stakeholders' perspectives and clarify who the customer is. The key issue is not the number of errors but having a systematic process to identify the sources of error and drive them down. In some cases, it may be possible to implement this approach directly—for example, prescribing. Computer generated prescriptions (11% errors) were eight times more accurate than hand written forms (88% errors) in a recent hospital based study.[13] Procedures such as organ transplants might be more difficult to assess because failure is related to the patient's characteristics as well as to the operator. However, high throughput procedures, such as knee replacement, might benefit from the approach.

These approaches are not identical in their methods or in the insights afforded. For example, lean thinking and theory of constraints present different perspectives on the use of capital intensive resources. For example, if a scanner is expensive, the natural response would be to try to scan as many people as possible with each one. However, lean thinking shows that high efficiency is only part of the story and that in many cases the cost of moving people from unit to unit, together with the waste involved in looping back through systems, in waiting for a slot, in unnecessary procedures, or in remedial action, often undermines and outweighs any savings made through high utilisation. On this basis, if an expensive piece of equipment supports more effective and efficient pathways, its cost may be justified even if utilisation is low. Theory of constraints, in contrast, focuses on relieving bottlenecks rather than agonising over apparently wasteful idle resources.

Scenario simulation

In most of the examples mentioned above solutions cannot be implemented without evaluation because of the high risks associated with failure. A clear idea is also needed of how the methods would translate before the putative benefits can be realised. One way to identify the potential of specific industrial and commercial philosophies is through computer simulation.[14] Military strategists, with their synthetic environments probably lead the field.[15] Box 4 provides an example of simulation for screening[16] and shows how it could be extended to a scenario simulation. Accessible tools for large scale scenario simulations have not yet been developed. Currently available scenario games, such as Theme Hospital,[17] are intended for home entertainment and lack the analytical power and operational (not to mention clinical) perspective for such applications. However, simulation based approaches could be developed to provide intellectual underpinning to a promising agenda, anchoring the benefits of progress before the tide changes and a new wave of initiatives sweeps over the system.

Conclusions

The three methodologies described here have common features. Each emphasises the concept of production as a complex interaction of individual activities and recognises that, for production to be efficient and effective, it is necessary to coordinate and balance activities, identify those that constitute weak links or bottlenecks, and take appropriate remedial action. All approaches require strong leadership, adopt algorithmic approaches to problem solving based around iterative improvement, and promote the participation of people in all parts of the system. In the context of health care, these perspectives imply that we should not expect to invent systems that work perfectly immediately but rather that a process of gradual improvement should be designed into them, with all stakeholders participating in the improvement process. Most radically, this might include patients themselves.

Box 4: Scenario simulation for screening for diabetic retinopathy

Current provision of screening for diabetic retinopathy varies widely between regions. No consensus exists about the staff, settings, or methods for primary screening. There is also disagreement about the appropriate screening intervals. A simulation model provided a flexible environment in which to test a wide range of scenarios, which would have been impossible to compare by practical experimentation.[16]

In a gaming extension to this simulation, various stakeholders (doctors, nurses, managers, patients, etc) could interact with the simulation. They could, for example, make decisions about the different locations, timing, and providers of services. The players could see the effect of such decisions on their peer group and other communities and respond accordingly. Resultant policy decisions would thus be made with a much fuller understanding of the probable benefits and drawbacks to all involved

Summary points

An array of industrial and commercial process philosophies could be useful for those seeking to modernise the NHS

If these can be applied effectively to health care they could improve quality of care, reduce waiting times, and provide a less stressed working environment

Strategic simulation of healthcare delivery could be useful to test the effects of commercial models on the NHS

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Contributors and sources: TY has 16 years' industrial experience including research and development (communications) and healthcare strategy. SB, CC, and JH have many years of experience in the application of a range of management approaches, both quantitative and qualitative, to healthcare applications. RD is an expert in health services research and has developed and used simulation approaches for the assessment of policies relating to specific populations, such as those with coronary heart disease or diabetes. PH has worked on numerous applications of stochastic modelling in health services research, including workforce planning, bed capacities, diabetes, and HIV.

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