Koskela, Lauri, Rooke, John, Codinhoto, Ricardo and Kagioglou, Mike

Do we need one science of production in healthcare?

DO WE NEED ONE SCIENCE OF PRODUCTION IN HEALTHCARE?

L. Koskela[1], J. Rooke[2], R. Codinhoto[3] and M. Kagioglou[4]

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ABSTRACT

The question addressed is: Is there need, in health care, for one consolidated science of production? For responding to this question, the classical science of production is reviewed and the current approaches to production and service in healthcare are analysed as for their evolution and current status. It is found that these current movements are not self-aware of the restrictions deriving from their backgrounds, and of the resultant partiality in their approaches. It is concluded that improvement of healthcare is slowed down by the fragmentation of the related disciplines; thus one consolidated science of production (of healthcare) is needed.

KEYWORDS

Evidence-based healthcare, improvement science, lean healthcare, service science, production science

1 INTRODUCTION

In the world of healthcare, there is an increasing recognition that excellent medical care cannot be provided only through clinical knowledge and skills, backed up by technology and pharmaceutical knowledge, but also knowledge and skills about the practical business of organizing and providing care, that is, about healthcare as production and service, are needed. The current popular movements towards this purpose include especially lean healthcare, improvement science, and evidence-based management. Interestingly, there is now a young movement towards the development of a generic service science, which obviously in

[1] Professor, School of the Built Environment, University of Salford, l.j.koskela@salford.ac.uk

[2] Research Fellow, HaCIRIC, University of Salford, j.a.rooke@eml.cc

[3] Lecturer, School of the Built Environment, University of Salford, r.codinhoto@salford.ac.uk

[4] Professor, School of the Built Environment, University of Salford, m.kagioglou@salford.ac.uk

principle covers also healthcare.

This somewhat mixed bag of current approaches contrasts to the situation in Antiquity and still during Renaissance, when medicine was seen to fall into *techne*, the Aristotelian science of production. Would we still benefit in healthcare from one consolidated science of production?

For responding to this question, the classical science of production is reviewed and the current approaches to production and service in healthcare are evaluated as for their evolution and current status. Then the findings are discussed, and concluding remarks are provided.

2 THE ARISTOTELIAN SCIENCE OF PRODUCTION: *TECHNE*

Aristotle proposed three sciences: **contemplative** (or theoretical) science, **practical** science and **productive** science. Theoretical knowledge is pursued for the sake of truth. The practical sciences are concerned with how we should act in various situations. In turn, the science of production is oriented towards the making of useful or beautiful objects. Poetry, medicine, and house-building were given as examples of fields covered by the productive sciences. An important difference between theoretical science, on the one hand, and practical as well as productive sciences, on the other, is that the former studies universals, invariable things, whereas the latter focus on particulars, variable things[5].

Aristotle presents an account (in current terminology, theory) of producing, consisting of thinking and making. This thinking – Aristotle uses also the term deliberation – compares to what we now understand under designing and planning. The key statement on the theory of production is in Nicomachean Ethics: "*For the person who deliberates seems to investigate and analyse in the way described as though he were analysing a geometrical construction...*"

The broad similarity suggested here between designing (and making) and the method of analysis in geometry is a potentially powerful analogy, as the geometric method was sophisticated and well defined already at this time. The central idea in design (modelled according to geometric analysis) is to assume the sought thing already realized and to reason backwards to identify means for how it could be produced until one comes to something at hand or possible to acquire, i.e. the means that are necessary to produce it and the relationships amongst those means; this is the analysis stage. Then, starting from these means, the sought

[5] In the field of theory of knowledge, a more modern distinction is between Knowing That and Knowing How (O'Brien, 2006; Morton, 2008). Knowing that refers to theoretical knowledge, explanations and facts. For someone to know that, the criteria of justification, truth and belief must be satisfied. In contrast, knowing how does not necessarily require knowledge of fact or theory (Morton, 2008).

thing is progressively constructed; this is the synthesis stage.

In Metaphysics, Aristotle gives an example related to medicine on the use of the method of analysis:

The healthy subject is produced as the result of the following train of thought:- since this is health, if the subject is to be healthy this must first be present, e.g. a uniform state of body, and if this is to be present, there must be heat; and the physician goes on thinking thus until he reduces the matter to a final something which he himself can produce. Then the process from this point onward, i.e. the process towards health, is called a 'making'.

Of central importance for Aristotle's scientific project was his doctrine of four causes (Falcon 2011): formal (the form), material (that out of which), efficient (the primary source of the change or rest) and final (the end, that for the sake of which a thing is done). Out of these, the final cause had the explanatory priority (ibid.). Each science was expected to produce knowledge about causes. Especially, regarding production science, master craftsman knows the cause, reasons why things are done as they are done, whereas an artisan is without this knowledge (Parry 2007), acting on experience.

However, there is a tension between (universal) causal knowledge and experience gained through particular cases. In the beginning of Metaphysics, Aristotle suggests that doctors having only experience may be more successful in treating patients than those having only a theoretical understanding. This is because "it is the particular that must be treated".

In contrast to theoretical and practical sciences, Aristotle wrote very little about productive science. One contributing factor for this was that in ancient Greece, the technical arts were taken care of by slaves, and the productive science was considered inferior to the two other sciences (Katz 1990). Nevertheless, the idea of productive science and its contents were passed down in Antiquity. This is demonstrated in the works of Galen (129 – c. 210 AD), who wrote on medicine and philosophy. Galen made an explicit connection between the method of geometry and the therapeutic method (Grant 1989), which he saw as falling into *techne*. Similarly to Aristotle, Galen (1991) held that the starting point of medicine is health.

However, apparently because of the collapse of the Western part of the Roman empire, and the scarcity of scholars mastering Greek, this understanding of *techne* seems not to have been widely passed on to the following generations of scholars.

Among the rare scholars addressing *techne* is the Renaissance Aristotelian philosopher Zabarella (1533 – 1589), who returns to the question of the differences between contemplative science and practical and productive arts. According to his view, science deals with what already exists, but arts are concerned with creation (Mikkeli 2009). In discussing whether medicine falls into natural philosophy or arts, he concluded that natural philosophy must consider the universal qualities of health and sickness, while the art of medicine concentrates on finding remedies for particular diseases.

However, besides Zabarella, it is difficult to find other Renaissance treatments of *techne*. The Enlightenment was set into movement by the progress of natural science – rooted in Aristotle’s theoretical science. The other two sciences of Aristotle were overshadowed, and his authority challenged (Gilbert 1967). As a consequence, by the 20th century, the idea and full scope of productive science seem to have been almost disappeared. However, there have been isolated attempts to revive or utilize techne as a useful element in medicine (Phillips 2002).

3 CURRENT APPROACHES AND THEIR EVALUATION

3.1 Improvement science

Quality Management, often referred to as improvement science, originated in the work of Shewhart (1931). It is credited with a major contribution to the US war effort in the 1940's and the success of Japanese manufacturing in the latter half of the Twentieth Century (Hunter 1992). Despite early fears that it was simply a management fad, practitioners have been found to share theoretically and empirically grounded principles (Hackman & Wageman 1995). The approach has been widely applied in health care settings, supported by organizations such as the Institute for Healthcare Improvement, the United States Agency for International Development, the Health Foundation and the NHS Institute for Innovation and Improvement.

The starting point for improvement science analysis is customer requirements. These are converted into specifications that provide a measure for the performance of a given (determined and stable) standard process. Controlling variation from these specifications is the purpose of quality management (Shewhart 1931; Koskela 2000).

Statistical process control (SPC) is the central technique of quality management, a key tool being the control (or run) chart, which allows the detection of changes in the statistical composition of a process. A key advantage of SPC over other statistical methods is that it allows analysis of changes over time, rather than providing a static atemporal picture. The observed variation is analysed into ‘common cause variation', attributable to systemic causes and 'special cause variation' attributable to some change in the system, whether a deliberate intervention, a human error, or other cause. Benneyan, Lloyd & Plsek (2003) provide a clear and detailed account of the application of the technique in health care settings. In the context of healthcare, increasingly sophisticated methods of SPC have been developed, such as the use of risk adjusted cumulative sum charts, as a means of detecting special cause variation in treatment or waiting times (Gandy et al 2010). A recent literature review concluded that *"[s]tatistical process control is a versatile tool which can help diverse stakeholders to manage change in healthcare and improve patients' health*" (Thor et al 2007:387).

A standard set of tools exists to further analyse the causes of variation, including Juran's adoption of the Pareto principle for prioritising problems and Ishikawa's fishbone diagram to aid the analysis of cause and effect. These are employed within the context of an experimental method or learning cycle known variously as the Shewhart, Deming, PDCA or PDSA cycle. These terms all refer to a scientific procedure in which an intervention is planned on the basis of available evidence, carried out and monitored. The results of the intervention are then used as the basis for planning further action. This procedure may be carried out by more or less ad hoc quality improvement teams or by more permanent quality circles. In both cases, it is important that cause and effect are treated as existing within the context of the wider healthcare system, such as the hospital or local healthcare economy (Caplen 1978; Bell, D., McNaney, N. & Jones, M. 2006).

Deming (1994) has attempted to integrate the approach with philosophical and psychological insights into a 'system of profound knowledge' which addresses the human aspects of improvement. Six sigma is another attempt to integrate the insights of improvement science into a formal method, based on Shewhart's learning cycle. The six sigma cycle of define, measure, analyze, improve, control is rigorously applied to all problems. Perceived problems with this mechanical and often over elaborate approach have led to recent attempts to integrate six sigma with lean thinking (de Koning et al 2006).

Nicolay et al (2007) found that the improvement science approach "can have significant effects on improving surgical care". The evidence on management systems was found to be less convincing, but this may have been due to the adoption of inappropriate methodological assumptions in the research, as discussed below (Nicolay et al 2011:324).

The improvement science approach has lately led to a critique of narrowness of medical research methodology (Peden & Rooney 2009; Berwick 2010). Noting the inability of the randomised control trial (RCT) method to establish the scientific basis of even such widely approved healthcare practices as the employment of cardiovascular rapid response teams, Berwick calls for a broadening of the current approach to: (1) apply a wider range of research methods; (2) reduce the proof threshold for action on evidence in favour of incremental change guided by the PDSA cycle; (3) combat bias by encouraging the local study of evidence, rather than implementing generic formal methods; (4) enhance two-way communication by promoting mutual respect between academics and practitioners.

3.2 Lean healthcare

Lean production might be regarded as the full development of the time focus that characterises SPC. While SPC is retrospective in its approach, recording variation and acting to prevent its recurrence, Lean is focused on the design and control of standardised production flows in order to eliminate waste, defined as anything in the process that does not add value to the output. Thus, while improvement science focuses on the product, Lean places more emphasis on the production process. Like improvement science, Lean originated in manufacturing, principally in the innovative philosophy and practices of the Toyota car manufacturing company.

The principle concepts are the ideas of 'flow' and ‘value’. Flow emphasises that production takes place in time and is an articulated process in which the performance of each production operation impacts on the others. Value is focused on realising necessary/required benefits for internal and external clients. Thus, a lean analysis proceeds by the identification and analysis of flows and value, in order to identify and eliminate waste (Koskela 1992; Womack & Jones 1996). Lean shares the scientific approach and customer value orientation of improvement science, while acknowledging the importance of building effective relationships (Liker 2004; Rooke et al 2012).

Ohno (1988) identifies seven types of waste, including: overproduction; waiting; transportation; processing; inventory; movement; defective product. Cookson et al (2011) apply this analysis to care in an emergency department, finding waste in all seven categories. However, some of these categorizations are questionable. For instance, the multiple recording of information is categorized as 'overproduction'. In Ohno's analysis, overproduction refers to product rather than process. It is arguable therefore that the 'overproduction' category should be reserved for the inappropriate provision of care and that information waste should be regarded as a processing waste. Similarly, the unnecessary reassessment of patients should also be categorized as processing, the 'rework' category being reserved for the consequences of insufficient or inappropriate treatment. Shingo (1985) also provides an analysis of the production process that can be used as a basis for identifying waste. This consists of four phases: processing, inspection, transportation and storage.

There are many reports of successful lean initiatives in healthcare. Two are detailed here. Van Lent et al (2009) report a successful intervention in a Dutch chemotherapy day unit, which achieved a 24% increase in treatments and bed utilization, a 12% increase in staff productivity and 81% reduction in overtime. Dickson et al (2009) were able to decrease length of stay and improve patient satisfaction in a US emergency department, without increasing costs and in the face of a 9.23% increase in patient visits. They note the importance of:

- giving frontline staff the lead role in identifying waste and designing solutions;

- employing a systematic method, beginning with the identification and mapping of flows, rather than introducing ad hoc efficiency savings.

In a recent review of the lean healthcare literature, Brando de Souza (2009) observes a growing interest in the UK, but points out the speculative nature of much of the material and also the lack of application to management systems. Another problem identified is the narrow breadth of scope of lean initiatives in healthcare, which are yet to extend across organizational boundaries to encompass the whole supply chain. In a review of initiatives in US emergency departments, Holden (2011: 265) finds that lean "*appears to offer significant improvement initiatives*". However, "*questions remain about Lean's effects on patient health and employees and how Lean can be best implemented in health care*". In a study of implementation in the English NHS, Radnor et al (2011) confirm the narrow scope of current applications, identifying theoretically significant problems relating to the identification of the customer and the maintenance of standards and continual improvement. It may be these limitations that have led some commentators to see Lean merely as a tool, or set of tools for the elimination of waste (Ackerman et al 2011).

3.3 Evidence-based approach

Evidence-based practice is the process by which decision-making is strengthened through the use of evidence from scientific research findings in addition to individual experience. In medical practice the evidence-based approach or evidence-based medicine has been used enthusiastically with the aim of supporting clinicians to identify efficient and effective treatment routes. In the practice of medicine, for instance, data-bases containing scientific evidence have been developed aiming to determine which methods are most effective for changing clinicians' behaviour and patient health status (Cook et al., 1997b). In this respect, the evidence-base is used to inform clinicians about the efficiency and effectiveness of treatment routes in terms of time for healing or maintenance of life, possible side effects and its impacts on well being and associated costs for the healthcare system and their patients. In other words, the evidence-base can provide enough information for a clinician to consciously suggest (or not) whether to move from a traditional (well tested) treatment route to a new (alternative and less tested) one. The process is participative and should consider patients' opinion in the decision. Once a route is agreed, the treatment itself becomes a trial that is reported back in scientific terms and adding to the evidence-base.

Finding evidence means that results from two clinical trials (at least) are available, that are similar in terms of testing characteristics (test applied, sample size, population characteristic and its similarity with the patients case) demonstrate that research findings independently corroborate one another. The identification process involves the conduct of systematic literature reviews where all the criteria for searching evidence are made explicit, therefore making it a replicable, and transparent process. The rigour of systematic reviews aims to minimise bias through exhaustive literature searches and by providing an audit trail of the reviewer's decisions, procedures and conclusions (Cook et al., 1997a; Tranfield et al., 2003). According to Meade and Richardson (1997) the methodological aspects are the most important ones as methodological features of different investigations can influence the results of studies.

Although the establishment of evidence should be based on the integration of very similar cases, it has been proven difficult to find studies with such a level of similarity. In this case, research following slightly different approaches (e.g. using different factors such as direct and indirect evidence) may be included in the systematic review. Therefore, more attention should be given to the integration of the research findings (Mulrow and Cook, 1997).

In this respect, evidence-based medicine can be seen as a mechanism that supports continuous improvement that supports change. However, this approach is criticised, as systematic reviews are in general very extensive and time consuming. As such, it does not fit with current pressures for time in the delivery of healthcare services. We argue that this approach, whether applied to medicine or healthcare, only emphasises '*episteme*' in Aristotelian terms.

3.4 Service science

The continuous shifting from manufacturing-based economies to service-based ones has also been highlighted in research (Chase and Apte, 2007, Li et al., 2002). In this respect, the demand for services as an input to the production of goods has grown steadily so that the separation between goods and services has become something of an artificial distinction (Bryson et al., 2004). Service science is an attempt to bring together ideas from a wide range of disciplines, inter alia, computer science, cognitive psychology, economics, organizational behaviour, human resources management, marketing and operations research. It seems to have originated in IBM's Service Science, Management, and Engineering initiative (Wikipedia 2012), to be rapidly taken up by other IT companies including HP, Microsoft, Cisco, SAP, Ericsson, Intel, Oracle, Infosys, and Symantec (SRII 2012). In Europe, the Networked European Software and Services Initiative group (NESSI) has established a Services Sciences Working Group.

Noting the transition of advanced economies from manufacturing to increasingly service based industry, Schneider & Brown (1995) advocate three areas of focus for 'winning the service game':

1. the customer as ultimate judge of the service provided;

2. customer facing staff as key personnel both in determining customer perception and as conduits for new knowledge of customer requirements;

3. the co-ordinating role of management.

While much of this focus is on 'soft' issues such as customer satisfaction, company culture and staff training, Schneider & Brown warn against falling into the '*human resources trap*' of neglecting issues such as "*the physical facility, billing accuracy and timeliness*" (1995:5).

It has been proposed that service science should be founded on a 'service-dominant logic' (Maglio & Spohrer 2008; Lusch et al 2008). Lusch et al (2008) suggest three fundamentals of such an approach:

1. a service is seen as a process, rather than a unit of output;

2. the analytic focus switches from 'static resources', such as raw materials, to 'dynamic resources', such as knowledge and ability;

3. value is no longer conceived of as something which producers create and deliver to customers, but as a collaborative process between providers and customers.

Spohrer et al (2008) and Vargo et al (2008) bring systems thinking to bear, arguing that the 'service system' is the fundamental abstraction of service science. A service system is defined as "an open system (1) capable of improving the state of another system through sharing or applying its resources [...] and (2) capable of improving its own state by acquiring external resources." (Spohrer et al 2008:7). Service systems interact through exchange relationships to generate value for each other.

The idea that value is co-created with customers has proved to be problematic. The notion derives from two observations: (1) that economic exchange is based on service, the undertaking of an activity on behalf of another; (2) that the customer is the sole arbiter of value. Nevertheless, as Grőnroos (2010) points out, value cannot always be treated as a product of co-creation. Of course, from a systems perspective, provider and customer both have an essential role to play in value creation, but it is only on some occasions that the two fulfil these roles collaboratively. This would seem particularly important when considering Schneider & Brown's (1995) points 2 and 3.

Nonetheless, the concept of co-creation would appear to have powerful applications in a service industry such as healthcare, where co-creation can be observed in almost all contexts, including: the appropriate accessing of health services; the conduct of medical examinations; the management of periods of waiting and observation; the administration of treatment; and health promotion. Treating the latter category, Kohtamäki (2009) notes the importance of stakeholder analysis in the development of occupational healthcare strategies, while Kivisaari (2009) finds that co-creation can play an advantageous role in scaling up experimental initiatives. McColl-Kennedy et al (2012) identify five practice styles among patients co-creating value in the context of cancer treatment.

4 DISCUSSION

An account of the classical science of production and current corresponding initiatives reveals three problematic issues, discussed in the following.

4.1 Improvement science and lean healthcare

It was found that improvement science derives from statistical quality movement and is intrinsically oriented towards the conformance to specification of products and process outcomes, i.e. static things. In contrast, lean healthcare derives from the Toyota Production System and is intrinsically oriented towards improving the flow of production, i.e., temporal phenomena. Although their origins and conceptualizations are different, they share the same aim: improvement of production. In practice, they seem to overlap.

Because improvement science and lean healthcare focus on different but often synergistic means towards the same aim, there is no reason to keep them separate; they should be merged, conceptually and methodologically.

4.2 Evidence-based medicine: episteme or techne?

Evidence-based medicine derives mostly from natural science methodology (*episteme*), and thus assumes that the phenomena focused on fall into those phenomena studied by (natural) science through experimental methods. Unfortunately, this is not the case. As pointed out by Aristotle, doctors treat particular cases (rather than universal), and thus experience may be more important than knowledge of universal principles. Interestingly, one strand of the discussion on evidence-based medicine has addressed exactly this problem: the relative significance of clinical experience, judgment and skill versus statistical knowledge of evidence of different treatments (Sackett et al. 1996). One aspect here is that for the sake of scientific experimentation, patients with only the focused medical problem are selected. In clinical practice, patients with several simultaneous medical problems are often encountered. How the scientific evidence should be extrapolated into such cases inevitably requires clinical judgment. Another aspect is that it is sometimes difficult to describe and standardize a treatment, regarding which evidence has been acquired, so that the users of that evidence could replicate precisely the same treatment in clinical practice (Kok & al., 2012). The PDSA based approach suggested by Berwick offers a possible approach to resolving these dilemmas.

Furthermore, it has been suggested that patient values and situation should play a role in medical decision making. This brings topics recently promoted by service science into the picture, namely the role of the client in co-creation of value (of the treatment).

Thus, it is evident that evidence-based medicine, being based on the ethos of *episteme*, has collided with issues explained by the science of production. This suggests that evidence-based medicine (as well as its outgrowths in other fields) could be advantageously repositioned and reinterpreted as falling into the science of production.

4.3 Service science and production science

Progress has been made in the definition of service science, however its development has occurred in isolation from historical and current generic understanding of production; this can hardly have been an advantage. But the efforts to formulate service science, as initial and ahistorical as they are, also reveal the scarcity of similar efforts on the side of production science.

But even more importantly, the question whether there should be one production/service science, instead of separate sciences for production and service, arises. Services usually use material products as an element of service provision, and there is often an element of service attached to material products. Given this overlap between services and (material) production, a unified production/service science would seem to be an attractive goal.

5 CONCLUSIONS

Are we in an inferior position because of a lack of a unified science of production? Based on the analyses made, the answer is: yes. This is justified by observations showing that the current movements studied are not self-aware of the restrictions deriving from their backgrounds, and of the resultant partiality in their approaches. This is especially egregious regarding improvement science and lean healthcare. Regarding evidence-based medicine, the constraints caused by its origin as an approach falling into (natural) science have only incrementally been recognized. In turn, the promoters of service science seem to be unaware of the long tradition of the mother discipline, the science of production.

It is thus concluded that improvement of healthcare is slowed down by the fragmentation of the related disciplines; thus one consolidated science of production would be needed, for the sake of healthcare as well as of many other practical fields.

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