A CHANGE IS AS GOOD AS A REST: USING THE THEORY OF CONSTRAINTS TO RESOLVE RESOURCE CONSTRAINTS IN A LARGE PUBLIC HOSPITAL

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ABSTRACT

Public health care providers typically struggle with the need to meet demand for services, within limited budgets. This paper discusses an analysis of a large public hospital, using the Theory of Constraints (TOC) to explore complex cause-effect relationships, mapping the root cause of long-standing conflicts and suggesting solutions, then piloting their implementation. Trial project outcomes include dramatically reduced patient wait-times and staff overtime, smoothed workload, increased patient satisfaction and improved staff morale and retention, with patient safety and integrity of treatment maintained.

Keywords: Theory of Constraints, planning & scheduling, healthcare, hospital management, problem structuring

INTRODUCTION

Improving patient satisfaction in a busy public hospital pharmacy was the original motivation for this study. Public hospitals typically struggle to balance high quality service delivery with budget constraints and significant, longstanding tensions can be the result. The research subject is a lead provider of tertiary and secondary health services in the North Island of New Zealand. It is divided into various functional departments, from Information Technology (IT) and Health Records to various healthcare providers who include doctors, nursing, and pharmacy staff. Healthcare providers report to their Business Managers, who have accountability for the budgets. Hospital revenue is obtained from the Ministry of Health (MoH), through agreed contracts for various types of surgery and services. Healthcare providers aim to deliver to agreed volumes set out in the contracts. There is a conflict in trying to meet patient demand, when the MoH has no contractual obligation to reimburse the hospital for delivery of services that are above and beyond the contractual services agreed.

INTRODUCING THE THEORY OF CONSTRAINTS

In the late 1970’s, physicist Dr Eliyahu Goldratt helped a friend improve chicken coop production. Goldratt noticed that bottlenecks in production played a key part in determining the output of coops. He developed a production scheduling algorithm, based on his observations. Goldratt soon noticed that policies and behaviours acted as constraints and that they could be harder to tackle than purely physical constraints. Thus, the Theory of Constraints (TOC) was created – logical methods to help uncover and address policy and behavioural constraints that act as barriers to improvement [9] [11] [26].

The TOC Thinking Processes

Garvin and Roberto [10] identify the importance of viewing decision making as a process involving discussion and debate, rather than an event. Goldratt’s Theory of Constraints [11, 12] provides a unique set of tools for the process of robust decision making. It has been successfully implemented in production, logistics, distribution, project management, research and development, and sales and marketing for over two decades [19]. The iterative nature of the tools facilitates constructive working relationships and promotes an understanding of the difference between inquiry and advocacy. Constructive conflict resolution enables individual assumptions to be tested, avoids personal friction and directs focus to the problem at hand [19].

TOC’s thinking processes comprise a suite of five logic diagrams (four trees and a conflict or ‘evaporating’ cloud) and a set of logic rules [12, 17, 21]. The diagrams use two different types of logic. The researchers used the Current Reality Branches (CRB) and Future Reality Branches (FRB), both of which use sufficiency logic that
speaks to cause and effect – if ‘this’…then ‘that’. The other two tools, the Evaporating Cloud and the Prerequisite Tree (PRT), use necessary condition thinking in order to have ‘A’…we need ‘B’.

**Why change?** The first step is to agree there are problems that need addressing since they are preventing the organisation from achieving its goals [1].

**What to change?** The second step is to identify what to change? This is achieved by developing a generic evaporating cloud (EC) or Core Problem Cloud [15] [5] [6] [23] from the three individual ECs, which identify the Undesirable Effects (UDEs). By surfacing the assumptions inherent in the generic EC, a picture of the current reality (the CRB) is developed. The CRB is essentially a gap analysis tool that helps examine the cause and effect logic behind the current situation, determining why that situation is different from the preferred state (which can also be captured in an Intermediate Objectives map [8]). This validates the why change as well as identifying what to change.

**What to change to?** The Future Reality Branch or FRB answers the question of what to change to? The FRB is constructed and injections identified, that will create Desirable Effects (DEs), to replace the CRB’s undesirable ones (UDEs). A crucial part of the analysis involves identifying potential side effects (additional UDEs) and avoiding them. The PRT assists with this, as below.

**How to cause the change? – The action plan.** The PRT identifies obstacles to the implementation of the changes and milestones that will eliminate each obstacle. The overall objective providing quality care to patients can be achieved by addressing the question of how to cause the change?

**Overview of the Application of TOC to the Hospital Environment**
Five thinking process tools from Goldratt’s Theory of Constraints were used to explore the longstanding tensions and their undesirable consequences in a major public hospital, following the approach in Cox Blackstone & Schleier [5] and Cox, Mabin & Davies [6]. A series of individual evaporating clouds (EC) and a generic evaporating cloud were developed, to describe, analyse, and resolve the tensions or conflicts in the following related services:

- pharmacy – to meet production (service delivery) demands
- oncology – between doctors and nurses, regarding the amount of treatment provided and proposed changes to data verification in the Electronic Health Record system (EHR).

Current reality branches (CRB) logically outlined the current interdependent relationships that exist within the hospital. Inadequate communication/understanding between doctors and managers, along with limited policy direction, were interrelated factors that were causing the hospital to not achieve its primary objective: providing quality care to patients. The system oscillated between allocating resources based on doctors’ demands, to allocations based on management decisions. A CRB for each side of the conflict was constructed to provide a clearer understanding of the problem and develop potential solutions, including:

- global measures, rather than local silo-based optima
- agreed processes for managing bottlenecks that constrain the throughput
- agreed policy on the requisite criteria for service delivery

The prerequisite tree (PRT) identified critical obstacles that must be overcome when implementing the proposed changes, to enable the hospital’s primary objective, providing quality care to patients, to be achieved. Global policies were then developed, moving the focus away from local optima. Thus global responsibility for service delivery could be achieved, with a resulting improved understanding of the different pressure points, eliminating the (non-revenue) over-delivery of services.

**INDIVIDUAL CLOUDS**
Individual interviews were conducted with the Business Manager, the Pharmacy Team Leader, and the Nursing Team Leader in Oncology. Evaporating clouds (EC) were then created to present the dilemmas facing the different personnel. Whilst the three interviews raised independent problems, common themes became evident:

- workload pressure
- resources unable to meet the demand for care
- tension between doctors and other staff
From the Business Manager’s perspective, there was a conflict between managers and clinicians regarding how data would be verified in the new Electronic Health Record (EHR) system. Clinicians wanted to retain the current method of verification which would require more IT developmental time, incur additional costs and delay the project. IT managers on the other hand, were confident that the new system of verification, using patient specific data (Patient NHI), would provide similar accuracy in verification. Because of their differences, there was a risk that clinicians would not use the new data verification system.

In Pharmacy, the conflict was based on staffing in the Production Unit. The current unit workload required more staff to cope with increasing demands of chemotherapy production, resulting in related areas (e.g. Medicines Information or Dispensary) not being resourced adequately, with impacts on service delivery. Work in the Production Unit was also physically demanding and required significant training. Given the choice, staff preferred to work in more mentally-stimulating, less ‘physical’ areas, like medicines information, rather than Production. High numbers of vacancies, coupled with the high workload, did not improve staff morale.

In the Oncology Unit, nurses and administrative staff were in conflict with doctors. Doctors wanted to treat and follow up on all patients in the Oncology Unit, resulting in high workloads for all unit staff, which exceeded MoH contracted volumes. Nurses resented the expectation to deliver high volumes of scheduled treatments that meant that there was little time for professional development (PD). The lack of professional development opportunities contributed to low staff morale and high staff turnover.

THE GENERIC CLOUD DERIVATION

Three evaporating clouds were created to depict each situation presented by the individual interviewees. On analysis, the core problem was deduced as being primarily about how decisions about resource allocation were made. As space constraints restrict, please refer to the authors for the full EC depiction.

The generic EC aims to provide confirmation that the conflict exists and is perpetuating a major problem, among other purposes [17]. Assumptions surfaced using ‘if-then-because’ logic [6] provide extra clarity for the next stage of the analysis. Restate the cloud above: If D doctors were able to demand how resources were allocated, then B doctors could provide patients with the best treatment outcomes. This was seen to be in conflict with D’ if the management decided on all resource allocation, then C the hospital could operate within its resources.

Figure 1: Generic and Individual Evaporating Clouds
In order for the hospital to provide quality patient care (A), doctors must be able to provide best treatment outcomes for patients (B), and the hospital must operate within its resources (C). B and C are necessary conditions for A. And in order for doctors to provide patients with the best treatment outcomes (B), doctors must decide how resources are allocated (D). On the other hand, equally importantly, in order for the hospital to operate within its resources (C), management must decide on all resource allocation (D’). Clearly D and D’ are mutually exclusive – hence the conflict. The generic B, doctors can provide the best outcomes for patients, was a synthesis of the B requirements of the 3 individual clouds, namely that: doctors must have 100% accurate patient information and the ability to schedule treatments when they were required, and pharmacy staff must meet urgent orders to ensure best treatment outcomes for patients. The generic C The hospital operates within its resources, was likewise a synthesis of the 3 C requirements: management must have the new EHR project on time and within budget, nursing resources must be used well, and pharmacy staff must meet all service requirements within its resources, despite the competing demands of the Production Unit. Eliminating the need for one of the prerequisites (D or D’) means that the conflict will no longer exist. This is called ‘evaporating the cloud’. It also constitutes a win for both sides, because it satisfies both the conditions (B & C) necessary to achieve the objective (A) [22]. Because this conflict remains unresolved at present, there is: on-going conflict between the parties, concerning whether resources should be allocated based on doctors’ demands - or based on management decisions.

The UDEs identified in the interviews associated with the individual clouds included:

- bottlenecks in pharmacy production
- high pharmacy and nursing workloads, contributing to low staff morale
- throughput problems, with patients experiencing long waiting periods
- over delivery of services, which were not funded
- a lack of clinician confidence in the proposed data verification in the EHR
- a lack of staff training and development
- differing KPI measurements, which created friction amongst clinicians and managers

The resulting current reality was portrayed in a Current Reality Tree that can be summed up thus: If the conflict is whether resources should be allocated based on doctors’ treatment decisions and demands or management decisions, then this may create some of the UDEs identified in the individual clouds:

- high workloads for both pharmacy production and nursing staff
- IT rework for patient verification
- funding (resource) problems, if there is over delivery of unfunded service and
- discontent for nursing staff who do not have professional development time.

What this means for pharmacy in particular, is shown in a ‘Current Reality Branch’ or CRB (a section of the CRT, not included here, due to space constraints). The CRB surfaces differences between the current and preferred system realities [8]. Reading from bottom to top: If doctors decide on treatment schedules to provide best outcomes for patients, and pharmacy must respond immediately to requests based on treatments, then production staff must react to demands set by doctors. If that is the case, and if there is limited workload planning and treatment schedules are variable, then there is a huge variability in workload. Continuing, we find that the Pharmacy production unit is understaffed, there is a high turnover of staff, delays to treatments occur, the hospital cannot operate within its resources, the best treatment outcomes for patients cannot be achieved, and as a result, the hospital does not provide the best quality care for its patients. Linking back to the Evaporating Cloud, neither B nor C from the EC are met, so A cannot be achieved either. Even when the doctors are responsible for setting treatment plans, the system cannot provide the best treatment. This was completely unexpected, a threshold concept. The proposal arising from the CRB for Pharmacy was that doctors should make decisions, but within agreed guidelines. The Thinking Processes behind formulating this break-through proposal are mapped out next.

**WHAT TO CHANGE TO?**

The next step (diagram not shown, due to space restraints) is to construct a ‘Future Reality Tree (FRT), which serves several purposes. It provides a logical means to verify that the proposed action will in fact produce the desired result, and identifies potentially unfavourable consequences of contemplated actions, and what’s needed
(injections) to overcome them [8]. Proposed solutions/actions, whether derived from the EC or the FRT are called ‘injections’. This is essentially a ‘what-if’ exercise, identifying what actions and conditions are necessary and sufficient to deliver the desired changes, and indicating potential UDEs [16]. The FRB relating to the B-D side starts from the position that D is the chosen alternative out of D and D’. It shows the conditions under which D can be a sensible choice, and shows what other injections/actions are needed to make this work.

NEGATIVE BRANCH RESERVATION

As with any proposed solution, injections can also potentially introduce negative side effects. A Negative Branch (NBR) is the TOC ‘tool’ used to identify and map out the causal relationships linking an injection designed to overcome a UDE, to potential negative outcomes. For example, the injection introducing a peer review group to monitor the allocation of resources as a means of increasing the communication and collaboration that seems to be required for all the needs of the parties to be met, could result in a number of doctors feeling threatened, and ultimately resigning from the hospital, which in turn places the overall objective, A, in jeopardy. A possible solution to mitigate this potential negative side effect is to ensure that the peer review group comprises a high-level multidisciplinary team. This would give the team the expert and legitimate authority required to carry out this task. Apply to the authors for the NBR diagram.

HOW TO MAKE THE CHANGE?

The PRT helps implement decisions, based on the course of action identified using the sequence of TOC tools. The process of building the tree involves three steps:

a. identifying the obstacles
b. determining the intermediate objectives needed to overcome each obstacle
c. mapping the order for implementing the intermediate objectives [21]

Obstacles to Implementation

More than twenty obstacles were identified, with a selection listed here:

- Lack of time to implement change due to high workload
- Staff retention problems require continuous recruitment of new staff
- Limited understanding of the pressures facing different departments & staff groups
- Limited communication between departments
- Each department makes its own decisions about the allocation of resources

Identifying the Obstacles

Obstacles (O) are identified from the two FRBs. They must be entities that currently exist [5]. Each obstacle was checked for causality existence: If [obstacle], then we cannot achieve objective, the hospital provides quality care. For example: If O1 resources are insufficient to meet demand, then the hospital cannot achieve its objective of providing quality patient care.

Obstacles are approached systematically, using the PRT to reveal new problems, flaws in logic, and breakthrough injections. The obstacles cluster around three related difficulties:

1. managing demand within current resources
2. the impact of workload pressure on staff and their working relationships
3. how resources are allocated.

A significant obstacle for the hospital is the localised performance targets for individual departments that result from the MoH’s funding contract for specific outputs. Not only does the hospital operate in an environment with high demand and capped resources, but individualised measures appear to pit departments and staffing groups against each other. Because hospitals are funded only for the number of treatments specified in its contract with the MoH, any treatments provided above the contracted amount are not funded. While the MoH funding contract could be considered as an obstacle that is a ‘fact of life’, its impact can at least be reduced.

Determining the Intermediate Objectives to Overcome Obstacles

Each intermediate objective is a milestone that needs to be accomplished, if the final objective is to be achieved [13]. Obstacles are translated into intermediate objectives (IO) that show how each one would be eliminated, or
how its relevance to the key objective can be eliminated [5]. Validate the IOs using causal reservation logic: *If [IO.] then [obstacle] no longer prevents us from achieving [objective] [21].*

The most significant of the intermediate objectives is to *include a multi-disciplinary approach to all activities.* This resolves obstacles created by operating with purely individualised practices and measures. The Prerequisite Tree (PRT) is an action plan that answers the question ‘what do we do first’ in solving a complex problem. Intermediate objectives are sequenced in the right order to show ‘how to cause the change?’ Like the EC, It is a *necessity* structure [8]. The PRT is read top down “in order to…we must...” as is the custom for necessity logic. In order for the hospital to provide quality care for patients…we must take a multi-disciplinary approach, we must develop alliances with other healthcare providers, we must identify and eliminate bottlenecks, we must have experienced staff available…and in order to have experienced staff available, we must allocate and protect Professional Development…(refer to the authors for the PRT). It is important to word obstacles as ‘conditions’, using words like ‘is’ or ‘have’, never expressed as ‘need’. A need is not an obstacle [8]. Scheinkopf [21] recommends including only *current* obstacles, warning against including *potential* concerns in the PRT.

**PILOT PROJECT IMPLEMENTATION**

The findings of the initial TOC analysis had identified potential solutions, including shifting away from the pursuit of local optima, to global optima. However, a lack of input from clinicians in the development of the three evaporating clouds (ECs), somewhat limited the analysis, with only managers and team leaders interviewed. On completion of the MBA group project, the group member working in the hospital discussed the analysis with clinicians, who were in general agreement with the findings. She gained agreement with her hospital colleagues to use the detailed TOC analysis as the basis for a pilot project to test the solutions. The results of the pilot were positive and show the value of the tools in a hospital setting. The learning from the project highlighted one key area of conflict and ways to resolve it. With the depth of understanding gained through the detailed analysis about *what to change*, the staff involved were able to gain requisite buy-in and move quite quickly into piloting the project implementation. The resulting improvements made to service delivery helped the hospital to better meet their overall goal *providing quality care to patients* [18].

**What to change?** The pharmacy unit is responsible for manufacturing chemotherapy drugs for the Oncology Unit. Staff struggled to keep up with the workload and there were stress factors for both departments, requiring urgent change. Patients were waiting long periods for their treatment, increasing the pressure on nursing staff. Within the pharmacy, the workload tended to fluctuate widely, and staff suffered ‘burnout’ and dissatisfaction. Patients were also dissatisfied. The current drug manufacturing system needed to change. On investigation, it was apparent there were several delays in the system. The process involved the doctor writing out a prescription for the drug and ‘waiting for specialist approval’, whereby drugs would only be manufactured *after* approval by a specialist was given – a key area for change. There was a belief that this ‘specialist approval’ step was required to minimise wastage and to control costs – because chemotherapy drugs are hugely expensive. However, the system created a raft of inefficiencies, including time-consuming phone calls between the two departments checking on the status of the patients. Thus the conflict was traced back to the two requirements: *There is a need to minimise wastage whilst at the same time, keeping waiting time minimal.* The challenge was to develop a more efficient system for manufacturing. One of the proposed solutions to pilot was *to make all drugs immediately, without specialist approval.*

**How to make the change?** Meetings were arranged to discuss the project, firstly with the pharmacy team, and then buy in was sought from the Clinical Director and Nurse Manager in the Oncology Unit. It was agreed that the pilot would run for four weeks and before piloting the proposed solutions, baseline data would be collected. The data analysis was crucial, and a great deal of information was collected so that the effects of the pilot project could be evaluated. This included supply delays, waiting times, patient satisfaction, staff overtime and wastage of drugs. The baseline data results were hardly surprising: In the week before the pilot commenced, delays in supply of drugs of 340 minutes were experienced. The only good news was that the volume of wastage was a mere 0.4%. Overtime amounted to 61 hours for nursing staff, and 8.5 hours each for pharmacists and technicians, while Oncology patients were waiting for between 1 and 4 hours for their drugs.

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RESULTS OF THE PILOT PROJECT

Impact on waiting times – The impact of no longer requiring specialist approval had a dramatic effect on waiting times. Patient waiting was reduced by 84%.

Impact on staff overtime – Similarly, the act of dropping specialist approvals reduced staff overtime for nursing staff to 23 hours, a two-thirds (67%) reduction. The need for overtime for all other staff was eliminated. Correspondingly, stress levels fell for all concerned [18].

Impact on wastage cost – Without specialist approval, drugs wastage increased to 4%. This was a significant, but not entirely unexpected, rise from the base figure of 0.4% prior to the pilot. Further meetings were held with the Oncology Unit to refine the process, and it was proposed that the verification process (requiring approval by specialist) was appropriate in cases where the cost of drugs was high. The other drugs – mainly low cost, high volume drugs - were to be made immediately. This policy was immediately implemented.

The pilot project was extended beyond the initial four weeks. At 3 months, with the two-tier system in place, drugs made ahead of time, but not used for a patient, were generally soon needed for another patient. Wastage costs showed a return close to the baseline of 0.4%, despite only 10% of drugs being subject to specialist approval prior to making. The initial reductions in wait times and overtime were maintained. Monitoring and fine-tuning the ‘make immediately’ proposal prompted a better solution that satisfied all parties. The two-tiered solution was developed and executed once the initial pilot results showed that wastage was unsustainable for expensive drugs. This was a win-win situation, meeting the needs of both sides, to keep costs and overtime down, waiting times short, and a smoothed workload [18].

DISCUSSION

As de Bono says, ‘a good solution is obvious in hindsight’ [7]. This appears common for TOC solutions [1]. The win-win solution, as piloted, reduced wait times markedly and increased patient satisfaction. Staff could work more efficiently, with less idle time and smoother workload. Moreover, there has been notably improved staff morale and retention of specialist staff. Though the problem was not mapped as an evaporating cloud at the time, the problem and its solution can be nicely summed up by the Evaporating Cloud shown in Figure 2. TOC thinking was evident in the process of arriving at the win-win solution to this long-standing problem – posing the right questions and challenging people’s assumptions in a non-threatening manner.

**Figure 2: The Drug Production Dilemma and its solution represented as an Evaporating Cloud**

*Powerful solutions ... start with the right questions.* Eliyahu M. Goldratt

Often the ‘right questions’ are more to do with policies and opinions, and the underlying causes for interdepartmental differences, not things that can be easily quantified. There may be no ‘right’ answer, as many versions of the truth can exist. It seems the ‘truth’ depends on the starting assumptions, which can vary greatly between individuals. Not all assumptions are equally valid or robust to scrutiny, and this provides rich avenues for win-win solutions. In some organisational settings, the right questions and answers are more easily expressed by words than mathematics. Thus, the need for softer methods for structuring and thinking through problematic situations – as an alternative to mathematical modelling approaches, an opportunity for TOC and other soft OR / PSM’s.
So what were the lessons learned?

- There is value in analysing a system and challenging the long held status quo.
- Doing so enables us to identify the core conflict which in this case can be stated quite generically as a conflict over who decides on the allocation of resources. If such unresolved tensions are left unaddressed, productivity is hampered. For the system to work well, the issue needs to be resolved in a win-win manner, avoiding compromise and flip-flopping.
- The new two-tier policy provides an example of breaking this conflict in one area. It provides a way of working ‘smart’ – with a pull system to manufacture in step with demand, meeting both clinical and management needs, as well as better serving patients’ needs.
- The importance of collaboration cannot be overemphasised, each understanding the drivers of certain types of behaviours and constraints within our own departments. Communication between Pharmacy and the Oncology Unit improved as a result of this project and has led to other projects.
- Because situations change, it is important that the effectiveness of the policy continues to be monitored, to ensure that the benefits are sustained.
- Not everyone needs to be involved in the analysis to get to a robust solution – understanding what to change and what to change to.
- However, when looking at how to make the change happen, it is essential to have as many perspectives as practically possible, especially to identify the likely obstacles to implementation and options for overcoming these.

The beauty of the TOC tools is they allow and explain multiple view points, rather than looking for who's right and who's wrong. While relatively time-consuming to use, applying a TOC approach paved the way for a thorough resolution to the conflicts identified. With wide buy-in to the tools being a pre-requisite to successfully mapping the situation and the solutions, small steps were sought first, before attempting a system-wide implementation.

**REFLECTIONS ON THE STUDY**

The analysis of the hospital situation was carried out in 2006 as an MBA project by the first three authors, with guidance from the last author. The third author then applied the results in the pilot implementation, with great success. She has since been appointed to head another health sector organisation. On a recent visit to the oncology unit, she noted that four years on, the two-tier concept remained. However, a subsequent decision to outsource production of low-cost, high volume drugs means that the pharmacy is now making only the high cost drugs that required specialist approval. The TOC study at the very least had provided a valuable process that distinguished between these two tiers to pinpoint a solution to a long-standing problem. Perceivably, this outsourcing step could be part of a plan to focus on the next constraint as part of a process of on-going improvement. On the other hand, without buy-in to the process and understanding the need to answer the question why, without the proof of a need for change [4], symptoms can overwhelm. Logical thinking can take a back seat. As revealed in the findings, the resulting improved communication between Pharmacy and Oncology led to better collaboration on a number of issues. However it is apparent that without a champion to lead the changes, further applications are unlikely.

**CONTRIBUTION TO THE DECISION SCIENCES**

Applying TOC in healthcare settings may be a growing trend due to its ‘distinct theoretical and practical advantages’ over some other quality improvement management philosophies [2], though applications are still relatively rare in the literature [25]. There are now many examples of TOC’s benefits in describing the setting, the people and the specific issues in such a way as to give rise to timely and profound improvements in healthcare, within resource constraints. Kim, Mabin and Davies [14] identified four papers using the TOC Thinking Processes (TP) in healthcare settings, eg Lubish et al [15]. Other notable TOC contributions include Umble and Umble’s [24] description of a successful application of TOC’s buffer management approach (DBR) to reduce waiting times for accident and emergency care and admissions at three UK hospitals. Meanwhile, clinician Myriam Hunink [12] utilised the Evaporating Cloud and Current Reality Trees to ‘make a well-founded
decision’ and facilitate improved communication, in the care of a critically ill patient. Ronen and Pass cite several papers on healthcare, stating that of all the service industries, TOC is relatively most popular in healthcare organisations [20]. While Cavana [3] used systems dynamics to show the significance of tension between clinicians and health managers, their conclusions concur with this and similar healthcare studies [27] using TOC. Accordingly, further research into the similarities and differences of approaches and findings across the various papers, books and chapters on TOC used in healthcare would be warranted.

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Selected references only are listed - please apply to the authors for further details.


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