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Article *in* International Journal of Science and Research (IJSR) · January 2015

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International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Securing the Future: A Systems Approach to Continuous Improvement in Health Care by Applying the Theory of Constraints

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Abstract: ***Today, more than ever, change is inevitable in healthcare organizations to satisfying ever increasing expectations. Consumers expect higher service quality than the price they're willing to pay to acquire those products and services. More than ever, employees expect job security. Shareholders expect that today's investments will yield a higher rate of return over a shorter timeframe. Management is constantly pressured to keep costs under control. In the coming decade, we are likely to see a lot of focus directed towards applying management principles to solutions of complex social issues such as environmental sustainability, energy security, access to healthcare etc. This will also underline the need for increased interdisciplinary interaction and influence on business management. In light of today's competitive pressures and a rapidly changing environment, to not change is to give way to one's competitors. To improve means to change. We know that to improve means we must: provide services that solve customers' problems, release services consistent with market demand, reduce variability in our processes, have measurements that indicate success relative to achieving our goal and reward people for their contribution to change. Many organizations have concluded that a process of on-going improvement is an absolute necessity. Theory of Constraints (TOC) brings a new dimension to management philosophy and provides an interesting challenge to the traditional ways of looking at an organization's profitability. Adopted within a wide variety of organizations and settings, it appears that organizations using TOC have determined that it can help them achieve a number of management objectives, including continuous improvement. Using TOC should be guided by the purpose or requirements it is necessary to meet. The goal of every organization is the same; optimize profitability by meeting customer requirements better than the competition. The TOC is both descriptive and prescriptive in nature that describes the cause of system constraints and provides guidance on how to resolve them. TOC provides a set of holistic processes and rules, all based on a systems approach that exploits the inherent simplicity within complex systems through focusing on the few "leverage points" as a way to synchronize the parts to achieve ongoing improvement in the performance of the system as a whole. This paper will clarify the concepts on the TOC and will facilitate its successful implementation in organisations with special reference to healthcare institutions.***

Keywords: Theory of Constraints; The goal; TQM, Lean, Critical chain project management, Body of knowledge; Drum-buffer-rope; Fundamental concepts; Goldratt; Healthcare, Systms Approach, Continuous Improvement, Throughput, Inventory, Operating expense, Thinking process

1. Background

The melting of barriers among nations and their increasing interconnectedness, accelerated by technology, has led to a change in the world order that has had a profound impact on global business. The emergence of nations (China, India, Malaysia, etc) has replaced the era of unquestioned dominance of the Western countries or any one particular region, paving the way for a flattened business arena where developments in one part of the other are certain to have a spiraling impact. Perhaps the best evidence of this is the recent financial crisis. In a knowledge driven era of highly specialized experts, businesses that can share and multiply that expertise the fastest will win the race. As the world becomes ever more complex, more and more of what we do is knowledge work, the application of highly specialized knowledge and expertise. An organization's competitive advantage revolves around its most advanced talent - those leading edge knowledge workers who solve challenging problems, develop new products and take the business in novel directions. Naturally, competitive businesses want to protect this asset. They can patent inventions and trademark brands but they can't so easily nail down the expertise that mobile employees carry around in their heads. This is the fundamental driver behind the development of knowledge management systems, ways of capturing, storing and sharing expertise across an organization.

Against the backdrop of a competitive global economy and the sustainability and ethical expectations of organisations, knowledge about reputation, strategy development and approaches to growth, innovation, organisational change, measuring business performance and the power of the customer is essential. The TOC is a systems-management philosophy developed by Eliyahu M. Goldratt in 1984. The basic premise of TOC is that constraints establish the limits of performance for any system. Most organizations contain only a few core constraints. Managers should focus on effectively managing the capacity and capability of these constraints if they are to improve the performance of their organization. TOC is focused on the weakest ring(s) in the chain to improve the performance of systems. Organizations should be more focused on understanding their own structure in terms of processes to survive in a global competition. In this situation, TOC becomes an important problem structuring and solving methodology which changes the way of thinking of managers. The TOC defines a set of tools that change agents can use to manage constraints, thereby increasing profits. Most businesses can

be viewed as a linked set of processes that transform inputs into saleable outputs. TOC conceptually models this system as a chain, and advocates the familiar adage that a "chain is only as strong as its weakest link." Goldratt defines a five- step process that a change agent can use to strengthen the weakest link, or links. In The Goal, Goldratt proves that most organizations have very few true constraints. Since the focus only needs to be on the constraints, implementing TOC can result in substantial improvement without tying up a great deal of resources, with results after three months of effort.

2. Theory of Constraints: Transforming ideas?

TOC has broad applications in diverse organizational settings. For example, TOC has proved to be a milestone concept leading to process improvement in organizations. TOC challenges managers to rethink some of their fundamental assumptions about how to achieve the goals of their organizations, about what they consider productive actions, and about the real purpose of cost management. Emphasizing the need to maximize the throughput, TOC focuses on understanding and managing the constraints that stand between an organization and the attainment of its goals. Once the constraints are identified, TOC subordinates all the nonconstraining resources of the organization to the needs of its core constraints. The result is optimization of the total system of resources.

TOC is a vital part of this expanded toolkit, providing unique insights and focus into the ongoing challenges of identifying the products and services that will maximize customer value-added and organizational profitability. Key principles include:

- If processes and organizations function as chains or flows, the weakest links can be found and strengthened.
- An organization that maximizes the output of every machine will not perform as well as one that ensures optimization of the flow of materials and value created through its linked set of activities.
- One event causes another to happen in any organization. Capturing the essence of cause and effect within the system and identifying measurements that emulate these relationships are the keys to optimizing system performance.
- Most of the constraints faced in systems originate from policies, not physical things. Physical constraints, such as the number of nurses in a hospital can be objectively identified and dealt with. Policy constraints (e.g., behavior patterns, attitudes, lack of information, and assumptions) are potentially more damaging than physical constraints, yet are much more difficult to identify and deal with. The belief that producing in large batches is optimal is an example of a policy constraint that can make implementing TOC or related advanced manufacturing approaches difficult.
- All organizations are systems made up of interdependent activities, each with its own level and type of variability.

Management needs to understand and focus on the total system impact of a decision or event, not just on its local or immediate effects.

TOC has broad applications in organizations. Its benefits cross multiple boundaries and functions, resulting in uses and benefits including:

- Decreased production lead times;
- Improved quality of products and services;
- Dramatic increases in profitability;
- Reduced inventory levels;
- Reduced bottlenecks;
- Management of constraints;
- Curbing of statistical fluctuations;
- Improved competitive position;
- Facilitation of strategic marketing and operational decisions;
- Introduction of the marginal pricing concept; and
- Application of continuous improvement at the supply chain level.

TOC can be used effectively to improve performance in areas like manufacturing, marketing and administration. TOC can be used in conjunction with other management techniques such as total quality management (TQM) and just-in-time (JIT) to provide a comprehensive, linked set of techniques that emphasize continuous improvement in all areas of operation. TOC has also been applied at the supply chain level to coordinate the activities of upstream and downstream trading partners.

The TOC states that every system must have at least one constraint limiting its output.

3. Consequences of the TOC

1) The more complex the system, the less independent process. Usually complex systems have only one constraint at a given time.
2) A system of optimum processes cannot be an optimum
3) An optimum system runs the constraint (or bottleneck) at optimum capacity (focused on the goal of the system), and all optimum capacity (focused on the goal of the system), and all other process steps must have excess capacity.

The core idea of the TOC is that every real system stem such as a profit--making enterprise must have at least one constraint.
The TOC is a thinking process that enables people to invent simple solutions to seemingly complex problems. Every system must have at least one constraint limiting output. There is no choice in the matter; either you manage the constraints or they mange you. The constraint will determine the output of the system whether they are acknowledged and managed, or not. TOC focuses improvement efforts where they will have the greatest immediate impact on the bottom line. It provides a reliable process that insists on follow through.

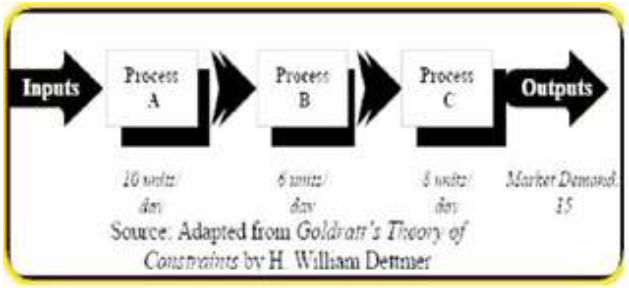
Finding the Focal Point

TOC is about two things: focus and follow through. Before a company can properly focus, one necessary condition is that they answer the following question: what is the goal of

a for-profit enterprise? Once the goal is identified, a necessary condition to success in achieving the goal is to identify which measurement(s) will be used to judge progress.

4. Systems as Chains

A system is a collection of interrelated, independent processes that work together to turn inputs into outputs in the pursuit of some goal. A chain always has one weakest link. If one applies force to the chain at an increasing rate, it would eventually break at the weakest link. The weakest link is the constraint that prevents the system (chain) from doing any better at achieving its goal (accepting force). At any given time there is only one constraint in a system that limits the output of the entire system. The remaining "links" are known as nonconstraints. After strengthening one constraint, the system is stronger. However, the system does not become infinitely stronger. The constraint simply migrates to a different component of the system. Some other link is now the weakest and all the other links are nonconstraints. [1,, 2, 3, 4, 5, 6, 7, 8, 9, 10,] To better understand the TOC, consider a production system that runs raw materials through three component processes and then turns them into a finished product.[Fig 1]



Within this system, each process is equivalent to a link in the production chain. Where is the constraint in this chain? Process B is the weakest link. Process B produces the least at only six units per day. Process A and C are the nonconstraints. Imagine that the manufacturer improves process B until it can produce 18 units per day. Now, process C becomes the system constraint while the nonconstraints are everywhere else. If process improvements continue until all processes are producing 18 units/day or higher, the system constraint becomes the marketplace, which can accept only 15 units per day. At this point, internal constraints have been replaced by an external constraint. TOC emphasizes fixing the weakest link in the chain—the system constraint—and temporarily ignoring the nonconstraints. In this way, the theory has a profound impact on process improvement. [1-11] created a simple relationship chart between three system- level measurements: throughput (T), inventory (I), and operating expense (OE). [1-11] [Table 1 & Fig 2, 3]

Table 1: Relationship chart between three system- level measurements: throughput (T), inventory (I), and operating expense (OE)

Dimension	Examples
Throughput: Rate at which an entire system generates money through sales of a product or service	• Money (for-profit organization) • Delivery of a product or service to the customer (nonprofit organization)
Inventory: All of the money a system invests in the products or services it intends to sell	• Raw materials • Unfinished goods • Purchased parts • Investment in equipment/facilities
Operating expense: All of the money a system spends in turning inventory into throughput	• Direct labor • Utilities • Consumable supplies • Depreciation of assets

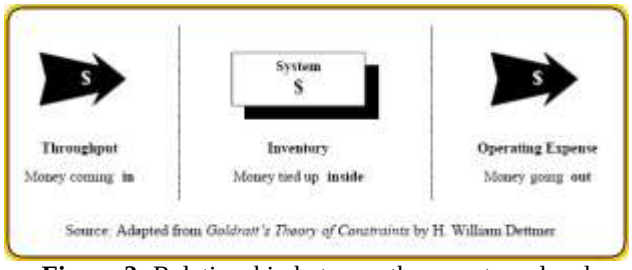


Figure 2: Relationship between three system- level measurements: throughput (T), inventory (I), and operating expense (OE)

Given Goldratt's three dimensions, organizations have three different options for system improvement: increasing T, reducing I, or reducing OE. The practical limits of reducing inventory and operating expenses are relatively low, as a system cannot produce many outputs without them. Theoretically, there's no upper limit to how much an organization can increase its throughput, but market sizes are limited. The potential for increasing T tend to be much higher than the potential for decreasing I and OE. Therefore, a basic model for system improvements focuses on increasing T and making reduction of I and OE a secondary priority, as shown below:

Figure 3: Basic model for system improvements

Rather than spreading limited time, energy, and resources across an entire system teams focus on that part of the system with the potential to produce immediate system improvement.

Basic Principles

Goldratt outlines several principles that help creates an environment conductive to the prescriptive part of his theory. The prescriptive part of the theory of constraints helps organizations answer three management questions regarding systems and their constraints: where is the constraint, what should we do with the constraint and how do we implement the change? [1-11]

The Five Focusing Steps:

Step 1: Identify the system constraint.
Step 2: Decide how to exploit the constraint.
Step3: Subordinate everything else.
Step 4: Elevate the constraint.
Step 5: Go back to Step 1.

After a constraint is broken, the organization repeats the steps all over again, looking for the next thing constraining link. At the same time, the organization needs to monitor how the changes related to subsequent constraints impact the already improved constraints.

The Five Logical Tools:

1. Current reality tree (CRT). Helps organizations work backward from an undesirable effect to identify the core problem.
2. Conflict resolution diagram (CRD). Allows organizations to resolve hidden conflicts that usually perpetuate chronic problems (also known as the "evaporating cloud")
3. Future reality tree (FRT). Enables organizations verifies an action produces the desired results. It also identifies and removes any unfavorable new consequences from the action.
4. Prerequisite tree (PRT). Helps organizations implement a decision by providing a recommended sequence of events and identifying potential obstacles.
5. Transition tree (TT). Provides organizations with a detailed, step-by-step action plan for implementing a decision

The five logic trees can be used individually or together as an integrated thinking process. The table below shows how the five tools can be used together in answering the three management questions about change. The constraints determine the performance of a system. A constraint is anything that prevents a system from achieving a higher performance relative to its goal. A system is any collection of interconnected parts sharing a common goal. Constraints may be resource constraints such as a person or department that cannot keep up with market demand. If this department could produce more, more would be sold and the firm would make more money. If all departments can keep up with market demand then a market constraint exists. If more could be sold, the capacity exists to produce it and the firm would make more money. There are also policy constraints and dummy constraints. A policy constraint is a management decision or business culture that limits the system. [1-11]

The Seven Focusing Steps

Goldratt suggested five focusing steps for managing resource and market constraints. Later others suggested that this be expanded to seven steps for more completeness by adding two steps at the front. Presented below is the seven step version followed by an example of its application. The seven focusing steps are: decide on the goal of the system, determine the system's performance measures, identify the system's constraint(s), decide how to exploit the system's constraint(s), subordinate everything else to the decision taken in step 4, elevate the system's constraint(s) and if in a previous step the constraint is broken, go back to step 3. Do not let Inertia cause a system constraint. [1-11] [Table 2, 3]

Systems operate according to the Pareto principle.	Most of the undesirable effects within a system are caused by a few core problems (causes).
Undesirable effects reveal core problems.	Core problems are almost never apparent on the surface. They manifest themselves through a number of undesirable effects (UDEs) linked by a network of cause and effect.
Solving core problems eliminates resulting UDEs.	Elimination of individual UDEs gives a false sense of security while ignoring the underlying core problem. Solutions that do this are likely to be short-lived. Solution of a core problem simultaneously eliminates all resulting UDEs.
To solve core problems, you must challenge underlying assumptions.	Core problems are usually perpetuated by hidden or underlying conflict. Solution of core problems requires challenging the assumptions underlying conflict and invalidating at least one.
System constraints are either physical or policy.	Physical constraints are relatively easy to identify and simple to eliminate. Policy constraints are usually more difficult to identify and eliminate, but removing them normally results in a larger degree of system improvement than eliminating a physical constraint.
Solutions tend to resist change.	Inertia is the worst enemy of a process of ongoing improvement. Solutions tend to assume a mass of their own that resists further change.
Ideas are not solutions.	Even the best ideas cannot realize their potential unless they are implemented. Most great ideas fail in the implementation stage.

Systems thinking is preferable to analytical thinking.	In managing change and solving problems, systems thinking is preferable to analytical thinking.
Ongoing improvement is imperative.	An optimal solution deteriorates over time as the system's environment changes. A process of ongoing improvement is required to update and maintain the effectiveness of a solution.
The system optimum is not the sum of the local optima.	If a system is performing as well as it can, not more than one of its component parts will be. If all parts are performing as well as they can, the system as a whole will not be.
Systems are analogous to chains.	Each system has a "weakest link" (constraint) that ultimately limits the success of the entire system.
It is pointless to strengthen nonconstraints.	Strengthening any link in a chain other than the weakest one does nothing to improve the strength of the whole chain.
Understand a system before changing it.	Knowing what to change requires a thorough understanding of the system's current reality, its goal, and the magnitude and direction of the difference between the two.

The focusing steps form a basis for continuous improvement. There is always a constraint. The implication of no constraint would be infinite performance for the system. The steps may cause constraint after constraint to be broken; a new constraint emerges but the system performs at a higher level. Second, the Exploit step should always precede the Elevate step. When people find that a resource constraint exists, there is a natural tendency to want to get more of the resource. One should get the maximum performance from the existing resource before getting more of the constraint resource. TOC is applied to logically and systematically answer these three questions essential to any process of ongoing improvement: what to change, to what to change and how to cause the change?

More specific uses of the Thinking Processes can be used to significantly enhance vital management skills, such as: win-win conflict resolution, effective communication, team building skills, delegation, and empowerment. [1-11]

A step-by-step process for using the TOC:

Step 1: Identify the Constraint.
The first step is to identify your weakest link – this is the factor that's holding you back the most. Start by looking at the processes that you use regularly. Are you working as efficiently as you could be, or are there bottlenecks – for example, because your people lack skills or training, or because you lack capacity in a key area? Here, it can help to use tools like Flow Charts, Swim Lane Diagrams, Storyboarding, and Failure Modes and Effects Analysis to map out your processes and identify what's causing issues. You can also brainstorm constraints with team members, and use tools like the 5 Whys Technique and Root Cause Analysis to identify possible issues. Constraints may not just be physical. They can also include intangible factors such as ineffective communication, restrictive company policies, or even poor team morale.

A system can only have one constraint at a time. So, one need to decide which factor is the weakest link, and focus on that. If this is not obvious, use tools like Pareto Analysis or Queuing Models to identify the constraint.

Step 2: Manage the Constraint

Once you have identified the constraint, you need to figure out how to manage it. What can you do to increase efficiency in this area and cure the problem? (Goldratt calls this "exploiting the constraint."). The solutions will vary depending on the team, the goals, and the constraint you're trying to overcome. You can review approaches used in Lean Manufacturing, Kanban, Kaizen, and the 5S System to see if these can help you manage your constraint. Try to brainstorm possible solutions with the team, and to use problem-solving tools such as the Five Whys and Cause and Effect Analysis to identify the real issues behind complex problems.

Step 3: Evaluate Performance

See how the constraint is performing with the fixes you have put into place. Is it working well? Or is it still holding back the performance of the rest of the system? If the constraint is still negatively affecting performance, move back to step 2. If you have dealt with the constraint

effectively, you can move back to step 1 and identify another constraint.

A Management Paradigm

The TOC is a management paradigm that views any manageable system as being limited in achieving more of its goals by a very small number of constraints. There is always at least one constraint, and TOC uses a focusing process to identify the constraint and restructure the rest of the organization around it. If a constraint's throughput capacity is elevated to the point where it is no longer the system's limiting factor, this is said to "break" the constraint. The limiting factor is now some other part of the system, or may be external to the system (an external constraint). This is not to be confused with a breakdown.

Buffers are used throughout the theory of constraints. They often result as part of the exploit and subordinate steps of the five focusing steps. Buffers are placed before the governing constraint, thus ensuring that the constraint is never starved. Buffers are also placed behind the constraint to prevent downstream failure from blocking the constraint's output. Buffers used in this way protect the constraint from variations in the rest of the system and should allow for normal variation of processing time and the occasional upset (Murphy) before and behind the constraint. Buffers ultimately buy you time, as in the time before work reaches the constraint and are often verbalized as time buffers. There should always be enough work in the time queue before the constraint and adequate offloading space behind the constraint.

A prerequisite in the theory is that with one constraint in the system, all other parts of the system must have sufficient capacity to keep up with the work at the constraint and to catch up if time was lost. In a balanced line, as espoused by Kanban, when one work center goes down for a period longer than the buffer allows, then the entire system must wait until that work center is restored. [1-11]

There are many ways to apply buffers, but the most often used is a visual system of designating the buffer in three colors: green (okay), yellow (caution) and red (action required). Creating this kind of visibility enables the system as a whole to align and thus subordinate to the need of the constraint in a holistic manner.

The thinking processes are a set of tools to help managers walk through the steps of initiating and implementing a project. When used in a logical flow, the Thinking Processes help walk through a buy-in process: Gain agreement on the problem, Gain agreement on the direction for a solution, Gain agreement that the solution solves the problem, Agree to overcome any potential negative ramifications and Agree to overcome any obstacles to implementation.

TOC practitioners sometimes refer to these in the negative as working through layers of resistance to a change. Recently, the current reality tree (CRT) and future reality tree (FRT) have been applied to an argumentative academic paper.[1-11] TOC takes a scientific approach to improvement. It hypothesizes that every complex system consists of multiple linked activities, one of which acts as a constraint upon the entire system (i.e. the constraint activity is the "weakest link in the chain"). Every process has a constraint (bottleneck) and focusing is the fastest and most effective path to improved productivity. A successful TOC implementation will have the following benefits: increased profit, fast improvement, improved capacity, reduced lead times and reduced inventory.[1-11]

Core Concept of TOC

The core concept of the TOC is that every process has a single constraint and that total process throughput can only be improved when the constraint is improved. A very important corollary to this is that spending time optimizing non-constraints will not provide significant benefits; only improvements to the constraint will further the goal. TOC seeks to provide precise and sustained focus on improving the current constraint until it no longer limits throughput, at which point the focus moves to the next constraint. The underlying power of TOC flows from its ability to generate a tremendously strong focus towards a single goal (profit) and to removing the principal impediment (the constraint) to achieving more of that goal. In fact, Goldratt considers focus to be the essence of TOC.

The Five Focusing Steps

The TOC provides a specific methodology for identifying and eliminating constraints, referred to as the Five Focusing Steps. As shown in the following diagram, it is a cyclical process. [Fig 4]

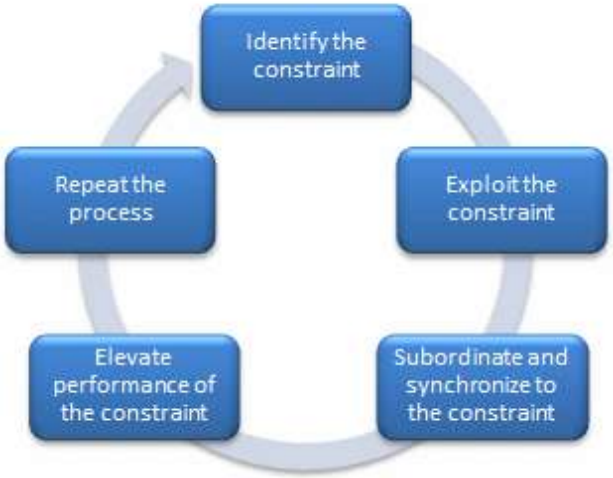


Figure 4: The Theory of Constraints uses a process known as the Five Focusing Steps to identify and eliminate constraints (i.e. bottlenecks).

The Five Focusing Steps are further described in the

following Table 4.

Step	*Objective*
Identify	Identify the current constraint (the single part of the process that limits the rate at which the goal is achieved).
Exploit	Make quick improvements to the throughput of the constraint using existing resources (i.e. make the most of what you have).
Subordinate	Review all other activities in the process to ensure that they are aligned with and truly support the needs of the constraint.
Elevate	If the constraint still exists (i.e. it has not moved), consider what further actions can be taken to eliminate it from being the constraint. Normally, actions are continued at this step until the constraint has been "broken" (until it has moved somewhere else). In some cases, capital investment may be required.
Repeat	The Five Focusing Steps are a continuous improvement cycle. Therefore, once a constraint is resolved the next constraint should immediately be addressed. This step is a reminder to never become complacent – aggressively improve the current constraint…and then immediately move on to the next constraint.

The Thinking Processes

The TOC includes a sophisticated problem solving methodology called the Thinking Processes optimized for complex systems with many interdependencies. They are designed as scientific "cause and effect" tools, which strive to first identify the root causes of undesirable effects (referred to as UDEs), and then remove the UDEs without creating new ones. The Thinking Processes are used to answer the following three questions, which are essential to TOC: what needs to be changed?, what should it be changed to?, and what actions will cause the change?.

Examples of tools that have been formalized as part of the Thinking Processes include:

Throughput Accounting

The strongest emphasis is on increasing Throughput. TOC is saying to focus less on cutting expenses (Investment and Operating Expenses) and focus more on building sales (Throughput).

Drum-Buffer-Rope

Drum-Buffer-Rope (DBR) is a method of synchronizing production to the constraint while minimizing inventory and work-in-process. The "Drum" is the constraint. The speed at which the constraint runs sets the "beat" for the process and determines total throughput. The "Buffer" is the level of inventory needed to maintain consistent production. The "Rope" is a signal generated by the constraint indicating that some amount of inventory has been consumed. The role of the rope is to maintain throughput without creating an accumulation of excess inventory. [1-11]

Implementing TOC

Step One – Identify the Constraint: Look for large accumulations of work-in-process on the plant floor, Look for areas where process expeditors are frequently involved, Review equipment performance data to determine which equipment has the longest average cycle time, Ask operators where they think equipment is not keeping up with demand and The deliverable for this step is the identification of the single piece of equipment that is constraining process throughput.

Step Two – Exploit the Constraint: make the most of what you have – maximize throughput of the constraint using currently available resources. Create a suitably sized inventory buffer immediately in front of the constraint to ensure that it can keep operating even if an upstream process stops. Check quality immediately before the constraint so only known good parts are processed by the constraint. Ensure that the constraint is continuously scheduled for operation. The deliverable for this step is improved utilization of the constraint, which in turn will result in improved throughput for the process. If the actions taken in this step "break" the constraint (i.e. the constraint moves) jump ahead to Step Five. Otherwise, continue to Step Three.

Step Three – Subordinate and Synchronize to the Constraint. The primary objective is to support the needs of the constraint (i.e. subordinate to the constraint). All non-constraint equipment has some degree of excess capacity. This excess capacity is a virtue, as it enables smoother operation of the constraint. The deliverable for this step is fewer instances of constraint operation being stopped by upstream or downstream equipment, which in turn results in improved throughput for the process. If the actions taken in this step "break" the constraint (i.e. the constraint moves) jump ahead to Step Five. Otherwise, continue to Step Four.

Step Four – Elevate Performance of the Constraint
In this step, more substantive changes are implemented to "break" the constraint. These changes may necessitate a significant investment of time and/or money (e.g. adding equipment or hiring more staff). The key is to ensure that all such investments are evaluated for effectiveness.

Step Five – Repeat the Process

Integrating the TOC with Lean
One of the most powerful aspects of the TOC is its laser-like focus on improving the constraint. While Lean Manufacturing can be focused, more typically it is implemented as a broad-spectrum tool. TOC can serve as a highly effective mechanism for prioritizing improvement projects, while Lean Manufacturing can provide a rich toolbox of improvement techniques. The result – manufacturing effectiveness is significantly increased by eliminating waste from the parts of the

system that are the largest constraints on opportunity and profitability. [1-11] [Fig 5]

Figure 5: The Five Focusing Steps of the Theory of Constraints can utilize established lean manufacturing tools as shown in the above diagram.

A Framework for Applying TOC's Process

The principal tenet of TOC is that any system has at least one constraint which limits its performance. Since a system can at best perform only as well as its constraints, TOC emphasizes that improving constraint's performance directly results in enhancing total system performance. The theory seems to be a natural fit for the resource-constrained publicly funded health systems and in fact some of its tools and concepts have been applied to this setting. TOC is about leveraging the constraint to improve the performance of the system. While each of its tools and concepts can be, and for the most part have been, applied to the setting of publicly funded health systems, the theory can only be said to have been customized to this setting when the purpose of the various tools can be gauged with regards to the purpose of the theory. In other words, one should be able to answer if applying a tool of TOC has in fact improved overall system performance through leveraging system's constraint.

The details of the drum-buffer-rope technique, TOC's scheduling methodology for physically constrained systems, were spelled out in another book: "The Race" (Goldratt and Fox, 1986). Drum, or the bottleneck, sets the pace of the system and is protected by the buffer. The rope is the communication mechanism to signal the release of raw material at the right time. Buffer management is a related TOC application that determines the size and monitors the status of buffers. Buffer levels can be set to some initial levels. Over time, buffers can be monitored and their right level can be determined through experience.[12] Lubitsh et al (2005) investigated the impact that applying TOC has had on three NHS Trust departments, Neurosurgery, Eye, and ENT, with regards to reducing waiting lists in the system and improving throughput of patients. Using data that was collected on a number of NHS performance indicators before and after the intervention (over a period of 40 months), they found that for both Eyes and ENT, most measures improved. However, significant improvements could not be verified for Neurosurgery, possibly due to the size of the system, complexity of treating neurological disorder, heavy reliance on support services, impact of emergencies on elective work, and the motivation and receptiveness of staff to the proposed changes. This finding emphasizes the importance of taking into account the social environment in order to maximize the benefits of TOC in an organization.[12, 13]

Positive financial and operational results are related to a nurturing environment supported by improved communication, coordination, cooperation, and participatory management style. If the organization takes care of its people, then its people take care of the organization in terms of improved market share, bottom line improvements, and financial stability.

Kershaw (2000) applied the focusing steps to an outpatient oncology clinic administering chemotherapy to patients. The process is composed of six steps: checking in with the receptionist, blood tests in the lab, pretreatment process conducted by nurses in the exam room, physician consult in the exam room, chemotherapy administration in the treatment room, and scheduling a follow-up appointment with the receptionist. To identify the bottleneck, patient volumes were compared to the capacity of resources at each step of the treatment process and the treatment chairs were found to be the primary constrained resource. Improvement efforts were focused on the constraint. First, the three components of the treatment time- establishing intravenous access, administering prescribed drugs, and performing post treatment education were analyzed. It was decided that the post treatment education could be performed during drug administration and that the intravenous access, for more routine patients, could be established in the blood lab by lab technicians. Moreover, mobile supply caddies were set up so that time was not lost due to nurses looking for equipment and supplies when patients experienced undesirable side effects. At the end of the study, the capacity was increased by 20 to 25 percent.[12, 14]

Rotstein et al (2002) present a retrospective study of whether or not the bottleneck in a particular emergency department had been the physicians, to evaluate under what conditions adding medical staff would be a valuable strategy. This is a contribution, though probably not very generalisable to the first step of the process of ongoing improvement: identifying the bottleneck. The marginal benefit of shortening non-trauma patients' length of stay during a period when a physician in the evening shift had been added was examined for different patient volumes using the SAS software package. To exclude other parameters that might have contributed to this change in the length of stay, the length of stay of the patients visiting in the morning shift served as a control group, as no staff were added to the morning shift during the period that the staffing level in the evening shift was examined. The study showed that the physician could only be regarded as the bottleneck within the 80-119 patient volume range.[12, 15]

Gupta and Kline (2008) present the application of TOC's

process of ongoing improvement to a Chemical Dependency unit within a community mental health center. In identifying the constraint, wait times are taken as a clue to spot psychiatrists as the primary constraint of the system, and the therapists as the secondary. In the later steps of subordinating the system to the constraints, it is revealed that the clinical support function also demonstrates inadequate capacity. A number of recommendations are made, including moving the psychiatrist's office closer to the waiting area which proved to save enough time for the psychiatrist to personally schedule new patients for Psychiatric Evaluation and make reminder calls for these patients. As a result, the no-show rate for Psychiatric Evaluation appointment fell from 43% to 20%. Other recommendations regarding increasing pay of clinical staff support await agency action at the executive level. It was advised that the patients with a certain number of missed appointments per year should have their cases closed.[12, 16]

Siha (1999) summarizes the complexities encountered in the medical environment, namely stochastic cure times, dependent events, and probabilistic care plans, and suggests that the drum-buffer rope technique might be useful in this environment. The goal of health systems has not been widely discussed in the TOC literature. Some of the few suggested goals include "maximize life expectancy and quality of life at an acceptable cost to society" (Hunink, 2001), "to maximize the units of health" (Breen et. al., 2002), "providing safe care while thinking of money only as an operating expense – something to be reduced" (McNutt et. al., 2004), "to treat more patients both now and in the future" (Wright and King, 2006), to "maximize quality medical services provided to its customers, subject to budgetary constraints" (Ronen et. al., 2006), and "to make more health, today as well as in the future" (Schaefers et. al., 2007). Schaefers et al (2007) recently presented a more relevant paper in defining TOC's performance measures for the health industry. They generalize the classical TOC's goal statement for publicly traded for-profit companies, namely "making money, both now and in the future", to be applicable to any type of institution, by rephrasing the goal as: "to continuously make more goal units today as well as in the future." [12, 17, 18, 19, 20, 21, 22, 23]

To define the goal unit for a non-profit hospital, they take TOC's approach in that the goal unit should be the "value of the product or service in the eyes of the organization's customer". They claim that "the patient's objective is to receive the care that will maximize his life expectation with an acceptable to good life quality", and as such meeting this objective should be the hospital's goal. Therefore, a measurement is needed that captures both life quality and life expectation. They formulate the goal unit LETLIQ.

Taylor and Sheffiled (2002) applied TOC's thinking process to a Texas-based claims processing company that files, processes, and follows up medical insurance claims from local medical providers. Twelve UDEs were identified. A current reality tree was constructed that identified one of the UDEs (medical costs are growing faster than reimbursement levels) as the core problem. An evaporating cloud was built with the objective of achieving the opposite of the core problem, i.e. increasing the margin between reimbursement and cost. To this aim, claims should be entered correctly, and they should be entered promptly. The former requires taking time to properly training the staff; the latter requires putting new staff to work immediately. As such, there exists a conflict. Five injections were considered: (a) add more edit checks to the system; (b) ensure that the claims processing entity receives EOBs; (c) provide additional staff training; (d) ensure that all valid claims are paid; and (e) ensure that claims are filed for the maximum legal amount. Finally, a future reality tree was developed to demonstrate the positive effect of these injections in addressing the UDEs.[24]

Taylor and Churchwell (2004) apply the thinking process to tackle the problems of the General Medical Medicine (GMS) department of a Texas psychiatric state hospital. Within 24 hours of admission, patients should have a History and Physicals (H&P) exam at the GMS department.[25] Also, patients who develop medical conditions that require treatment are referred by the attending physician to the GMS department for a consult (evaluation and treatment). Patients might be sent back to the attending physician with recommendations for treatment, or be treated at the GMS. Severely ill patients are referred to outside medical services. A total of eleven UDEs were identified. A current reality tree identified one of the UDEs (the decrease in the legislative funding) as the core problem. Two evaporating clouds were made, one to deal with the conflict between reducing workload and expenses and maintaining patient satisfaction; the other one to deal with the conflict between boosting nursing morale and increasing output. Injections were designed that, through a future reality tree, were shown to affect the hospital positively even if legislative funding decreases.[12]

McNutt and Odwazny (2004) discuss how the TOC provides the Patient Safety Committee of Rush University Medical Center with a conceptual framework for identifying core causes of error and offers the committee a model for planning safety improvements. The committee uses individual cases of serious adverse events, as opposed to trends or frequencies, to conduct an independent review of what has happened. First a chain of events leading to the adverse event, a timeline starting from the first discernible clinical decision and ending with the adverse event, is built. Despite the presence of multiple weak steps in the chain of events, the committee looks for a single step in the chain that is most likely responsible for the series of events that led to the adverse event. In investigating each case, the team develops a current reality tree by asking all possible logical questions to understand the causes. The tree pinpoints a single core cause. Next the steps are redrawn to see if a better way can be devised. Frequently, the core cause is a conflict, and that's why the team hears a lot of yelling and objections to their proposals.[12, 20]

Umble and Umble (2006) report the application of buffer

management techniques to reduce Accident and Emergency (A&E) department waiting times and the waiting times of acute hospital admissions of A&E patients in three NHS facilities.[26] Acknowledging that DBR is not applicable in this environment because it is not possible to schedule the arrival of patients, they take advantage of the buffer management techniques for project environments. Unlike most project environments where, due to the uniqueness of each project, there is a lack of feedback mechanisms to improve problematic processes for future projects, they identify the health care environment as a "highly repetitive multi-project environment" where buffer management concepts can be utilized to their full potential. Each patient is regarded as a new project, the progress of which, from patient arrival to discharge from A&E or admission to acute beds, is monitored and compared against the performance standards set by the NHS. If there is reason to believe that the patient will not make it in time to meet the performance standards (e.g. patient is in the tracking or expedite buffer zones), then the resources are managed and the patient is expedited (if necessary) through the remaining steps to ensure the standards are met. Moreover, each week, a team of representatives review the sources of delays and focus their collective attention on improving the performance of the single activity that most negatively impacts waiting times. Statistical analyses of pre-implementation and post-implementation records demonstrate significant improvements with regards to the percentage of patients for whom the performance standards have been met.

To improve patient experience through providing more timely services in an outpatient cancer treatment setting, we proposed the adoption of a scheduling policy based on the theory of constraint's drum-buffer-rope (DBR) technique. With the use of a discrete event simulation model populated with historical data, we compared this policy against "high constraint utilization" and "low wait time" scenarios. DBR proved to be an effective mechanism in balancing the inherent tradeoff between the two performance measures of instances of delayed treatment and average patient wait time. To find the appropriate level of compromise in one performance measure in favor of the other, the linkage of these measures to system-wide performance measures, as developed in the fourth chapter of this thesis, are proposed.[12]

The goal refers to increase the quality and quantity of lives both now and in the future. This goal statement leads us to choose the quality adjusted life-years (QALY) as the unit of measurement for the goal. The advantage of using QALY as the unit of measurement is that it simultaneously captures gains from reduced morbidity (quality gain) and reduced mortality (quantity gain), and combines these two into a single measure (Drummond, 1987).[27] The view is that the QALY is a good basic definition of what we are trying to achieve in health care, and maximizing QALYs is quite an appropriate goal. Schaefers et. al. (2007) formulate the goal with some units of life time expectancy multiplied by an index of life quality, and try to link the performance measures to this goal.[23] Their fundamental idea in formulating the performance measures has some similarities to ours, but it falls short in showing a comprehensive relationship between all the performance measures and the goal, especially when it comes to operating expenses.

The TOC process of ongoing improvement would suggest exploiting and subordinating everything else to the effective capacity, as the constraint of the system, in times of rationing. The TOC process of ongoing improvement would favor providing services to those most likely to benefit from them (i.e. those with higher "return on health investment" on every QALY invested in health services). If the amount of time wasted to receive health services is relatively the same for everybody, this could be equivalent to those with higher clinical priorities, as conceptualized with the "health program effectiveness" element of the model. It would be advisable to offload the provision of health programs that could use less scarce resources to those resources, so that the scarcest capacity is saved for the ones that really need it. An example would be to offload the care of a diabetes patient who could benefit either from a specialist or a dietician to a dietician, when the supply of specialists is scarce.[12]

TOC has the potential to improve the resource-constrained publicly funded health systems by focusing improvement efforts on system constraints. Building upon a system dynamics representation of TOC's classical goal and performance measures for publicly traded for-profit companies, we developed a similar model that defined the goal and performance measures for publicly funded health systems. The model was then expanded, at a conceptual level, to include various factors affecting health system performance with the aim to guide the TOC's process of ongoing improvement.

Drum-buffer-rope proved to be an effective mechanism in balancing the inherent tradeoff between the two performance measures of instances of delayed treatment and average patient wait time. To find the appropriate level of compromise in one performance measure in favor of the other, the linkage of these measures to system-wide performance measures, were proposed.[12]

Applications in Healthcare

A unifying approach that helps doctors, nurses and managers work together to achieve a breakthrough in healthcare performance. The TOC was developed as an improvement methodology to create breakthroughs in performance in seemingly complex organisations. As a physicist Goldratt used the history of the study of disease to explain his struggle to find a systematic approach to management and the development of the TOC methodology (Goldratt, 1987). He explained the development of a systematic approach as moving through three distinct stages: classification, correlation, and cause and effect.[28]

The first stage – **classification** – is as old as the Old

Testament. When certain symptoms of disease appeared houses were quarantined and, as symptoms developed, the individual was isolated. However, with other symptoms that were not spread through human contact it was understood that isolation was not necessary. Diseases were classified not only by their symptoms but also by their potential for infection. These forms of classification helped to localise and prevent the spread of disease. [28]

In the management of modern hospitals the classification stage of a systematic approach to improvement comes via hospital data. The claimed benefit of classified data is improved communication. However, using this data can be time-consuming and expensive. In England the NHS tried to develop an integrated patient record system, which claimed that "NHS Connecting for Health supports the NHS in providing better, safer care by delivering computer systems and services which improve the way patient information is stored and accessed" (NHS, 2007). However, the project failed and the £12 billion scheme was axed in September 2011. The second stage of a systematic approach to disease – **correlation** – was only achieved comparatively recently. Edward Jenner found that if serum is transferred from an infected cow to a human body, the human would notbe infected with smallpox. Immunisation had been discovered. Medicine was no longer limited to preventing the spread of the disease but to preventing and, in some future cases, eliminating it. For Goldratt the importance of this stage was in understanding how to improve things. However, the question of why was not yet answered. Without the 'why' it is perhaps not surprising that it took over seventy years for Jenner's methods to be widely accepted.[28]

In Built to Last: Successful Habits of Visionary Companies (Collins, J.C. and Porras, J.I., 1994), Collins and Porras robustly and elegantly describe the characteristics of long-running, top- performing companies. It breaks many of the myths about the need for charismatic leaders and provides an excellent insight into the question of how these top companies continue to outperform their competitors. Finally, the third stage – cause and effect – was achieved by Louis Pasteur when he made a leap of imagination: an assumption that those tiny things that Leeuwenhoek found under his microscope more than a hundred years before, those things we call germs, are the cause of diseases. As a result the field of microbiology sprang to life. Many years later Goldratt explained that, through hard work and an understanding of cause and effect, medicine was able to create immunisation for a very broad spectrum of diseases where this was not created spontaneously in nature.[28]

The main purpose of Goldratt's comparisons of the study of medicine with the study of organisational systems relative to management was to highlight the significance of medicine as a mature science that has, for many years, been in this third stage of cause and effect. This stage is based upon the search for the minimum number of assumptions that will explain, by direct logical derivation, the maximum number of natural phenomena. In healthcare the goal is to provide affordable, high-quality and timely care. There are literally thousands of different patient pathways and on any one day there is a combination of unplanned and emergency admissions, and planned outpatient and inpatient treatments.

If we look at one effect – the flow of patients through the system – it is easy to recognise that patients' lengths of stay in hospital vary considerably, from a few hours to many days. One hypothesis might be that the only cause of the spread is the variation in clinical recovery time across patients. There is a more dominant cause of variation in length of stay, a cause related to disruption or delay, either during the patient's journey or at the end of their care. This underlying cause impacts upon the quality of care and often puts staff under together with the common experience of health professionals, indicates the quality and timeliness of care rapidly deteriorates when staff are overstretched. Catastrophic failures most often occur during extended periods of unreasonable staff pressure.[28]

Having Robust Patient Centred Priority System

The best way to identify the underlying constraint is to start with the creation of a robust and trustworthy patient-centred priority system and then identify which resource or task combination most often disrupts this patient-centred prioritisation. Diagnosis starts at the beginning of a patient's care and continues throughout their care. This continuation of diagnosis results in new tasks emerging throughout the patient's journey. This is caused by, for example: clinical recovery time varying significantly from patient to patient even when patients are suffering from the same illness type, any patient may have a mix of illnesses, recovery time becoming extended for some patients when they are not treated in a timely manner. An analysis of a European 800 beds acute hospital shows that in a scenario in which every planned discharge date was reviewed every day and half the patients recovered faster and half slower than expected, then every day gained from those who recovered faster would allow approximately 3, 000 extra patients to be treated a year. If we assume the average throughput per patient is €2, 000 then this is equivalent to €6.0 million extra throughput.[29, 30, 31, 32, 33, 34, 35]

Managing According to Patient Priorities

Synchronising the flow of current patients around an initial planned discharge date is not sufficient to maintain a robust and trustworthy patient-centred prioritisation. Priorities must not only be based on updating the actual rate of recovery of the patient but also the latest understanding of disruptions or delays. Hectic priorities cause chaos across the system and result in clinical and managerial staff bouncing from crisis to crisis. Even when patient flows are synchronised, a priority system can still lead to chaos. There are many different sources of variability in the day-to-day running of a hospital. Murphy's Law is also alive and well. QFI Discharge Jonah is based on a unique modification to Goldratt's buffer management process. Buffer management sets priorities in a four-colour-coded system according to the degree to which the buffer time is consumed. Each

patient's planned discharge date is buffered. The impact of changing a planned discharge date and/or disruption/delay to any one patient is understood and taken into account when adjusting the priority list across all patients. If a patient has passed their planned discharge date or is predicted to pass their planned discharge date because of the remaining duration of an outstanding task taking longer than the remaining time of the planned discharge date, then the patient status will be black. This enables staff to address the first and most fundamental question: "Of all the patients I could attend to next, which one should I choose?" Having the correct answer to this question provides the most important piece of information a resource, such as a doctor, nurse, manager or central department, requires if it is to play its role in improving patient flow. [29, 30, 31, 32, 33, 34, 35]

Implementing a Sustained Breakthrough in performance

When a robust and regularly updated priority list is threatened by a non-clinical cause of disruption or delay it is far better to identify and permanently eradicate the cause than to adjust the priority list. Recording the resource that is causing disruption or delay to a patient journey as the patient moves through the green, amber, red and black buffer zones makes the resource immediately aware it is disrupting the patient's journey. This then allows the resource the opportunity to take effective and proactive action. The process also enables analysis of the few resources most often causing the most disruption/delay across the most patients – the constraint(s). This is a robust way to focus improvement initiatives and improve overall performance of the system. QFI Discharge Jonah enables this analysis to be carried out even when the dependency between tasks is unclear or emerges during the patient journey. It also allows clinicians andmanagers to answer the second key question: "Which task, resource or task/resource combination is most often causing the most delay across the most patients?" People are willing to adopt an approach when they understand and agree with the underpinning logic, and understand that the logic is being checked in their own hospital through a series of controlled experiments. It is important that the first (and subsequent) actions are: common sense, even if not common practice; can be rapidly implemented; do not require daring acts of leadership; and deliver immediate and substantial benefits in line with expectations. [29, 30, 31, 32, 33, 34, 35]

Results from more than fifty implementations across the world have shown that the identification and eradication of the few underlying constraints reveal the inherent simplicity of the system. A hospital that follows this approach will quickly find itself with shorter lengths of stay, resulting in higher-quality, more timely care delivered by staff who feel less stretched. However, this is when the real challenge begins. In the past the reaction of senior management to the released beds has been to 'right size' the capacity to achieve cost savings. This is understandable in the current economic climate. However, there is a choice. The more sensible way to deal with the exposed excess capacity is to capitalise on it; to encourage clinicians to take advantage of the improved performance and improve the quality and timeliness of the care they provide, eliminate unnecessary backlogs and help the hospital to flourish. Doctors, nurses and managers working together in a patient-centric system delivering higher quality, more timely care and a breakthrough in financial performance. [29, 30, 31, 32, 33, 34, 35]

Generic Problem Solving

TOC is a scientific process for generic problem solving that can be associated with an increase in productivity. TOC has simultaneously increased throughput and reduced both operating expenses and inventory by identifying the bottleneck in advance you can reduce the variability through reducing the material ordered into the system. Efforts specifically targeted at the "buffers" located before a bottleneck ensure that material going through the bottleneck does not have to be "reworked". Scheduling the bottleneck resource results in better use of the bottleneck area. It was this area that paid the greatest dividends in terms of net profit. Having a buffer before the constraint ensures that the bottleneck is less vulnerable to random disturbances in workflow.[36]

Knight (2001) argued that utilisation of the bottleneck in a health care setting can impact overall productivity without compromising quality of care or making staff work harder. He claimed that the bottleneck can be affected by the lack of synchronisation of previous and subsequent stages in the chain. For example, surgeons and theatre staff may not be able to operate because there are no beds available since they have been filled with patients admitted unnecessarily early.[37]
A study investigated the impact of TOC, on three NHS Trust departments: Neurosurgery, Eyes and ENT. It particularly examined reduction in waiting lists in the system and improving throughput of patients. This study has demonstrated that the application of TOC can have a beneficial impact on "bottom-line" indicators - in a health care context, on such things as waiting lists and patient throughput. Moreover, TOC has the potential to effect system-wide changes rather than "local efficiencies" as the movement of several indicators up or down simultaneously, shows. TOC has the benefit of not being a "one size" fits all technique for bringing about organisational change because all stakeholders are engaged in identifying both problems and solutions. Thus, it can be customized to local needs and conditions and promote "ownership" of change initiatives. TOC worked best in eyes and ENT where routine surgery is the norm and had no effect in neurosurgery where presenting conditions are more ambiguous and life-threatening emergencies are common.[36]

Dominant Improvement Styles

Patient Safety is a dominant paradigm in healthcare today. Effective organizations will first adopt a proven method for improvement, and then apply tools correctly with understanding. Improvement methods are contrasted along aspects including 1. original purpose, 2. implicit

goals, 3. focus of attention and effort, 4. social values, 5. size and types of problems approached, 6. characteristics of the organization to use the method and, 7. typical tools and artifacts.

High-Level Side-by-Side Comparison of Dominant Improvement Styles
Quetsch JL, Society for Health Systems, Orlando, February 18 2007

	Label:	6-sigma	Lean	Theory of Constraints	Patient Safety	
1	Original Purpose	Maximize reliability	Maximize value	Maximize profit	Minimize bad results	1
2	Goal or Theme	Eliminate variation	Eliminate waste	Reality accounting	Eliminate error	2
3	Focus of effort	Statistical correlation	Process visibility	Optimal pace	Peer review	3
4	Social Values	Uniformity in all things.	Adapt to do more with same resources.	Maximize return on investment	Judgment, autonomy and teamwork	4
		Statisticians drive	Grass roots driven	Throughput accountants drive	Care professionals drive	
		Adhere to the defined, decreed best process	Agree to perform the current best common process	Think through implications, follow to real cash flow consequences	Adhere to professions, each profession knows best practice	
		customer voice factored in, statistician judges value	customer is only judge, value is what will customer pay?	global cash flow shows value.	no uniform measure of value. Measures are typically ratio indicators, actuarial risk, quality of life.	
5	Types of Problem	Statistically tractable problems (large counts of similar items)	Whatever is discovered, visibility enables common sense.	Optimization. Each local unit optimized for global result.	Incident reports, surveillance	5
		Large problems, prefer $500k	No contribution is too small.	Single minded focus on the current constraint	Politically correct problems	
6	Organizational fit	Large organizations, central control style, operations chiefs make decisions	Any size organization, delegated control, line mangers make decisions	Any size organization, central view for global information, accountants make decisions	Any size organization, healthcare professionals control, decisions emerge	6
7	Typical artifacts	Statistical graphs, control loops	Value stream maps, project schedules	Stories, metaphor, chains of reason, chains of producers	Policy statements, inspection reports	7

The Problem of Capacity Management

The TOC can be applied with the success to healthcare organizations, to solve problems of capacity management, reducing the inpatient length of stay and increasing the satisfaction from the offering services as has been proven by international research. The TOC thinking process can be applied to service organisations reevaluating and defining the basic measurements needed to guide decisions and provide essential feedback on improvement (Motwani & Klein & Harowitz, 1996). TOC contributes significantly to the detection of bottlenecks within the systems and to the efforts for the normalization of patient flow, increasing the whole capacity of hospitals (Garner & Bailey, 1992; Kershaw, 2000; Motwani & Klein & Harowitz, 1996; Phipps, 1999).[37, 38]

In complex systems like healthcare, there is always going to be a rate limiting step along pathways. Knowing where the constraints are makes it possible to focus improvement effort and allows specific operational management effort in order to increase and maintain throughput.

There is national information on known ‘hot spots'. These include: diagnostic capacity for some diagnostic tests and Theatre capacity. It is important to make sure that you identify the real constraint. For example, assumptions are often made about a surgeon's time being the most expensive resource, or about a specific piece of kit. Increasing capacity for the wrong thing will make the processes much worse, as well as making things harder for staff or worse at other steps in the patient pathway. So, identify the system's constraint (this limits throughput) and get the most out of the constraint - exploit it.

The constraint must always be managed, as it determines the rate at which patients go through the system. Ensure that there is no idle or wasted time at this point in the process. For example, if a radiologist is found to be the constraint in a given process, any time the radiologist is waiting for patients or equipment would be considered wasted time and this in turn affects the overall throughput. It is also important to always work this part of the process. First see if time can be released by improving the organisation of work processes and work environments. Where the constraint is equipment, it is important to ensure that it is always in use. Routine servicing of radiotherapy machines (a frequent constraint in the radiotherapy process) during the working week, will impact on throughput.

1) Support the system's constraint - subordinate everything else to it: it is here that the organisation needs to ensure that its own policies, resources, behaviours, measurements etc support the constraint to ensure that it is always working. This may require behaviour change in the organisation. To protect inevitable variation at the constraint. TOC recommends putting a ‘buffer' (a small queue) in front of the constraint to ensure it is always fed and there is no ‘down time'. An example might be that patients are scheduled to arrive at a time so there are an average of two or three patients in the waiting room.

2) Elevate the system's constraint: if the constraint still exists after exploiting and subordinating everything else to it, then during this step the constraint is elevated and 'broken' by investing resources in it. This may require capital expenditure, overtime and increased bed or theatre capacity. This step is only necessary if the constraint is a true bottleneck. If you break the bottleneck, the constraint will move - and it is often not easy to predict where to.
3) However, knowing the constraint may be sufficient to help improve the process and to help its operational management.
4) Go back to step one, don't allow inertia to become the system's constraint. When the constraint is broken, go back to step one. This step highlights the need to focus on continuous improvement.

Staff at the Radcliffe Infirmary carried out a TOC workshop, prompted by 64 elective neuro-surgical cancellations in a three month period combined with increased sickness levels. The neurosurgeon and the anaesthetists all believed they were the constraint in the process, however on examination the problem was found to be bed capacity. Changes introduced included one member of staff being given the role of bed manager whilst the maximum daily number of elective patients was reduced from eleven to six. Although initially these changes seemed counterproductive, the overall impact included reductions in patient cancellations, a drastic cut in out of hours operations and an increase in throughput of 16 per cent.[39, 40]

This study investigated the impact of Theory of Constraints on three NHS trust departments, Neurosurgery, Opthalmology and Ear, Nose and Throat (ENT), in relation to reducing waiting lists and improving throughput of patients. Significant improvements were made in ENT and Opthalmology, but not in Neurology due to the size of the system, its complexity and its heavy reliance on support services. The authors of this study recommend that an organisation's social environment is taken in account in order to maximise the benefits of TOC.[40, 41] TOC has most recently been applied to healthcare with regard to reducing waiting times and increasing throughput. Its application alongside Lean Thinking is now well recognised in the Healthcare.[40, 41]

The imperative to improve both technical and service quality while simultaneously reducing costs is quite clear. The TOC is an emerging philosophy that rests on two assumptions: systems thinking and if a constraint "is anything that limits a system from achieving higher performance versus its goal, " then every system must have at least one constraints or limiting factors. Recognition of the existence of constraints represents an excellent opportunity for improvement because it allows one to focus ones efforts in the most productive area-identifying and managing the constraints.[42]

As a result of multiple developments in health care and health care policy, hospital administrators, policy makers and researchers are increasingly challenged to reflect on the meaning of good hospital governance and how they can implement it in the hospital organisations. Due to the unique societal position of hospitals—which involves a large diversity of stakeholders—Corporate governance can provide for a comprehensive 'frame of reference', to which the hospital sector will have to give its own interpretation. The duty of Management is to: help formulate strategy; steward the expenditure of public money; ensure probity and transparency; and appoint, monitor and support top management. Good governance is crucial for effective public services and improved social outcomes. [43]

Improving the Dynamics of Delivery

Healthcare from a dynamic point of view is like a chain. We should seek out the dynamical weakest link and strengthen it and protect it. It is not just the detail of healthcare that must improve; it is the dynamics of the delivery that must improve as well. The healthcare process is best viewed as a patient. Healthcare professionals know about rate limiting steps (that are of course a dynamic entity). The weakest link in our static chain is analogous to the rate limiting step in a dynamic system. The key to success is the identification of the weakest link, the rate limiting step in our process. Once we know where this is, it then offers us huge leveragability. The linkage is provided by patients. The patients transmit things like variability. The less mechanized a particular step is, the more variability it will have. The exercise of Judgment and discretion is a feature of healthcare. We should therefore, expect some variability. The potential mix of any one single patient's complicating factors means variability is rife within this process. If variability is rife, then it is only natural that we should attempt to reduce it, and hence the attraction of the various methodologies.

All the systems have weakest link. There are no balanced lines. There is no way that we could balance health even of such a concept existed, we do not have the control over the rate at which new work enters the system. The TOC continues in this fashion using time as a logical rope recognizing the role of constraint.

Some things are universal. Health care systems do not work optimally, especially in hospitals — regardless of whether they are academic or community hospitals. Managing throughput is a challenge, resources are constrained, the number of beds is often limited, and patients experience long delays in the emergency department while waiting for beds. Most institutions have tried many solutions without sustained improvement. Clinicians and managers blame each other and act to protect their own turf. Business consultants appear, and they suggest further changes, but their "tweaks" provide only temporary relief. These undesirable events are not unique to medicine; they occur in abundance in other professions and industries. During the past two decades, an approach dubbed the "theory of constraints" has grown in popularity and success in industry. This approach began with Eliyahu Goldratt's particularly readable "business novel" entitled The Goal, which is currently in its third edition (North River Press, 2004).

Several related books have been published since then. The newest book in that array, We All Fall Down, extends the principles and analytic approaches of the theory of constraints to health care systems. The story is set in a mid-sized academic hospital in the United Kingdom, and the characters and their foibles are so familiar as to be both comforting and frightening.[44]

The crucial insight of the TOC

In today's economic climate, organizations that have implemented the ToC continue to thrive and grow in difficult times, continuing to achieve real bottom line growth, whether by improving productivity or increased revenues. The TOC consists of the Jonah Thinking Processes and an established set of logistical solutions:

- Critical Chain Project Management
- Drum-Buffer-Rope Scheduling
- Constraint-based Strategy
- Supply Chain Management
- Distribution Systems
- Throughput Accounting
- Jonah Thinking Processes

The crucial insight of the TOC is that only a few elements (constraints) in a business control the results of the entire organization. TOC tools identify these constraints, and focus the entire organization on simple, effective solutions to problems that seemed insurmountably complex and unsolvable. The theory of constraints has three underlying assumptions:

- ***Convergence - Inherent Simplicity;*** *The more complex a system is to describe, the simpler it is to manage.*
- **Consistency - There are no conflicts in nature;** If two interpretations of a natural phenomenon are in conflict, one or possibly both must be wrong
- **Respect - People are not stupid;** Even when people do things that seem stupid they have a reason for that behavior

TOC is a proven method that can be used by existing personnel to increase throughput, reliability, and quality while decreasing inventory, WIP, late deliveries, and overtime. Successful organizations also adopt the Theory of Constraints to help make tactical & strategic decisions for continuous improvement. TOC is a tool to manage bottlenecks and the scope of tools and breadth of application of Theory of Constraints is substantial.

Theory of Constraints Jonah Thinking Processes:

- Evaporating Cloud or conflict diagram
- Current Reality Tree (CRT)
- Future Reality Tree (FRT)
- Negative Branch Reservation (NBR) or branch
- Prerequisite Tree (PrT)
- Transition Tree (TrT)
- Strategy and Tactics Tree (S&T)

TOC in healthcare ranging from a discussion of buffer management (a major TOC tool for focusing improvement) to the implementation of TOC in a large family practice clinic (having about 70 employees), to a specialty medicine clinic (oral surgery), to an acute hospital, to a mental hospital, to the healthcare supply chain and finally ending with a discussion of a hospital strategy and tactics tree (the TOC methodology for developing and implementing a strategic plan).

Most if not all countries are faced with a massive healthcare problem. Some organizations have made significant improvement by using the TOC philosophy to continuously improve. TOC is the best methodology for today BUT there will always be a need for continuous improvement. These tools are part of the journey to excellent healthcare organizations. The use of TOC in healthcare is an emerging field. The use of the five-focusing steps (5FS), throughput accounting (TA), drum-buffer-rope (DBR), buffer management (BM), the engines of harmony, and the thinking processes (TP) are the merging applications in healthcare. Many medical providers use a patient appointment scheduling system based on fixed appointment times to schedule patient flow; the use of TOC in this type of scheduling system is a new and significant area of study. The TOC tools (the TP) and BM were used to improve scheduling, execution, and patient flow by eliminating the major causes of interruptions, thus providing a smoother flow of patients to and from the provider. The attendee benefits from understanding: the application of each TOC tool to the medical practice through various examples in an actual practice, the use of BM to proactively improve appointment scheduling and execution systems and the major causes of poor organizational performance across a medical practice. [50]

A case study[51] provided a blended, holistic approach to operational excellence in an acute hospital. The hospital services a population of about 260, 000 residents and 5 million tourists. The presentation goal and key learning points relate to sharing practical experience of what can be gained within a year by using the implementation of a blended approach to operational excellence of an acute hospital. The key learning is: a two-pronged approach works, involve everyone, resistance to change has a lot to do with the mermaid syndrome (taking comfort in not changing), learning to see, pathway integration, the speed of implementation is important, project management and sustained results are vital.[51]

Applying TOCin healthcare

Goldratt proposed a focusing process as follows:

1. **Identify** the system's **constraints**.
2. Decide how to **Exploit** the system's **constraints**.
3. **Subordinate everything else** to the above decisions.
4. **Elevate** the system's **constraints**.
5. If in the previous steps a constraint has been broken, **go back** to step 1, but do not allow inertia to cause a system constraint.

Thus we need to;

- Define the **system**.
- Define the **goal** of the system.
- Define the **necessary conditions**.
- Define the **fundamental measurements**.
- Define the **role of the constraints**.
- Define the **role of the non-constraints**.

Action Plan

1. **Identify** the system's **constraints**.
2. Decide how to **Exploit** the system's **constraints**.
3. **Subordinate everything else** to the above decisions.
4. **Elevate** the system's **constraints**
5. **Go Back - Don't Stop Improving**

To improve healthcare there is a need to approach it in a systemic manner. Understand the overall context and then begin to look for the constraints that stop us from improving our output. It is possible to implement rapid, significant, and sustainable improvement in this environment – healthcare. Know what to do, then do your best. [52-54]

TOC identifies a five step process to achieve continuous flow and improve throughput:

1. Identify the system's constraint (this limits throughput)
- Map out the process or patient pathways at a high level (process mapping)
- Identify the steps or parts of the process where there are the longest delays for patients.
- Then map this part of the process or the patient journey in more detail so you really understand what is going on. Do this to the level of what one person does, in one place, with one piece of equipment, at one time. Look at the process templates tool at this stage, in conjunction with capacity and demand analysis.
- Look carefully for the true constraint. The constraint is often a lack of availability of a specific skill or piece of equipment. Waiting lists or backlog of work tends to occur before the bottleneck in the patient journey, and clear after the patient has gone past the stage with the constraint.
- Keep asking 'why' to try to discover the real reason for the delay (five whys).

  For example, 'the clinic always overruns and patients have to wait for a long time'.

  - Why? The consultant does not have time to see all her patients in clinic.
  - Why? She has to see everyone who attends (including first visit assessments and follow-up patients).
  - Why? It is what she has always done.

- Now you have a good idea about the location of the constraint and some of its measures of demand, capacity, backlog and activity.

5. Get the Most Out of the Constraint - Exploit It

The constraint must always be managed, as it determines the rate at which patients go through the system. Ensure that there is no idle or wasted time at this point in the process. For example, if a radiologist is found to be the constraint in a given process, any time the radiologist is waiting for patients or equipment would be considered wasted time and this in turn affects the overall throughput.

It is also important to always work this part of the process. First see if time can be released by improving the organisation of work processes and work environments.

Other examples that may help to ensure maximum utilisation are multi-skilling staff, as well as assisting with set up and paperwork activities to enable trained staff to concentrate on the use of the machinery itself.

Where the constraint is equipment, it is important to ensure that it is always in use. Routine servicing of radiotherapy machines (a frequent constraint in the radiotherapy process) during the working week, will impact on throughput.

At the same time, see if processes can be improved. For example, prepping patients outside of the theatre to release theatre time, if theatres are the constraint. Detailed process templates will help to identify opportunities and help the operational management of constraints. This information will help you develop careful schedules around the constraint. This is important, as every minute that is not used at the constraint is a minute lost to the whole process.

Once you get the most out of a constraint, the bottleneck may move to another step in the process.

6. Support the system's constraint - subordinate everything else to it

The organisation needs to ensure that its own policies, resources, behaviours, measurements etc support the constraint to ensure that it is always working. This may require behaviour change in the organisation.

To protect inevitable variation at the constraint (demand and capacity), TOC recommends putting a 'buffer' (a small queue) in front of the constraint to ensure it is always fed and there is no 'down time'. An example might be that patients are scheduled to arrive at a time so there is an average of two or three patients in the waiting room.

7. Elevate the System's Constraint

If the constraint still exists after exploiting and subordinating everything else to it, then during this step the constraint is elevated and 'broken' by investing resources in it. This may require capital expenditure,

overtime and increased bed or theatre capacity. This step is only necessary if the constraint is a true bottleneck. If you break the bottleneck, the constraint will move - and it is often not easy to predict where to. Knowing the constraint may be sufficient to help improve the process and to help its operational management.

8. Go back to step one, don't allow inertia to become the system's constraint

When the constraint is broken, go back to step one. This step highlights the need to focus on continuous improvement. [52-54]

The use of TOC in healthcare is an emerging field. The authors describes the use of the five-focusing steps (5FS), throughput accounting (TA), drum-buffer-rope (DBR), buffer management (BM), the engines of harmony, and the thinking processes (TP) in a family practice organization. Many medical providers use an patient appointment scheduling system based on fixed appointment times to schedule patient flow; the use of TOC in this type of scheduling system is a new and significant area of study. The TOC tools (the TP) and BM were used to improve scheduling, execution, and patient flow by eliminating the major causes of interruptions, thus providing a smoother flow of patients to and from the provider. The attendee benefits from understanding: 1. The application of each TOC tool to the medical practice through various examples in an actual practice. 2. The use of BM to proactively improve appointment scheduling and execution systems. 3. The major causes of poor organizational performance across a medical practice

Improving Global Healthcare with the TOC

Maintaining good health is a universal and timeless desire of people worldwide, a fact that has remained unchanged through the ages. TOC improves system performance through leveraging the constraint(s). While the theory seems to be a natural fit for resource-constrained publicly funded health systems, there is a lack of literature addressing the modifications required to adopt TOC and define the goal and performance measures. This paper develops a system dynamics representation of the classical TOC's system-wide goal and performance measures for publicly traded for-profit companies, which forms the basis for developing a similar model for publicly funded health systems. The model is then expanded to include some of the factors that affect system performance, providing a framework to apply TOC's process of ongoing improvement in publicly funded health systems. Future research is required to more accurately define the factors affecting system performance and populate the model with evidence-based estimates for various parameters in order to use the model to guide TOC's process of ongoing improvement.

Some Case Scenarios

Staff at the Radcliffe Infirmary carried out a TOC workshop, [55] prompted by 64 elective neurosurgical cancellations in a three month period combined with increased sickness levels. The neurosurgeon and the anaesthetists all believed they were the constraint in the process, however on examination the problem was found to be bed capacity. Changes introduced included one member of staff being given the role of bed manager whilst the maximum daily number of elective patients was reduced from eleven to six. Although initially these changes seemed counterproductive, the overall impact included reductions in patient cancellations, a drastic cut in out of hours operations and an increase in throughput of 16 per cent.

A study [56] investigated the impact of TOC on three NHS trust departments, Neurosurgery, Opthalmology and Ear, Nose and Throat (ENT), in relation to reducing waiting lists and improving throughput of patients. Significant improvements were made in ENT and Opthalmology, but not in Neurology due to the size of the system, its complexity and its heavy reliance on support services. The authors of this study recommend that an organisation's social environment is taken in account in order to maximise the benefits of Theory of Constraints.

Healthcare is accelerating towards a crisis of affordability. The likely outcome is deterioration in both access and quality of care. It is time to make explicit how and why a TOC-focused approach is the only option.

A case study [57] provided a blended, holistic approach to operational excellence in an acute hospital. The hospital services a population of about 260, 000 residents and 5 million tourists. The presentation goal and key learning points relate to sharing practical experience of what can be gained within a year by using the implementation of a blended approach to operational excellence of an acute hospital. The key learnings are: a two-pronged approach works, involve everyone, resistance to change has a lot to do with the mermaid syndrome (taking comfort in not changing), learning to see, pathway integration, the speed of implementation is important, project management and sustained results are vital.

TOC is an emerging philosophy that rests on two assumptions: (1) systems thinking and (2) if a constraint "is anything that limits a system from achieving higher performance versus its goal, " then every system must have at least one (and at most no more than a few) constraints or limiting factors. Recognition of the existence of constraints represents an excellent opportunity for improvement because it allows one to focus ones efforts in the most productive area - identifying and managing the constraints. [58]

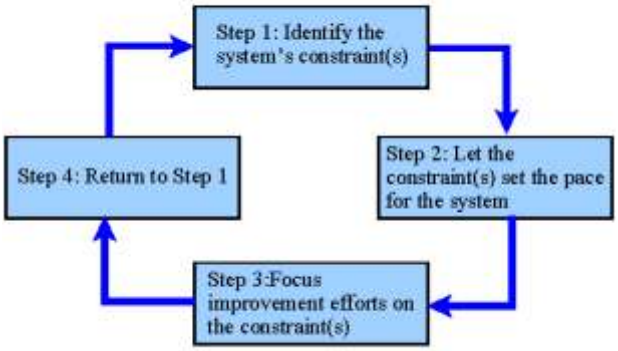
TOC concept can be used in the healthcare industry to manage costs, improve efficiency in operations, and to increase customer satisfaction. Healthcare providers must work to drive costs down and increase patient volume in order to compensate for the lack of sufficient revenue. This is where TOC can help.

Throughput can be modified from the standard meaning to "reimbursement rate less the cost of drugs and medical supplies for the number of patients seen and treated."

Second, a **unit of output** in this industry is basically a human being. Third, an example of an **external constraint** in healthcare terms is when the availability of drugs and medical supplies are restricted. Finally, an example of an **internal constraint** is where patient volume exceeds the capacity of a procedure in the patient treatment process.

Kershaw[59] lays out a four step process that should be followed to implement TOC effectively, and then relates these steps to the healthcare industry as a whole.

Exhibit 1
TOC Four-Step Process



* Adapted from Kershaw, p. 26.

Exhibit 2 - TOC Implementation in Manufacturing and Healthcare Settings

Steps	Manufacturing	Healthcare
1. Identify the constraints.	Is there sufficient demand for product? Adequate raw material supply? Does demand exceed capacity for machine or process?	Is there sufficient patient volume? Availability of drugs/medical supplies? Does patient volume exceed capacity for treatment or patient type?
2. Let constraints set the pace.	Purchase material based on constraints capacity. Schedule unconstrained processes based on constraints' capacity.	Purchase drugs/supplies based on constraints capacity. Schedule patients based on constraints' capacity.
3. Focus improvement efforts on constraints.	Reduce setup time. Move work to unconstrained machine or process. Eliminate or reduce machine downtime. Only schedule work that contributes to throughput. Modify process to increase capacity of machine. Schedule overtime. Acquire additional equipment.	Reduce preparation time. Move part of treatment to unconstrained resources. Eliminate or reduce the time the constrained resource is not used. Move other treatments to unconstrained resources. Modify treatment procedures to increase capacity. Increase hours of operation. Hire additional staff.
4. Start over.		

The key concept or step in using TOC to manage constraints is Step 3. This step is used to expand the constraints' capacity in order to increase throughput.

The XYZ Oncology Clinic

"If the clinic can identify ways to increase its ability to administer chemotherapy on a daily basis, it can improve patient throughput and profitability."

The basic treatment process is as follows:

1. Check in with receptionist.
2. Go to waiting room.
3. Go to lab for blood tests.
4. Go to waiting room.
5. Go to exam room for pretreatment process.
6. See doctor.
7. Go to waiting room.
8. Go to treatment room for chemotherapy.
9. Go back to receptionist for follow-up appointment.

TOC can help any profit-seeking company reduce costs and improve processes, no matter what the output. TOC must be applied carefully, taking into account the crucial elements involved including customer satisfaction, employee morale, and the nature of the procedures. With the proper implementation, TOC can lead to both short-term and long-term profitability.

Focus on System Improvement

TOC focuses on system improvement. A system is defined as a series of interdependent processes. Ananalogy for a system is the chain: a group of interdependent links working together toward the overall goal. The constraint is a weak link. The performance of the entire chain is limited by the strength of the weakest link.

Identify the Constraint Exploit

Once the constraint is identified, the process is improved or otherwise supported to achieve its utmost capacity without major expensive upgrades or changes. In other words, the constraint is exploited.

Subordinate

When the constraining process is working at maximum capacity, the speeds of other subordinate processes are paced to the speed or capacity of the constraint. Some processes will sacrifice individual productivity for the benefit of the entire system.
Subordinate processes are usually found ahead of the constraint in the value stream.

Processes after the constraint are not a major concern—they are probably already producing under capacity because they have to wait on the constraining process.

Elevate

If the output of the overall system is not satisfactory, further improvement is required. The company may now contemplate major changes to the constraint.

Changes can involve capital improvement, reorganization or other major expenditures of time or money. This is called elevating the constraint or taking whatever action is necessary to eliminate it.

Repeat

Once the first constraint is broken, another part of the system or process chain becomes the new constraint. Now is the time to repeat the cycle of improvement. The performance of the entire system is re-evaluated by searching for the new constraint process, exploiting the process, subordinating and elevating.

By focusing on constraints, this methodology produces positive effects on the flow time of the product or service through the system. Reduction of waste in the constraint increases throughput and improves throughput time. When the constraint is improved, variation is reduced, and quality is improved.

TOC methodology operates on several assumptions:

• As in the case of lean, the organization places a value on the speed at which its product or service travels through the system. Speed and volume are the main determinants of success.

• Current processes are essential to produce the desired output.

• The product or service design is stable.

TOC helps a team identify the most important bottleneck in an organization's processes and systems in order to deal with it and improve performance. This tool helps the user understand and apply this theory as part of the improvement of organizational systems.[60]

TOC Helps Cure Healthcare Problems

"The TOC methods helped the XYZ clinic significantly. The clinic saw an increase in treatment capacity by 20% to 25% with the average number of patients per day increasing from 24 or 25 to about 30. In addition, the average amount of treatment time decreased from 2.5 hours to 2 hours or less. Also, with further process improvements, the clinic will see increases in patient volume per day of up to 60% in treatment capacity".[50]

A hospital can seem very complex but at its heart it is a system of dependent events experiencing statistical fluctuations (Fig. 6).

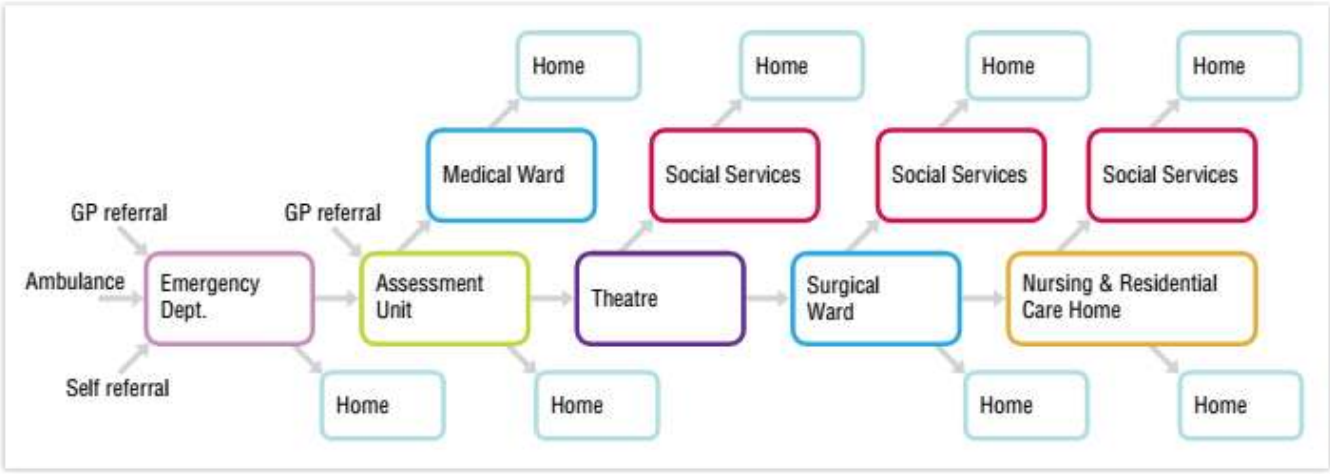


Figure 6: An example of a health and social care chain of activities

Research indicates the quality and timeliness of care rapidly deteriorates when staff are overstretched. Major failures most often occur during extended periods of unreasonable staff pressure. However, simply adding additional resource risks financial viability as it increases operating expense in a regime of zero revenue growth. At the same time, trying to find consensus regarding the system-wide underlying cause of this unnecessary disruption or delay is often met with a barrage of finger-pointing and accusations.

Strategy 1: having a robust and trustworthy patient-centred priority system

The best way to identify the underlying constraint is to start with the creation of a robust and trustworthy patient-centred priority system and then identify which resource or task combination most often disrupts this patient-centred prioritisation.

Strategy 2: managing according to patient priorities. Synchronising the flow of current patients around an initial planned discharge date is not sufficient to maintain a robust and trustworthy patient-centred prioritisation.

- Identifying the causes of disruption/delay for a patient
- Identifying the cause of disruption/delay across the most patients

Strategy 3: implementing a sustained breakthrough in performance

Recording the resource that is causing disruption or delay to a patient journey as the patient moves through the

green, amber, red and black buffer zones makes the resource immediately aware it is disrupting the patient's journey. This then allows the resource the opportunity to take effective and proactive action.

This is a robust way to focus improvement initiatives and improve overall performance of the system.

What to change? The process helps focus our initial exploration so that we know what, of all the things that could be changed, will have the biggest impact on the whole system.

What to change to? This is where the development of a second-order breakthrough is possible. Through the rigour of cause-and-effect analysis and an ability to identify and modify proven TOC-based solutions, it is possible to develop rapidly implementable solutions tailored to the environment.

How to achieve the change? People are willing to adopt an approach when they understand and agree with the underpinning logic, and understand that the logic is being checked in their own hospital through a series of controlled experiments. It is important that the first (and subsequent) actions are: common sense; can be rapidly implemented; do not require daring acts of leadership; and deliver immediate and substantial benefits in line with expectations.

Research has shown that the identification and eradication of the few underlying constraints reveal the inherent simplicity of the system. A hospital that follows this approach will quickly find itself with shorter lengths of stay, resulting in higher-quality, more timely care delivered by staff who feels less stretched. The more sensible way to deal with the exposed excess capacity is to capitalize on it; to encourage clinicians to take advantage of the improved performance and improve the quality and timeliness of the care they provide, eliminate unnecessary backlogs and help the hospital to flourish.[57, 61] Doctors, nurses and managers working together in a patient-centric system delivering higher quality, more timely care and a breakthrough in financial performance.

Learning from NHS Experiences

TOC has most recently been applied to healthcare with regard to reducing waiting times and increasing throughput. Its application alongside Lean Thinking is now well recognised in the NHS.[62]

Working with QFI, the developers of Jonah approach within a few months the results were visible: the average length of stay decreased. The Jonah project uses an innovative approach that cuts across all disciplines and partner agencies.[62]

- To reduce our length of stay by a third within a matter of weeks and make big improvements to the quality of our patients' rehabilitation and discharge. The process has developed staff's confidence in their ability to take control and make changes which improve quality and productivity and has significantly improved multi-agency working
- Improved productivity: an average length of stay of 20 days from 40 days was achieved which is maintained and is likely to reduce further, thus benefiting patients and delivering best value.

TOC applies the cause-and-effect thinking processes used in the hard sciences to understand and improve all systems, but particularly, organizations. The process a clinician applies to treating a patient is an excellent analogy for explaining how TOC recommends going about solving a systems problem. If we were to describe the overall process used by a clinician treating a patient it would look something like:

Diagnosis: Knowing the futility of treating the symptoms, a clinician begins with a list of observable symptoms and uses cause and effect to seek out the underlying common cause for all of them, the "disease" or core problem.

Design of a Treatment Plan: Considering the uniqueness of the patient and his/her diagnosis, a treatment plan is developed that first and foremost treats the disease (e.g., surgery), but also suggests what other things must be done alongside that "cure" to ensure the treatment will work (e.g., pain relief and bed rest) and that the best possible health is restored to the patient (e.g., physical therapy). In this process, any potential side effects of the treatment are identified, and the means for preventing or mitigating them become key elements of the treatment.

Execution of the Treatment Plan: Taking into consideration, the uniqueness of the patient's situation, a plan is developed for how to implement the treatment (e.g., surgery and pre-op work are scheduled, arrangements for transportation to and from the hospital are secured, hospital beds to be used at home are ordered).

What to change

1. Identify the Core Conflict causing the symptoms, or UnDesireable Effects (UDEs), of the chosen subject using the Three-Cloud Process.

2. Build a Current Reality Tree that validates the identification of the Core Conflict, helps us understand the existing cause-and-effect relation-ships of the subject and identifies the conspiring formal and informal policies, measurements and behaviors that support the existence of the UDEs

What to change to

3. Identify and break the assumptions that allow the Core Conflict to persist
4. Construct a Future Reality Tree that lays out the complete solution/strategy that:

- Resolves all of the UDEs by making their opposites, the Desired Effects, exist

- Ensures alignment with the Strategic Objectives (SO) of the bigger system that the subject is a part
- Ensures that no new negative side-effects (Negative Branches) will occur from implementing the solution/strategy
- Identifies what changes in the culture (formal and informal policies, measurements and procedures) of the system and/or sub-system must be made to ensure the symptoms are resolved
- Leverages the existing TOC applications that are needed to make the solution/ strategy work, and
- Quantifies the "bottom line" value of achieving those DEs and SOs

How to cause change

5. Build a Tactical Objectives Map that charts the overall course for getting from the current reality to the future reality, where the solution/strategy is fully implemented.

Flesh out the details of what each part of the system/sub-system must contribute, and when, to achieve each of the mile-stones of the TO Map using a PreRequisite Tree (PRT)

6. Create detailed task interdependency diagram, using Transition Trees (TRTs) when necessary to flesh out crucial actions Internalize TOC's 6 Steps of Buy-In to achieve the needed approvals, buy-in, or active collaboration to proceed with implementation via the design/customization (again, using TRTs) and role-playing of specific buy-ins the participant will have to perform in their subject environment, and

Transform action plans into a complete project network that can be effectively managed using project management techniques (preferably, TOC's Critical Chain project management solution).

Although the 5 Steps of TOC can be applied to every process at every level in an organization, which is how TOC is frequently often implemented, the true power - and results - comes from:

- Understanding the interdependencies between and across processes that contribute to delivering a product or service,
- Understanding the impact that those interdependencies and normal variability have on their combined, overall performance, and
- Appropriately buffering for interdependencies and normal variability so that that performance can be predictably and consistently high.

TOC challenges managers to rethink some of their fundamental assumptions about how to achieve the goals of their organizations, about what they consider productive actions, and about the real purpose of cost management. Emphasizing the need to maximize the through-put—revenues earned through sales—TOC focuses on understanding and managing the constraints that stand between an organization and the attainment of its goals. Once the constraints are identified, TOC subordinates all the nonconstraining resources of the organization to the needs of its core constraints. The result is optimization of the total system of resources.

TOC emphasizes the optimization of performance within the defined set of constraints of the existing processes and product offerings. TOC provides an action framework that combines the activities of managers around a few highly visible system elements.

TOC represents a tremendous change in management, focus, and direction. It is a transition shaped by several fundamental concepts that can be used to build a profitable foundation for any organization. These concepts include:

- A new measuring system;
- A process of continuous process improvement;
- A fundamental decision process focusing on global rather than local issues;
- A new method for analyzing the relationships between resources and processes and deter-mining where to focus the company's efforts;
- New methods for analyzing policy problems to arrive at simpler solutions; and
- A new management approach for providing strategic and tactical direction.

TOC incorporates the idea that the goal or mission of an organization is the reason the organization exists. Only the owners of the organization can determine its goal or mission. For a publicly held, "for-profit" organization, the goal would be to maximize profitability today and tomorrow, because that is why the shareholders have invested.
TOC management systems normally consist of the following elements:

Logistics/scheduling. The scheduling methodologies of drum-buffer-rope, buffer management, V-A-T logical structures analysis, the five-step focusing process, and supply chain management are used to establish and control the flow of materials to the final product within a TOC environment.
Performance measurement. Built around the core metrics of throughput, inventory, and operating expense, TOC develops and uses a series of measurements that directly link financial performance with nonfinancial performance.

Problem-solving/thinking process. This process consists of effect-cause-effect (ECE) diagramming and its components, the ECE audit process, and the "evaporating cloud" methodology for conflict resolution. The essence of ECE is the scientific method, which suggests that if a secondary confirming effect is found when a cause or event occurs, then it can be argued that the cause truly leads to the hypothesized effect. In other words, two or more occurrences of the same cause-and-effect relationship are needed to uncover the primary cause of the majority of the detected problems within the system.
Project management. The standard concepts in project scheduling and management have been the critical path

method (CPM) and the program evaluation review technique (PERT). TOC's critical chain concept removes the implicit assumption of infinite capacity from the project management domain, just as the TOC drum-buffer-rope technique removes it from the factory floor domain.

Technology Assessment

Applying assessment methods commonly used in healthcare, such as randomized controlled trials, and financial analysis, often proves challenging when assessing technologies that strive to improve productivity. The traditional way of seeking the procurement and implementation of process improving technology is based on financial analyses. These are often not only laborious, but also based on weak assumptions about the interrelationship between technology, processes, and the institutional environment. There is a need for a more pragmatic managerial approach. The primary focus of technology assessment should be on the ability of technologies to remove or alleviate organizational constraints, in order to increase throughput rather than reduce costs. Ultimately, the latter will happen as a consequence of the former. Most healthcare providers are urged to improve their productivity to cope with increasing demand under resource constraints. There is a rising trend of seeking improvements in productivity through the use of technology, ICT (information and communication technology) in particular. There is a need for a more pragmatic, managerial approach to evaluating process improving technologies. Such an approach would need to focus on the ability of a particular technology to move the organization towards its goal. Every organization has a goal and defining it clearly is of great importance. The generic goal of any for-profit business organization is to "make money now as well as in the future" [63], "without violating the necessary conditions of providing a satisfying work environment for employees and ensuring customer satisfaction", e.g., by offering quality products or services. The two prerequisites should not be confused as separate goals. They are threshold conditions which need to be satisfied at least to some minimum level, above which their impact on performance diminishes. The goal, on the other hand, has no upper limit, and it is something that should constantly be pursued. Efficiency studies must be based on the assumption that a certain clinically justified level of service of a given quality is necessary, and the challenge is to produce those at the lowest (or optimal) cost. New technologies are traditionally assessed on the basis of simplified financial estimates, with the operational impact being overlooked. This paper suggests an alternative approach based on Operations Management (OM), following the theory of constraints (TOC). The TOC approach is more pragmatic and suitable for technology evaluation in a fast-paced and growing health technology market. It holds that the performance of the system can only be increased by improving the performance of the primary constraint. Therefore technologies should be assessed on the basis of their ability to improve the performance of the constraint. The suggested approach further stresses that prioritizing throughput over cost will reduce costs, while focusing on cost reduction will ultimately reduce throughput. Once the operational aspects have been assessed, financial methods are bound to be more reliable and useful.[63]

9. Some Fundamental Concepts

Managers should focus on effectively managing the capacity and capability of these constraints if they are to improve the performance of their organization. TOC has broad applications in diverse organizational settings. TOC challenges managers to rethink some of their fundamental assumptions about how to achieve the goals of their organizations, about what they consider productive actions, and about the real purpose of cost management. Once the constraints are identified, TOC subordinates all the nonconstraining resources of the organization to the needs of its core constraints. The result is optimization of the total system of resources. TOC is a vital to maximize customer value-added and organizational profitability. TOC represents a tremendous change in management, focus, and direction. It is a transition shaped by several fundamental concepts that can be used to build a profitable foundation for any organization. These concepts include:

- A new measuring system;
- A process of continuous process improvement;
- A fundamental decision process focusing on global rather than local issues;
- A new method for analyzing the relationships between resources and processes and deter-mining
- Where to focus the company's efforts;
- New methods for analyzing policy problems to arrive at simpler solutions; and
- A new management approach for providing strategic and tactical direction.

The TOC incorporates the idea that the goal or mission of an organization is the reason the organization exists. Only the owners of the organization can determine its goal or mission. For a publicly held, "for-profit" organization, the goal would be to maximize profitability today and tomorrow, because that is why the shareholders have invested. TOC has broad applications in organizations. As such, its benefits cross multiple boundaries and functions, resulting in uses and benefits including: decreased production lead times; improved quality of products and services; dramatic increases in profitability; reduced inventory levels; reduced bottlenecks; management of constraints; curbing of statistical fluctuations; improved competitive position; facilitation of strategic marketing and operational decisions; introduction of the marginal pricing concept; and application of continuous improvement at the supply chain level. TOC can be used in conjunction with other management techniques such as total quality management (TQM) and just-in-time (JIT) to pro-vide a comprehensive, linked set of techniques that emphasize continuous improvement in all areas of operation. TOC has also been applied at the supply chain level to coordinate the activities of upstream and downstream trading partners.

Constraints can be classified in one of the following categories: behavioral, managerial, capacity, market, and logistical, each having its own impact on the smooth operation of the organization. For example, behavioral constraints are those behaviors and work habits exhibited by employees that result in poor performance from a global perspective. Managerial constraints are erroneous management strategies, policies, and decision mechanisms. Logistical constraints involve limitations placed on the system by the planning and control systems. Constraints interact to reduce throughput. The key is to understand the real and created constraints that exist throughout the system and to identify how they are affecting the total throughput of the organization.

Buffer Management

Under the TOC, buffer management forms the basis for shop floor control. Specifically, nonconstrained resources are scheduled to ensure that they are working on the right jobs, at the right times in the sequence, and in the right production batch quantities to meet the requirements of the constrained resource's schedule and related customer delivery needs. Buffer management can serve as an early warn-ing system. Strategic placement of buffers can be used to identify process problems prior to their emergence, as holes between the "drum" or gating operation's schedule attainment and that of the constrained resource become evident. Fine-tuning the amounts of protective time, capacity, and work-in process buffers is called dynamic buffering. Using continuous improvement techniques, reductions in buffer sizes are made until problems appear.[64, 65]

Supply Chain Management

TOC can be applied outside of the boundaries of the organization, reaching backward and forward in the supply chain to reduce inventories, improve throughput, and increase responsiveness to changing customer needs. Leveraging the concept of the primary constraint across the supply chain creates priorities and schedules that ensure that the system-wide limiting factors serve as the basis for the development of integrated scheduling and logistics planning and execution. These linkages can take the form of protective capacity or protective time or inventory buffers. The goal is to maximize the profitability of the entire system by ensuring that the system's constraint is used to pace the entire flow of materials and value from the beginning to the end of the production cycle. DBR scheduling is applied across organizational boundaries to ensure that the constrained resources are used effectively.[64, 65]

Some benefits that can be expected from extending TOC concepts to the supply chain include:

- Reductions in supply chain inventories;
- Increased responsiveness and flexibility as inventories and wasteful obstacles and barri-ers to
- Effective production are removed;
- Improved on-time delivery performance to the final customer;
- Enhanced value creation for customers;
- Improved profitability/throughput for the sup-ply chain;
- Reductions in total assets invested in the sys-tem as only essential increments to available capacity
- Are added;
- Simplification of relationships as objectives are clarified;
- Reductions in cost across the supply chain; and
- Improved competitive position.

To optimize the benefits of integrated supply chain management, the separate organizations have to come to operate as one synchronous whole that follows the same "drummer."

Market Segmentation

A market is effectively segmented when an organization can sell exactly the same product at two different prices to two different markets, without having either market affected by the other. Key to market segmentation efforts are: product mix decisions; and product pricing decisions. Whenever a limitation exists restricting the amount of product that can be produced, a decision must be made to choose one product (or product line) over another so that profits can be maximized.[64]

Performance Measurement

The proof of effectiveness for any change effort is the degree to which it improves performance. The assessment needed to determine whether an improvement has occurred begins with the validation of the touted improvements against some standard. While measurements such as return on investment (ROI) are often used, it sheds little light on whether an improvement has occurred based on the application of the TOC model. There must be a direct linkage established between the financial measurements used, such as net profit and ROI, and those used operationally. TOC is particularly effective in establishing this connection.[64, 65]

Operational Measures

TOC measurements are based on a simple relationship that highlights the effect that any local action (i.e., constraint management) has on progress toward the organization's goal. All of its measurements, both financial and operational build from the same three basic concept - throughput, inventory, and operating expenses.[64, 65]

- Throughput (T)—the rate at which the entire system generates money through sales (product and/or service). To calculate T, subtract all money that has not been generated by the organization.
- Inventory (I)—all the money the system invests in things it intends to sell.
- Operating expenses (OE)—all the money the system spends turning inventory into through-put. OE includes expenditures such as direct and indirect labor, supplies, outside contractors, and interest payments. These costs

are considered operating expenses because the employees are all responsible for turning inventory into throughput. Depreciation is also classified as an operating expense because it represents a cost of turning inventory into throughput.

TOC measures concentrate on increasing throughput and decreasing both inventory and operating expenses. TOC emphasizes how efficiently an organization must manufacture its products for optimum success in the marketplace rather than how efficiently the organization must manufacture the product. TOC promotes creating products/services that customers need and value. The flow of production is set according to market demand. The marriages of the three core elements of TOC measurement (T, I, and OE) provide significant amounts of information about the productivity of the system and its ability to turn investments in resources into sales and profits. The higher the inventory turnover ratio, the greater the velocity of materials through the system, the greater its effectiveness.[64, 65]

Throughput Accounting (TA)

Throughput accounting, TA, provides a well-defined set of performance measurements that physically link operational to financial results. Management can use these linkages to support the implementation of TOC. TA is a direct out-come of the use of throughput, inventory, and operating expense as management decision tools that replace most of an organization's traditional cost management reports and analysis.[64, 65]

TA operationalizes the key facets of TOC management. TA focuses management's attention on three basic objectives: increasing throughput; reducing inventory; and reducing operating expenses. The emphasis in TA is on the underlying cash flow of the organization. In TA the key leverage point is growth in through-put, the ability to "make the economic pie bigger. TA is a useful tool for analysis, one that needs to be employed when applicable, developed in a reliable way, and accurately maintained and modified over time.

Constraints Accounting (CA)

Constraints accounting is an accounting report-ing technique, consistent with a process of ongoing improvement and implementation of TOC, which includes: explicit consideration of the role of constraints; specification of throughput contribution effects; and decoupling of throughput (T) from operational expense (OE). CA requires identification of the constraints as well as the means of monitoring them and understanding their behavior. CA is a stage beyond, when there is acceptance of the need to know and measure physical constraints and after there is the capability to do that measuring and planning.[64, 65]

TOC and Cost Management

TOC presents a significantly different perspective on how best to control operations. It does not work well with conventional accounting systems that emphasize cost absorption and standard cost variance analysis. The reasons for this are many, including the fact that building inventory to "earn hours" of labor and overhead is an alien concept in the TOC environment. Behind these worrisome trends lies the management accounting system and its excessive focus on unit costs and allocations. Minimizing cost is not a growth strategy; maximizing throughput is.[64, 65]

Absorption Costing

Absorption costing develops a full product cost by combining the cost of raw materials, direct labor, and a —fair share" of manufacturing overhead. Absorption costing has been found to be inconsistent with a throughput environment because it penalizes managers who reduce inventories. Excess inventories are a signal that production should be cut back. This can lead to unabsorbed overhead in the traditional cost world, but under TOC reducing inventories results in increased throughput. The former can be seen as a negative result for a production manager, while the latter is the driving force behind TOC. In TOC, inventory is to be eliminated; in absorption costing it is the basis for covering costs.[64, 65]

Variable Costing

TA resembles variable costing because of its heavy emphasis on managing the incremental change in costs due to volume shifts (more throughput). TOC uses a much stricter definition of variable cost than is used for contribution margin analysis. While many similarities exist between TOC and variable costing, there is one significant difference: A product cost is not the goal of TOC. TOC brings a new dimension to management philosophy and provides an interesting challenge to the traditional ways of looking at an organization's profitability. Organizations using TOC have determined that it can help them achieve a number of management objectives, including continuous improvement. The goal of every organization is the same; optimize profitability by meeting customer requirements better than the competition. It is this purpose the information system needs to serve.[64, 65]

The TOC is perhaps the most advanced operations management philosophy in existence. Its usefulness has been widely proven. It has been used in conjunction with Lean and TQM and may help to focus these initiatives on the organization's constraints to increase their impact. The TOC applies the cause-and-effect thinking processes used in the hard sciences to understand and improve all systems, but particularly, organizations. The process a clinician applies to treating a patient is an excellent analogy for explaining how TOC recommends going about solving a systems problem. If we were to describe the overall process used by a clinician treating a patient it would look something like:

1) Diagnosis: Knowing the futility of treating the symptoms, a clinician begins with a list of observable symptoms and uses cause and effect to seek out the

underlying common cause for all of them, the "disease" or core problem.

2) Design of a Treatment Plan: Considering the uniqueness of the patient and his/her diagnosis, a treatment plan is developed that first and foremost treats the disease (e.g., surgery), but also suggests what other things must be done alongside that "cure" to ensure the treatment will work (e.g., pain relief and bed rest) and that the best possible health is restored to the patient (e.g., physical therapy). In this process, any potential side effects of the treatment are identified, and the means for preventing or mitigating them become key elements of the treatment.
3) Execution of the Treatment Plan: Taking into consideration, the uniqueness of the patient's situation, a plan is developed for how to implement the treatment (e.g., surgery and pre-op work are scheduled, arrangements for transportation to and from the hospital are secured, hospital beds to be used at home are ordered).

The TOC processes used to improve the health of an organization (or solve any problem) are almost identical; however, the terminology is changed to better suit the language of problem-solving in organizations. In TOC, the process is described via the use of three questions: what to change, what to change to, and how to cause the change?

Identify the Core Conflict causing the symptoms, or Undesireable Effects (UDEs), of the chosen subject using the Three-Cloud Process. Build a Current Reality Tree that validates the identification of the Core Conflict, helps us understand the existing cause-and-effect relationships of the subject and identifies the conspiring formal and informal policies, measurements and behaviors that support the existence of the UDEs.

By challenging the logical assumptions behind the Core Conflict, a solution to the Core Conflict is identified. A plan for successfully implementing the strategy is created, including what actions must be taken, by whom and when.

Because resistance to change can block even the most perfectly laid strategies and plans, building active consensus and collaboration, or buy-in is crucial.

Build a Tactical Objectives Map that charts the overall course for getting from the current reality to the future reality, where the solution/strategy is fully implemented. Identify the details of what each part of the system/sub-system must contribute, and when, to achieve each of the milestones of the TO Map using a PreRequisite Tree (PRT). Create detailed task interdependency diagram, using Transition Trees (TRTs) when necessary to flesh out crucial actions overcoming resistance to change.

Exceptional Governance

The development of Health is a holistic process related to the overall growth and development of social, cultural, economic, educational, political and environmental factors. Health policies are influenced by the policies concerned with these areas.[63] For a variety of reasons (professional, public, political) countries now seek to establish visible systems for managing quality in healthcare. The motives, the settings and the details may vary, but the general challenge facing the enthusiasts is remarkably common.[66, 67, 68]

Efficient governance of hospitals requires the responsible and effective use of funds, professional management and competent governing structures. By establishing and maintaining the public's trust, being good stewards of the community's resources, and ensuring high quality care Hospital Administrators can be an important asset on the governing board in fulfilling those duties.

Administrators add the perspective of the patient care process as well as a unique understanding of family issues; they grapple with overall health care concerns such as staff shortages, patient safety and quality of care; and they are the most knowledgeable about diseases and new treatment modalities, as well as being aware of the ethical dilemmas posed by new technologies.

As a result of multiple developments in health care and health care policy, hospital administrators, policy makers and researchers are increasingly challenged to reflect on the meaning of good hospital governance and how they can implement it in the hospital organisations. Due to the unique societal position of hospitals—which involves a large diversity of stakeholders—Corporate governance can provide for a comprehensive 'frame of reference', to which the hospital sector will have to give its own interpretation. The duty of Management is to: help formulate strategy; steward the expenditure of public money; ensure probity and transparency; and appoint, monitor and support top management. Good governance is crucial for effective public services and improved social outcomes.[67, 68, 69]

Hospitals consume the largest share of government health resources, yet, until recently, they have not been a focus of health policy and research in developing countries, where the resources are in negative proportion to the demands placed on services of health care institutions, and where the possibility of resources being increased in the short run is very remote, the only hope for the increase in the effectiveness of the health care system being the effective management of hospitals. A professional administrator with multidisciplinary training would ensure the optimal use of resources. We live in the age of perfection at all levels. Hence, professional training is the basic requirement for the personnel to function effectively in a hospital. Professional training is required to be imparted by the institutions specialized in professional training. Professional management has an immense scope and a bright future market on account of the increasing demand for specialized and quality health care. Better management or lack of it will determine the future of health service.[69, 70, 71]

The prosperity of organisations is recognized as being dependent on their comparative productivity. Productivity

expresses a relationship between outputs from a system and the inputs which go into this creation. Hospital activities have to be assessed. Results have to be evaluated. The medical and paramedical staff has to quantify procedure and assess them qualitatively in order to improve the standards of care. Assessment techniques already introduced in many hospitals have succeeded in reducing the number of antibiotics (and their cost) and the amount of blood used in certain operations and also cutting the wait for operations. As long as there is unused capability in the individual or the productive system, increases in productivity can be achieved without decline in quality. If one focuses on quality while holding speed constant, quality should improve, waste should be eliminated, and productivity should increase. This can happen as long as the individual, or group of individuals, is willing to exert effort and has the capacity to achieve the quality-productivity levels desired. It is the operations manager's task to provide the facilities, tools and desired (motivation) to do so.[67-71]

The economic and social development of human society is based on scientific discovery and the associated march of technological progress and achievement in the field of organization. The exploitation of the technological advances cannot take place without the ability to organize large numbers of people to carry out highly complex tasks. Building an organization involves structure and methods of working, building people together with a sense of belonging and a sense of common purpose continuing over time, and cementing the whole together with some shared values and ideas. It is a process of social architecture, of institute building. The best starting point for an organisation design is the organisation's purpose and the particular strategies or objectives relating to that purpose. There is a need to concentrate on adopting organisations to the new possibilities opening up as a result of development in information technology, on the effects of instability and heightened competition, on strategies on organisation complexity and how to deal with it and on the influence of changing values and challenges in the legitimacy of large scale organization.[68-71]

TOC has developed a process based on the psychology of change that acknowledges and systematically addresses the questions people intuitively ask when evaluating a change. TOC solutions have emerged that have applicability across all organizations, both for-profit or not-for-profit. These applications continue to evolve, resulting in more and more significant and sustainable overall and bottom line performance improvements.

10. Difficulties in the TOC

The primary difficulty that TOC poses to a manager wishing to implement it is that TOC is a complete paradigm shift from traditional operations management. First, the schedule must be done in an entirely new way, drum-buffer-rope, which requires some workstations to be idle at times. Second, the control mechanism within the shop must be changed from individual due dates at work stations to buffer management. Third, performance measures must be changed from efficiency-based measures to throughput dollar days and inventory dollar days. Finally, there must be a tremendous amount of education throughout the entire organization so that everyone understands the nature of this wholesale change and why it is necessary. Because of the comprehensiveness of the needed change, smaller organizations have had more success in adopting TOC than have larger ones.

The TOC is a management innovation that runs contrary to conventional wisdom with benefits of faster services, greater flexibility, and a sensible re-shuffling of management priorities for profitable growth. TOC makes constraints work for you rather than against you. TOC approach is a perfect complement to other improvement tools such as TQM and Business Process Reengineering. It focuses improvement efforts where they are likely to be most effective. The constraint, or bottleneck, in the system is determined by the step that has the smallest capacity. Improvements efforts must be focused on the constraint to be effective. Focusing your effort on the weakest link will bring the biggest benefit. Identify the weakest link, which is the constraint. Do not place a greater strain on the system than the weakest link can handle-if you do, the chain will break. Concentrate to improve the weakest link. If the improvement efforts are successful, eventually the weakest link will improve to the point where it is no longer the weakest link. At this point, the new weakest link must be identified, and improvement efforts must be shifted over to that link. This simple sequential process provides a powerful strategy for continuous improvement. The TOC is a set of holistic processes and insights, all based on a systems approach that simplifies the improving and managing of complex organizations by focusing on the few physical and logical constraining leverage points. It provides a tool set to build and implement the levers (holistic rules) that synchronize the parts to achieve an order of magnitude improvement in the performance of the system as a whole. Elegant in concept and design, TOC focuses management’s attention on the factors that impede system performance. TOC emphasizes the optimization of performance within the defined set of constraints of the existing processes and product offerings. TOC provides an action framework that combines the activities of managers around a few highly visible system elements. TOC is the only consistent approach to process improvement. Much of the problem in modern healthcare has to do with the dynamics of the organizations. Robust Research is required to assess the benefits of its application to Healthcare institutions.

Futuristic

Each improvement method is a way of seeing the world. Successful improvers are adept at defining the problem or opportunity in helpful ways. TOC offers a way forward, a methodology that is delivering unprecedented breakthroughs in the quality and timeliness of care and financial performance. It is also proving to be a methodology that doctors, nurses and managers can all embrace. More research studies are required to determine

the actual benefits that can be derived after applying TOC in healthcare system.

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