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Application of Goldratt's Thinking Process to Constraints Within an Emergency Department—A Case Study

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APPLICATION OF GOLDRATT'S THINKING PROCESS TO CONSTRAINTS WITHIN AN EMERGENCY DEPARTMENT—A CASE STUDY

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APPLICATION OF GOLDRATT'S THINKING PROCESS TO CONSTRAINTS WITHIN AN EMERGENCY DEPARTMENT—A CASE STUDY

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I dedicate this thesis to my wife, Ruth W. Manini, my parents Ven. Rev. Paul O. Amonge and Josephine Anyango and lastly my siblings: Esther, Judy, Phena, Linda, Olivia, Susan, Jenipher and Moses who are a great inspiration to me. I would also like to dedicate this thesis to my great friends all over the world.

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Emergency department (ED) acts as a feeder to many hospitals as it determines a large proportion of admissions. ED also acts as a buffer zone for many patients who cannot get care in other institutions due to insurance issues. Most hospitals are trying to invest heavily on their EDs, but cannot meet patients' satisfaction in terms of cost and quality of care. There is great need for EDs to understand customers' expectation given the rising cost of healthcare.

The focus of this study is at an ED center in Bowling Green Kentucky, using theory of constraints (TOC) thinking process application tools to capture in detail the core and apply TOC to resolve the problems identified. The research was able to identify the core problems as: Backlog of patients in ED, delay in making dispositions, and patients waits on ED to transfer to another facility. The research was able to address the core issues by answering three questions: What to change? This was answered by the CRT "ED unable to meet patients' expectation." What to change to? This was answered by the EC "Positive patient outcomes". How to change? This was answered by the FRT by using injections that resulted to "ED is able to meet patients' expectations most of the time."

Introduction

Emergency departments (EDs) in the United States are an essential part of the public health because they provide care to patients that do not have access to other medical services. The Emergency Medical Treatment and Active Labor Act (EMTALA) of 1986 assured that ED patients cannot be refused treatment, regardless of their ability to pay (Bitterman, 2002). Hence, ED provides care to everyone within the United States. EDs in developed countries experience overcrowding, leading to problems such as long wait times, ambulance refusal, prolonged pain for waiting patients, and poor patient outcomes. Additionally, overwhelmed EDs are unable to respond to community emergencies and disasters (Kent & Lous, 2005). EDs are challenging places for physicians to work and have severe resource constraints. In Canada, a survey was conducted of ED physicians that indicated that 24.5% of them are not happy with their jobs because of stressful conditions (Carter & Lapierre, 2001).

Statement of Purpose

The ED is the most sensitive area of a hospital as it is the point of entry for many patients. EDs have problems that have place patients at risk of getting lower quality healthcare. The intent of this study was to determine the major constraint in EDs by using the tenants of Theory of Constraints (TOC) and develop solutions using TOC tools to resolve the core problem. Staff working at EDs completed survey questions to help determine the major constraint in EDs. The research approach used TOC established methods of Current Reality Tree (CRT), Evaporation Cloud (EC), and the Future Reality Tree (FRT).

Significance of Research

The quality of healthcare all over the world, especially in the United States of America, is in turmoil. Patients are not able to get access to high quality and affordable healthcare. Patients are demanding contained cost, improved healthcare accessibly, and improved customer services within the healthcare business model (Taylor III & Nayak, 2012). With increased patient volume in hospitals, there is enormous overcrowding in EDs to the extent that there are billboards alerting customers of the wait time of the ED in that particular area. The patients are at risk by delay and the inability of the staff to provide the necessary care needed. EDs are intended to provide a continuous flow of patients, from diagnosis to treatment, rather than storing or gathering patients.

According to TOC, every system has a constraint, such that systems designed to have throughput or flow have troughs and peaks of activity that exceed capacity. For example, roads that exceed capacity lead to traffic jams (Richardson & Mountain, 2009). TOC offers a way forward to solving problems in EDs. The methodology provides a framework for staff within the hospitals to deliver unprecedented results with timely care, high quality, and financial gain. It is a methodology that doctors, administrators, and nurses can embrace, given that it is a theory that fits the problem--constrained healthcare system (Knight, 2011). TOC has increased physicians' accountability for better patient flow, with the aim of allowing ED to cater to the larger volume of patients that is predicted to occur (Song, Tucker, & Murrell, 2013).

Problem Statement

Within emergency medicine there is mismatch that often prevents the timely caring for patients and resource availability. Just like military medicine, emergency medicine has minimal control over the rate at which patients can be served to due to uncertainties (FitzGerald, Jelinek, Scott, & Gerdtz, 2010).

There are three TOC paradigms that have evolved over the last twenty-five years: operations strategies, thinking process, and performance measurements. This paper will solely focus on the thinking process paradigm that has managers looking for ways to elevate the system constraint in order to achieve throughput. The TOC thinking process tools help in decision making. They are the Current Reality Tree (CRT), Future Reality Tree (FRT), Prerequisite Tree (PT), Transition Tree (TT), and Evaporating Cloud (EC). The thinking process involves three steps. The first step is what to change? This leads to agreeing on the problems that are hindering an organization from achieving its goals using the CRT. The second step is what to change to? This is achieved by identifying the constraints preventing the change using the EC tool, which validates why the change is needed as well as identifying the change. The final step is how to change? The FRT tool answers this question by providing injections to the problems and identifying the side effects of the problem, or avoiding them (Mabin, Babington, Caldwell, Yee, & Moore, 2001).

In an attempt to improve EDs' patient flow, it is essential to focus on the constraint, which is explained with the analogy of a chain. If a chain is pulled from both ends, where will it break? It will break at the weakest point, which is the constraint.

Unless the weakest link is strengthened, the overall chain will not change. In TOC, the strength of the chain is measured by throughput. Thus, if the chain is managed in EDs, there will be a continuous flow of patients. Figure 1, shows a typical patient flow diagram at a regular ED from the time a patient checks in with the receptionist until check out (GlaceEMR, 2007). From the diagram it is evident that the system is very cumbersome and complicated given many stages a patient have to go through to get treatment.

Very few studies have been conducted on application of TOC on EDs. The available literature shows that TOC has worked within the healthcare system. Application of TOC helped reduce wait time by 23% at a hospital in the United Kingdom and Holland (Startton & Knight, 2010). Conforti (2007) also applied TOC to an Italian hospital that helped resolved scheduling problems during radiotherapy. A medical clinic in West Virginia used the five focusing steps of TOC to conclude that they needed to eliminate unnecessary procedures (Creasy & Ramey, 2013). Owens (2010), showed that a hospital in Toronto could use the TOC buffer system to reduce cost and flow of patients within the system. The literature supports the claim that TOC can help improve systems within healthcare.

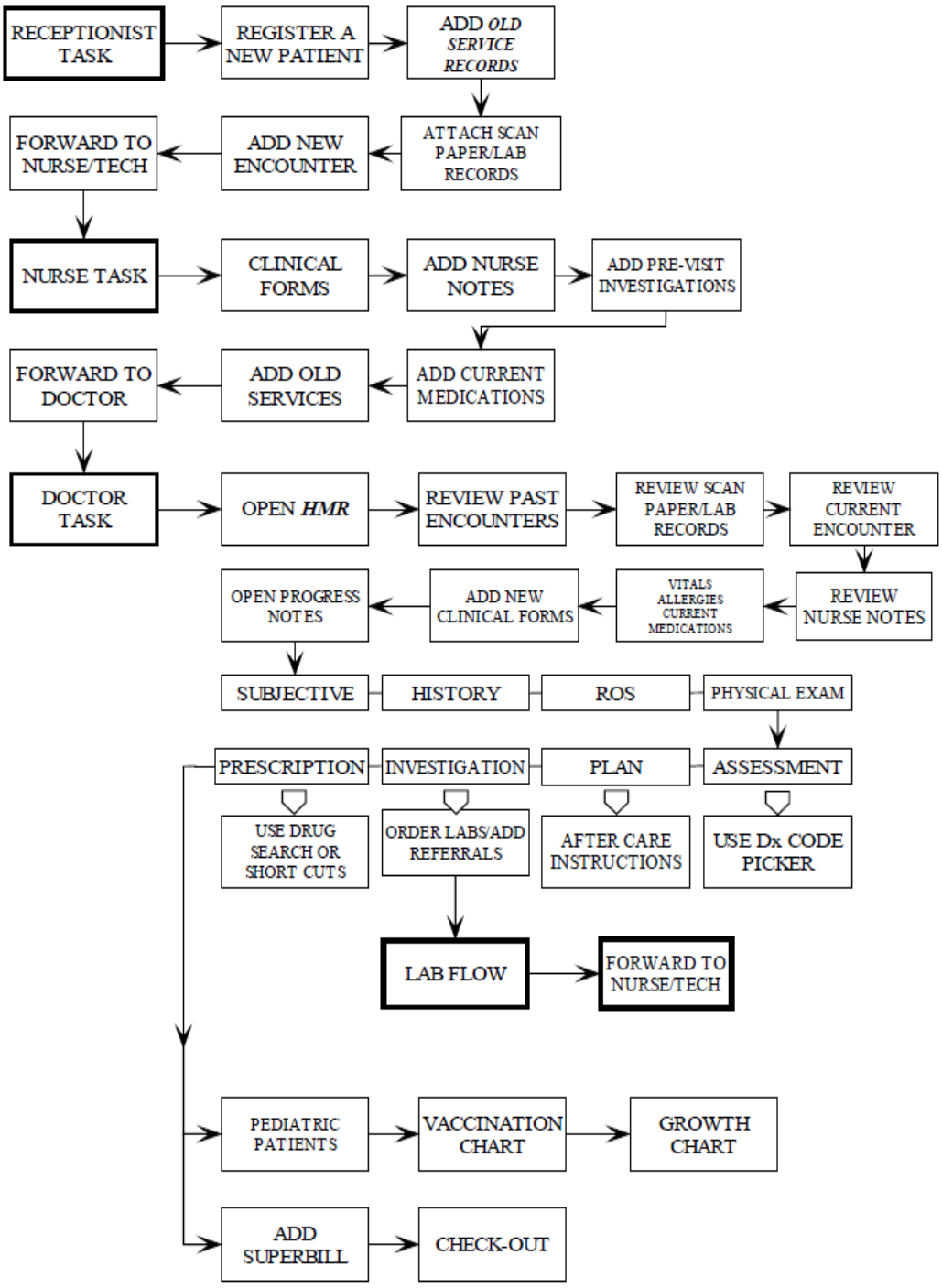

Figure 1. Flow Diagram (GlacerEMR, 2007)

Research Questions

This research will address the following questions

1. Can Undesirable Effects (UDEs) in EDs facilities be captured in sufficient detail to identify the core problem?
2. Can the thinking process of TOC be applied to EDs to increase patient flow and improve effectiveness?

Limitations

This study was limited to the following

- EDs in Bowling Green, Kentucky that service a population of approximately 61,000 and that of the neighboring communities.
- Some EDs in the area were not willing to participate in the research.
- Survey participants included staff such as doctors, nurses, hospital administrators and technicians that have direct contact with patients.
- Participation was voluntary and confidential.

Assumptions

The research was completed under the following assumptions.

- Results from the questionnaires were accurate and reflected the true perceptions of the respondent.
- All respondents participated in the research in good faith and sought to improve the flow of patients through their care systems.

Definition of Terms

For the purpose of this research, the following definitions applied:

- *FIFO*: First In First Out system used by some hospitals to screen patients after they have been sorted through the triage system, where the first patient is given priority (Conforti, 2007).
- *ICD*: Intermediate Care Department. An institution that capable of providing around the clock personal care, developmental, habilitation and supportive health services. Such facilities have certified nursing services that cater to patients certified by a physician and who do not need continuous skilled nursing care (Mur-Veeman & Govers, 2011).
- *PCP*: Primary Care Physician. A family physician who provide care to basic needs across a continuum of different problems (Bodenheimer, 1999).

Review of Literature

What is TOC?

The TOC, also known as constraints management, is a management philosophy that was developed by Israeli physicist Dr. Eliyahu Goldratt. In the 1970s, Dr. Goldratt studied manufacturing companies and came to the conclusion that they were making mistakes. He developed a software known as Optimized Manufacturing Technology (OPT), but due to license issues, the software did not get the attention of many scientists (Gulsun, Ozgurler, Kurtcan, & Guresen, 2009). The TOC evolved and Goldratt was able to explain his concept of OPT in the form of a novel in the book *The Goal* (Goldratt & Cox, 1984). Throughout the book, the TOC was explained in the form of a life story using a climate of everyday production (Rahman, 2002).

The Theory emphasized the importance of improving system performance by utilizing the existing resources in a system, more so by exploiting the constraints or bottlenecks. The concept of the TOC is based on the fact that every system has at least one constraint that controls the rate of throughput. Hence, a system can only perform well as well as the existing bottlenecks. Thus, improving a systems constraint is geared towards enhancing total system performance (Sadat, 2009). The TOC is composed of three major components: logistics (operations strategy), performance measurements, and thinking process, as shown in Figure 2.

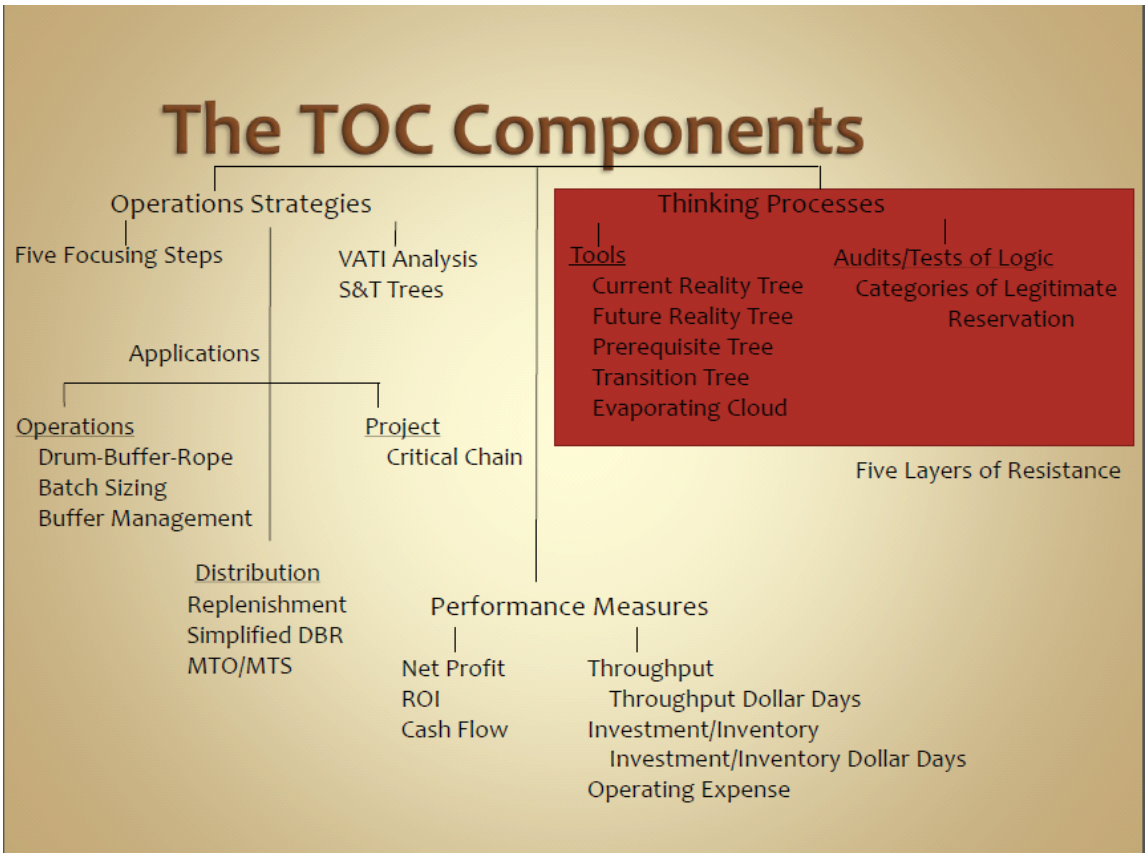

Figure 2. Components of TOC. Adopted from "Class lectures and notes" by A.M Doggett. Architectural Manufacturing Science (A.M.S) Department, Western Kentucky University (W.K.U).

Operations strategies has two segments, V-A-T-I analysis and five focusing steps. V-A-T-I analysis classifies companies in relation to product flow. The "V" represent plants with few raw materials, but many final products. An "A" plant has extensive raw materials, assembled into a final product. A "T" plant has very many final products, which is a result of assembly of limited number of components. In the "I" plant, production flows from the start to the end, with minimal assembly and no divergence points (Srikanth, 2010).

According to Goldratt and Cox (2004), the five focusing steps are based on the notion of TOC improvement performance focused on the constraints using five steps:

1. Identify the constraint(s)—a system cannot function at full potential unless constraints within the system are identified.
2. Exploit the constraint (s)—a system should make the best potential use of the constraint.
3. Subordinate the non-constraint (s)—elements or factors that do not affect the system performance are generally known as non-constraints. Therefore, decisions affecting constraints should be a priority. Non-constraints must subordinate their activity with regard to the constraint.
4. Elevate the constraint (s)—further improvement of the entire system is needed to increase capacity of the constraint after the first three steps to increase throughput.
5. Return to step 1.—after making changes to the constraint a new constraint might emerge. Hence, it is necessary to go back to step 1. Do not let inertia become the constant.

Thinking Process

As indicated earlier, the purpose of this paper is to focus on the TOC component of thinking process tools also known as the logical thinking process developed by Goldratt (Goldratt & Cox, 1992). The thinking process is composed of five distinct trees or tools as shown in Table 1.

After developing the five tools of thinking process, Goldratt discovered that each tree can also be productive when applied in isolation (Dettmer, 1998). Therefore, the bulk of this research will focus on CRT, FRT and EC tools only.

Table 1

Application of Thinking Tools

Application Tool	Use
Current Reality Tree (CRT)	Illustrates cause-and-effect and identifies core causes
Evaporating Cloud (EC)	Identifies the conflict in a problem and develops solutions to the problem using injections
Future Reality Tree (FRT)	Verifies the effectiveness of the solutions or injections from the EC
Prerequisite Tree (PRT)	Helps identify obstacles to implementing proposed solutions that could prevent successful completion
Transition Tree (TRT)	Provides a path to develop an intended action plan to implement a solution.

(Goldratt & Cox, 1999)

TOC as a process that relies heavily on managers knowing the system that they are trying to improve. The initial step in the thinking process is to understand what to change in a system, which relates to diagnosis in medicine. The second step is to know what to change it to, which also relates to medicine when doctors apply treatment to a patient. The final step is to know how to change it. Hospital administrators, through thinking process, need to be able to answer these three questions to determine the success of throughput of patients through the ED system:

1. What to change?
2. What to change to?
3. How to change?

What to Change

In a system, there are symptoms of core problems, which are called undesirable effects (UDEs), but the UDEs are mere symptoms of the bigger problem. The main problem needs to be identified and removed from the system. To identify the main problem, a methodology of cause and effect is used to uncover the problem associated with the UDEs. The UDEs are interlinked through determining their cause and effect relationship in a CRT also known as a logic tree. This helps determine what to change. Figure 3, shows an example of a basic logic tree.

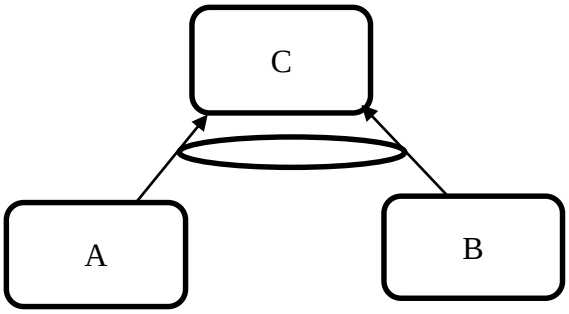

Figure 3. Basic logic tree

A logic tree is represented in a form of a diagram to connect the cause and effect, which are encapsulated in a rectangular box as shown in Figure 3. The boxes are connected with a series of arrows indicating the cause and the effect is. In this case, A and B are the cause and C is the effect. The ellipsis crossing the connection arrows represent AND. Hence, both A AND B cause the effect C. The CRT uses sufficiency logic and as such, the tree can be read as IF A and B THEN C.

Figure 4 is an example of a basic logic tree with AND as a connector that explains the cause and effect logic for a fire. All the three entities A, B, and C are essential for a fire to start. The tree can be read as: If there is spark/heat, fuel and oxygen then a fire will start. Hence without A, B and C fire will not start.

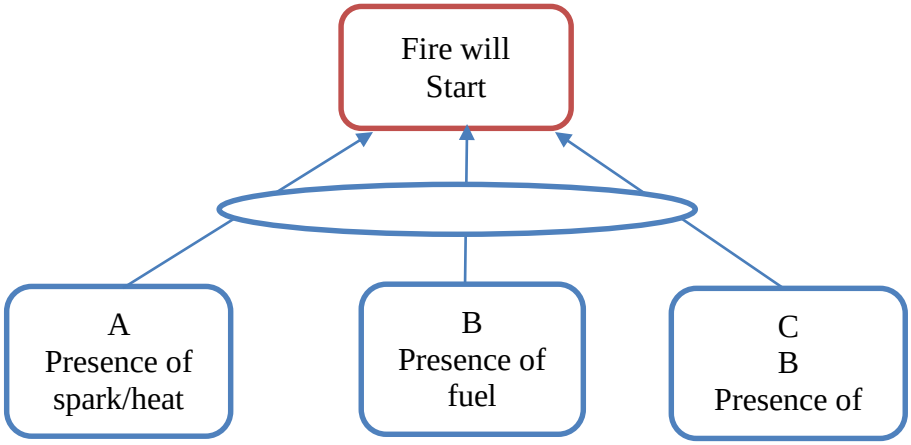

*Figure 4.*1st Example of a logic tree

Figure 5 is another example of a basic logic tree with an "OR" as a connector. It explains the cause and effect logic on how a car can last for a long time. Any of the three entities A, B or C will create an effect on their own. A car will last for a long time if serviced on time, driven calmly, or by listening for odd noises. The difference is that in Figure 4 all causes together create an effect and in Figure 5 any cause will create the effect.

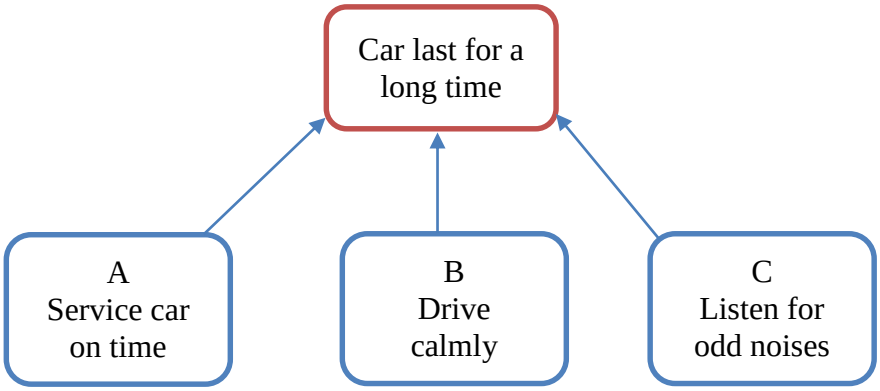

Figure 5. 2nd Example of a logic tree

What to Change To

After knowing what a system needs to improve, it is essential to identify ways of eliminating problems. This means, generating a reality that is the opposite of the constraints that exist. An EC is developed to help remove the problem. The first step is to have an objective that is opposite of the problem at hand. Second, list at least two requirements of the objective, with each requirement having at least one prerequisite, as shown in Figure 6. All the requirements and prerequisites are based on critical thinking of the problem (Cox III & Scheleier Jr, 2010). One can then develop "injections or solutions" that will resolve to the problem.

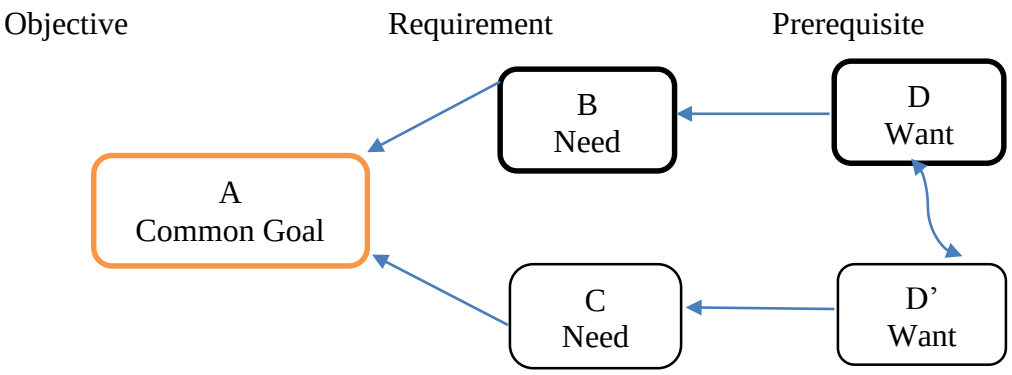

Figure 6. Evaporating Cloud

The core problem in the system is known as the D entity and its opposite D'. D' is read as D-prime. The common goal of the EDs and Urgent Care facilities is to have an A. To fulfill the goal, A needs B and C. B must also have D and C requires D'. D' is read as D-prime. For D and D' to exist, they are opposite of each other and cannot coexist. The evaporating cloud in Figure 5 uses necessary conditions logic and is read as:

- In order to have objective A, one must have requirement B
- In order to have requirement B, one must have prerequisite D
- In order to have objective A, one must have requirement C
- In order to have requirement C, one must have prerequisite D'

Figure 7 is an example of an EC. The common objective (A), is to have a fair and accurate election.

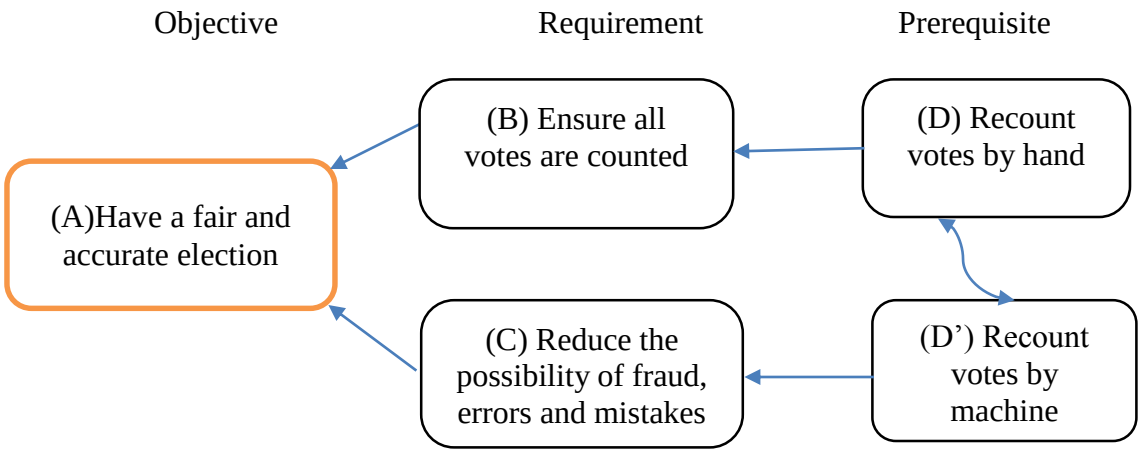

Figure 7. Example of Evaporating Cloud. Adopted from "Class lectures and notes" by A.M Doggett. Architectural Manufacturing Science (A.M.S) Department, Western Kentucky University (W.K.U).

The EC is read as follows:

- In order to have a fair and accurate election. I must ensure all votes are counted and reduce the possibility of fraud, error and mistakes.
- In order to ensure all votes are counted, I must recount votes by hand.
- In order to reduce the possibility of fraud, errors and mistakes, I must recount votes by machine.
- If one recount the votes by hand, then one does not recount the votes by machine.

The validity of this is EC can be checked and verified with assumptions in Table 2.

Table 2

Verification of EC

In order to.....	**Because..... (Assumptions)**
AB **In order to have a fair and accurate election, I must ensure all votes are counted.**	• Everyone wants their vote counted • Each vote is very vital in any election
AC **In order to have a fair and accurate election, I must reduce the possibility of fraud, error and mistakes**	• Mistakes and errors make voters lose faith in election • Mistakes and errors undermines the democratic system
BD **In order to ensure that all votes are counted, I must recount all votes by hand.**	• Machine miss votes • It's hard to rely on technology • Machines can be used to rig votes
CD' **In order to reduce the possibility of fraud, errors and mistakes, I must recount votes by machine.**	• People are prone to making errors • People will intentionally tamper with votes • Machines are more accurate than people.
DD' (OPPOSITE OF EACH OTHER) **(Why can't D and D' coexist?) because →**	• Party officials want elections done their way • Laws control how elections are done • People are eager to get quick election results.

If the assumptions for a good relationship (e.g. BD) can be shown to be invald, the dilemma or conflict eveporates. If, however, all the assumptions are valid, injections (solutions) must be be developed to resolve the dilemma. Some possible injections for this dillema could be, print copies of valid votes, compare machines tally with paper tally and provide statistics of human error versus machine error.

How to Change

The implementation stage is what happens to create the change. In the first step, one needs to know how to successfully implement the changes needed. In the second step, there should be defined measures of what the future looks like with specific changes that should be in place. With this, there is a need for a map with a detailed plan of action. The map should lead from the present to the improved future. The FRT tool is used to help build sufficient conditions to move from the current situation to a better future. The FRT provides an overview of the cause and effect relationship between the changes and their impact on the future (Dettmer, 1997).

Benefits of TOC

The Theory of Constraints (TOC) has produced tremendous results in the manufacturing sector. In the early 1990s, General Motors (GM) invested billions of dollars in quality improvements to challenge the competitive edge of Japanese quality and price. Through the TOC logic trees, GM identified ways of increasing customer satisfaction while reducing cost. The Ford Electronics plant based in Ontario, Canada was having problems delivering components to its customers within sixteen days and was determined to reduce delivery time. Through the TOC, the company cycle time dropped by 90 percent with the production schedule also dropping by one day; an improvement that increased the company's work capacity (Dettmer, 1998). The TOC is also emerging as a tool to solve problems within the service industry given the notion that any system or organization has a constraint that limits its performance (Goldratt & Cox, 2004).

Application of TOC to Health Services

Service industries such as health care systems can improve system performance using the TOC. Within the medical sector, patients struggle to get the best services due to problems within the hospital system, especially in the Emergency Department (ED). Patients also experience undesirable effects. A single effect is not considered a problem in itself, but rather as a symptom of a the bigger issue within the system. According to Aoki, Ohta, Kikuchi, and Oishi, (2008), physicians who cater to a patient with the main complaints of sore throat, fever and cough, would not just prescribe a cough medicine for cough or an inflammatory medicine for the throat. Instead, the doctor would rather listen to the patient's chest using a stethoscope and if there is abnormality they would need a chest radiograph. If there is a disorder, the doctor would conduct appropriate diagnosis and treatment. Thus, TOC is an application that provides doctors a frame work of diagnosis and treatment, which in management is referred to as selection and focus. This means a doctor is able to identify what needs to be treated, so that they can treat the correct disorder.

Constraints in EDs. The intent of the Emergency Department (ED) in hospitals is to provide a continuous outflow of patients through diagnosis and treatment. Alternatively, the intent is not to store patients within ED. According to Kent and Lous (2005), most emergency rooms in developed countries cannot keep up with the number of patients visiting their facilities due to a number of resource constraints. Overcrowding and resource scarcity are the two main problems in emergency rooms that make them incapable of responding to disasters and community emergencies. EDs become overcrowded when patients' treatment needs are not met. Hence, the rate of treatment is

less and quality suffers as a result, even with the presence of optimal staff and space to work with. Overcrowding can also be a systematic problem, where there are more patients than available staffed beds, leading to excessive waiting times. Crowding involves patients waiting for treatment, those being monitored in non-treatment areas, and those waiting for transfer to inpatient units (IU). Influx, throughput and outflux are the main reason why EDs experience overcrowding. Influx has increased because the older generation is growing in numbers and they need medical attention. Outflux exists when patients need to leave ED for further treatment, but the inpatient unit is not ready for them because a room is not available (Kolb, Schoening, Peck, & Lee, 2008).

As a result of overcrowding, most hospitals divert ambulances to other health institutions, while emergency workers get orders to initiate critical bypass. This means hospitals cannot admit any patients, even if in critical condition, without jeopardizing the care of patients within that institution. Most hospitals in Canada are forced into this practice in winter seasons due to a back-up of patients. Overcrowding has also led to high problems with proper physician and support staffing, which leads to low morale in hospitals (Kent & Lous, 2005).

TOC in Urgent Care and EDs. Clinch Valley Medical Clinic in West Virginia adopted TOC in 2009. Initially, the clinic used preadmission testing (PAT) as a tool to improve their process. With PAT, the first step of a patients' experience within the hospital was to provide information, which included medical records, lab results, medications, etc. The process also involved activities such as patient education and communication, patient scheduling, and medical documentation. However, the PAT process failed because patients had wait times of 20 minutes on average. To fix this, the

clinic opted for TOC and used the five TOC focusing principles of identifying, exploiting, subordinating, elevating, and continually identifying bottlenecks. The clinic concluded that they needed to analyze the process and eliminate unnecessary procedures (Creasy & Ramey, 2013).

A West Texas hospital emergency department used TOC thinking process to determine why the institution was losing revenue. It was determined that ten major (UDEs) affected the performance of the emergency department. The UDEs included wait times, the triage process, staff communication, bill collections, service provided and information management. Consequently, the hospital concluded that the core problem was the triage services provided by the hospital (Nayak & Taylor, 2012).

TOC was used to improve patient flow within emergency, planned health and social care in the United Kingdom (UK) and Holland. The application of TOC helped reduce wait time by 23%. Within the emergency rooms, the hospitals used the TOC application of drum, buffer, rope (DBR) with a target of a four-hour treatment beginning with patients' entry (Stratton & Knight, 2010).

Conforti (2007) applied TOC to Italian hospitals to help resolve scheduling problems in radiotherapy. Radiotherapy scheduling is different from other patient scheduling because the radiation schedule depends on factors such as number, size, and location of tumors, the overall health of the patient, and their weight. The aim of the schedule model is to maximize the number of patients. During mapping of the patient schedule, some assumptions were taken into consideration. For the first visit, patients need more time than subsequent visits because they have to be introduced to treatment modules that involve a lot of screening. Before starting treatment, the doctor determines

what the patient needs and collects data such as the correct position for patient during treatment. There is an assumption that each patient takes 15 minutes for every session. The patients are treated based on the First In First Out (FIFO) rule. A computer software was used to help build a scheduling model after going through the Five focusing Steps (5FS) and using DBR principles.

Emergency departments use management plans to cater to patients. In the UK, the government uses the scope of a plan based on the National Health Services' (NHS) four-hour treatment of patients based on TOC scheduling methodology drum-buffer-rope (DBR).

- Drum: This is the pacing item or constraint of a system and determines the throughput of patients through the hospital. In this situation, the drum is un-forecasted patient demand. This means there are uncertainties of when patients arrive.
- Rope: Used to release patients to the first operation at a pace determined by the drum. Since there is a four-hour window after patients' arrival, the rope may not be necessary because there are no patients to release to the system.
- Buffers: Placed in strategic points to remove deviations due to uncertainties (Mohammadi & Eneyo, 2012).

In this case, buffer time is the four-hour window that starts on patient's entry. It is strategically placed to prevent constraints from starvation or overload. The time is divided into three equal zones of 80 minutes each. Most hospitals use a computer software to help them track the stages and manage the buffer consumption. There is no order of discharge; it presents itself when the patient is ready because one cannot

prioritize clinical discharge. The patients are in the red when they have passed the last 80 minutes within the system. A pop-up on the computer screen will let the hospital know to expedite the patient by advising on the resources available. The delay problems are analyzed by a system that charts the problems when they enter certain color-coded zones. The color coding of yellow, black and red are used to prioritize patients based on their illness. Red means urgent, yellow semi-urgent, and black means catastrophic. This information is used to help create buffers in the system that can be addressed during weekly meetings, with an aim at continuous improvements in the emergencies department (Stratton & Knight, 2010).

Buffers in EDs

A study by Owens (2010) to ease ED overcrowding in Mount Sinai Hospital Toronto, Canada, introduced a buffer between the ED and in-patient wards, known as the short stay unit. This was done because newly arriving patients needed quick attention to determine their disposition. As a result, the hospital was able to show positive impacts on cost and flow of patients within the system.

The notion of blocked beds as a buffer is used in the UK and Dutch hospitals. Bed blocking is a result of patients getting treated, but not being released to the next part of the chain such as home care or nursing homes. This is due to lack of space in the nursing homes or slow referral procedures between facilities. Bed blocking leads to increases in cost and wait times for new patients that need treatment. To resolve the problem of bed blocking, hospitals established an Intermediate Care Department (ICD) in support of nursing homes (Mur-Veeman & Govers, 2011). A study conducted by the University of

Maastritch determined whether the ICDs reduced bed-blocking and cost. According to the research, 65% of the ICDs were not cost effective and forced the nursing homes to cover cost. However, waiting time and cost was reduced for patients because the ICD was less expensive than a hospital bed. ICDs reduced pressure on hospitals and they were able to admit more patients because of the improved hospital flow. However, management never acted to sustain the capacity within the system leading to wait times for those who needed admission to ICD. In this case, the buffer did not balance overall patient flow with its expected fluctuations. The rate at which patients were released from the hospital should have equaled the rate at which patients left the ICD giving maximum flow within the system (Mur-Veeman & Govers, 2006).

Emergency Department Process – Triage

The word triage is from the French word *trier*, which means to sort. The word was originally used by farmers to sort out their agricultural products. Today the word is used in emergency rooms to help resolve the situation of overcrowding. The intent of using triage is that not all patients who need certain forms of care such as medication, therapy, transplant, or intensive care can get immediate access to their needs. The system helps allocate the patients according to their conditions, given that patients who are critically ill are given first priority rather than non-critical patients (Aacharya, Gastmas, & Denier, 2011). Triage differs when it comes to disaster and emergency situations. When there is a disaster, patients with lower survival chances are not revived (Mace & Mayer, 2009).

Emergency rooms in developed countries categorize their patients using three-color zoning. Yellow and red medical cards are assigned to semi-critical and critical patients, while green is for non-critical patients. The zoning sets a target for patient wait times. Red patients need immediate attention with no wait time, while yellow wait time is 15 minutes for new patients and 30 minutes for prior patients. Green new patients wait 90 minutes while green prior patients wait two hours (Ahmad, Ghani, Kamil, & Tahar, 2008).

EDs depend on triage as it is able to allot limited resources to medical needs. The allotment of patients is necessary, especially in situations where there is discrepancy between medical needs and available resources in terms of quality, time or location. Emergency medicine, like military medicine has little control over the rate and number of presentations within a time frame. Mass causality events occur in military treatment facilities without notice and soldiers have to prioritize who gets treatment first (FitzGerald, Jelinek, Scott, & Gerdtz, 2010).

Summary on Literature Review

From the literature review the philosophy of TOC dwells on the importance of improving system performance by exploiting the existing constraints, given that every system has at least one constraint (Sadat, 2009). TOC is divided into three components, operating strategy, performance measurement and thinking process. This study concentrated on thinking process of three application tools namely: CRT, EC, and FRT. For the thinking process to work, there is need to answer three questions, what to change? what to change to? and how to change? (Dettmer, 1998).

Methodology

Participants

Intent of the research was to conduct studies on multiples EDs and Urgent Cares but only one ED was willing to cooperate .The study was conducted in an ED facility located in Bowling Green, Kentucky. EDs and Urgent cares in Bowling Green service approximately 100 thousand people and the neighboring communities. The researcher made initial visits to the selected facilities to brief hospital the administrators on the nature of this study. Data was collected from participants such as doctors, nurses, technicians, management and non-management personnel that work within the ED using a survey. Participation in the survey was confidential and voluntary and the study complied with university IRB guidelines.

Instrumentation and Materials

The survey (see Appendix A) asked the ED staff to list ten problems that prevents the flow of patients in a timely manner when admitted until they are released or discharged. The word discharge was emphasized to the staff, in that the research is trying to identify problems within the system and not after they have been released to go home, or transferred for further treatment. The staff were asked to list the problems in order with number one problem being the main problem and ten being the least problem. This helped narrow down problems that were perceived to have more weight. The staff were also instructed to list the problems using complete sentences. A second survey (see Appendix B) asked for participants' feedback after problem analysis. The researcher generated a CRT and sent it back to participant's to validate the CRT. There were clear instructions on how to read a CRT and ample space to provide necessary feedback.

A third survey (see Appendix C) also asked for participants' feedback after a problem analysis. An EC was generated by the researcher and sent to the participants for validation. There were also clear instructions on how to read the EC and ample space provided for feedback.

Procedure

Contact was made with the ED to notify them of the nature of research. After the initial contact was made, survey questions were distributed by the hospital administrator to staff that were identified to have direct contact with patients when they are admitted until they are discharged.

This research used the snowflake method (Scheinkopf, 2010) to collect and analyze data. There were several steps involved in this method:

1. The researcher identified a subject matter or subject of study and identified those who have knowledge on the system and the problem to be addressed. In this case, ED personnel such as doctors, nurses, administrative staff, technical staff, support staff, and others were identified by the ED administrator. The first survey asked what prevents the flow of patients as mentioned earlier.
2. The first survey was distributed to the participants who identified ten undesirable effects of the system within the ED. The UDEs were ranked by participants on a scale of one to ten with ten being the least problem. The participants were given five working days to complete the survey.
3. The researcher collected the ranked survey list of UDEs from the participants. Using cause and effect logic, the researcher was able to group UDEs that were closely related and summarized them to eleven UDEs. Next, the researcher

developed a cause and effect diagram tree using his own intuition, which was reviewed and modified with assistance from the university TOC expert resulting in the initial CRT.

4. The researcher gave participants the CRT generated from step 3 and asked for their feedback, corrections, and additional comments. The participants were given five working business days to give their opinions.
5. The researcher collected the 2nd survey from the participants and compiled feedback, corrections or additional comments received. With the compiled feedback, the researcher made changes and modifications to the CRT and identified potential core problems.
6. The researcher developed an EC based on the CRT to identify the core problem, test assumptions and create solutions or injections.
7. The researcher sent the completed EC to participants for comments, feedback or corrections. The participants were given five working business days to give their own opinions.
8. The researcher received final feedbacks, comments or corrections from the participants. These were compiled and adjustments were made on EC.
9. The researcher took the injections from step 6 and placed them into CRT to create a desired effect.
10. The researcher constructed an FRT to address any remaining negative effects to predict the effect of injections from the solutions to the problem. This was reviewed and modified with the assistance from the University TOC expert.
11. A FRT was developed showing the effect of changes on the ED system.

Threats to Validity

The potential threats to the validity of the study included the following

- The participants in the research may have lacked knowledge on the purpose of the study affecting the interest and response.
- The feedback from the participants was based on their own personal perceptions and bias.
- The study was limited to Bowling Green Kentucky, and excluded other regions. Thus, the results cannot be generalized to other locations.
- The individuals who participated were based on their interest and cooperation.

Data Analysis

The data analysis process was done in three phases while using the Delphi method to get participants opinions based on their expertise. First, after getting a list of UDEs from the participants, the UDEs were compiled and grouped based on similarity and themes using intuition. Using the ranking of the UDEs from the participants, calculations for a mean were derived for each grouping using Excel, that led to narrowing of UDEs to eleven and the rest eliminated because they had the highest mean score. With the UDEs in place, a CRT diagram was generated and sent to participants for feedback. The second phase of analysis involved the feedback/comments received from the participants. The comments were analyzed by observing similarities and themes to amend the CRT. The final phase of data analysis was from feedback received from participants based on the EC. The feedback/comments were analyzed based on intuition and resulted in the final version of the EC. From the CRT and the EC, the FRT was created and revised with the expertise from the University TOC expert.

Findings

The first questionnaire asked healthcare professionals to list ten problems on a scale of one to ten, with ten being the least pressing problem, that their facility experiences that does not allow prompt and timely patient flow from patient check in until discharge. Discharge means that the patient leaves the facility for home or for further treatment somewhere else. The facilitator left eighty questionnaires at the healthcare facilities with the hospital administrator and picked them up seven days later. Thirty questionnaires were returned (37.5% response) that resulted in three hundred UDE's.

Undesirable Effects

The UDEs were entered into a spread sheet, creating a column for each respondent to help compare and group the UDEs using intuition as shown in Appendix B. The grouping process was done by identifying common themes between UDEs, frequent use of certain words, and the relationship between UDEs and pattern of effects. For example, as a result of the grouping, one of the major UDEs was unavailability of beds. That resulted from the use frequent use of the word bed. There was also relationships between clean beds and unavailability of staff to clean beds, and a pattern of effects of patients waiting on clean beds. The researcher grouped the UDE's into eleven main areas:

- Unavailability of beds
- Lack of healthcare professionals
- Lack of technical staff
- Improper patient discharge protocol
- Delay in lab results

- Lack of mode of transportation
- Inadequate equipment
- Inadequate supply
- Delay in making and passing reports
- Influx of patients
- Poor work relationships

The eleven UDEs were entered into an Excel sheet to determine which UDEs had the greatest weight. Mean and standard deviation were calculated for each of the UDEs. Table 3 shows the rankings of the UDEs from the lowest mean to the highest. The lowest mean indicated the UDE that ranked the highest on a scale of one to ten.

Table 3

Ranking of the UDEs

Ranks	UDEs	Mean	Standard Deviation
1	Lack of health care professional	2.80	2.51
2	Lack of technical staff	4.18	2.81
3	Improper patient discharge protocol	4.36	2.67
4	Poor work relationship	4.56	1.50
5	Influx of patients	5.20	2.81
6	Delay in lab Results	5.21	2.62
7	Inadequate equipment	5.25	2.41
8	Delay in making and passing reports	5.88	3.46
9	Unavailability of beds	6.13	2.75
10	Inadequate supply	7.11	2.37
11	Lack of mode of transportation	7.50	1.87

What to Change

With the UDEs ranked as shown in Table 3, the researcher was able to relate the UDEs using cause and effect logic by focusing on the top six problems. The main effect was that the ED facilities were unable to meet patients' expectations. This came as a result of drawing a CRT diagrams using six iterations. This diagram was validated by a TOC professional in the department of Architectural, Manufacturing Sciences at Western Kentucky University. The CRT is shown in Figure 5. The core problem or effect, is

located at the top of the CRT. All the other UDEs are interconnected to the core problem using the arrows that points to the problem through intermediate UDEs. Some of the intermediate UDEs have no incoming arrows, progressing upwards. The logic is read from the bottom to the top by following the arrows. It depicts a chain of cause-and-effect reasoning (IF.....THEN) in graphical form, where ellipses represent an "AND." logic For Example in Figure 8, starting from the entity on the top left of “no transportation”. The logic tree can be read as:

- IF there is no transportation, THEN the patient is waiting on family/taxi to pick them up.
- IF there is no transportation AND it’s after 11:00 PM, THEN patient waits on ED to be transferred to another facility.
- IF patient waits on ED to be transferred to another facility, THEN there is backlog of patients in ED.
- Finally, IF there is backlog in ED, THEN ER is unable to meet patient expectation.

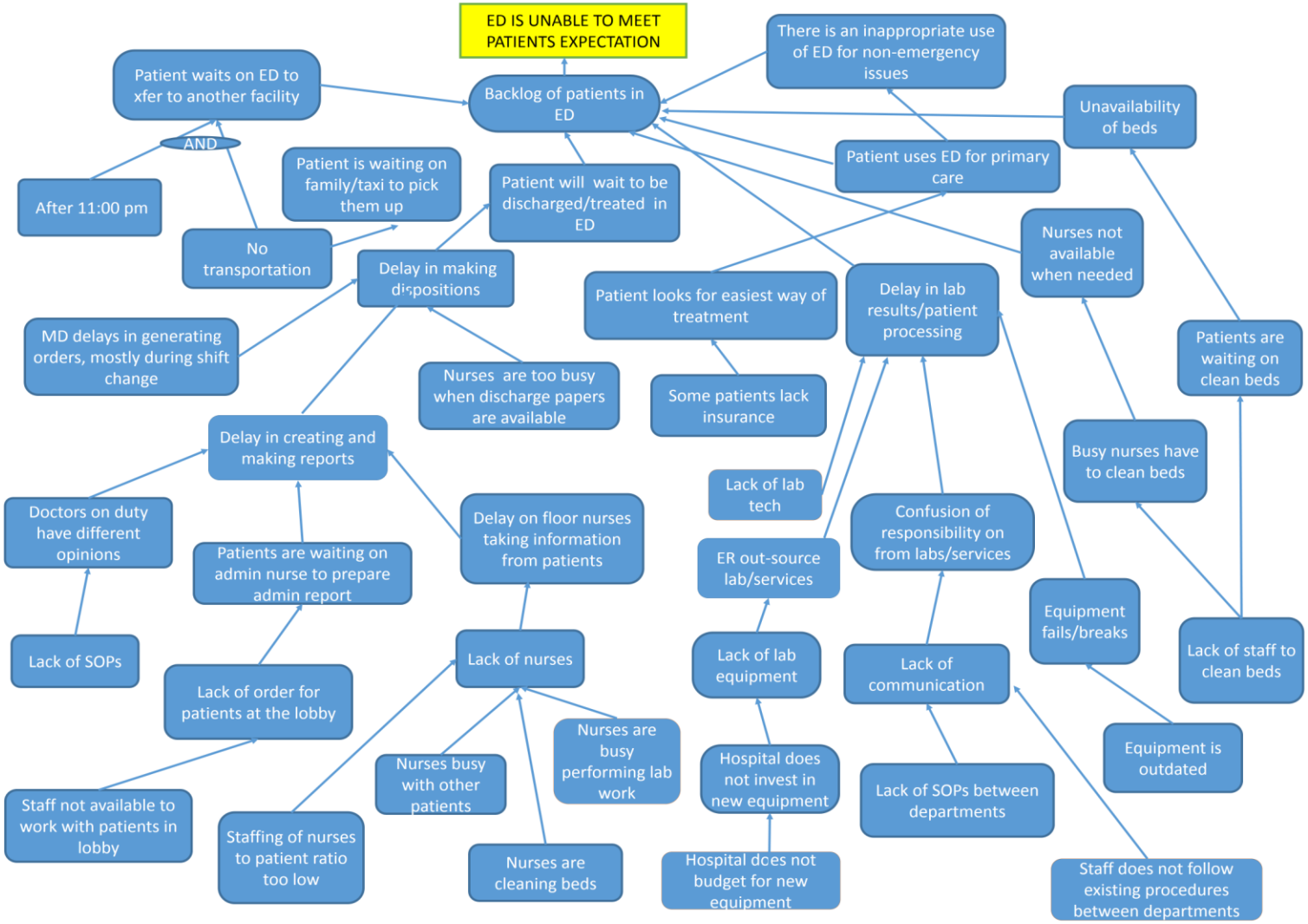

Figure 8. Initial CRT

Copies of the CRT were printed out and taken to the ED participants to validate the CRT and ask for their opinion. Feedback was received from the participants and their comments were as captured in Appendix C. Based on the feedback two more CRT's were generated that led to the final CRT as shown in Figure 9. The added entities were captured in bold to help identify the difference between initial and final CRT.

The final CRT begins from the bottom and is read as follows:

- If staff does not follow existing procedures between departments then there is lack of communication.
- If there is lack of standard operating procedures between departments then there is lack of commutation.
- If there is lack of communication then there is confusion of responsibility on lab/services.
- If there is confusion of responsibility on lab/services then there is delay in lab results/patient processing.
- If hospital does not budget for new equipment then hospital does not invest in new equipment.
- If hospital does not invest in new equipment then there is lack of lab equipment.
- If there is lack of lab equipment then ED out-source lab/services.
- If ED outsource lab/services then there is delay in lab results/patient processing.
- If there is not a designated ED phlebotomist there is lab of lab technician.
- If there is lack of lab technician then there is delay in drawing specimen samples.
- If there is delay in drawing specimen samples then there is delay in lab results/patient processing.

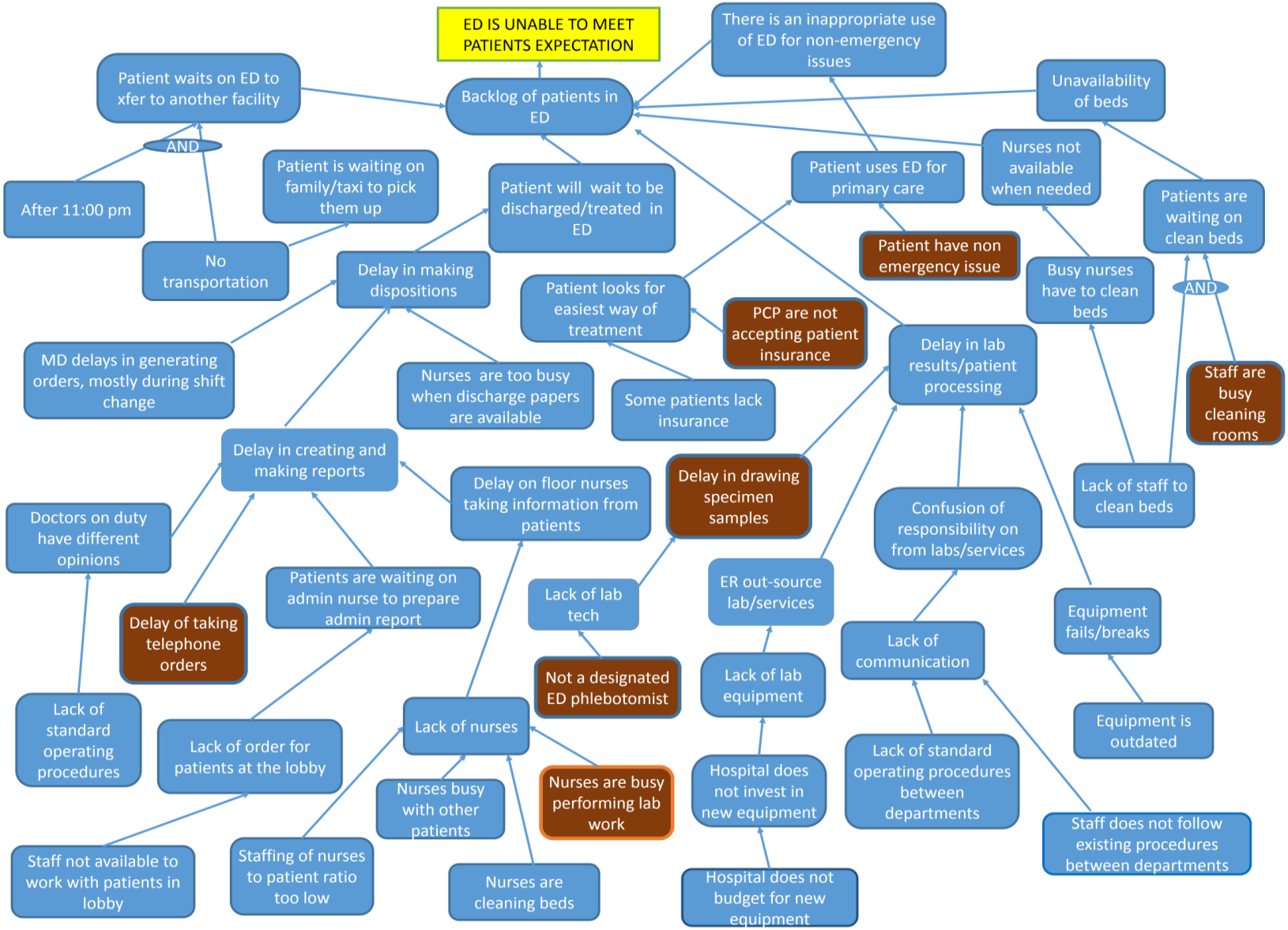

Figure 9. Final CRT

- If equipment fails/break then there is delay in lab results/patient processing.
- If there is delay in lab results/patient processing then there is backlog of patients in ED.
- If there is lack of staff to clean beds then busy nurses have to clean beds.
- If busy nurses have to clean beds then nurses are not available when needed.
- If nurses are not available when needed then there is backlog of patients in ED.
- If there is lack of staff to clean beds and staff are busy cleaning rooms then patients are waiting on clean beds.
- If patients are waiting on clean beds, then there is unavailability of beds.
- If there is unavailability of beds, then there is backlog of patients in ED.
- If staffing of nurses to patient ratio is too low then there is lack of nurses.
- If nurses are busy with other patients then there is lack of nurses.
- If nurses are busy cleaning beds then there is lack of nurses.
- If nurses are busy performing lab work then there is lack of nurses.
- If there is lack of nurses then there is delay on floor nurses taking information from patients.
- If there is delay on floor nurses taking information from patients then there is delay in creating and submitting reports.
- If staff is not available to work with patients in the lobby then there is lack of order for patients at the lobby.
- If there is lack of order for patients at the lobby then patients are waiting on administrative nurse to prepare administration report.

- If patients are waiting on administrative nurse to prepare administrative report then there is delay in creating and submitting reports.
- If there is lack of standard operating procedures then doctors on duty have different opinions.
- If doctors on duty have different opinions then there is delay in creating and making reports.
- If there is a delay of taking telephone orders then there is delay in creating and making reports.
- If there is delay in creating and submitting reports then there is delay in making dispositions.
- If nurses are too busy when discharge papers are available then there is delay in making dispositions.
- If MD delays in generating orders, mostly during shift change, then there is delay in making dispositions.
- If there is a delay in making dispositions, then patients will wait to be discharged/treated in ED.
- If patient will wait to be discharged/treated in ED then there is backlog of patients in ED.
- If some patients lack insurance then patients look for the easiest way for treatment.
- If the PCP is not accepting patients insurance, then patients will look for the easiest way of treatment.

- If patients look for the easiest way of treatment, then patients will use ED for primary care.
- If patients have non-emergency issues then patients will use ED for primary care.
- If patients uses ED for primary care, then there is inappropriate use of ED for non-emergency issues.
- If there is an inappropriate use of ED for non-emergency issues then there is backlog of patients in ED.
- If there is no transportation then a patient is waiting on family/taxi to pick them up.
- If it is after 11:00 PM and there is no transportation then a patient will wait on ED to transfer them to another facility.
- If patients waits on ED to transfer them to another facility then there is backlog of patients.
- If there is backlog of patients then ED is unable to meet patient's expectation.

What to Change to

With the aid of the final CRT, the researcher was able to check the entities that are causes only. Using the CRT was able identify a dilemma D and D' (the entities without any incoming arrows) as shown in Figure 10. The dilemma was identified and checked for causality existence: If obstacle D and D' then we cannot achieve the common objective. Five EC iterations were created to one common objective "A", patient expecting a positive outcome when they visit ED. In order to achieve A the system must satisfy the different requirement of B and C with the prerequisite to satisfy D which is the opposite of D' as shown. The validity of the EC was checked by verifying assumptions in Table 4. Value Based Purchasing (VBP) assumption on line AB, is program was put in place by the Affordable Care Act (ACA) in 2010 and became effective in 2013. VBP is a major step towards changing Medicare from a payer of claims but rather a purchaser of quality healthcare for its beneficiaries (Borah et al., 2012). VBP program measures the value of care provided to the clients using different criteria for processes of care, outcomes and patient-centeredness. The program holds back one percent of the Medicare base DRG payments (Borah et al., 2012).Copies of the EC were printed and taken to the participants to validate the entities, and assumptions and the injections between the entities.

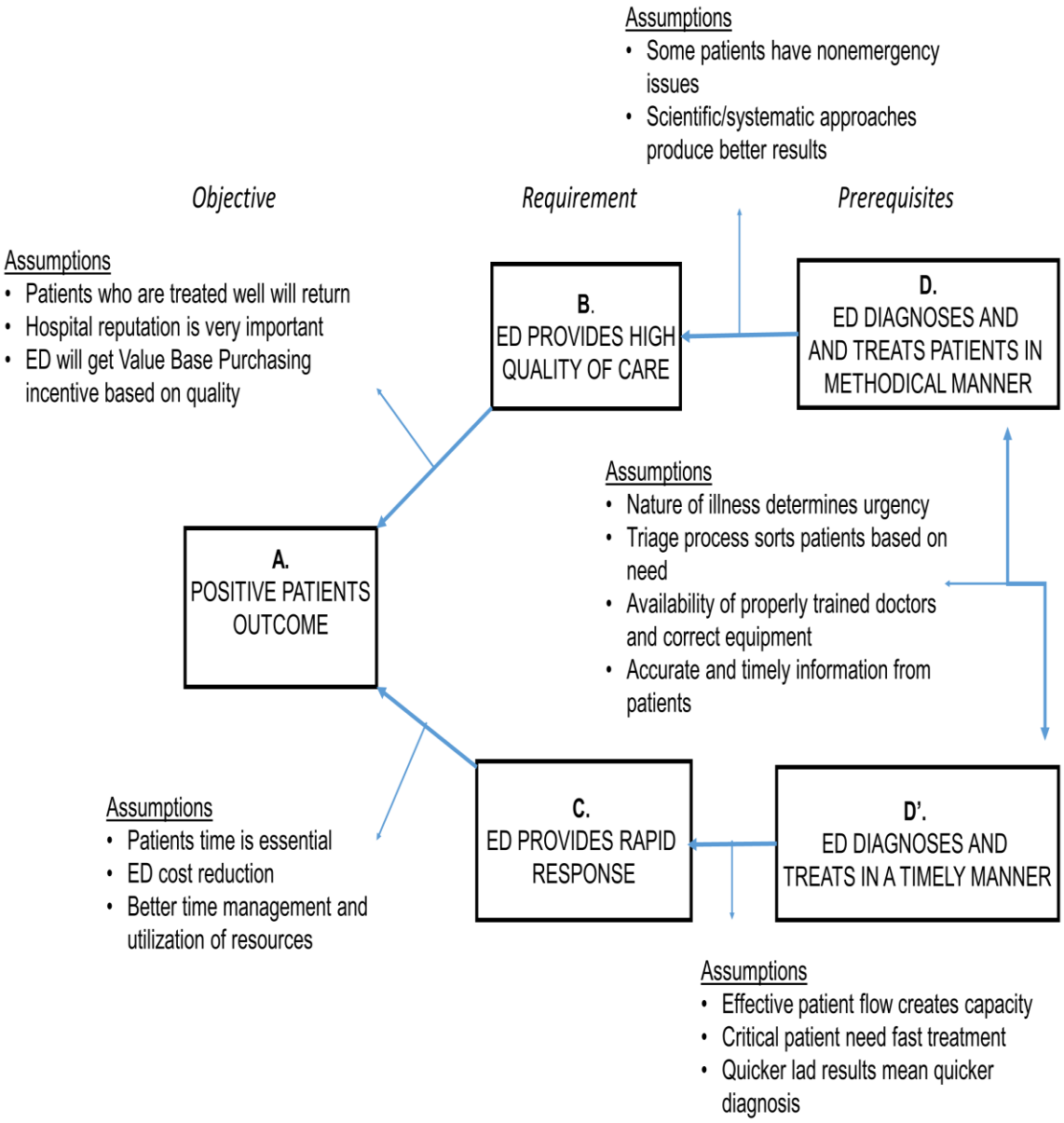

Figure 10. Initial EC

Table 4

Verification of initial EC

In order to.....	**Because..... (Assumptions)**
AB **In order to have positive patient outcome ED has to provide high quality care**	• Patients who are treated well will return • Hospital reputation is important • ED will get Value Bases Purchasing (VBP) incentive based on quality
AC **In order to have positive patient outcome ED has to provide rapid response**	• Patients time is essential • ED cost reduction • Better time management and utilization of resources
BD **In order for ED to provide high quality care ED has to diagnoses and treat patients in a methodical manner**	• Some patients have nonemergency issues • Scientific/systematic approaches produce better results
CD' **In order for ED to provide rapid response ED has to diagnose and treat in a timely manner**	• Effective patient flow creates capacity • Critical patients need fast treatment • Quicker lab results mean quicker diagnosis
DD' (OPPOSITE OF EACH OTHER) **(Why can't D and D' coexist?) because** →	• Nature of illness determines urgency • Triage process sorts patients based on need • Availability of properly trained doctors and nurses and correct equipment • Accurate and timely information from patients

EC survey instrument that were sent out to the participants were received back. From the feedback received (see Appendix F), the participants agreed with the dilemma, common objective and assumptions on the EC. There was some input from participants on the assumptions, which helped make final changes to the final EC as shown in Figure 11. The changes that are made are in bold letters. The validity of the EC was checked by verifying assumptions in Table 5. The final EC logically shows the assumptions are valid. However, the dilemma cannot be addressed without an injection to resolve the core problem as shown on the CRT. The injections must be able to evaporate the dilemma shown in the EC and address the entities on the CRT that the core problem.

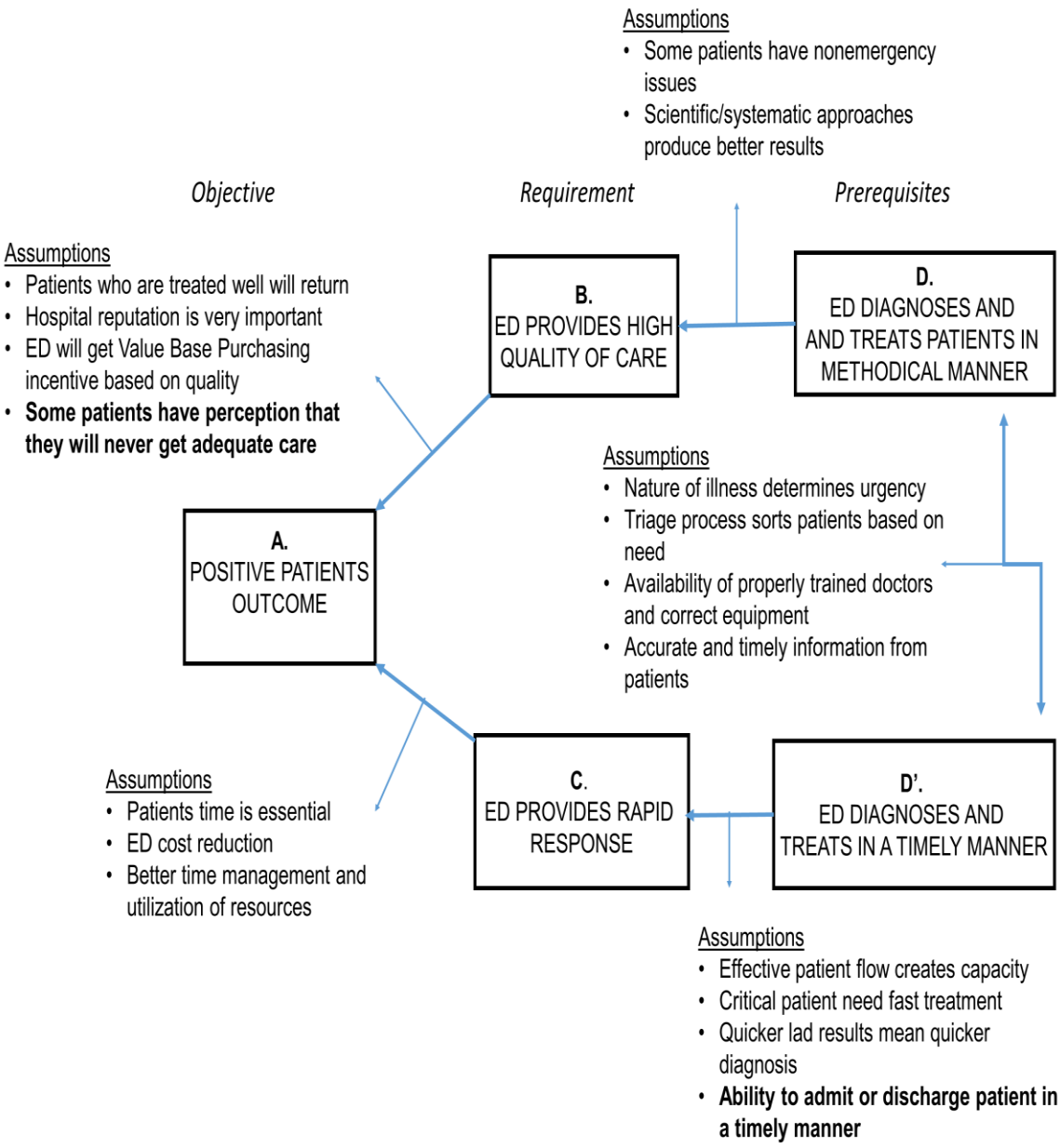

Figure 11. Final EC

Table 5

Verification of final EC

In order to.....	**Because.....**
AB **In order to have positive patient outcome ED has to provide high quality care**	• Patients who are treated well will return • Hospital reputation is important • ED will get Value Bases Purchasing (VBP) incentive based on quality
AC **In order to have positive patient outcome ED has to provide rapid response**	• Patients time is essential • ED cost reduction • Better time management and utilization of resources
BD **In order for ED to provide high quality care ED has to diagnoses and treat patients in a methodical manner**	• Some patients have nonemergency issues • Scientific/systematic approaches produce better results • **Some patients have perception that they will never get adequate car**e
CD' **In order for ED to provide rapid response ED has to diagnose and treat in a timely manner**	• Effective patient flow creates capacity • Critical patients need fast treatment • Quicker lab results mean quicker diagnosis • **Ability to admit or discharge patients in a timely manner**
DD' (OPPOSITE OF EACH OTHER) **(Why can't D and D' coexist?) because** →	• Nature of illness determines urgency • Triage process sorts patients based on need • Availability of properly trained doctors and nurses and correct equipment • Accurate and timely information from patients

How to Change

The next step is to consider if injections will provide direct desirable effects. The injections with the logically based common cause produce the desired effects and can be connected to develop a future outcome shown by a FRT diagram. The FRT was created by the researcher and was verified and modified with the assistance from the University TOC expert.

As shown in Figure 11, four injections were identified and placed into the tree to help create a vision for the future. The four injections are noted by the letter INJ on the top left of the entities boxes to help different them with the other entities. However, the injections were not able to evaporate all the UDEs and the unaffected UDEs were left in bold entities. The FRT is also read from the bottom to top just like the CRT, but the UDEs in bold are left out in the verbiage as they are not evaporated. FRT in Figure 11 is read as follows:

- If ED has well documented and easy to understand SOPs for staff to follow then there is existing SOPs between departments.
- If staff are encouraged to use SOPs in accordance to ED values then staff will follow existing procedures between departments.
- If staff follow existing procedures between departments and existing SOPs between departments then there is good communication.
- If there is good communication then there is understanding of responsibility labs/services
- If there is understanding of responsibility labs/services then there is improvement in lab results/patient processing.

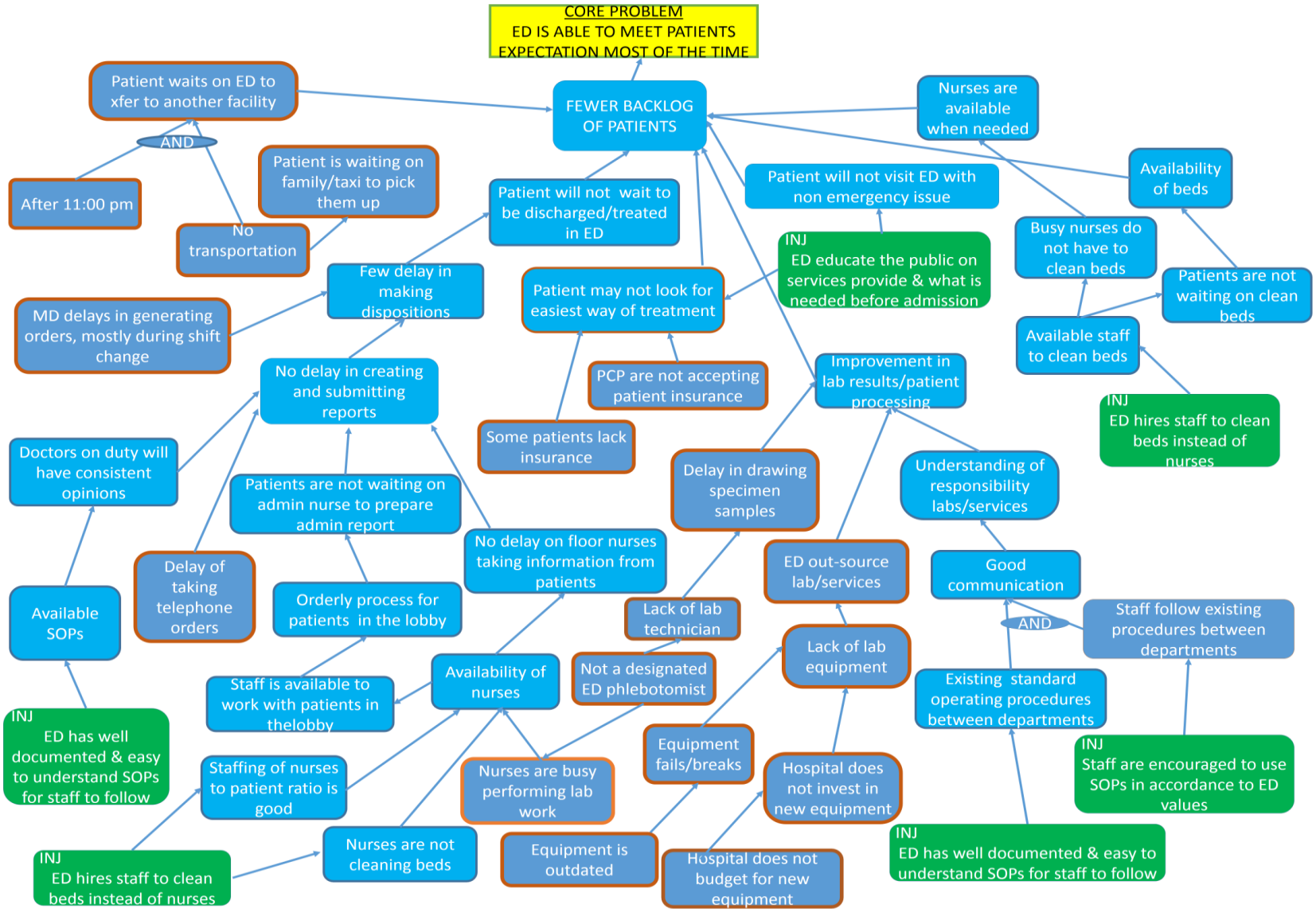

Figure 12. FRT

- If there is improvement in lad results/patient processing then there is fewer backlog of patients.
- If the ED educates the public on services provided and what is needed before admission then patients will not visit the ED with non-emergency issues.
- If patients will not visit the ED with non-emergency issues then there are fewer backlogs of patients.
- If the ED hires staff to clean beds instead of nurses then there will be available staff to clean beds.
- If there are available staff to clean beds then patients are not waiting on clean beds.
- If there are available staff to clean beds then busy nurses do not have to clean beds.
- If busy nurses do not have to clean beds then nurses are available when needed.
- If nurses are available when needed then there are fewer backlog of patients.
- If patients are not waiting on clean beds then there are an availability of beds.
- If there is availability of beds then there are fewer backlog of patients.
- If ED hires staff to clean beds instead of nurses, then the staffing of nurses to patient ratio is good.
- If staffing of nurses to patient ratio is good then there are an availability of nurses.
- If ED hires staff to clean beds instead of nurses, then nurses are not cleaning beds.
- If nurses are not cleaning beds then there are an availability of nurses.

- If there is an availability of nurses then there is no delay on floor nurses taking information from patients.
- If there is no delay on floor nurses taking information from patients then there is no delay in creating and submitting reports.
- If there is an availability of beds then staff is available to work with patients in the lobby.
- If staff is available to work with patients in the lobby then there is orderly process for patients in the lobby.
- If there is orderly process for patients in the lobby then patients are not waiting on admin nurse to prepare admin report.
- If patients are not waiting on admin nurse to prepare admin report then there is no delay in creating and submitting reports.
- If ED has well documented and easy to follow SOPs for staff to follow there is available SOPs.
- If there are available SOPs then doctors on duty will have consistent opinions.
- If doctors have consistent opinions there is no delay in creating and submitting reports.
- If there is no delay in creating and submitting reports there is few delay in making dispositions.
- If there are few delays in making dispositions then patients will not wait to be discharged/treated in ED.
- If patient will not wait to be discharged/treated in ED then there is fewer backlog of patients.

- If there is fewer backlog of patients then ED is able to meet patients' expectation most of the time.

As mentioned earlier, some UDEs in Figure 11 were not affected by the injections and were marked by bold entities for identification purposes. However, the other entities were evaporated that led to ED ability to meet patients expectation most of the times noted by the CP. Given the result from the FRT in Figure 11, it lead to the development of other entities on the top right of Figure 12, that led to potential increase of revenue within the institution. As a result, the new entities evaporated some of the unaffected UDEs from figure 11 as shown in Figure 12. However, not all UDEs were evaporated and the ones unaffected were left in bold. This figure will be discussed in more detail in the conclusion.

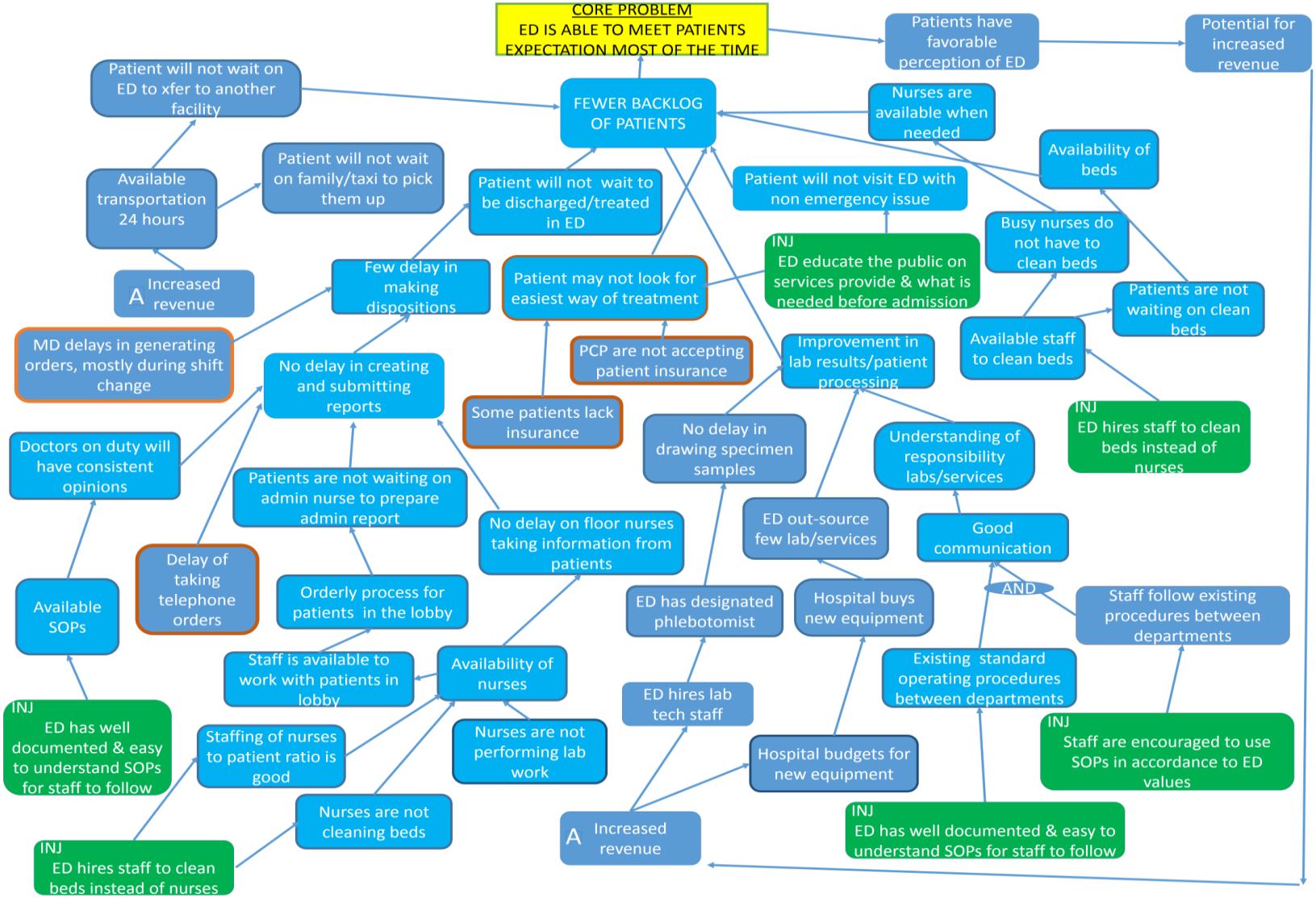

Figure 13. FRT

Conclusion

TOC has widely been used in the manufacturing industry and there are trends showing that it can be used successfully in service industries such as healthcare. The thinking process uses logic trees that provide a foundation for what to change to. Through this process, a problem can be identified, a solution built, and so identify the setback and provide the solution. According to Mabin (n.d), the TOC system focusses on the current experience within a system or organization, which are the cause and effect relationship that leads to the problem and the road map to eliminate the problem. TOC does not model an entire system, but just the core problems.

The purpose of this research was to identify the major constraint in an ED facility in Bowling Green, Kentucky and develop a solution with the aid of the TOC thinking process tools. The study had to address two research questions: 1) Can UDEs in an ED facility be captured in sufficient detail to identify the core problem? 2) Can the thinking process of TOC be applied to EDs to increase patient flow and improve effectiveness? In reference to the first question, the results from this study appear to provide answers. The resulting ranking of the UDEs (Table 3) was able to answer the first research question by the list of eleven UDEs. The lowest mean indicated the UDE that was ranked the highest in terms of participants' perception from an initial pool of three hundred UDEs. From the CRT, three main core problems were captured namely:

- Backlog of patients in ED
- Delay in making dispositions
- Patients waits on ED to transfer to another facility

It is evident that within the ED there was backlog of patients waiting to get services. This was a result of several factors. There was unavailability of beds because ED did not have staff to clean the beds and so the nurses were forced to clean. With the nurses cleaning the beds, there was shortage of nurses that could attend to patients. Another factor was the delay in lab results and patient out processing. The ED lacks some lab services or have outdated equipment and so they are forced to out-source, which led to delay. The ED also lacked proper standard operating procedures and so the staff were confused on who was responsible for what. All of these factors led to a backlog of patients.

With delay in making dispositions, nurses and doctors play a role on when a patient can be discharged and from the CRT, with nurses still cleaning the beds, there will be no one available to clear the patients as they wait for the discharge. Doctors treat patients, but they delay writing reports to discharge patients because there are no clear guidelines on when the report should be written. The ED does not have staff to attend to patients at the lobby. Nurses rotate in shift to cover the front desk, which leads to delays in disposition because it takes away resources that could treats or write reports.

Lastly, patients waits on ED to transfer to another facility. When patients are released from the ED, they are either transferred to another institution or discharged to go home. Most of the time, they take space with the ED because they wait on their families or taxi to pick them up. ED has not invested in transportation and so ED depends on third parties to transport patients to other institutions and these services are not available after 11:00 p.m.

Some patients' lack of insurance is a fourth major UDE, but was not addressed in the subsequent analysis. The reason was that, there is no control over patients' insurance status and this UDE was ranked lower compared to the other UDEs shown in Table 3. Collectively, these core problems led to the main core problem of ED unable to meet patients' expectations as shown in Figure 7. When patients visit ED for treatment, they expect shorter wait times as they expect to be treated and discharged in a timely manner.

The second research question was, "Can the thinking process of TOC be applied to ED to increase the patient flow and improve effectiveness?" With the CRT, the core problem was identified within the ED that the facility was unable to meet patients' expectations. This identified what needed to be changed within the ED. With the core problem at hand, the next step for the researcher was to identify what to change to. With the EC, as seen in Figure 11, the objective was to have a positive patient outcome. However, in order to do so, the ED has a dilemma that needs to be solved. The ED diagnoses and treats patients in a methodical manner or the ED diagnoses and treats in a timely manner. These would seem to be mutually exclusive given that if an ED diagnoses and treats in a timely manner typically means they would not provide methodical and quality care. At the same time if ED diagnoses and treats patients in a methodical manner, then patients would not receive timely service because ED would dwell on methodical quality. To solve this dilemma and address the core problem of the CRT, four injections were introduced using the EC.

- The ED hired staff to clean beds instead of nurses
- The staff are encouraged to use SOPs in accordance to ED values
- The ED has well documented and easy to understand SOPs for staff to follow

- The ED educated the public on services provided and what is needed for admission

An FRT was developed with the injections as seen in Figure 12 and 13. All the injections were noted with the abbreviation INJ and were placed on the CRT to develop an FRT. The injections eliminated most of the UDEs that led to ED's ability to meet patients' expectations. However, not all the problems were eliminated as shown in Figure 12. The injections could not eliminate the UDEs in bold boxes because there is no relationship between them and a positive outcome for the UDEs. However, if this FRT were to be implemented, the ED would be able to meet patients' expectations most of the time. It is expected that the institution, by implementing these changes, would begin to have a favorable patient perception of the ED, which would lead to a potential increase of revenue. Favorable perception means that patients will think positively about the ED; hence, they will keep coming back and recommend the institution to family and friends, which would lead to patient growth. As a result, a positive reinforcing loop could be developed where funds would be put back into the ED system. With additional available revenue, outdated equipment could be replaced, transportation provided and more staff hired. This is shown in the FRT in Figure 13. Additional revenue would eliminate the bold UDEs that were not eliminated in Figure 12.

UDEs not Addressed

However, the revenue will not be able to eliminate all the UDEs and four UDEs are left unaffected. The following UDEs were not addressed.

- Some patients lack insurance .Not everyone in society will always have insurance even though the law stipulates that it should be. It is close to impossible to eliminate lack of insurance.
- PCPs are not accepting patient insurance. Some primary care providers do not accept certain insurances and so patients seek medical attention at ED because they cannot be turned away. It is impossible to force PCPs to accept all patient's insurances.
- Medical doctor delay in generating orders mostly during shift change. This UDE was added to the CRT as a result of feedback received from the participants, but was not investigated further as it could not be confirmed.
- Delay of taking telephone orders. This was another late addition to the CRT as a result of feedback received, but was not investigated further as it was from a single respondent.

Summary

With the final FRT, the research was able to eliminate most of the UDEs from the CRT. The core problem of ED not meeting patients' expectations changed to the ED is able to meet patients' expectations most of the time. The TOC thinking process study at the ED facility produced results that answered both research questions. Moreover, this research tackled the three questions of TOC thinking process:

- What to change? This was answered by the CRT "ED is unable to meet patients expectation"
- What to change to? This was answered by the EC "Positive patient outcomes"

- How to change? This was answered by the FRT using the injections that led to "ED is able to meet patients' expectations most of the time."

While the intent of the study was to identify the core problem with the ED using TOC, it is evident that as a result of this study, ED could create positive patient outcomes and generate more revenue if all the changes were implemented. This would mean a great deal to institution given that many healthcare facilities are currently struggling to control high costs and provide adequate healthcare.

Suggestions for Further Studies

All the data collected was based on the perception from ED personal such as nurses, doctors, technical staff, support staff and others identified by the ED administrator. The researcher would recommend that a similar research is done using patients' perception of the ED. In addition, further studies should try and focus on a wide variety of EDs and not just one. In this research, it was a daunting task seeking multiple institutional cooperation. Having several EDs in an area would determine if different EDs have the same UDEs. Finally, the researcher recommends that future studies be conducted in EDs using other components of TOC such as the five focusing steps and drum buffer rope to see if the identified UDEs can be eliminated using other applications. This would give EDs a different approach toward addressing UDEs.

Appendix A: Survey Instrument

A Leading American University with International Reach
Department of Architectural and Manufacturing Sciences

Date 8 January 13, 2015

Dear Participant:

I am a graduate student at Western Kentucky University, Bowling Green in Architectural and Manufacturing Sciences Department. I am doing research on how to manage constraints in Emergency Rooms and Urgent Cares using a management philosophy of Theory of Constraints (TOC). The philosophy aims to achieve most efficient flow of patients through a continuous process. I am inviting you to participate in the research study that involves completing the attached survey and giving feedback on my data analysis that will come at a later stage.

The purpose of this survey is to identify problems that EMERGENCY ROOMS and URGENT CARE facilities experience that does not allow prompt and timely patient flow from the time patient check in until they are discharged (Discharged means that the patient leaves ER or Urgent care facility for home or for further treatment somewhere else).

Your participation in this survey is completely voluntary and confidential and should take you about fifteen minutes. Your response to the survey will be combined with other responses to determine the most common problems. A copy of the thesis research will be available upon request.

If you have any questions regarding the survey or my thesis research, please contact Augustine Amonge (augustine.otieno@topper.wku.edu / 270-320-3309) or my thesis advisor Dr. Mark Doggett (mark.doggett@wku.edu / 270-745-6951). Your participation is highly appreciated.

Sincerely,

Augustine Amonge

Mark Doggett, PhD
Western Kentucky University
1906 College Heights Blvd.
Bowling Green, KY 42101

The intent of the questions below is to gather demographics information only. Responses will be confidential and will not be shown to anyone.

What is the type of facility?

☐ Urgent Care

☐ Emergency Department

☐ Other explain

_____

What is your job?

☐ Doctor (any type)

☐ Nurse (any type)

☐ Administrative staff

☐ Technical staff

☐ Staff support

☐ Other explain: _____

What is your experience as a Health Care Professional?

☐ less than 1 year

☐ 1 -- 5 years

☐ 5 -- 10 years

☐ 10 -- 15 years

☐ 15 -- 20 years

☐ More than 20 years

Please list **TEN** problems in a scale of 1 to 10, with 10 being the least problem, that your facility experiences that does not allow prompt and timely patient flow from patient check in until discharge. (Discharge means that the patient leaves the facility for home or for further treatment somewhere else). Use complete sentences if possible.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

Appendix B: CRT Survey Instrument

A Leading American University with International Reach
Department of Architectural and Manufacturing Sciences

Date 15 April 2015

Dear Participant:

Thanks for your continuous support in this research, attached is a copy of a Current Reality Tree diagram (CRT) also known as a logic tree. It helps identify the effects between the perceived problem and potential root cause.

The logic tree is read from the bottom to the top by following the arrows. It depicts a chain of cause-and-effect reasoning (IF…AND…THEN) in graphical form, where ellipses represent an "AND."

Please give your opinion on what you think about the attached CRT and feel free to write any notes on the document as much as you can.

If you have any questions regarding the survey or my thesis research, please contact Augustine Amonge (augustine.otieno@topper.wku.edu / 270-320-3309) or my thesis advisor Dr. Mark Doggett (mark.doggett@wku.edu / 270-745-6951). Your participation is highly appreciated.

Sincerely,

Augustine Amonge

Mark Doggett, PhD
Western Kentucky University
1906 College Heights Blvd.
Bowling Green, KY 42101

Appendix C: EC Survey Instrument

WKU
A Leading American University with International Reach
Department of Architectural and Manufacturing Sciences

Date 20 May 2015

Dear Participant:

Thanks for your continuous support in this research, attached is a copy of an Evaporating Cloud (EC) diagram. Evaporating Cloud provides a simple graphic structure for questions to check the necessary conditions in any conflict.

In this case there are two conflicts D and D' (which are the opposite of each other) and the common goal is A. To help resolve the conflict there is need for B and C. In between the A, B, C, D and D' there are assumptions made. The Evaporating Cloud can be read as shown on the table on page 3.

Please give your opinion on what you think about the attached Evaporating Cloud and feel free to write any notes on the document as much as you can.

If you have any questions regarding the survey or my thesis research, please contact Augustine Amonge (augustine.otieno@topper.wku.edu / 270-320-3309) or my thesis advisor Dr. Mark Doggett (mark.doggett@wku.edu / 270-745-6951). Your participation is highly appreciated.

Sincerely,

Augustine Amonge

Mark Doggett, PhD
Western Kentucky University
1906 College Heights Blvd.
Bowling Green, KY 42101

Appendix D: Grouping of UDEs

Unavailability of Beds

Beds not cleared (4)

Beds not cleaned (10)

Not enough room/staff to always adequately provide the pt care that is needed for pt acquity (1)

Rooms not clean when admitting (9)

Having an overcrowded ER- All rooms are full (1)

Rooms assigned to patients for admission are dirty. Have to wait for housekeeping to clean (7)

Awaiting bed assignment (6)

Awaiting clean rooms (7)

Not enough rooms/beds in ED (5)

Fast track rooms sharing main triage room and main ER rooms -- occ have to take fast track room for acute pt (6)

Waiting on room assignment for pt admit (5)

Delay in getting admissions to the floor due to dirty rooms on the floor. (8)

When staff discharge patient, they don't clean the room immediately and leave the patient on the tracker which makes it looks like the room is occupied (2)

We are sometime given room number for admission only to find out the room is dirty (wait 30-45 min for housekeeping to clean room) (7)

As with any facility, once rooms are full patients stop moving. Having multi-functional rooms help (7)

Accountability for rooms: Nursing responsibility and accountability for their own rooms to be stocked and for the next pt arrival is lacking and delay patient care when supplies are not present when needed. (9)

Lack of Healthcare Professionals

Short Nurses (2)

Short Physicians (3)

Nurse-patient ratio (8)

Decreased staffing for days there are call in and not enough nurses to run fast track or have float nurses (2)

Needing additional providers (Doctors/NP) for high census days (3)

Nurse patient ratio (6)

Low RN Staffing (1)

Low MD Staffing (5)

Understaffed RNs, techs (1)

RN's having too many pts (2)

Occasionally not enough RN's (1)

Lack of doctors on NP's at times (4)

Less staffing on nights (1)

Need more nursing staff on nights (2)

Staff availability to come get pt at the check in-esp when ER is not busy but not quite full. Have to make several calls occasionally (1)

RN is assigned too many patients at the same time. One RN dividing by the 4 patients leads to unnecessary delays (1)

Staffing shortage especially when there are multiple call ins on delay (6)

Busy ER and not enough staff (4)

Under staffing (1)

I nurse to 4 patient assignments (1)

Nurse/Physician shortage on schedule some days (3)

Lack of staffing from providers to nurses to (1)

Lack of important resources: Nurses to take patients, dirty beds (2)

Staffing ratio 4:1 pts to nurses (7)

Staffing. It's very difficult to predict the causes but it seems as if there is never enough help (2)

Lack of Technical Staff

Staffing: Only one clerk for entire ER. 22 ER to handle beds/calls/X-rays (5)

Patient Nurse Ration ours is 4-1. That is a lot when you have no techs (7)

No techs/EMT for help (2)

Not having a tech to assist the RN with tasks that are not specific to an RN (2)

ED Staffing cleaning and turning over dirty rooms for the next patient (7)

No tech to help with EKG'S and blood draws and cleaning rooms (10)

Not enough staff (1)

Not having techs or CNA's to help RN with patient care (7)

Lack of ED techs thus having to run labs, take patients to radiology, clean their own rooms, etc (1)

Need a midnight tech (1)

RN's having to do EKG, VS, taking blood/urine, and other specimen to the lab (3)

No housekeeping staff for ED only (3)

Improper Patient Discharge Protocol

Dr forgot to put in orders, put up discharge orders etc (especially at MD shift charge) (3)

Takes too long to get pt. discharged after plan of care is completed (4)

MD Delay of making dispositions (2)

Awaiting the doctors discharge instructions and prescription if needed once the treatment is complete (4)

Delay in getting patients discharged from the ER to hospital admissions due to lack of receiving nurse to take speedy report (2)

MD and midlevel providers not discharging patient when all test are back. They tend to focus on arrival first (7)

Doctors do not review patient results for discharge in a timely manner to proceed with discharge instructions (1)

Primary nurses take too long to discharge patients and idle patients nurses will not help (2)

Discharge planning from provider (10)

MDs in procedure and not able to discharge other patients (6)

Nurses are busy when discharge papers are made available, no ancillary staff to check vital signs, DC IV sites (7)

Delay in Lab results

Lab not always being able to come draw blood in a timely manner (5)

Setting pts for Xray (6)

Ancillary department delays (3)

Flow to and from Xray. No one is accountable for that responsibility (1)

Waiting for imaging results (7)

Awaiting lad results (9)

Awaiting radiology (10)

Not enough help getting pt's to CT, Xray. The ER needs a dedicated X-RAY tech to get pt's (3)

There is no after-hours radiology thus diagnosis tests have to be sent and read and then sent back (9)

Radiology delays - sharing CT/Radiology w/inpt's, output & ER. Told to wait past input or output with apt (2)

Lab delays -- phlebotomist cover entire hospital! ER needs own (4)

Delays in physicians admitting and consulting on ER patients (5)

Delay in results from ancillary departments (X-ray lab) (6)

Transporting patients to x-ray and transporting specimen to labs (8)

Patients do not get their radiology exams done in a timely manner (3)

Labs are drawn and taken to lab 30 minutes later lab calls and wants labs redrawn because specimen hemolyged. (4)

Nurses don’t follow up to make sure their patients order are complete i.e UA's to lab or pts to X-RAY (5)

Some delays are due to results being returned by the lab (2)

Results window (7)

Lack of Mode of Transportation

Transport to floor (9)

Waiting for ems transport away from ED (5)

Waiting for transport to take p.t to admitting room (9)

No transporters after 11 pm (7)

Awaiting transportation (7)

Waiting on transport to take pt upstairs (8)

Waiting on EMS for pt transport to other appropriate facility (9)

Patient awaiting transportation when dismissed (family, cab, ambulance) (9)

Waiting for transport to take a patient to the floor for admission (3)

Patients waiting for a ride from family or waiting for ambulance to transport to nursing home or another hospital (10)

Transport will not call to inform us there will be delay in them getting patients to admission room (7)

Pts arriving by EMS that do not have a ride home (6)

Transport delay when pt is ready (8)

Awaiting discharge transport whether it be Ems, taxi, or family (8)

Inadequate Equipment

Not having materials needed to get, labs, or procedures done in a timely manner (10)

Not having IV pumps located in each room (4)

Functioning of Equipment (IV pumps/computers) (5)

Equipment down - one of two CT's & MRI down a lot or ultrasound gone--have to call in US tech or tele box and not picking up (3)

Computers slow at times of updating--several min's occasionally -- also slow in crossing over from CPOE to EDM or to Pixas (5)

Duplicate documentation. i.e EDM has duplicate screens for teaching throughout program at least 3 places may be 4 (7)

Delays occur due to lack of equipment and staff, such as limited number of CT scanners(3)

Delay in care occur due to having to call personnel in from call, such as intensive care nurse or ultrasound technicians (4)

Resources to assist with care i.e EKG, Phlebotomy, transport, room turnover, too many steps to complete (1)

Inter-disciplinary availability I.E Radiology, lab, etc (9)

Not having the right equipment (8)

System down -- PAC'S/SNR/LAB (6)

Equipment not working (4)

Non user friendly computer system (3)

Computer/labs printer: Annex has lab printer that only prints of computer used in Annex and has label printers for new pts but does not work causing RN to leave annex to go to main ED for label (6)

We need better equipment. Istat trop testers. There is a machine that can give CBC results in 2 min at the bed side (6)

Inadequate Supply

Supply Placement: MD and Clerk not staffed on annex side drawing hours of use (4)

Looking for medications that are not in the ER (10)

Medication Avail: Annex in ER does not have access to medication. Must go to main ED for all medication (3)

Stocks and supplies availability (8)

Searching for needed supplies (7)

Medication shortage--doctor's order sets for wounds abd meds not avail. Have to find dose and change orders or call pharmacy (8)

Medication not scanning or with changes of manufacturer with new bar codes not extended in computer - have to call pharmacist to add. (9)

Not having medications needed here in ER (6)

Patient flow is impacted by facility resources, if a patient must be transferred for resources, often case of flow is delayed due to communication needed. (9)

Delay in Making and Passing Reports

Nurse report hold up (6)

Floors unable to take report in timely manner (2)

Lack of standing orders for those who are waiting in lobby (1)

Waiting for admitting nurse to be ready for report (8)

Add on order (10)

Waiting on RN to take report for admit (6)

Not being able to give report to the floor (4)

Awaiting admitting or consulting physicians to call back with admission orders or arrive to see patient (4)

Awaiting for the receiving nurse on other floors to take report so we can send the patient upstairs when admitted (6)

Hard to call report on pts to the floor (9)

Waiting for floor RN to take report (2)

Doctors on staff have different flow - awaiting MD revals, waiting on admission orders from hospitalist and new room assignments (10)

Receiving admit orders to be completed prior to pt being moved upstairs (10)

We hold patients in ED after getting admission orders because receiving nurse will not take report (2)

Hospitals or Doctors putting in extra orders before the pts can go (1)

Useless charting or repeat charting (9)

Hand or typing our charting. I have heard in larger cities they have ability to dictate their notes (10)

Influx of Patients

I feel we behind partly due to the overwhelming flow of non-emergent patients. We see several chronic issues or complaints that are going: Or not serious in nature (1)

We are afraid to tell patients they are fine and do not need thousands of dollars' worth of test (3)

Pts are non-compliant with orders or with their own conditions (5)

Pts using ER for primary care facility (6)

Patients requesting further MEDS or prescriptions when attempting to discharge them (10

Multiple people signing in for treatment at one time with only one recept nurse (7)

Patient education--Pts are not always aware that complaint may not be completely resolved upon discharge, but improved (10)

Overcrowding in the ER due to inappropriate use of the ER by non-emergency complaints (1)

Large influx of patients greater than whats is normal count (4)

Pt asking for change in prescriptions or a work/school excuse (8)

Increased acuity level in patient care (5)

Patients networking frequently for chronic illness, due to inability to see primary care provider (6)

People using ER AS primary care, taking monitored beds rather than emergency (9)

Patients taking too long to tell why they are here/telling unnecessary information (5)

Pt expectations -- using resources for chronic treatment (5)

# of non-urgent visits in ED (2)

Poor Work Relationship

Miscommunication (5)

Lack of team work (7)

Teamwork breakdown (4)

Lack of communication on the part of the physician to the RN regarding his desire for patient care/plan/outcome (3)

Communication between team (4)

Lack of team work (5)

Certain nurses being slow (3)

Conflicting protocol’s from different departments (3

Communication: With new improved computer charts and tracking system there is less communication (verbal) between staff (7)

Appendix E: Participants Feedback from CRT

Below are the comments from the participants' on what they thought about the initial CRT

- Have to remember healthcare is a team approach and every team member needs to exhibit 100% effort.
- Most pt's are placed in immediate bedding- if not triage nurse evaluates them.
- When efficiently ran, the ratio is time- when the acquity is high sometimes that can be an issue because as a whole, pt's are sicker when they come to ER due to no primary care physicians.
- I think that as a whole the hospital does a great job to ensure that we have correct equipment for our jobs.
- When turning over a lot pt's , it's hard to keep up with the demand.
- Delay of the doctor calling back
- Delay of taking telephone orders instead of doctors entering own orders into systems.
- Patients think its first come first serve. It's more of a severity by severity case. It leaves them unsatisfied and angry.
- Is it that they lack insurance of PCP's not accepting the insurance they have.
- Delay of telephone orders having to be entered into system.
- Delays due to housekeeping cleaning rooms.
- Staff is busy cleaning room.
- Good CRT. Shows cause and effect of problems faced to ER's.
- Drawing blood/transporting pt's to x-ray

- Delay in lab being drawn
- Not enough lab techs or phlebotomist or not a designed ER phlebotomist.
- Insurance status isn't known to RN's or MD's.
- New equipment is available just may not be in the budget for the quarter.
- Policies and procedures are in place for the most part but staff will adapt the policy for suit their needs.
- Not enough Ed techs to help with cleaning rooms for taking pt's to radiology.

Appendix F: Participants Feedback from EC

Below are feedback comments received from the percipients based on the EC

- Patient may not always think care is adequate
- Multiple department change time in ED etc. X-ray registration etc.
- Very true
- Lack of providers willing to take Medicaid patients greatly impacts the ED volume.
- Great job
- Ability to transfer patients to be admitted in timely manner either to room in hospital or transfer to another hospital.
- Patients may not believe they were treated well if they have unrealistic expectations of how they should be treated (ex: receiving narcotics for minor problems). For this reason, the patient may not return although they received high quality care.
- Lab, x-rays, ultrasound etc. All these diagnosis being performed quickly result in quicker diagnosis.
- Systematic approaches are not always timely. Waiting on outside consults (i.e. specialized physicians or hospitalist)

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