Evaluating the Impact of a Quality Improvement Initiative Designed to Decrease the Turnaround Time for CT scans In a Level 1 Trauma Center

Maxwell Baptiste

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Abstract

Computed tomography (CT) scanning is an essential form of medical imaging; however, the high demand for CT scans in emergency departments (ED) can create problematic bottlenecks for care in a time-sensitive environment. Therefore, the present project represents a quasi-experimental study of an intervention intended to facilitate faster and more efficient CT imaging in smaller urban hospitals.

Objectives: A partial replication of Gyftopoulos et al.'s (2019) approach was trialed at a smaller hospital. The aim was to provide recommendations for smaller hospitals that would give them the ability to effectively replicate the incorporation of a radiology flow associate (RFA) into their workflow to have more efficient throughput and reduced turnaround times in CT. The objective was to determine if a trained RFA, as an intervention, could decrease emergency department CT turnaround times, as well as the disposition and treatment of the patients.

Methodology: The intervention was tested using all patients from two 4-week periods, one pre-test and one post-test, in a quasi-experimental research design. The project will take place at a smaller New York City emergency department level 1 trauma hospital. The sample comprised 1,466 patients treated at one smaller New York City hospital that has 450 beds and discharges on average 2,070 patients per month.

Results: The results revealed no significant difference in CT turnaround time for patients with an RFA versus patients without an RFA; a significant and moderate, positive relationship between time to admission and CT turnaround time; and a significant and moderate, positive relationship between time to discharge and CT turnaround time.

Conclusions: The turnaround time of CT scans in the ED has a definite and often severe influence on a patient's length of stay, whether for admission or discharge purposes; thus, it is recommended that the hospital management investigate strategies to assist in the prevention of bottlenecks in the ED due to a delay in CT results.

Keywords: Computed tomography, radiology flow associate, emergency department turnaround times, emergency department expeditor

Dedications

To my Super Hero,

Beryl Baptiste (mom), words cannot express the void I have in my heart since you left me on January 4, 2020. I miss you every day, and I wish you were here to witness this accomplishment.

Throughout my life, you instilled in me the value of hard work and determination and always showed me what it means to be strong, compassionate, and resilient during the toughest times. Undertaking this doctoral degree required me to use every one of those attributes! Today, as I look to complete this chapter of my life, my only wish is that you were here to share this moment with me as I accept this doctorate degree. I know you would have had the biggest smile and with your eyes beaming with pride. Having your pictures at my workstation as I did my assignments inspired me to work harder and helped me realize this moment.

I dedicate this achievement to you, my dear mother, in honor of all the sacrifices (many), and dedication you showed me, until you couldn't anymore. You were my biggest cheerleader; you held me down in the best and worst of times. But above all, you were my best friend and my real-life super hero.

I love you and miss you mom.

Your Loving Son!

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Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

Computed tomography (CT) scanning is an essential form of medical imaging. Research has shown steady growth in the amount of CT imaging requested by healthcare practitioners and is estimated to reach over 84 million procedures by 2022 (iData Research, 2018). The high demand for CT scans in emergency departments (ED) can, however, create problematic bottlenecks for care in a time-sensitive environment (Cory, 2020). Therefore, the present project represented a quasi-experimental study of an intervention intended to facilitate faster and more efficient CT imaging in smaller urban hospitals.

This project was a partial replication of research by Gyftopoulos et al. (2019). In that study, the researchers sought to improve CT scan times at a large academic medical center in New York City through the creation of an emergency department expeditor role. The person in this role was tasked with performing the workup needed to prepare patients so they can be cleared to undergo ED CT imaging. The expeditor role in the study by Gyftopoulos et al. (2019, p. 327) was able to improve CT imagining times to a statistically significant degree, but their implementation was geared toward a large academic hospital.

Hence, in this project, a partial replication of Gyftopoulos et al.'s (2019) approach was trialed at a smaller hospital. The aim for the research results was to provide recommendations for smaller hospitals that would give them the ability to effectively replicate the incorporation of a radiology flow associate (RFA) into their workflow to have more efficient throughput and reduced turnaround times in CT. The objective of this research was to determine if a trained RFA, as an intervention, can decrease emergency department CT turnaround times as well as the disposition and treatment of the patients. The intervention was tested using all patients from two 4-week periods, one pre-test and one post-test, in a quasi-experimental research design. The project took place at a smaller New York City emergency department level 1 trauma hospital.

Background

In the United States (U.S.), emergency departments in hospitals receive over 130 million patients each year. Over 75 million of those patients require a CT scan (*FastStats - Emergency Department Visits*, 2022); iData Research, 2018). CT scanning refers to a diagnostic imaging procedure that uses X-rays and computers to perform 360-degree rotations around the outside of the body to produce structural images inside of the body (Rehani et al., 2020).

CT scans provide detailed images of the bones as well as other organs and structures (Patel & Orlando, 2022). Cancer tumors, fractures, strokes, heart disease, liver mass, aortic dissections, internal injuries caused by major traumas, and many other medical conditions are the more frequent types of conditions requiring imaging request (Cleveland Clinic, 2020). Of the top five leading causes of death in the United States, four require CT imaging for diagnosis: strokes, heart disease, COVID-19, and cancer (*FastStats - Leading Causes of Death*, 2022). Because of their versatility and wide applicability, emergency department doctors rely heavily on CT scans when making diagnostic, treatment, and admission decisions (American Health Imaging, 2018).

Unfortunately, this same utility and ubiquity has given rise to problems. In particular, research has shown steady growth in the amount of CT imaging requested by healthcare practitioners and is estimated to reach over 84 million procedures by 2022 (iData Research, 2018). Because CT scanning capacity has not grown as quickly as demand for CT scans, this increase in use of the scans has been a prime contributor to heightened wait times at emergency departments (Croy, 2020). The rise of the COVID-19 pandemic has created further problems in terms of greater need for emergency medical services and, at the same time, heightened demands placed on those services (Hartnett et al., 2020). Although the full effect of the pandemic is difficult to determine given its parallel effect of making people wary of hospitals and less likely to go to the emergency department even if they required it, COVID-19 has overall increased the burden on emergency departments (Reichert et al., 2020).

The dangers of delayed CT scan times and turnarounds are especially well-illustrated by one of their key applications, diagnosis of strokes. More than 795,000 people will experience a stroke each year in the United States, of which 610,000 will suffer a stroke for the first time (CDC, 2021). According to the guidelines provided by the American Heart Association, the expectation for patients presenting in the ED with suspected acute strokes is to receive a head CT scan in less than 25 minutes from door to CT scanner and a clinical decision for an intervention must be made in order for the patient to have the first needle puncture in less than 60 minutes from door to needle (Fonarow et al., 2011, p. 2983). Patients are expected to be admitted into the stroke unit within 3 hours from the time they enter the hospital. Reducing delays in excess of 5.9 hours is a must for CT imaging, as studies show that for every 15 minutes in reduction of delay, there is an improvement of an estimate 4% in clinical outcomes along with a 5% reduction in mortality (Sanjeevi et al., 2016, p. 267).

Likewise, chest CT scans are critical in detecting lifesaving diagnosis such as pulmonary embolism or blood clots that travel into the lung, and with COVID-19 presenting with respiratory symptoms, having a CT scan of the chest has been vital in determining course of treatment (Schalekamp et al., 2021). These are only a few examples of why the increased turnaround time for CT scans in emergency departments represents a serious problem. In general, worse turnaround creates unnecessary risk of greater harm to patients, especially in the emergency context.

The proposed intervention addressed escalating CT scan turnaround times by utilizing a radiology flow associate (RFA). Currently, along with scanning the patient, the CT Technologist is responsible for performing all the workup required to get the patient ready for their scan. The RFA alleviates the CT technologist of all the tasks pertaining to getting the patient ready for their CT scans, which allowed the technologist to focus on scanning patients. In this role, the RFA assumes all communications in and out of the department between the patient care team, radiologists, and any parties that play a role in preparing the patient for their scan. The RFA should therefore help alleviate CT scan times by streamlining the process and making the technologists' jobs more efficient. This intervention served two purposes. The first was to act as a program evaluation for the RFA role itself, helping to demonstrate the ways in which this role can (or cannot) benefit hospitals. But, because the RFA represents a way of improving the entire department, it was also thought of as a quality improvement (QI) initiative. In this regard, the study and its intervention served a dual purpose that is ideal for creating a substantive and lasting change.

This intervention was implemented from the standpoint of the CDC's (1999) theoretical framework for program evaluation in public health. The CDC's framework suggests that public health issues, such as ED overcrowding, can be addressed through two key components, namely a set of six steps and the assessment of four key operational aspects. The six steps of the CDC's framework include (a) engaging stakeholders, (b) describing the program, (c) focusing the evaluation design, (d) gathering credible evidence, (e) justifying conclusions, and (f) ensuring use and sharing lessons learned. All of these steps will be applied to the adoption of the prosed intervention and reporting on it. Crucially, the key areas of assessment, in alignment with the CDC's (1999) framework, are (a) utility, (b) feasibility, (c) propriety, and (d) accuracy. These concepts and their application are addressed in greater depth in Chapter 2.

Problem Statement

The general problem is that in hospital EDs around the world, overcrowding and extended lengths of stay have become a serious health delivery problem that can lead to adverse patient outcomes including increased mortality rates (Driesen et al., 2018; Kaushik et al., 2018). Unfortunately, U.S. hospitals have been found to struggle with chronically overcrowded EDs (Grover et al., 2018). Prior research illustrates that overcrowding in EDs leads to a multitude of adverse effects, including long wait times, worsened patient outcomes, and increased mortality (Morley et al., 2018; Zhang et al., 2019). The specific problem is that long turnaround times to CT scan a patient can lead to longer stays in the ED, which in turn can lead to decreased patient health services, and reduced patient satisfaction (Bhatt et al., 2019; de Kok et al., 2021; Hawkins, 2007; O'Neill et al., 2020).

Significance

The significance of this project rested primarily on the detriments of slow or delayed CT scans and the commensurate benefits of reduced turnaround times. The potential harms of delayed imaging and diagnosis are difficult to overstate. As noted previously, a reduction of 15 minutes in CT scan turnaround time is associated with a 4% improvement in stroke outcomes and 5% reduction in mortality for stroke patients (Sanjeevi et al., 2016). Specific cases of patient deaths that could have been prevented by more timely application of CT scans were identified long before the current bottleneck in CT turnaround times (Salem et al., 2005). Lack of a timely CT scan has also been identified as one of the key predictors in determining the overall outcomes of patients with a severe head injury and the potential for traumatic brain injury (Zimmerman et al., 2020). Time to diagnosis and treatment is also of great significance for pulmonary embolisms, as delays in the diagnosis of a pulmonary embolism are associated with a significantly worse 30-day prognosis (Goyard et al., 2018). While not all patients presenting at EDs have serious, time-sensitive diagnoses, there are enough that do to make the problem of deep and substantial significance in terms of improving quality of care and clinical outcomes.

In a study by Gyftopoulos et al. (2019), a way of decreasing CT scan turnaround in large, academic hospitals was tested and validated. However, there are significant operational differences between a large research hospital and a smaller trauma hospital. In this regard, it is unclear if the same approach used by Gyftopoulos et al. (2019) would be equally applicable in a smaller hospital. The present study was also significant because it sought to address the research and practice gap by determining the extent to which a comparable intervention, the employment of an RFA to coordinate CT scanning communications, can similarly improve CT scan turnaround times and key related outcomes in the context of a smaller hospital. By proving the effectiveness of the intervention, then the results of this project will have widespread relevance, offering a model for other smaller hospitals to decrease CT scan turnaround times for their emergency departments and thereby help improve patient outcomes in regards to many dangerous, time-sensitive diagnoses.

Purpose of the Research

The purposes of this study were to examine the effect of applying an ED expeditor, namely a radiology flow associate (RFA), to the ED CT scanning process at a smaller New York City hospital and to determine if any benefits from the RFA are carried through to patient outcomes. Moreover, the results of this project can be shared with smaller hospitals to demonstrate how the incorporation of an RFA into their workflow may influence efficiency and turnaround times in CT.

Research Questions and Hypotheses

The proposed study was guided by three quantitative research questions. For each research question, a null and alternative hypothesis was stated. The research questions and hypotheses are as follows:

RQ1: Does having a radiology CT flow associate (RFA) decrease computed tomography (CT) turnaround times?

$H1_0$: Having an RFA does not significantly decrease CT turnaround times.

$H1_A$: Having a RFA significantly decreases CT turnaround times.

RQ2: Do computed tomography (CT) turnaround times increase the length of time it takes to admit a patient?

$H2_0$: CT turnaround times do not significantly increase the length of time it takes to admit a patient.

$H2_A$: CT turnaround times significantly increase the length of time it takes to admit a patient.

RQ3: Do computed tomography (CT) turnaround times increase the length of time it takes to discharge a patient?

$H3_0$: CT turnaround times do not significantly increase the length of time it takes to discharge a patient.

$H3_A$: CT turnaround times significantly increase the length of time it takes to discharge a patient.

Operational Terms

Computed tomography (CT) scan. A CT scan refers to a diagnostic imaging procedure that uses X-rays and computers to perform 360-degree rotations around the outside of the body to produce structural images inside of the body (Rehani et al., 2020).

Emergency department (ED). EDs are the departments of hospitals that receive and care for patients in need of immediate care, especially those whose needs are unexpected (e.g., a sudden injury; Gyftopoulos et al., 2019).

Radiology flow associate (RFA). A RFA is a novel role in the hospital. The RFA will assume all communications in and out of the radiology department between the patient care team, radiologists, and any parties that play a role in preparing the patient for their scan.

Assumptions, Limitations, and Delimitations

Assumptions

Assumptions are the foundational truths upon which a study is based (Balnaves & Caputi, 2001). There will be several assumptions for this study. The first assumption was that the hospital in this study would faithfully implement the intervention as intended. The second assumption was that the data assessing the outcomes of the intervention would be faithfully and accurately reported. Finally, it was assumed that the implementation of an RFA could reasonably be understood as both a program evaluation and a QI initiative at the same time.

Limitations

Limitations are weaknesses of a study and are typically unavoidable (Balnaves & Caputi, 2001). There are several limitations in this study. First, a quasi-experimental design is weaker than a fully experimental design. However, feasibility and research ethics dictated that a quasi-experimental design was necessary in this project. Second, the project was limited in that it only assessed the effects of the intervention over a narrow post-test timeframe. This means it was hard to know if the intervention was in full effect yet or, conversely, if any observed effects would wear off over time. Third, the project was limited by factors outside the researcher’s control, such as seasonal changes in the nature of injuries or other external events that could have some impact on variables such as CT scan turnaround times. These limitations do weaken the project, but their effect is not expected to be highly significant or to too badly impair the overall conclusions that can be drawn from the project.

Delimitations

Delimitations are deliberate boundaries placed on the project (Balnaves & Caputi, 2001). There are several delimitations in this project. First, the project was delimited to a single hospital in New York City. This delimitation was chosen in line with the methodology of the prior project this research partially replicated, and also because of practical considerations. Second, the project was limited to CT scans because of their particular importance in the treatment process and because of the research and practice gap pertaining to them. Third, the project was delimited to EDs because of both the criticality of speed in the emergency context and because of the noted issues with CT scans in the ED context.

Summary

The purposes of the quasi-experimental study were to determine the effect on patient outcomes from utilizing an RFA to manage the CT scanning process at a smaller New York City hospital. Specifically, the study inquired whether having an RFA decreased CT turnaround times, and whether CT turnaround times increased the length of time to admit and discharge patients. The results of the study can be shared with other smaller hospitals to help achieve more efficient throughput and reduced turnaround times in CT through the utilization of an RFA.

Chapter 1 shared a discussion of the foundational elements of the study, including the problem, purpose, research question, and the significance of the study. Chapter 2 will discuss the literature related to the study, sharing an argument in favor of its focus and methodological approach. That approach and the study’s quasi-experimental design is discussed in Chapter 3, along with the population and sample, procedures for recruitment and collection, steps in the analysis process, and ethical considerations. Chapter 4 discusses the findings of the study as they related to the study's research questions and hypotheses. Chapter 5 summarizes and interprets the findings, discussing them with reference to literature and theory before offering limitations, recommendations for future research, and a conclusion.

Chapter 2

Review of the Literature

Globally, hospital emergency departments (EDs) are overcrowded with extended lengths of stay. This problem has become serious in the health delivery sector, which can lead to adverse patient outcomes including increased mortality rates (Driesen et al., 2018; Kaushik et al., 2018). According to Grover et al. (2018), the current United States (U.S.) healthcare environment is characterized by expensive care and crowded hospitals and EDs. Patients in overcrowded EDs can experience long waits to see a physician, and ED physicians can experience long waits to see the results of requested imaging such as CT scans and diagnostic tests prior to making a diagnosis and beginning treatment of the patient (Morley et al., 2018; Zhang et al., 2019). The specific problem is that long turnaround times for CT scan results can lead to longer stays in the ED, which in turn can lead to decreased patient health services, and reduced patient satisfaction (Bhatt et al., 2019; de Kok et al., 2021; Hawkins, 2007; O'Neill et al., 2020).

Turnaround times for CT scans and other radiology diagnostic results are a critical factor in the quality of patient services provided by a hospital's ED. The authors of previous studies have concluded that reducing turnaround times for physicians awaiting the results of CT scans can decrease lengths of stay for patients in the ED (Alemu et al., 2019;-Kaushik et al., 2018; Perotte et al., 2018). There has been, however, insufficient research on the role of a Radiology Flow Associate (RFA) in the ED. The current study aims to help fill this gap in knowledge and includes an exploration of existing literature that touches on topics related to whether the presence of an RFA in the ED or a similar radiology expeditor in the ED could impact turnaround times for radiology imaging leading to decreased lengths of stay and improvements in patient care.

This chapter, Chapter 2, will provide a review of existing literature on the primary constructs related to the present study. The researcher will identify gaps in the extant literature regarding hospital EDs and trauma centers and how the use of an RFA or similar coordinator or expeditor in the ED can reduce turnaround times for CT scans requested by ED physicians. After a brief review of the research strategy, the chapter will provide a scholarly discussion of EDs and trauma centers, lengths of stay for patients, overcrowding in the ED, processes and procedures in the ED, CT scans, reducing turnaround times, and the utilization of radiology flow associates (RFAs) or other ED-based radiology coordinators or expeditors. The chapter closes with a summary of the reviewed literature and an introduction to Chapter 3 and its examination of the methodologies used in the current study.

Literature Review Strategy

The literature review is undertaken with searches of multiple online databases including PubMed, ProQuest, and the Education Resources Information Center (ERIC). The researcher also uses Google Scholar to extend the scope of the review. These databases are searched for peer-reviewed results of studies of similar topics primarily in the past five years but extending further back in time for earlier research and for seminal studies of relative theories and methodologies. The key search terms that are included in these searches are the following: *emergency department, trauma center, CT scans, overcrowding, turnaround times, length of stay, radiology flow associate,* and *ED* *expeditor*. These terms are used alone and in various combinations, incorporating suitable combinations of "OR" and "AND" in an effort to find and synthesize related research.

Background to the Problem

Physicians rely on CT scans and other radiology diagnostic tests to accurately diagnose patients and plan effective treatments. Delays in receiving the results of those requested scans and tests can add to patients' overall lengths of stay in the ED (Alemu et al., 2019; Kaushik et al., 2018; Morley et al., 2018; Perotte et al., 2018) and can cause delays in healthcare decision-making that can result in poor patient outcomes (Hawkins, 2007; Nazerian et al., 2019; Zhang et al., 2019). Overcrowding is a problem common to many hospital EDs and trauma centers (Hooker et al., 2019; Lindner & Woitok, 2021; Savioli et al., 2022) and it can add to long turnaround times for radiology imaging and diagnostic test results due to the sheer volume of requests (Morley et al., 2018; Rasouli et al., 2019). The current study aims to provide new information about effective methods for decreasing turnaround times for CT scan results requested by personnel in the ED. Filling gaps in knowledge in this area can help to reduce CT scan turnaround times, decrease patients' lengths of stay in the ED, and improve treatment outcomes for patients in the ED.

Previous researchers have touched on overcrowding in the ED and long turnaround times for radiology imaging results but have recommended additional research to help fill gaps in existing literature. In a study on ED throughputs and how they add to lengths of stay for patients, Rogg et al. (2017) reported that among ED patients who need CT scans of the head, bottlenecks in departmental flow led to longer turnaround times for radiology reports and longer stays in the ED for patients. These researchers recommended, however, that additional research should be conducted to better understand the causes of delays in ordering CT scans and having the results delivered to the ordering physician (Rogg et al., 2017). The following year, Driesen et al. (2018) studied lengths of stay in the ED at an academic hospital in the Netherlands and found that many patients experienced lengths of stay of over 6 hours. Driesen et al. (2018) found that the primary causes of patients' increased lengths of stay in the ED were related to hospital-wide organizational inefficiencies and were beyond the control of the ED. The study's authors recommended additional research on the root causes of delays in the overall acute care chain in an effort to reduce overcrowding and lengths of stay in the ED (Driesen et al., 2018). The researchers behind both of these studies determined that additional research on these topics could lead to improvements in patient healthcare in the ED.

Other more recent studies have been conducted by researchers who came to some of the same conclusions. In a study of factors that influence lengths of stay at a hospital ED in Southern Ethiopia, Alemu et al. (2019) found that long stays in the ED can be due to a lack of beds, overcrowding in the ED, and slow turnaround times for delivering radiology imaging and laboratory test results. These researchers recommended additional studies focused on causes of long stays in the ED and factors that may reduce those lengths of stay. In the same year, Rasouli et al. (2019) reviewed the results of 158 studies of overcrowding in hospital EDs and found that overcrowded EDs can lead to increased lengths of stay and poor patient outcomes. These researchers noted that one way in which overcrowding negatively impacts patients' lengths of stay in the ED is delayed turnaround times for radiology imaging results. The researchers indicated that additional studies could provide new information about methods for reducing ED overcrowding and the resulting long stays for patients (Rasouli et al., 2019). None of these prior studies included an examination of the use of an RFA or radiology coordinator or expeditor in the ED, which lies at the root of the current study. This study's results could provide new information to help fill gaps in existing literature and could lead to improvements in patient care in hospital EDs and trauma centers.

Theoretical Framework

This quasi-experimental study is based on the CDC's theoretical framework for program evaluation and quality improvement in public health. According to the CDC (1999), the CDC's framework provides a practical, nonprescriptive tool that can guide healthcare professionals in adhering to useful, feasible, ethical, and accurate processes. The CDC (1999) noted and recommended six steps in line with the framework for evaluating a healthcare program: engaging stakeholders; describing the program; focusing the evaluation design; gathering credible evidence; justifying conclusions; and ensuring use and sharing lessons learned.

Additionally, the CDC's framework contains a set of criteria for evaluating the quality of healthcare activities: utility, feasibility, propriety, and accuracy. The first of those standards, utility, involves providing for the informational needs of intended users. The second standard, feasibility, involves being prudent, frugal, diplomatic, and realistic. The third, propriety, involves ensuring legal and ethical behavior and consideration for the welfare of everyone involved. The fourth standard, accuracy, requires that researchers provide information that is technically accurate (CDC, 1999). This kind of evaluation can separate programs that promote health and prevent injury or disease from programs that do not, and it can be used to examine whether the magnitude of the investment matches the tasks to be accomplished (CDC, 1999). This framework has been explored and supported by other researchers since 1999. The following year, Milstein et al. (2000) wrote that the six steps laid out in the CDC theoretical framework can be used to tailor an evaluation to the specific program under consideration, and since the six steps are interdependent, they need not be undertaken in the order provided by the CDC but can be encountered in a nonlinear sequence with each step providing foundation for the subsequent steps. This framework will be combined with basic principles of quality improvement, supporting the quantification of relevant performance metrics to minimize harm while promoting accountability, justice, and transparency. The CDC's framework supports the current quality improvement study as the researcher explores and assesses programs used in hospital EDs for patient management and for imaging scan requests from ED physicians that will be used to assist in diagnosing patients. More specifically, this framework relates to the current study, as the set of standards (utility, feasibility, propriety, and accuracy) provides a criterion for evaluating the quality of patient management programs used in the EDs, as well as for imaging scan processes (CDC, 1999). McBride et al. (2015) and Logan et al. (2003) have underscored the relevance of the CDC framework for program evaluation in healthcare, focusing on assessing specific activities such as electronic health records and contact investigations.

The CDC's theoretical framework for program evaluation in public health will be followed to examine current ED methods and programs, to gather evidence from previous studies that touch on the topics of patient lengths of stay in the ED and turnaround times for test and scan results, and to provide new information to help fill a gap in knowledge that currently exists. The authors of other prior studies have supported the CDC’s framework and have used it as a foundation in research projects (Aulisio, 2020; Kidder & Chapel, 2018). Kidder and Chapel (2018) explored perspectives about program evaluation and wrote that evaluation refers to researchers’ gathering and analyzing data to determine the effectiveness and efficiency of various healthcare programs and to make suggestions for improvement. In a dissertation 2 years later, Aulisio (2020) utilized the CDC’s framework for program evaluation to assess the effectiveness of a graduate course in the University of Kentucky’s health professions program for increasing knowledge of interprofessional leadership roles in the healthcare sector. Aulisio (2020) wrote that the framework provided a clear and methodical process for program evaluation. Both groups of researchers found that the CDC’s framework for program evaluation in healthcare is a useful and effective tool, and they provided support for the framework as this current study hopes to do.

Hospital Emergency Departments

Modern hospitals and medical centers offer a variety of emergency services related to injury and disease, and these services are provided by representatives of the emergency department (ED) or trauma center. Professional caregivers in the ED, however, are challenged to work efficiently and effectively (Fernandez-Llatas et al., 2019; Rojas et al., 2019). Hospital EDs are globally overcrowded with patients having to wait for extended periods of time for treatment (Improta et al., 2018). This problem is significant as it leads to decreased patient satisfaction and significant increases in patient mortality rates (Improta et al., 2018). In EDs, the operation of adequate and timely triage protocols can predict patient outcomes up to and including life or death (Fernandez-

Llatas et al., 2019). The same researchers pointed out that in cases of stroke, reducing the time required for diagnosis and treatment can limit or avoid undesired cognitive decline in the stroke patient (Fernandez-Llatas et al., 2019). Reducing the number of ED visits and readmissions and reducing the amount of time spent in the ED on each visit can improve the patient's experience of care, improve the work life of healthcare providers, and reduce per capita costs (Hewner et al., 2018). Reducing lengths of stay in the ED can lead to improved quality of service for patients.

Making improvements in service quality in hospital EDs requires an assessment of current practices and recommendations for change. Analyzing the overall performance of EDs can reduce patient wait times, decrease patient congestion, and improve the quality of care (Rojas et al., 2019). The need for performance assessment in the ED underscores the value of the current study's use of the CDC's framework for program evaluation in healthcare. The current study's results could help to reduce lengths of stay in the ED by reducing turnaround times for CT scans and other radiology diagnostic imaging results. Rojas et al. (2019) reported that the primary cause of lengthening episode durations in an ED is the existence of a loop between the examination process and the treatment process, and as severity increases, the number of repetitions of the examination-treatment loop increases as well. Hewner et al. (2018) reported that achieving a healthcare system that is high in quality and high in value requires that healthcare providers be inspired and encouraged to develop novel solutions to patient care in all departments including the ED. The kind of novel solutions that can bring about improvements are at the center of this study with its exploration of using an RFA to reduce turnaround times for radiology imaging requested in the ED.

Increasing the quality of service and reducing lengths of stay is an important goal for large hospitals and for smaller hospitals, which are the primary focus of this study. Gaughan et al. (2020) examined whether small hospitals and rural hospitals are associated with lower levels of healthcare quality than large urban hospitals, but the researchers found that small hospitals with fewer than 400 beds are not associated with lower levels of service quality or patient outcomes except for heart attack mortality rates. The researchers concluded that heart attack mortality rates tend to be higher in small hospitals, but they did not specifically report that these higher heart attack mortality rates are due to a low quality of service in the EDs of small hospitals compared to large hospitals (Gaughan et al., 2020). Other prior researchers have determined that EDs in small hospitals can be less likely than EDs in large hospitals to adopt and use technology (Williams, 2022), and small hospitals may experience longer turnaround times for radiology imaging results (Friedberg et al., 2018). Vance et al. (2013) found little difference in the degree of quality provided by the EDs of small hospitals and large hospitals while Sandoval et al. (2019) found EDs in small hospitals to be less efficient in the use of radiology CT scans and other technology. The current study's exploration of expediting turnaround times in an effort to reduce lengths of stay in the ED could provide much-needed information for the administrators and caregivers in all hospitals, and especially those in small hospitals.

Level I Trauma Centers

Hospitals can provide emergency services through a trauma center specifically established to treat traumatic injuries and traumatic reactions to disease. Cudnik et al. (2009) studied trauma centers or Level I and Level II hospitals at 27 locations in Ohio and reported that patients treated in trauma centers have better outcomes than patients treated in non-trauma facilities. Patients taken to Level I trauma centers tended to have more debilitating injuries including penetrating injuries and injuries with complications, and overall, patients had improved outcomes and better survival rates in Level I trauma centers than in Level II trauma centers or non-trauma facilities (Cudnik et al., 2009). Candefjord et al. (2022) studied patient care and treatment at a trauma center in Sweden and reported that trauma centers are better equipped to provide adequate care to trauma patients, and trauma centers have an adjusted 30-day mortality rate up to 41% lower than non-trauma centers. Trauma centers can provide better patient outcomes due to their focus on trauma patients and their preparedness to react to a range of traumas.

The effectiveness of a trauma center depends on prehospital transportation, readiness of trauma center staff, and a medical center's willingness to spend the money requisite to provide trauma services. Candefjord et al. (2022) reported that a large percentage of trauma patients do not receive adequate emergency care, especially when seen in non-trauma facilities, leading to high rates of preventable deaths. These researchers also examined ambulatory patient transportation and noted that prehospital undertriage occurs when a severely injured patient is transported to a facility that does not offer appropriate trauma care, and overtriage occurs when minimally injured patients are transported to high level trauma centers (Candefjord et al., 2022). Ashley et al. (2019) determined that trauma centers are expected to maintain essential supplies and infrastructure to guarantee readiness to provide all kinds of optimal care to trauma patients, and this readiness can be costly. These researchers noted that a trauma center's average annual costs for all the components of readiness can total over $10 million

(Ashley et al., 2019). Based on the high costs of operating trauma centers, it follows that managing those costs while simultaneously providing all the supplies and services needed to treat a wide variety of traumas should be a primary concern of trauma centers everywhere, whether they are located in small rural areas where operating expenses may be lower or in large cities like New York where the price of everything is inherently higher.

Level I Trauma Centers in New York City

Trauma centers are operated in rural settings and in urban settings including New York City. Savel et al. (2018) studied a 100-year-old hospital in New York City and the process through which its surgical intensive care unit earned the American College of Surgeons’ designation of Level I trauma center. The researchers enumerated several factors required for the hospital to earn the Level I designation and demonstrate a preparedness to treat trauma patients. Those factors included intensive staffing changes, training of nurses and advanced practice practitioners, bed allocation issues, and optimizing interactions with closely related services and departments (Savel et al., 2018). Those optimized interactions with related services could include reduced turnaround times for CT scans and other imaging and tests. Shi et al. (2021) studied the impact of the COVID-19 pandemic on a Level I trauma center that serves eastern New York City and Nassau County, and the researchers reported that the trauma center typically serves 900 trauma patients per year. Trauma centers in New York City may have higher patient numbers than trauma centers in smaller cities or rural areas, but they operate with the same need to offer high quality patient services.

Lengths of Stay in the Emergency Department

Long stays in hospital EDs and trauma centers are not uncommon and are not a new phenomenon. The hospital emergency department is the first point of access to a hospital for many patients, and lengths of stay among patients in an ED are considered a key indicator of quality of care for the hospital as a whole (Kaushik et al., 2018).

Previous research has shown that reducing lengths of stay in the ED can result in benefits for patients, physicians, and hospitals. Long wait times in EDs are a significant concern for U.S. hospitals because they add to a hospital's overall burden of providing care to patients, and because long stays in the ED can have negative consequences for patients that include avoidable medical errors, negative impact on patient outcomes, and higher mortality rates (Kaushik et al., 2018). Zhang et al. (2019) confirmed that long lengths of stay in the ED are associated with an increase in patient mortality rates. Employing 1,997 patients in China, the researchers found a significantly lower mortality rate for patients with less than 6 hours of stay in the ED, compared to patients with 12 to 24 hours length of stay in the ED (Zhang et al., 2019). More specifically, mortality rate for patients with less than 6 hours of stay in ED was 21.4% while those with 12 to 24 hours length of stay in the ED had 31.9% mortality rate (Zhang et al., 2019). Moreover, patients who have stayed in the ED for more than 24 hours had 31.8% mortality rate, indicating a significant increased risk of death (Zhang et al., 2019).

As such, hospitals nationwide are being pressured to treat more patients with fewer EDs and fewer hospital beds (Kaushik et al., 2018), and these researchers added that even modest improvements in turnaround times for requested diagnostic test results can have a significant impact on patients' lengths of stay in EDs, while shorter lengths of stay per patient will allow a hospital's ED to see and treat more patients overall. Decreasing the average lengths of stay for patients in the ED should be a common goal for all hospitals and trauma centers.

Factors That Increase Length of Stay in the Emergency Department

Some prior studies have focused on several factors that contribute to extended lengths of stay in the ED. Overcrowding in the ED can result in significant delays in patients being triaged and treated, dramatically increasing lengths of stay in the ED (Morley et al., 2018). Delays in admitting patients to an intensive care unit (ICU) from the ED are common due to overcrowding and long turnaround times for test results (Zhang et al., 2019). Driesen et al. (2018) determined that many of the factors that contribute to longer stays in the ED are based on organizational inefficiencies throughout the hospital that are beyond the control of the ED, including the time required to receive results of diagnostic tests or radiology imaging. According to Perotte et al. (2018), a major reason for delays in diagnosis and treatment of patients in the ED is long turnaround times for test results and radiology images such as CT scans. Alemu et al. (2019) found that there are several factors that result in increased lengths of stay in the ED, including a lack of beds, overcrowding in the ED, and turnaround times required for diagnostic test results and radiology imaging. The same researchers determined that at a hospital in Ethiopia, those factors were significantly and positively associated with ED stays of up to 24 hours. More recently, Shi et al. (2021) noted that the advent of the COVID-19 pandemic put added pressure on healthcare systems worldwide with shortages of personal protective equipment and personnel. Obviously, personnel shortages in an ED or trauma center can result in longer stays for patients as there are fewer healthcare providers present at any given time to provide the needed services.

Benefits of Decreased Lengths of Stay in the Emergency Department

The authors of several previous studies have found that reducing lengths of stay in the ED can be beneficial to patient outcomes. Grover et al. (2018) studied methods for reducing ED crowding and reported that when ICU wards and other inpatient departments within a hospital are crowded, the result for patients in the ED is longer waits in chairs in a waiting area, even for patients experiencing pain and discomfort who would be better off in a bed. The researchers found that reducing lengths of stay in the ED prior to admittance to other hospital departments for inpatient procedures can result in improved patient satisfaction and reduced patient discomfort (Grover et al., 2018). Driesen et al. (2018) reported that many ED patients at a hospital in the Netherlands experienced a length of stay of over 6 hours, and the researchers noted that overcrowding and long stays in an ED are associated with negative outcomes for patients including increased mortality and significant delays in diagnosis, treatment, and hospital admission. The same researchers found several reasons for extended lengths of stay in the ED, most of which have to do with inefficient organization throughout the hospital, and many of which cannot be addressed by the ED alone. The reasons noted by Driesen et al. (2018) include shortage of beds available for transfer to hospital inpatient settings, and delays in turnaround times for radiology results and resultant delays in physician consultations that await those radiological images. Zhang et al. (2019) found that longer stays in the ED can lead to higher mortality rates. They reported that the crude mortality rate for patients with ED lengths of stay of less than 6 hours was 21.4% while those with lengths of stay of 12 to 24 hours had a crude mortality rate of 31.9% (Zhang et al., 2019). Kim et al. (2020) determined that overcrowding in hospital EDs and long stays in the ED can contribute to elevated rates of in-hospital cardiac arrest. They found that maximum ED occupancy had the strongest positive correlation with in-hospital cardiac arrest occurrence (p = .01). The researchers behind these studies confirmed that reducing lengths of stay in the ED can lead to improvements in patient outcomes and patient satisfaction.

Methods for Decreasing Lengths of Stay in the Emergency Department

Researchers have examined methods for reducing lengths of stay in the ED and some have focused on the use of telemedicine. Overcrowding in hospital EDs can be costly for hospitals and can compromise the quality of healthcare services provided to patients, so it is important to find ways to improve ED care (Sun et al., 2020), including finding ways to reduce lengths of stay in the ED. Sun et al. (2020) studied data from hospital ED visits throughout the state of New York from 2010 to 2014 in an effort to determine whether telemedicine could play a significant role in reducing patient lengths of stay in EDs and improving patient outcomes. The researchers determined that the use of telemedicine in the ED can lead to reductions in patients' lengths of stay, especially at times when there is a surge in demand or a shortage of supplies (Sun et al., 2020). McHugh et al. (2018) studied overcrowding at a hospital ED in New York City where a telehealth service called Telehealth Express Care Service was introduced and through which incoming ED patients with minor complaints were given the option of having a virtual visit with a board-certified physician located remotely. The researchers reported that after 6 months, over 1,300 patients had been treated with the telehealth service and those patients experienced increased satisfaction and reduced lengths of stay, with average lengths of stay dropping from 2.5 hours to 38 minutes (McHugh et al., 2018). The authors of both studies confirmed that the use of telemedicine can speed up the process of onboarding ED patients and can shorten their lengths of stay in the ED. Additional research on methods for decreasing lengths of stay in the ED, as in the current study, can lead to better patient healthcare management and improved outcomes for patients in the ED.

Overcrowding in the Emergency Department

Overcrowding is a common problem in today's EDs and trauma centers. Hospital EDs face multiple challenges in the delivery of fast, effective patient care, and those challenges can include overcrowding, long wait times, cost containment, and increasing demand from patients (Verbano & Crema, 2019). Savioli et al. (2022) defined overcrowding in a hospital ED as an imbalance between patients' needs for emergency care and the hospital's availability to provide the needed services. Driesen et al. (2018) defined ED overcrowding as a situation in which incoming patients' needs for emergency medical services exceed the available resources for patient care within the ED, the hospital, or both. According to Cairns et al. (2021), there were approximately 130 million ED visits in the United States in 2018 and roughly 22% of adults aged 18 and over visited the ED in 2019. Research reveals that hospital EDs and trauma centers today can experience overcrowding on a regular basis, which can negatively affect the delivery of patient health services.

Several prior studies have been conducted by researchers who more clearly identified reasons for ED overcrowding or problems that arise from ED overcrowding. Driesen et al. (2018) reported that one of the most common reasons for overcrowding in the ED is bed shortages. Morley et al. (2018) reported that overcrowding in EDs is a patient safety issue that is not based simply on population growth but can occur due to several factors including input (patients waiting to be seen), throughput, and output. More recently, Lindner and Woitok (2021) reported that overcrowding in hospital EDs is a worldwide phenomenon that creates problems for nurses and physicians and can lead to poor outcomes for patients. These researchers added that strategies to counter the problems inherent in overcrowding are urgently needed (Lindner & Woitok, 2021). The following year, Savioli et al. (2022) determined that overcrowding in the ED can negatively affect the triage process and lead to increased numbers of patients who are not able to obtain triage care, an increase in the lengths of stay for patients who do access triage care, and rising numbers of patients who voluntarily leave the ED without undergoing examination or treatment for their injuries or disorders. Savioli et al. (2022) added that since 1980, overcrowding has been a primary obstacle in the providing of correct, timely, and efficient hospital care, and the COVID-19 pandemic has contributed to the phenomenon.

Impact of COVID-19 Pandemic on Overcrowding in the Emergency Department

Perhaps surprisingly, the initial impact of the COVID-19 pandemic on hospital EDs and trauma centers was a reduction in the volume of incoming patients. Several research reports published in 2020, the year the pandemic started, were written by authors who noted a decrease in ED patients. Westgard et al. (2020) studied the impacts of the COVID-19 pandemic on the ED at a regional hospital in Minnesota and reported that in the months following the state’s emergency declaration regarding COVID-19, patient visits to the ED decreased by over 49%, especially among pediatric patients and elderly patients. Haskel et al. (2020) reported that in the initial months of the COVID-19 pandemic, the overall volume of orthopedic consults in hospital EDs decreased dramatically, due in part to governmental orders to stay home and limit interactions with others, which resulted in fewer accidents and traumatic injuries. These researchers reported that at a Level I Trauma Center in New York City, there was a 48.3% reduction in ED consults in 2020 compared to 2019 (Haskel et al., 2020). But while EDs reported fewer onboarding patients in the early months of 2020, personnel and supplies were stretched thin during this period because of the growing numbers of COVID-19 patients in other areas of the hospitals (Haskel et al., 2020). Kurt and Gunes (2020) studied the phenomenon of overcrowding in hospital EDs and found that at the outbreak of the COVID-19 pandemic, ED admissions dropped sharply, due in part to emergency stay-at-home orders from government organizations. They reported that at the hospital where their study took place, there were 47,681 patients seen in the ED between March 28, 2019 and April 28, 2019, and the same ED saw 9,455 patients between March 28, 2020 and April 28, 2020 ($P < .01$; Kurt & Gunes, 2020). These researchers concluded, however, that this reduction in incoming patients in EDs could lead to an increase in deaths at home, an increase of patients first entering EDs with worse prognoses, and an eventual rise in patient numbers in EDs that would eventually result in overcrowding (Kurt & Gunes, 2020). These researchers all reported on decreased patient numbers in the ED in the first months of the COVID-19 pandemic. Studies conducted more recently provided different information.

Several recent studies have confirmed that the COVID-19 pandemic eventually caused overcrowding problems in EDs in New York and elsewhere. Haskel et al. (2020)

noted that the COVID-19 pandemic was especially devastating to the New York City area because of the area's dense population and its reliance on mass transit. A year later, Reschen et al. (2021) reported that during the initial wave of the COVID-19 pandemic, daily attendance by incoming patients in a United Kingdom hospital's ED fell by 37%, but the researchers noted that within a year, ED admission numbers had returned to normal and had then grown to higher-than-normal numbers, especially for some specific patient groups including minority ethnic groups and patients with dementia or obesity. Reschen et al. (2021) added that throughout the United Kingdom, hospitals at the time of their study were experiencing unprecedented ED attendance and higher-than-usual mortality rates among patients in the ED because of COVID-19. Shi et al. (2021) reported that as of August of 2020, COVID-19 had infected 24 million people around the globe and killed over 820,000, and the medical needs created by this pandemic forced hospitals to make changes in how non-COVID diseases and disorders are treated. Savioli et al. (2022) determined that one cause of overcrowding in EDs during the COVID-19 pandemic is wait times for inpatient admittance to the hospital at large. The researchers noted that these longer wait times occur because of the necessity to screen all onboarding patients prior to their being assigned to a bed in a clean unit, as opposed to a COVID-19 unit, to prevent infection of existing patients (Savioli et al., 2022). These researchers recommended an improvement in coordination of care within hospital EDs to improve patient outcomes, and they suggested several strategies that could be undertaken by hospitals including the establishment of a flow management center within the ED (Savioli et al., 2022). This clearly supports the current study's goal of exploring the use of an RFA or expeditor in hospital emergency departments.

Overcrowding in New York City Emergency Departments

A few researchers have examined overcrowding specifically in EDs or trauma centers in the New York City area. Liyanage-Don et al. (2022) studied overcrowding in the ED at a quaternary academic medical center in New York City and reported that overcrowding at the time of ED admission was associated with patient perceptions of unfavorable interpersonal care. Other researchers who focused on EDs in the New York City area found methods that effectively reduced ED patient numbers. Laghezza et al. (2020) analyzed data from the CDC on overcrowding in the EDs at two hospitals in Manhattan (New York-Presbyterian/Weill Cornell Medicine and New York-Presbyterian/Lower Manhattan Hospital) and reported that at both hospitals, incoming ED patient numbers rose nearly 15% between 2006 and 2014. The researchers found that by using telemedicine to screen incoming ED patients, departmental throughput, efficiency, and patient safety were improved, with incoming ED patients being diagnosed by a qualified medical professional within a median time of 4 minutes from arrival compared to the national average time of 15 to 59 minutes for patients to be seen (CDC, 2020). Bains et al. (2020) examined overcrowding in various departments at NYU Langone Medical Center – Brooklyn and reported that in the early days of the COVID-19 pandemic, the hospital increased its general inpatient capacity by 85% and the hospital quadrupled its ICU capacity. Additional overcrowding was experienced in the ED, but the researchers implemented a Discharge Command Center that helped to review pending discharges and reduce lengths of stay. Among the study's 110 participants, 84 (76%) experienced reduced lengths of stay, and the researchers provided data using historic O:E LOS for the months of March and April, reporting that in March and April of 2018, this value was 0.89 and in March and April of 2019 it was 0.92 (mean 0.91). The scientists determined that with the intervention of the Discharge Command Center, O:E LOS for March and April 2020 was 0.84, a 7.7% reduction from baseline (Bains et al., 2020).

Impact of Overcrowding on Lengths of Stay in the Emergency Department

Several studies have shown a relationship between overcrowding in the ED and increased lengths of stay for ED patients. Morley et al. (2018) noted that the primary factor in time spent in the ED waiting room is the number of patients in the waiting room, with higher numbers of patients resulting in longer waits and increased lengths of stay. These researchers added that crowded EDs can result in delays in patients' being discharged or admitted to the hospital at large for inpatient treatment, causing patients to experience longer lengths of stay in the ED (Morley et al., 2018). Wachtel and Elalouf (2020) studied overcrowded EDs in hospitals in Israel and reported that in 2012, the average length of stay for patients in the ED was 2.27 hours. These researchers added that overcrowding and resultant long stays are common in hospital EDs around the world with reports claiming ED patient occupancy of more than 200% the norm, leading some EDs to refer incoming patients to other EDs in the area or to reject non-urgent cases outright (Wachtel & Elalouf, 2020). Rasouli et al. (2019) determined that overcrowding in hospital EDs has a negative effect on patients, healthcare systems, and the surrounding community, and the increased workload for emergency healthcare staff can result in delays in clinical decision making and increased lengths of stay for ED patients. All these studies were conducted by researchers who found an equivalence between overcrowding and long stays in the ED.

Research has also shown that overcrowding in EDs and the resulting increase in lengths of stay can have a negative impact on patients and hospital personnel. Morley et al. (2018) reported that overcrowding in hospital EDs can have negative consequences including poor patient outcomes and the inability of ED staff to adhere to guideline-recommended treatments. Morley et al. (2018) reported that causes of overcrowding in the ED include delays in the receipt of CT scans, and the researchers concluded that reducing turnaround times for test and scan results can result in less crowding in the ED as patients are diagnosed and discharged or admitted more quickly. Rasouli et al. (2019) found that overcrowding in EDs can lead to overutilization of diagnostic imaging, causing delays in turnaround times for the results of those images. These studies reveal a relationship between overcrowding and longer stays in the ED due in part to long turnaround times for radiology imaging results.

Emergency Department Processes and Procedures

ED and trauma center personnel follow specific processes and procedures during the onboarding, diagnosis, treatment, and discharge of patients. Garcia et al. (1995) reported that incoming patient queues in EDs are prioritized based on the sickness level of the patient, which can result in excessively long waits and overall lengths of stay for patients with low priority injuries or medical problems. Blackburn et al. (2019) explored the informational and communicational requirements of patients and staff in the ED and found that effective communication can result in the patient and family feeling well-informed and knowledgeable about options for treatment and care. These researchers offered several vehicles for improving patient satisfaction including posters, leaflets, and other displays of written information about triage and wait times (Blackburn et al., 2019).

One of the procedures frequently utilized in the ED is a physician request for CT scans or other radiology imaging, so that diagnosis and treatment can be more accurate and effective (Howell et al., 2018; Wada et al., 2018). Reducing turnaround times for CT scans can result in more efficient triage, faster patient treatment, and shorter stays in the ED.

Triage

A significant procedure provided by EDs and trauma centers is patient triage. According to Christian (2019), the word triage is based on the French verb “trier,” meaning “to sort,” and it was originally used in European markets in reference to the grouping of various consumer goods by quality and price. This researcher noted that the early use of the word also drew upon its secondary meaning, which is to assign a ranked value to what is being sorted. The prioritization or ranking aspect of the word triage is what is practiced daily in hospital EDs, where incoming patients are sorted according to the severity of their medical needs (Christian, 2019). Tam et al. (2018) studied triage practices at hospital EDs in several locations including Sweden and Taiwan, and the researchers reported that triage helps healthcare providers identify and prioritize the incoming patients who need urgent intervention and need for it to be provided quickly. Tam et al. (2018) added that triage systems and ED performance can be improved with increased collaboration between emergency departments. This finding supports the notion that establishing an RFA or other hospital staff member who is responsible for expediting the radiology imaging requests during triage can lead to improvements in patient treatment and reductions in lengths of stay in the ED.

Radiology Imaging Requests

Physicians rely on CT scans and other radiology imaging for the accurate diagnosis of patients. Requests for those imaging tests are often made by physicians in the ED (Kaushik et al., 2018; McConnell & Writtenberry-Loy, 1983). Nazerian et al. (2019) studied the relationship between diagnostic test requests and ED services and reported that the healthcare service system is experiencing a worldwide increase in diagnostic tests requested by physicians or other healthcare professionals in the ED. These researchers explored methods of reducing costs without negatively affecting the quality of emergency services provided by the ED. Martins et al. (2020) examined the high number of radiology imaging tests requested by ED personnel and found that over 75% of the requests were considered to be appropriate for patient diagnosis, but the researchers noted the importance of establishing defining guidelines to reduce the number of unnecessary imaging requests handled by radiology departments. A reduction in requests could result in faster turnaround times, and faster turnaround times could result in decreased lengths of stay in the ED.

Radiology Imaging Results

When ED physicians endure long turnaround times for test and scan results, patient outcomes can suffer. Sareen and Dutt (2018) reported that in modern medicine, diagnostic investigations are crucial as physicians rely on test results to aid in diagnosing patients and developing appropriate treatment plans, so it is vital that hospital diagnostic departments provide high quality test results. Radiology imaging relies heavily on laboratory test results to complete several advanced imaging studies that require contrast administration. Some errors can occur when blood for testing is drawn by nurses without sufficient experience instead of being drawn by phlebotomists who can provide more stability in how blood is drawn for testing, which can in turn minimize delays in image acquisition as the laboratory results are not delayed in reaching the CT technologist (Sareen & Dutt, 2018). Tung et al. (2020) focused on the relationship between effective communication of imaging results and adequate patient care but noted that this communication can be difficult to accomplish efficiently. The study's authors established a radiology report categorization system to organize diagnostic imaging requests and incorporate an automated communication system to convey the results, and the system led to a rate of almost 100% success in improving quality communication of radiology results to physicians and their patients (Tung et al., 2020). The current study can provide new information about ED practices that will reduce turnaround times for test and scan results, which could result in better patient services and reduced lengths of stay.

Radiology Imaging Results in Small Hospitals

Some prior studies have been conducted by researchers with a focus on comparing the services provided in small hospitals versus large hospitals, as explored in the current study. Williams (2022) examined the use of technology in small hospitals and wrote that small hospitals are less likely to adopt and utilize electronic medical records (EMR) than large hospitals, but the researcher noted that small hospitals can benefit from the use of EMR and other forms of healthcare-based technology systems. It is reasonable, then, to conclude that small hospitals could also benefit from other changes in protocol related to technology, including reducing turnaround times for radiology scans through the use of an RFA or similar coordinating or expediting professional in the ED focused on test and scan requests and the timely delivery of accurate, dependable results.

Friedberg et al. (2018) focused on radiology services available in small hospitals and in rural hospitals. The researchers determined that the small or rural hospitals that were part of their study fell short of meeting timely demands for radiology services and had difficulty recruiting and retaining radiology staff (Friedberg et al., 2018). The lack of additional research on turnaround times for radiology results in small hospitals points to the gap in current literature regarding the use of an RFA or similar coordinator or expeditor in the EDs of small hospitals.

Turnaround Times for Imaging Computed Tomography Scan Results

Lengths of stay for patients in the ED can depend in part on turnaround times for radiology CT imaging results. According to Hawkins (2007), the use of diagnostic tests is associated with longer lengths of stay in the ED by patients. Bhatt et al. (2019) noted that at Dhulikhel Hospital-Kathmandu University Hospital in Nepal, the predefined turnaround time for results of tests requested by ER staff is 1 hour, but the average turnaround time for tests from all departments is 1 hour and 19 minutes. Longer turnaround times can result in longer stays in the ED.

Keeping turnaround times for test and scan results as brief as possible is critical since physicians are awaiting the results before making a diagnosis and starting a treatment plan. Hawkins (2007) reported that turnaround time for the delivery of diagnostic test results is a key performance indicator for hospital departments, and the concept of quality is not limited to accuracy or precision of test screenings, but can also encompass availability, cost, relevance, and timeliness. This researcher noted that of these factors, timeliness is perhaps the most important to the ED physician who cannot make treatment decisions until the test results have been returned and examined. Hawkins

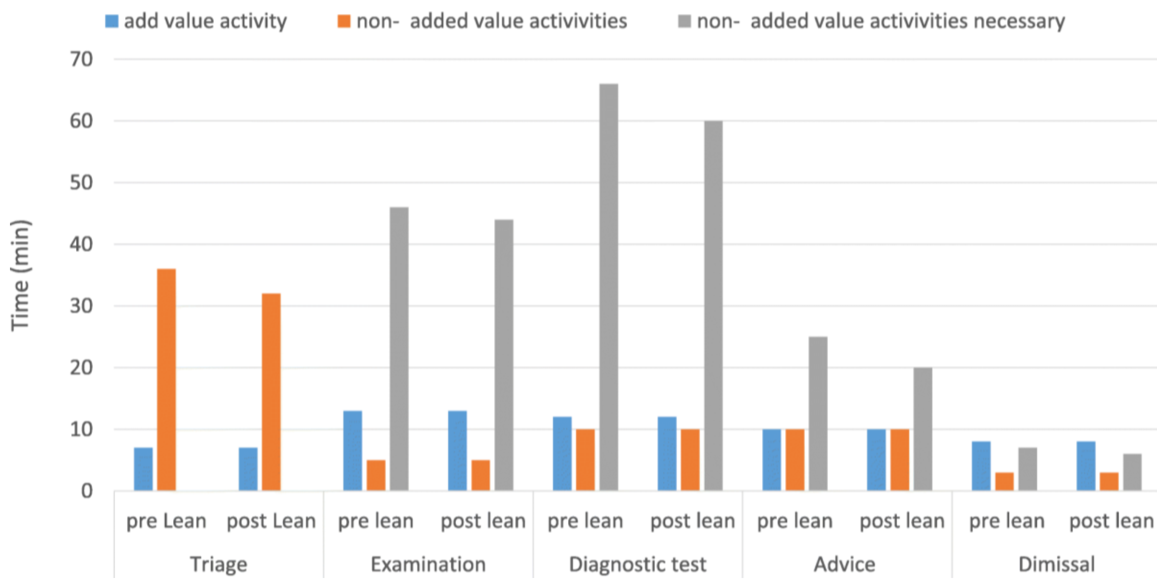
(2007) added that analysis of the test or scan is a factor in very little of the turnaround time for results, and the researcher found that non-analytical delays can be responsible for up to 96% of the total turnaround time for test or scan results. The study also noted that diagnostic staff tend to establish less timely goals for test results turnaround time than surgeons and other physicians (Hawkins, 2007). Similar conclusions were reached in another study conducted 12 years later in which Bhatt et al. (2019) found that the primary factor in the delay of diagnostic results being provided to physicians was the time needed to fix pre-analytical errors created by other departments and not time spent by the diagnostic department itself. Bhatt et al. (2019) reported that a hospital's diagnostic testing process is divided into three phases. The pre-analytical phase is the time between a physician's request for the test and the patient being prepared for testing. The analytical phase is the period when the testing is being conducted. The post-analytical phase is the time between the results being verified and the time when the requesting physician is provided with the results. These researchers determined that among the three phases, the pre-analytical and post-analytical phases comprise nearly 96% of the turnaround time (Bhatt et al., 2019). Studies support the notion that improved efficiency in managing test or scan requests and results can help to reduce turnaround times and in turn, decrease lengths of stay in the ED.

Methods for Reducing Turnaround Times for Test and Scan Results

Several prior studies have been undertaken over the years by researchers who focused on various ways to reduce turnaround times for test and scan results. Fifteen years ago, Hawkins (2007) determined that the use of satellite laboratories located within hospital EDs can reduce test result turnaround times and patient lengths of stay, with studies revealing that average turnaround times can be reduced by over 51 minutes and average lengths of stay in the ED can be reduced by as much as 41 minutes. In a more recent study, Improta et al. (2018) found that the application of lean thinking reduced turnaround times and emergency department throughput in an Italian hospital's ED thereby reducing overall lengths of stay in the ED and improving the quality of care provided to patients. The researchers redesigned the process in the ED in order to achieve the following outcomes: decrease the waiting time linked with consultation of reports/results; organized and better efficiency of flow with the nurse stations, specifically focused on drug layout to facilitate daily operations; and organized shifting strategy to optimize time and resources (Improta et al., 2018). Through this lean thinking strategy, the researchers found significantly positive increases in the performance of the ED in terms of triage codes and decreased waiting times (Improta et al., 2018). That is, a total of the five phases' waiting times (triage, examination, diagnostic test, advice, and dismissal) were significantly reduced (Improta et al., 2018). Figure 1 depicts this overall reduction in processing times, which were captured before and after the lean intervention. These studies reveal that turnaround times can be reduced through improved access to diagnostic services and through the application of the lean thinking strategy (Hawkins, 2007; Improta et al., 2018).

Figure 1

Processing Time Before and After Lean Intervention



Note. From Improta et al. (2018)

Some previous studies have been focused on technology-based methods for reducing turnaround times for CT scans. O'Neill et al. (2020) explored the use of artificial intelligence (AI) and machine learning techniques in hospital settings between September 2017 and March 2019 to quickly detect intracranial hemorrhage on non-contrast-enhanced CT images to improve workflow and reduce wait time for test results. Acute intracranial hemorrhage can occur as a result of traumatic or non-traumatic causes and CT scanning is the most widely used initial test for brain imaging, but obtaining and analyzing CT scan image results can take time, and speedy, accurate detection of intracranial hemorrhage is critical to the appropriate management of care and rapid triaging of patients (O'Neill et al., 2020). These researchers found that the use of AI and machine learning algorithms to detect signs of intracranial hemorrhage (ICH) in non-contrast-enhanced CT scans can reduce wait times for scan results and, in turn, can reduce overall lengths of stay in the ED. O'Neill et al. (2020) reported that wait times when the presence of ICH was determined by AI were 12.01 minutes per study compared to baseline wait times of 15.75 minutes without AI ($p < .0001$).

Ehrler et al. (2022) studied the effectiveness of a mobile app to reduce test result turnaround times and facilitate communication between caregivers in a hospital's pediatric ED, reporting that hospital resources can be wasted in searches for laboratory results and efforts to share information between scattered colleagues. The researchers found that among the study's participants (a representative sample of ER physicians and nurses), the use of a mobile app significantly reduced turnaround times for test results. According to their study and based on the elapsed time in minutes required to carry out the tested functions, the average turnaround time for laboratory test results in the ER was reduced from 23 minutes (interquartile range [IQR] 10.5-49.0) to 1 minute (IQR 1-5.0), revealing a 92.2% reduction in mean times ($p = 0.0079$). The researchers added that the average time required to find a colleague was reduced from 24 minutes to 1 minute for a 93.0% reduction in mean times (Ehrler et al., 2022). These results support the notion that the efficient use of modern technology can result in faster turnaround times for test results in the ER.

Several researchers have examined ways to reduce turnaround times through proximity to CT technologists or through the use of a radiology coordinator or expeditor in the ED. As previously mentioned, Hawkins (2007) reported that having satellite laboratories located within the ED can significantly reduce turnaround times. O'Neill et al. (2020) determined that reprioritizing ED worklists and wait queues can reduce lengths of stay for patients, and these researchers noted that the single most significant bottleneck for turnaround of medical reports such as CT scans is the amount of time scan results wait in a worklist prior to being read and acted upon. de Kok et al. (2021) studied turnaround times for radiology results in the ED and the impact of using lean-driven interventions in patient management including the presence of a dedicated radiologist in the ED during peak hours (12 a.m. – 8 p.m.). The researchers found that those methods significantly improved patient care and reduced turnaround times for radiology results. Participants in a control group reported turnaround times averaging 70 minutes while participants utilizing lean-driven interventions and dedicated radiologists in the ED reported turnaround times of 36 minutes with an IQR of 24-56 (de Kok et al., 2021). All these studies support the use of a radiology representative or coordinator in the ED to reduce turnaround times for radiology images, which is the basis for the current study of an RFA in the ED.

Computed Tomography Scans

One variety of radiology imaging that is common in EDs is the computed tomography (CT) scan. CT scans can be used to measure the geometrical dimensions (both internal and external) of a specimen (Villarraga-Gómez et al., 2019). Wada et al. (2018) reported that CT scans performed prior to emergency bleeding control can improve survival rates of ED patients, especially in patients suffering from severe trauma. The same researchers noted that in hospital EDs, CT scans have grown in importance for early diagnosis of patients, and the practice of having CT equipment located within the ED is growing in use and is leading to improved early diagnostic processes (Wada et al., 2018). CT scans have been updated and upgraded over the years, from improvements in the quality of scanned images to the addition of color in scanned images for better representation of the area of the body being scanned (Hsieh & Flohr, 2021). CT scans can be a powerful tool in patient diagnosis although they have only been a part of the healthcare industry for a few decades.

History of Computed Tomography Scans

CT scans have been used in the diagnosis of medical problems for roughly 50 years. According to Filler (2009), the CT scan was first used for medical purposes at Atkinson Morley's Hospital near London in 1971, launching the era of modern neuroimaging, and the scans were found to be an effective diagnostic tool. Even the earliest CT scans could be used to detect large tumors inside patients' bodies, and those tumors could be observed and evaluated using CT scans prior to the making of treatment or surgical decisions (Filler, 2009). This researcher reported that the earliest CT scans were developed by Electrical and Musical Industries, Ltd. (EMI), which had a huge bankroll for its engineering efforts due to the sale of EMI recordings of The Beatles in the 1960s. Filler (2009) noted that the scanning devices were originally marketed as EMI scanners rather than CT scanners. This researcher wrote that over the following decades, the scanner division of EMI was sold off to a British company called GEC, and GEC's scanner division, which was then known as Picker International, was renamed Marconi and sold to Philips in 2001 (Filler, 2009). Mohanty et al. (1991) reported that in their early years, CT scans were used to diagnose injuries in ED patients, but many of the CT scans ordered for minor head injuries were unnecessary, and the scans had little or no prognostic value. These researchers reported that the routine call for CT scans for minimal head injuries was an inefficient use of hospital personnel and equipment, and the policy of requesting CT scans for all head injuries added to the ever-increasing financial costs involved in operating a trauma center (Mohanty et al., 1991). In more recent years, physicians have used CT scans more efficiently, but requests for CT scans by physicians in the ED continue to be common.

CT scans are not still requested for all head injuries, but the use of CT scans as a diagnostic tool continues to be significant in the ED. Larson et al. (2011) examined trends in CT use in the ED and reported that between 1995 and 2007, the number of patient visits to the ED that incorporated a CT scan increased from 2.7 million to 16.2 million. These researchers noted that there is a higher rate of use of CT scans in the ED than in any other settings (Larson et al., 2011). More recently, Smith-Bindman et al. (2019) studied the use of CT scans in EDs in the United States and Canada from 2000 through 2016 and reported that the annual increase in their use has slowed somewhat. In adults, the researchers found an annual percentage increase of 11.6% in 2000-2006 and a lower annual percentage increase of 3.7% in 2013-2016. Filler (2009) examined the use of CT scans and determined that the detail and quality found in CT scan images has improved, as has the speed of scanning. This researcher indicated that clearer CT scans delivered with faster turnaround times aided in the diagnosis of sick or injured patients in the ED (Filler, 2009). More recently, Hsieh and Flohr (2021) reported that in the past few decades, the technology behind CT scans has been developed and improved so that CT scans now have multiple clinical applications including trauma, oncology, cardiac imaging, and stroke. Improvements in the quality of CT scans have resulted in their being ever more relied upon by physicians for patient diagnosis and treatment plans.

Usefulness of Computed Tomography Scans in Diagnosis

CT scans can have a positive influence on accurate diagnosis and treatment of patients with a range of disorders or injuries. Xu et al. (2021) found that the use of single-phase non-contrast CT scans are inexpensive and effective in detecting abnormalities in the pancreas for early detection of pancreatic cancer. Abdel-Basst et al. (2020) reported that the use of CT scans together with an examination of primary symptoms is helpful in diagnosing COVID-19 and differentiating between that disease and other viral chest disorders. Causey et al. (2018) determined that the use of CT scans is effective in revealing lung nodule malignancies and assisting in noninvasive early diagnosis of lung cancer. Howell et al. (2018) noted that olfactory impairment is a common result of head injury, and the researchers added that deficits in smell can be contingent on the location of the injury, noting that CT scans are an effective vehicle for detecting the location of a head injury. Robinson et al. (2020) reported that 20% of patients with normal abdominal examinations were found to have abdominal injuries when a CT scan was used. The use of CT scans can be beneficial to physicians in the timely diagnosis of a variety of medical issues and injuries, and the frequent use of CT scans can improve patient outcomes.

Turnaround Times for Computed Tomography Scans

The time a patient must spend in the ED can be increased with long waits for scan results. In a study of the causes of bottlenecks and extended lengths of stay in the ED, Rogg et al. (2017) found that for ED patients that need CT scans, the average turnaround time from patient arrival to a preliminary CT scan report was 3 hours and 13 minutes, and the researchers noted that of that time, 39 minutes was spent waiting for results. Kralikova and Suchanek (2018) reported that radiology reports are a primary method for the radiologist to communicate the results of an examination with the ordering physician, so reducing the report turnaround times can have a significant positive effect on faster patient treatment and improved outcomes. These researchers found that 10 minutes is an appropriate length of time between a physician's request for an image and the performance of the scan, and a turnaround time of 60 minutes from scan to delivered report is appropriate for all imaging modalities including CT scans (Kralikova & Suchanek, 2018). There will always be time spent waiting for results, but shorter turnaround times are preferable.

Reducing Turnaround Times for Computed Tomography Scans

Clearly, minimizing turnaround times for CT scan results is important. Previous researchers have concluded that reducing turnaround times for CT scans and other radiology imaging tests can improve patient care (Grover et al., 2018; Hawkins, 2007; Zhang et al., 2019) and reduce lengths of stay in the ED (Alemu et al., 2019; Driesen et al., 2018; Morley et al., 2018). Almutairi and Alyami (2021) reported that in healthcare, wasted time can compromise patient outcomes, especially for patients in critical condition, so it is important that turnaround times for CT scans be minimized, particularly for healthcare providers in the ED. Prior studies have been focused on methods for achieving minimization of turnaround times.

Methods for Reducing Turnaround Times for Computed Tomography Scans

Previous researchers have examined different methods for reducing turnaround times for CT scan results. Some have focused on technology while others have supported the notion of a coordinator or coordinating team in the ED to reduce turnaround times. Almutairi and Alyami (2021) studied the use of a Radiology Information System (RIS) to reduce turnaround times for CT scan results. These researchers explained that an RIS is an example of technology implementation in healthcare, and they determined that the use of an RIS can substantially improve turnaround times for CT scan results. Robinson et al. (2020) studied the role of an emergency radiologist housed within a hospital ED's Level 1 trauma center to produce CT scans and other radiology images with the goal of decreasing turnaround times. Oliveira et al. (2018) studied the impact of using a patient-flow physician coordinator (PFPC) in the ED to reduce patients' wait times and lengths of stay, and reported that the PFPC would be a senior physician charged with making quick assessments of incoming patients in the waiting area of the ED and managing patient flow within the ED. While not focused specifically on turnaround times for CT scans, these researchers found that the presence of a coordinator in the ED resulted in a reduction in patient wait times for a first medical consultation and the start of treatment. Oliveira et al. (2018) reported that from the introduction of the PFPC on April 1, 2015 through March 31, 2016, there was an 8% increase in ED patients admitted, but with wait times reduced by an average of 27.7 minutes (95% confidence interval [95% CI]: 25.9-29.5, $p < .0001$) with an overall decrease from an average of 86.7 minutes to 59.0 minutes for patients at all risk levels. Perotte et al. (2018) studied the use of a multi-disciplinary team of physicians, nurses, technicians, transporters, informaticians, and engineers working together to reduce long turnaround times for CT scans requested by ED personnel. These researchers found that over an 8-month period, when this intervention team worked together on turnaround of CT scans, the turnaround time was reduced by 1.2 hours (Perotte et al., 2018). Researchers have concluded that turnaround times for CT scans can be decreased with the use of a coordinator or coordinating team in the ED.

Using an RFA in the Emergency Department

Multiple databases were searched during this literature review, as noted at the start of this chapter, but no references were found to any previous studies that explored the use of an RFA for improving efficiency in the ED. Searches were conducted for studies of a radiology coordinator or a radiology expeditor in the ED, but no such research projects were discovered. Some prior researchers have recommended the use of some variation of a coordinator or liaison in the ED to improve efficiency, including an examination of the role of an ED expeditor, but these studies were not focused on an RFA or similar radiology-focused coordinator. The lack of RFA studies reveals a gap in existing literature and a need to fill that gap through an examination of the use of an RFA in the ED to reduce CT scan turnaround times, and in turn, lengths of stay in the ED.

Adapting the Role of an Expeditor or Other Emergency Department Coordinator

In a study conducted in 2018, researchers explored the role of an ED Expeditor for overall efficiency in the ED. Gyftopoulos et al. (2019 reported that up to 48% of hospital-associated medical care visits in the United States take place in an ED, which results in increased pressure on EDs to evaluate, diagnose, and select appropriate care for patients in a timely manner. The authors of this study noted that this drive for efficiency in patient management has led EDs to increasingly rely on outside sources, most notably turning to medical imaging, which can be a significant factor in the diagnosis of patients. The same researchers added that over a 12-year span, the percentage of patients in the ED whose caregivers had requested a CT scan as part of the patient workup had increased from 2.8% to 13.9% (Gyftopoulos et al., 2019. These researchers observed that improvements in turnaround times for CT scan results could improve overall patient management in the ED with faster patient triage and treatment, and they suggested the role of an ED Expeditor to bring about those improvements. Benabbas et al. (2020) studied the effectiveness of establishing an ED physician as a triage liaison provider to help expedite patient care in overcrowded EDs, and the researchers determined that the use of a triage liaison provider reduced the number of patients who left without being seen, but played an unsubstantial role in reducing overall lengths of stay in the ED. DeAnda (2018) explored the use of a nurse flow coordinator in the ED to expedite the patient throughput process and found that using this kind of ED coordinator helped to reduce the times between new patient arrival in the ED and discharge or assignment to an inpatient bed. This researcher reported that the time from arrival to bed assignment was reduced from 104 minutes to 84 minutes with the use of a nurse flow coordinator (DeAnda, 2018). None of these studies specifically examined the use of a coordinator of CT scan requests and results to reduce turnaround times and lengths of stay, further revealing the need for the current study of an RFA in the ED.

Summary

For several decades now, CT scans and other radiology images have been used as a vital element in accurately diagnosing patients in the ED or trauma center. The turnaround times of CT scans, however, add to patients' lengths of stay in the ED (Driesen et al., 2018; Kim et al., 2020). Multiple studies have been focused on reducing turnaround times for radiology imaging and diagnostic tests (Almutairi & Alyami, 2021; Hawkins, 2007; Oliveira et al., 2018; Perotte et al., 2018), but there has been insufficient research on the use of a radiology-focused coordinator or expeditor in the ED to improve turnaround times and reduce overall lengths of stay. Furthermore, several previous researchers have concluded that long stays in the ED can have a negative impact on patient health and outcomes (Driesen et al., 2018; Grover et al., 2018; Kaushik et al., 2018; Kim et al., 2020; Zhang et al., 2019).

The current study focused on whether having an RFA in the ED can lead to reductions in long turnaround times for scan results and long stays in the ED. The need for this study became evident through a review of existing literature on the subject of lengths of stay and turnaround times in the ED, few of which addressed the use of a coordinator or expeditor to speed up processes in the ED, and none of which examined the use of an RFA or radiology expeditor assigned to the ED. The lack of focus on this kind of radiology coordinator in the ED informs the current study's background and goal.

The CDC's framework for program evaluation in healthcare (CDC, 1999) provided a theoretical foundation for this study. This framework provided specific steps that can be followed for a productive assessment of healthcare programs including patient management and care in the ED, and it also provided four standards for quality assessment that guided this study's researcher, including standards of utility, feasibility, propriety, and accuracy. The current study utilized the CDC's framework to establish and conduct an exploration of lengths of stay and test or scan turnaround times and how an RFA or radiology expeditor in the ED can reduce those times and subsequent lengths of stay. Newfound knowledge in this area can help improve patient outcomes in the ED and can help curtail the burdens of overworked personnel in overcrowded EDs.

The following chapter, Chapter 3, will address the methodologies used by the researcher in the current study. The chapter will provide a more in-depth examination of the purpose of the study, the phenomenon and research questions explored, the research designs incorporated in the study, the data sample selection, the sources of data, and the impacted population. Chapter 3 will provide a discussion of the collection and management of data used in the study, the procedures used in analyzing the data, and the new information developed from that analysis. Chapter 3 will close with a summary of the methodologies used in the current study.

Chapter 3

Methodology

To recall from Chapter 1, the purpose of this study was to examine the effect of applying an emergency department expeditor, namely a radiology flow associate (RFA), to the emergency department CT scanning process at a smaller New York City hospital and to determine if any benefits from the RFA are carried through to patients. In Chapter 2, the research literature underlying this project was discussed in detail. Now, in Chapter 3, the research methodology by which the project was carried out is presented. The chapter begins with a discussion of the quantitative research methodology and quasi-experimental design. Then, the target population is discussed, along with the study site. Next, the instruments for collecting data are presented, namely hospital records, followed by a discussion of data collection. After data collection is data analysis, along with a discussion of the IRB approvals required. The chapter concludes with a discussion of the limitations and delimitations of the project.

Study Design

The research methodology for the project was quantitative. Quantitative research is empirical and relational in nature (Balnaves & Caputi, 2001). When conducting quantitative research, a researcher focuses on examining the relationships between key variables (Vogt, 2011). These variables are defined narrowly and specifically, including either inherently numerical values or variables for which existing, validated instruments exist to measure in quantified form (Balnaves & Caputi, 2001). Quantitative research is closed-ended in nature because of this numerical aspect of the data (Vogt, 2011). As a result, quantitative research cannot be used to explore new ideas. It can, however, be used to collect large-scale data very practically (Balnaves & Caputi, 2001). Such large-scale data are ideal for statistical analyses, allowing a quantitative project to produce very strong outcomes that are accurate to an arbitrary level of precision and that can be generalized to the entire target population (Vogt, 2011). Such characteristics make quantitative inquiry ideal for issues in the field of medicine, where precision is key (Balnaves & Caputi, 2001).

A quantitative method is applicable to this project for several key reasons. First and foremost, this project is explicitly relational in nature, involving the assessment of the relationship between the RFA implementation and key outcomes. Secondly, this project addresses narrowly defined quantitative variables. These variables are all either dichotomous or inherently numerical in nature as expressed in the three research questions. Thirdly, this project could benefit explicitly from the power of a quantified analysis. The goal of the project is to produce useful insights in terms of whether or not a similar RFA approach would be applicable or valuable at other smaller hospitals in New York City or elsewhere. Finally, the present project addresses medical issues, which means it is inherently aligned with a quantitative methodology.

There are several types of quantitative research designs. The most powerful of these is experimental research (Ross & Morrison, 2004). In experimental research, the researcher manipulates and controls the key variables while randomizing the participants into test and control groups (Frankfort-Nachmias & Nachmias, 2007). Experimental projects are ideal because they yield causal results—that is, they can prove that the observed effect is cause and effect, not merely association (Ross & Morrison, 2004). Unfortunately, because of the stringent conditions required in experimental research, it is often not practical. In particular, an experimental design requires not only control of the variables, but the ability to randomize participants into groups. Such randomization is not feasible for this project because it would require having at least two hospitals involved and giving one of those hospitals a randomly assigned control intervention. No such second hospital is available for this study, and it would be of questionable ethical merit to ask one hospital to accept a randomized control group assignment.

When an experimental design is not fully feasible, the next best option is a quasi-experimental design. A quasi-experimental design sacrifices some of the rigor of the experimental design for the ability to conduct the research more easily (Frankfort-Nachmias & Nachmias, 2007). Hence, though it cannot fully establish causation, a quasi-experimental project design can still yield strong results (Thyer, 2012). In this project, the quasi-experimental approach had a control and test group. In particular, the outcomes at the hospital in the period immediately before the RFA intervention was implemented was compared to the period after, allowing for a non-randomized but controlled project design. The results of this design cannot prove the efficacy of the intervention beyond all doubt, but they will still offer strong, practically applicable insights into it. This places the quasi-experimental design at an ideal point between rigor/design strength and feasibility of conducting, allowing the project to be conducted at one hospital that received the intervention, but still have a matched control group to test against.

Target Population

The population under study in this project was hospital patients at a single study site. The study site is a smaller New York City hospital that has 450 beds and discharges on average 2,070 patients on a monthly basis. Based on current estimates, the hospital performs approximately 100 CAT scans on a given day. After adjusting for weekends and other factors, the final value is around 1,800 CT scans per month.

Sampling and Sample Size

Sampling for the study was exhaustive, including all patients in the given population during the timeframe of the study. The project timeframe consisted of two 4-week sessions. The first session was the period directly before the RFA intervention was administered. The second session was the 4 weeks following the intervention. The two samples contained at least 1,800 participants each. A G*Power analysis suggested that a minimum necessary sample size for the pre- and post-test samples was about 109 each, using a statistical power of 80%, an effect size of .03, and a significance level of 0.05. The minimum required samples were met and well exceeded.

Inclusion

Inclusion criteria for the project were as follows. Participants needed to have had a CT scan performed at the hospital under study during either the pre-test period or the post-test period. As data collection involved anonymized medical records, participants did not need to agree to participate nor be aware of the project. In addition, the records for both children and adults were considered equally applicable for the study data. Any records that did not contain information regarding all of the key variables listed in the following section were not included in the sample.

Instrumentation

The instrumentation for this project consisted wholly of data recorded by the hospital. These data are as follows.

Radiology CT Flow Associate

RFA presence was the independent variable in RQ1. This variable was dichotomous in nature. It was measured as 0 for the pre-intervention data and as 1 for the post-intervention data.

CT Turnaround Times

CT turnaround times was the dependent variable in RQ1 and the independent variable in RQ3. CT turnaround times were retrieved from hospital records as a continuous variable representing time taken to complete a given CT scan.

Time to Admit a Patient

Patient admission times are the dependent variable in RQ2. This variable was measured as continuous and operationalized using hospital records as the length of the admission process related to a given CT scan.

Time to Discharge a Patient

Patient discharge times are the dependent variable in RQ3. This variable was measured as continuous and operationalized using hospital records as the length of the discharge process related to a given CT scan.

Data Collection

Data collection for the project was as follows. First, IRB approval was obtained as described in the following sections. Then, approval from the hospital itself was secured as site authorization. The hospital administrators were contacted to request permission to carry out the project. In this stage, the technical details of how the RFA was recruited, employed, and approached were finalized in coordination with the hospital administration. Gyftopoulos et al.’s (2019) work was used as a model for the process of establishing the RFA within the hospital setting.

Once the details were finalized, the hospital’s records were reviewed to ensure the pre-test period contained the necessary variables. Once the pre-test data are secured using existing records, an existing employee was promoted to the role of RFA. Following the promotion to the new role, a 4-week intervention period was enacted to allow the RFA to begin their work and the hospital to adapt to it.

Following the 1-month intervention period, a 4-week post-test period began. Data from the post-test period was recorded in the same fashion as during the pre-test period for comparison. At the conclusion of the post-test period, the hospital data analytic department prepared the pre-test and post-test datasets in the form of anonymized Microsoft excel spreadsheets containing only the project variables and no identifying information. These spreadsheets were provided to the researcher, who reviewed them to ensure all data needed was present. Then, the spreadsheet data was imported into IBM SPSS version 28 statistical analysis software to conduct the data analysis.

Data Analysis

Data analysis for the project involved inferential and descriptive statistics. All analyses were carried out using SPSS statistical analysis software. The first analysis was descriptive. The descriptive analysis involved two key steps. First, the study population was described using the demographic variables. Second, the statistical properties of each key variable were reviewed. These include, as appropriate, mean, median, mode, range, and/or frequency. Then, inferential statistics were used to answer the research questions.

RQ1: Does having a radiology CT flow associate (RFA) decrease CT turnaround times?

RQ1 was answered using the Mann-Whitney U test to assess whether or not two sets of continuous data from the same underlying population have different means (McClenaghan, 2022). For RQ1, the independent variable was dichotomous and represented by the pre- or post-test periods. The continuous dependent variable was CT turnaround times. If the Mann-Whitney U test showed that there was a significant difference in the means between pre- and post-test periods, the null hypothesis was retained.

RQ2: Does CT turnaround time increase the length of time it takes to admit a patient?

RQ3: Does CT turnaround time increase the length of time it takes to discharge a patient?

RQs 2 and 3 were answered using Spearman's rank order correlation. The original plan was to use multiple linear regression analysis to measure the extent to which multiple independent variables predict one or more dependent variables (Olive, 2017). However, data violated multiple assumptions of parametric testing, making Spearman's rank correlation the appropriate alternative to linear regression. For this project, the independent variable was CT turnaround time (continuous), and the dependent variables were time to admit a patient and time to discharge a patient. Each categorical variable was divided into binary dummy variables as required (Olive, 2017). The key outcome was whether—and the extent to which—the variable of CT turnaround time correlates with admission/discharge time. Hence, of interest is the Spearman's rho (*r*) value for the correlation coefficient, which indicates the strength and direction of the relationship.

Institutional Review Board

Since the study did not involve human subjects, Institutional Review Board (IRB) approval was not required. After the proposal was approved by the Capstone Committee, the researcher submitted an IRB application to NYU Langone Health IRB department who deemed the study did not meet the definition of human subject's research. The researcher submitted the NYU letter to the Radford University IRB, which concurred with the NYU determination that the study was not human subjects research and as a result, IRB approval was not needed. Copies of the letters are attached in Appendix A and Appendix B.

Chapter 4

Results

The purpose of this study was to examine the effect of applying an emergency department expeditor, namely a radiology flow associate (RFA), to the emergency department CT scanning process at a smaller New York City hospital and to determine if any benefits from the RFA were carried through to patients. This chapter includes an overview of the sample, including recruitment strategies and demographics. Additionally, this chapter includes the results from assumptions testing, which included the following assumptions: independence of observations, continuous dependent variable data, normality, outliers, linearity, and homogeneity of variance. Finally, the results of the statistical analyses used to answer the research questions are presented.

Sample

The sample for this study comprised 1,466 patients who were treated at one smaller New York City hospital that has 450 beds and discharges on average 2,070 patients per month. The sampling strategy for the study was exhaustive, meaning that all patients who met inclusion criteria during the timeframe of the study were included. Participants needed to have a CT scan performed at the hospital under study during either the pre-test period or the post-test period. Because data collection involved anonymized medical records, participants did not need to agree to participate nor be aware of the project. In addition, the records for both children and adults were considered equally applicable for the study data. Any records that did not contain information regarding all of the key variables were not included in the sample. Additionally, cases with missing data were excluded pairwise; therefore, the sample size differed for each analysis.

Recruitment Strategies

No participants were recruited for this study because pre-existing medical records were used as the source of data. However, approval from the hospital was secured as site authorization. Specifically, the hospital administrators were contacted to request permission to carry out the project.

Demographics

SPSS software was used to analyze data, including the descriptive statistics that were conducted to describe characteristics of the sample. The descriptive statistics used to describe categorical demographic characteristics were frequency and percentage. The results of these analyses revealed that 750 (51.2%) patients were male, 716 (48.8%) patients were female, 723 (49.3%) patients did not have an RFA, 743 (50.7%) patients had an RFA, 640 (43.7%) patients were admitted during the time of this study, and 826 (56.3%) patients were discharged at the time of this study (see Table 1). Table 2 provides the frequency and percent of women versus men and admitted versus discharged when grouped according to RFA status. The largest difference was between patients who were admitted without an RFA and patients who were discharged without an RFA.

Table 1

Demographic Characteristics

		N	%
Gender	Male	750	51.2%
	Female	716	48.8%
RFA Status	Without RFA	723	49.3%
	With RFA	743	50.7%
Disposition	Admitted	640	43.7%
	Discharged	826	56.3%

Table 2

Frequency of Gender and Disposition by RFA Status

RFA Status			Frequency	Percent	Valid Percent	Cumulative Percent
Without RFA	Gender	Female	354	49.0	49.0	49.0
		Male	369	51.0	51.0	100.0
		Total	723	100.0	100.0	
With RFA	Gender	Female	362	48.7	48.7	48.7
		Male	381	51.3	51.3	100.0
		Total	743	100.0	100.0	
Without RFA	Disposition	Admit	291	40.2	40.2	40.2
		Discharge	432	59.8	59.8	100.0
		Total	723	100.0	100.0	
With RFA	Disposition	Admit	349	47.0	47.0	47.0
		Discharge	394	53.0	53.0	100.0
		Total	743	100.0	100.0	

The descriptive statistics used to describe characteristics of the sample that were measured at the interval level of measurement (i.e., age, admission/discharge time, and CT turnaround time) were mean, median, variance, standard deviation, minimum, maximum, range, interquartile range, skewness, and kurtosis (see Table 3). According to the results, the mean age of patients included in this study was 59.31 years old. Additionally, the mean admission/discharge time was 372.30 minutes, and the mean CT turnaround time was 131.88 minutes.

Table 3

Descriptive Statistics

RFA Status				Statistic	Std. Error
Without RFA	Age	Mean		59.46	.762
		95% Confidence Interval for Mean	Lower Bound	57.96	
			Upper Bound	60.95	
		5% Trimmed Mean		59.91	
		Median		60.00	
		Variance		420.262	
		Std. Deviation		20.500	
		Minimum		0	
		Maximum		96	
		Range		96	
		Interquartile Range		33	
		Skewness		-.304	.091
		Kurtosis		-.825	.182
	Admission/Discharge Time	Mean		363.69	6.176
		95% Confidence Interval for Mean	Lower Bound	351.57	
			Upper Bound	375.81	
		5% Trimmed Mean		355.12	
		Median		352.00	
		Variance		27575.890	
		Std. Deviation		166.060	
		Minimum		16	
		Maximum		1076	
		Range		1060	
		Interquartile Range		193	
		Skewness		.872	.091
		Kurtosis		1.596	.182
	CT Turnaround Time	Mean		120.32	2.862
		95% Confidence Interval for Mean	Lower Bound	114.70	
			Upper Bound	125.94	
		5% Trimmed Mean		117.32	
		Median		119.00	
		Variance		5922.854	
		Std. Deviation		76.960	
		Minimum		0	
		Maximum		343	
		Range		343	
		Interquartile Range		121	
		Skewness		.438	.091
		Kurtosis		-.587	.182
With RFA	Age	Mean		59.16	.795
		95% Confidence Interval for Mean	Lower Bound	57.60	
			Upper Bound	60.72	
		5% Trimmed Mean		59.52	
		Median		63.00	
		Variance		469.649	
		Std. Deviation		21.671	
		Minimum		8	

	Maximum		98	
	Range		90	
	Interquartile Range		38	
	Skewness		-.261	.090
	Kurtosis		-1.055	.179
Admission/Discharge Time	Mean		380.67	6.169
	95% Confidence Interval for Mean	Lower Bound	368.56	
		Upper Bound	392.78	
	5% Trimmed Mean		376.85	
	Median		381.00	
	Variance		28271.570	
	Std. Deviation		168.142	
	Minimum		10	
	Maximum		1100	
	Range		1090	
	Interquartile Range		231	
	Skewness		.400	.090
	Kurtosis		.402	.179
CT Turnaround Time	Mean		143.13	4.274
	95% Confidence Interval for Mean	Lower Bound	134.74	
		Upper Bound	151.51	
	5% Trimmed Mean		134.05	
	Median		116.00	
	Variance		13569.716	
	Std. Deviation		116.489	
	Minimum		1	
	Maximum		581	
	Range		580	
	Interquartile Range		154	
	Skewness		1.070	.090
	Kurtosis		.657	.179

Results of the Study

Several assumptions of parametric testing were assessed to determine whether parametric or non-parametric tests could be used to analyze data. The assumptions that were tested include independence of observations, continuous dependent variable data, normality, outliers, linearity, and homogeneity of variance. The data violated the assumptions of parametric testing; therefore, a non-parametric test was used, including the Mann-Whitney U test for research question one and Spearman's Rank Order (rho) correlation for research questions two and three.

The assumption of independence of observations was met because participants were separated into two groups, one for those who were admitted and one for those who were discharged. Additionally, the assumption of continuous data for the dependent variables was met because the dependent variables in this study are measured at the interval level of measurement. Normality was assessed using the Kolmogorov-Smirnov test. For this test, a *p*-value greater than .05 signifies that the data met the assumption of normality. Based on the results of the Kolmogorov-Smirnov test, data for admission/discharge time and CT turnaround time violated the assumption of normality (see Table 4).

Table 4

Test for Normality

	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Admission/Discharge Time	.05	1466	<.001
CT Turnaround Time	.09	1466	<.001

Boxplots were used to assess the assumption of outliers. When data points are found outside of the box, the assumption of outliers is considered violated. The boxplots showed that data for admission/discharge time and CT turnaround time violated the assumption of outliers (see Figure 2 and Figure 3). The outliers that were identified in the boxplots were removed (i.e., 10 cases); however, removing the outliers produced additional outliers, signifying that there were too many outliers to show in boxplots.

Figure 2

Boxplots for Admission/Discharge Time

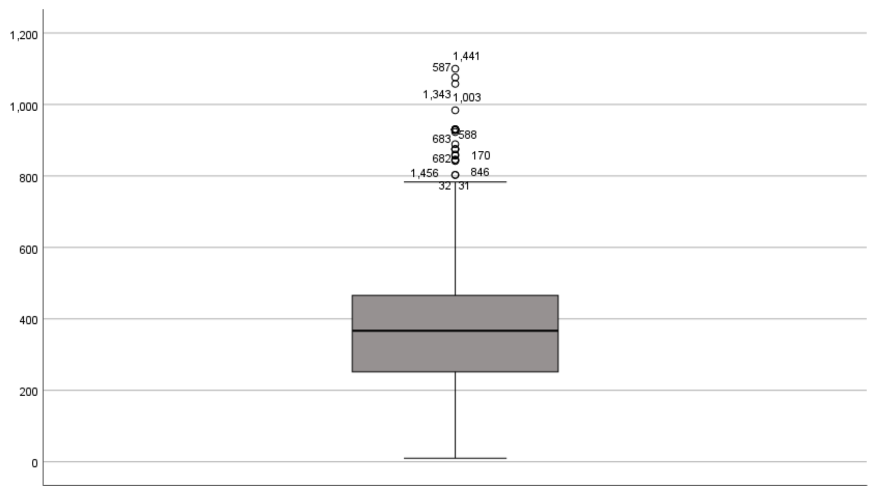
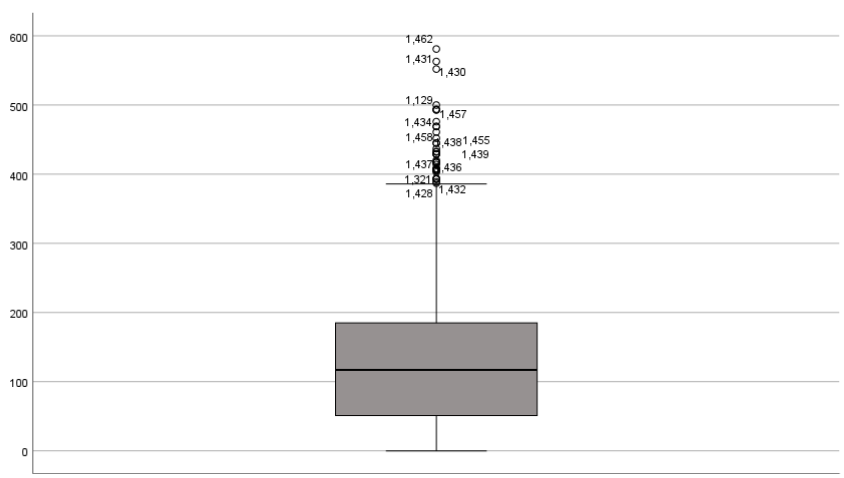


Figure 3

Boxplot for CT Turnaround Time



The assumption of linearity was assessed using Normal Q-Q plots. A visual inspection of the Q-Q plots that were included in the output for descriptive statistical analyses revealed that data for admissions/discharge time and CT turnaround time violated the assumption for linearity. Figure 4 and Figure 5 include the results of the Normal Q-Q plots.

Figure 4

Normal Q-Q Plot for Admission/Discharge Time

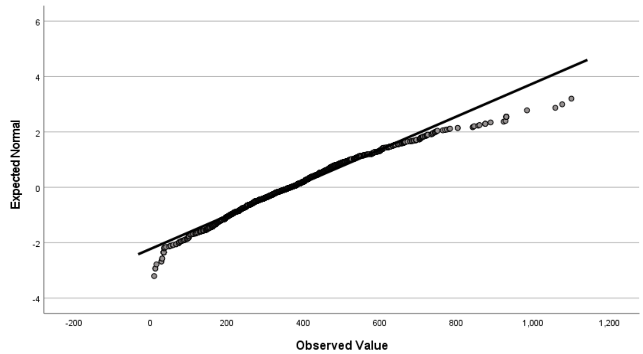
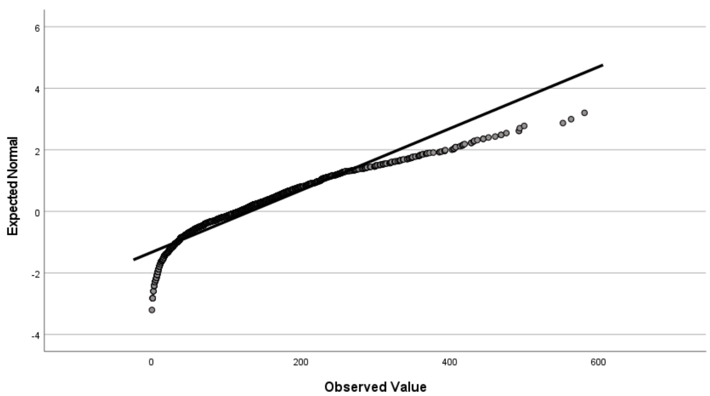


Figure 5

Normal Q-Q Plot for CT Turnaround Time



The assumption of homogeneity of variance for the dependent variable used to determine group differences was tested using Levene's test. With this test, a significance level greater than .05 signifies that the assumption has been met. The results of Levene's test showed that CT turnaround time violated the assumption of homogeneity of variance. Table 5 provides the results of Levene's tests. Because data violated each of the assumptions of parametric testing, the non-parametric test alternatives (i.e., the Mann-Whitney U test and Spearman's rho) were used.

Table 5

Levene's Test

	Levene's Test		
	Statistic	df	Sig.
CT Turnaround Time	86.08	1464	<.001

Research Question One

Research question one asked: Does having a radiology CT flow associate (RFA) decrease CT turnaround times? A Mann-Whitney U test was used to test the hypotheses related to this research question because data violated the assumptions of parametric testing. Prior to conducting the Mann-Whitney U test, cases were separated into two groups, those with an RFA and those without an RFA. The results of the Mann-Whitney U test showed no significant differences in CT turnaround time between individuals with an RFA and individuals without an RFA (U = 281703.00, z = 1.618, p = .106). Based on this result, the null hypothesis was retained. Table 6 provides the results of the Mann-Whitney U test.

Table 6

Results of the Independent-Samples Mann-Whitney U Test

CT Turnaround Time	Total N	1466	Retain the null hypothesis
	Mann-Whitney U	281703.000	
	Standardized Test Statistic	1.618	
	Asymptotic Sig. (2-sided test)	.106	

Research Question Two

Research question two asked: Does CT turnaround time impact patient length of time it takes to admit a patient? Spearman's rho correlation coefficient was used to test the hypotheses related to this research question because data violated the assumptions of parametric testing. Before testing for correlations, the data file was split so that only patients who were admitted were included in the analysis. The results of the correlation analysis revealed a significant and moderate, positive relationship between time to admission and CT turnaround time, $r = .41$, $p < .001$, indicating that an increase in one variable relates to an increase in the other variable (see Table 7). Based on the results, the null hypothesis is rejected.

Table 7

Nonparametric Correlations for Time to Admit and CT Turnaround Time

			Time to Admit	CT Turnaround Time
Spearman's rho	Time to Admit	Correlation Coefficient	1.00	.41
		Sig. (2-tailed)		<.001
		N	640	640
	CT Turnaround Time	Correlation Coefficient	.412	1.00
		Sig. (2-tailed)	<.001	
		N	640	640

Research Question Three

Research question three asked: Does CT turnaround time impact patient length of time it takes to discharge a patient? Spearman's rho correlation coefficient was used to test the hypotheses related to this research question because data violated the assumptions of parametric testing. Before testing for correlations, the data file was split so that only patients who were discharged were included in the analysis. The results of the correlation analysis revealed a significant and moderate, positive relationship between time to discharge and CT turnaround time, $r = .29$, $p < .001$, indicating that an increase in one variable relates to an increase in the other variable (see Table 8). Based on the results, the null hypothesis is rejected.

Table 8

Nonparametric Correlations for Time to Discharge and CT Turnaround Time

			Time to Discharge	CT Turnaround Time
Spearman’s rho	Time to Discharge	Correlation Coefficient	1.00	.29
		Sig. (2-tailed)		<.001
		N	826	826
	CT Turnaround Time	Correlation Coefficient	.295	1.00
		Sig. (2-tailed)	<.001	
		N	826	826

Summary

The results of the hypothesis testing for research question one revealed that there was no significant difference in CT turnaround time for patients with an RFA versus patients without an RFA. The results of the hypothesis testing for research question two revealed a significant and moderate, positive relationship between time to admission and CT turnaround time, meaning that an increase in CT turnaround time is related to an increase in the time it takes to admit a patient. The results of the hypothesis testing for research question three revealed a significant and moderate, positive relationship between time to discharge and CT turnaround time, meaning that an increase in CT turnaround time is related in an increase in the time it takes to discharge a patient. Chapter 5 provides discussions of the implications and recommendations that emerged from these findings.

Chapter 5

Discussion

The purpose of this study, a partial replication of research previously conducted by Gyftopoulos et al. (2019), was to determine whether the presence of a radiology flow assistant (RFA) in the emergency department (ED) could have an impact on the turnaround times for radiology imaging, resulting in overall improvements in patient care. This study aimed to provide recommendations for smaller hospitals that would allow for the effective replication of an RFA into their existing workflow to enhance the efficiency of the throughput and reduce the computed tomography (CT) turnaround times in the ED, and thus the duration of overall patient stay.

ED doctors rely heavily on CT scans when making decisions regarding diagnosis, treatment, and admission (American Health Imaging, 2018). Overcrowding due to the sheer volume of CT requests in the ED is a common problem, adding to extended turnaround times for radiology requests (Hooket et al., 2019; Linder & Woitok, 2021; Morley et al., 2018; Rasouli et al., 2019; Savioli et al., 2022). Long turnaround times in the ED for patients who needed CT scans caused bottlenecks, resulting in longer stays in the ED (Rogg et al., 2017). Alemu et al. (2019), Kaushik et al. (2018), and Perotte et al. (2018) stated that a reduction in turnaround times for physicians awaiting the results of CT scans can decrease the lengths of stays for patients in the ED.

Discussion of the Results

Data collected for this study were analyzed to identify whether the presence of an RFA or other radiology expeditors in the ED could have an impact on the turnaround times for radiology imaging, leading to decreased lengths of stay and overall improvements in patient care. The assumptions that were tested included the independence of observations, continuous dependent variable data, normality, outliers, linearity, and homogeneity of variance. The assumption of independence of observation was met as the participants were separated into two groups, one for those who were discharged and one for those who were admitted. The assumption of continuous data for the dependent variables was also met as the dependent variables in this study were measured at the interval level of measurement. The findings obtained were used to address the research questions identified by this study:

RQ1: Does having a radiology CT flow associate (RFA) decrease computed tomography (CT) turnaround times?

$H1_0$: Having an RFA does not significantly decrease CT turnaround times.

$H1_A$: Having an RFA significantly decreases CT turnaround times.

RQ2: Do computed tomography (CT) turnaround times increase the length of time it takes to admit a patient?

$H2_0$: CT turnaround times do not significantly increase the length of time it takes to admit a patient.

$H2_A$: CT turnaround times significantly increase the length of time it takes to admit a patient.

RQ3: Do computed tomography (CT) turnaround times increase the length of time it takes to discharge a patient?

$H3_0$: CT turnaround times do not significantly increase the length of time it takes to discharge a patient.

$H3_A$: CT turnaround times significantly increase the length of time it takes to discharge a patient.

Research Question 1

A Mann-Whitney U test was utilized to test the hypothesis relevant to this research question as data violated the assumption of parametric testing. Cases were separated into two groups, those with an RFA and those without. The results of the Mann-Whitney U test indicated that there was no significance in CT turnaround time between cases with an RFA and cases without ($z = 1.618$, $p = .106$). The null hypothesis was retained as a result of these findings. The factors that were identified as limitations in this study, including that the RFA was a new addition to the staff complement and not yet familiar with the processes and procedures, might have influenced the findings and outcomes of this study. The CT turnaround time with the presence of an established RFA might have been different. The narrow post-test timeframe associated with this study, thus whether the intervention of employing an RFA was in full effect when this study was conducted, could have influenced the observed effects. This study was also limited to the administration of CT scans, and not radiology in general, which could have influenced the outcome within the ED context. It is also possible that the full benefits of having an RFA in the ED were not realized yet at the time of this study, and that the functioning of the ED might have slowed down the functionality of the ED in the short term. The Radiology Administrator, a major stakeholder, was terminated and of the two budgeted RFA positions was reduced to one due to budgetary constraints when this study commenced, which was when the RFA was implemented. These factors could have had an impact on the outcomes of this study.

Research Question 2

The hypotheses related to RQ2 were tested by using Spearman's rho correlation coefficient as data violated the assumptions of parametric testing. The data file was split before testing to allow only patients who were discharged to participate in the analysis. A significant and moderate, positive relationship between the time to discharge and CT turnaround time, $r = .41$, $p < .001$, was indicative that an increase in one variable relates to an increase in the other variable. The null hypothesis is rejected based on these findings. Hawkins (2007), in correlation to the findings of RQ2, hypothesized that the lengths of stay of patients are associated with the use and turnaround times of diagnostic tests, such as radiology and CT scans. It can thus be accepted that the turnaround time of a CT scan can impact the length of time that it takes to admit a patient, as the results of the CT scan will determine whether the patient is admitted or not. A factor that might have influenced the outcome of this study is the restriction of initial workflow in the ED due to space limitations for holding patients in the ED CT holding area, limiting the number of patients that were called for CT scans from four to two at a time, influencing the turnaround time and the length of time that a patient spent in the ED prior to admission.

Research Question 3

The hypotheses related to RQ3 were tested by using Spearman's rho correlation coefficient as data violated the assumptions of parametric testing. The data file was split before testing to allow only patients who were discharged to participate in the analysis. A significant and moderate, positive relationship between the time to discharge and CT turnaround time, $r = .29$, $p < .001$, was indicative that an increase in one variable relates to an increase in the other variable. The null hypothesis is rejected based on these findings. The results obtained by the correlation analysis indicated that there was a significant, but moderate, positive relationship between the turnaround time from CT scan to discharge turnaround time. Limited space for holding patients together with prolonged waiting times for the results of CT scans may contribute to the increased waiting time of admitted patients, as two patients instead of four was called for CT scans, which could increase their overall length of stay. Another factor that could have impacted the overall length of patient stay was that the presence of the RFA in the radiology department was not established, which could have impacted the overall workflow of the radiology department negatively. The results of a CT scan can determine whether a patient that was admitted to hospital, can be discharged, and the length of patient stay is thus influenced.

Relationship of the Findings to Prior Research

The CDC's (1999) framework of program evaluation in healthcare provides four standards for quality assessment, which guided this study. These standards are standards of utility, feasibility, propriety, and accuracy. A review of the literature indicated that there are limited studies regarding the length of stay and turnaround times in the ED, and a lack of focus on a radiology coordinator in the ED was apparent. Rojas et al. (2019) found that professional caregivers in the ED or trauma center are challenged to work efficiently and effectively in a high-pressure environment where adequate and timely triage protocols can predict patient outcomes. The patient's experience of care, the improvement of the work life of the healthcare provider, as well as the allocation of ED resources can be improved when the number of ED visits and time spent in the ED and readmissions are limited (Hewner et al., 2018).

Kaushik et al. (2018) also posited that shorter lengths of stay per person will allow the hospital's ED to treat more patients overall.

Previous research has indicated that the reduction of turnaround times for CT scans in the ED can influence the overall lengths of stay for patients in the ED (Alemu et al., 2019; Kaushik et al., 2018; Perotte et al., 2018). The findings from this study aligned with these findings by indicating the turnaround time for CT scans can influence the time that it takes to admit a patient, as well as the length of stay for patients waiting to be discharged. However, limited and insufficient research on the role of an RFA in the ED is available in the existing literature. The findings from this study contribute to the existing body of knowledge by indicating that the presence of an RFA in the ED does not significantly influence the CT scan turnaround time. Findings from Oliveira et al. (2018) indicated that the presence of an RFA or patient flow physician coordinator, a senior physician charged with making quick assessments of incoming patients as well as managing the flow within the ED, resulted in a reduction in patient wait times for a first medical consultation, admission, and the start of treatment. Although this study found that there is no correlation between the presence or absence of an RFA on the turnaround time of CT scans, the limitations of this study should be considered. The presence of the RFA was new to the hospital, and the systems and procedures were unfamiliar. Space limitations also influenced the number of patients that were called for a CT scan, from four to two, which also could have influenced the outcome of this study, as the intensity experienced by the RFA within the ED was different than anticipated. It can thus be noted that, although the findings from this study indicated that the presence of an RFA in the ED had no effect on the turnaround time of CT scans within the ED, prior research by Oliviera et al. (2018) indicated the opposite when observed during different circumstances within the ED. Perotte et al. (2018) concurred with these findings by explaining that the waiting and turnaround times for a CT scan can be reduced by 1.2 hours when a coordinator and/or coordinating team is present in the ED, which is evidence that the turnaround time for a CT scan will influence the discharge time.

De Kok et al. (2021) and Almutairi and Alyami (2021) indicated that the use of an RFA in the ED can reduce turnaround times for radiology images in the ED when lean-driven interventions in patient management approaches are implemented. Although it is clear from the literature that although the presence of an RFA in an ED can influence the waiting time in the ED, factors such as the inclusion of technological involvement, which has been proven effective in reducing the turnaround time of CT scans in the ED, should be investigated and implemented where appropriate. The findings of this study, which indicated that the CT turnaround time influences the length of time that it takes to admit a patient, concur with those obtained from existing literature. Howell et al. (2018) and Wada et al. (2018) explained that CT scans are often requested upon the arrival of the patient at the ER to ensure that the diagnosis and treatment are accurate and effective, and further alluded that reduced turnaround times for CT scans can result in shorter stays in the ED. The findings of this study indicated that the turnaround time of obtaining the results from CT scans has an influence on the length of stay of a patient within the ED from the time of admission to the time of discharge. Rogg et al. (2017) concluded that bottlenecks within the departmental flow such as a prolonged waiting time for CT scan results led to longer turnaround times for the radiology department, thus delaying the timeframe from patient arrival at the ED to possible admission into the hospital. This study indicated that the time that a patient spent in the ED was prolonged due to space restrictions, increasing the length of stay in the ED. Patients who wait for their results spend a longer time in the ED, thus longer for possible admission, while patients who were admitted and are waiting for their results will spend a prolonged time in the hospital, as they are waiting to be discharged. Research conducted by Morley et al. (2018) agreed with the findings of this study by reporting the causes of overcrowding in the ER, thus increasing the time spent in the ED, including delays in the receipt of CT scans. Studies conducted by Rasouli et al. (2019) posited that overcrowding in EDs can lead to overutilization of diagnostic imaging such as CT scans, causing further delays in the turnaround times for the requested images. An efficient turnaround time for CT scans will have a moderate, but definite influence on the patient length of admittance.

Kralikova and Suchanek (2018) found that radiology reports are a primary method for radiologists to communicate the results of a CT scan with the physician who requested the scan. O'Neill et al. (2020) and Perotte et al. (2018) supported the finding of RQ3, by positing that a multi-disciplinary team of physicians, nurses, technicians, transporters, informaticians, and engineers work together to reduce the long turnaround times for CT scans that were requested by the ED. A study conducted by Ehrler et al. (2022) supported the research conducted by de Kok et al. (2021), which indicated that utilizing a mobile app between a representative sample of ER physicians and nurses significantly reduced the turnaround times for lab results, from 23 minutes (interquartile range [IQR] 10.5-49.0) to 1 minute (IQR 1-5.0) revealing a 92.2% reduction in mean times ($p = 0.0079$). It should also be noted that the researcher determined that the average time that it took to locate a colleague was reduced from 24 minutes to 1 minute for a 93.0% reduction in mean times (Ehrler et al., 2022).

Implications for Future Practice, Research, and Policy

The findings from this study are valuable as they indicated that there is a correlation between the turnaround times from CT scans and the patient's length of stay in the ED, whether at the time of admission or the time of discharge. The implications of a prolonged stay in the ED and the subsequent bottlenecks were discussed, and these have a significant influence on the patients as well as the ED. Slow turnaround times may influence the level of triage that a patient receives, with possible negative effects on the treatment that a patient needs. Morley et al. (2018) asserted that overcrowding in hospital EDs can have negative consequences, such as poor patient outcomes and an increased workload for emergency healthcare personnel.

The first recommendation for practice is for hospital management as well as ED personnel to separately identify the specific onboarding, diagnosis, treatment, and discharge of patients' procedures. Overcrowding in the ED is a primary factor influencing the length of stay for ED patients, and Morley et al. (2018) explained that the primary factor involved in the amount of time spent in the ED waiting room is the number of patients in the waiting room, with higher patient numbers leading to increased lengths of stay. The findings obtained by the hospital's management team regarding the procedures that influence the patient's length of stay should be measured against the findings of the ED personnel who are actively involved in the waiting room and have grassroots experience in the matter. This will identify specific processes and procedures that can influence the patient's overall length of stay, as well as assist with the development of strategies, such as the allocation of additional staff members to expedite the phases of waiting times, namely triage, examination, diagnostic test, advice, and dismissal (Improta et al., 2018). Effective triage systems will allow for the purposeful flow of patients to the respective stations, thus easing the overall pressure on the ED, as supported by Improta et al. (2018), who found a significant positive increase in the ED's performance relevant to triage codes and decreased waiting times.

The second recommendation for practice is for the ED stakeholders to investigate the viability of using technological advancements such as a mobile app to reduce the time wasted in efforts to share information and results between colleagues. Ehrler et al. (2022) found that the average time that it took to find a colleague to obtain or share information was reduced from 24 minutes to 1 minute with the introduction of modern technology. Faster turnaround times for CT scan results in the ED can significantly increase the length of patient stay, whether from admission or dismissal, as was indicated in the findings of RQ2 and RQ3 of this study. An app that is relevant to the ED in question can be developed to suit the specific needs of that ED, which will allow for the optimal flow of processes and streamline the throughput of patients.

Future research opportunities relevant to this topic can include an investigation into whether the presence of an RFA in the ED or other radiology expeditors in the ED could have an impact on the turnaround times for radiology imaging, leading to decreased lengths of stay and overall improvements in patient care in a hospital where the practice of having an RFA already is an established practice. A limitation identified for this study was that the presence of the RFA at the hospital was new and that this might have been a restrictive factor. Further research can include a qualitative element, allowing for the radiologists, hospital management, and the RFA to provide their opinions and insights using semi-structured interviews. Conducting a mixed-method study within an established environment may yield a deeper insight and understanding into the field of research.

A second opportunity for further research is an investigation into the root causes of the factors that influence overcrowding and lengths of stay in the ED. It was indicated by the literature that the turnaround times for CT scans in the ED significantly influence the duration of the stay of patients in the ED. Subsequent overcrowding is also a challenge that is faced by EDs, causing delays in healthcare decision making, which can have serious effects on patient outcomes. A statistical analysis of the average duration of stay at the ED for patients in need of a CT scan can be done, followed by interviews with the ED staff as well as the relevant management team. Such a study will allow the researcher to identify common themes from the data analysis, as well as the input from the doctors and nurses who would be able to identify inefficiencies on an operational level. These findings can be presented to the hospital management team, who can investigate possible strategies for improvement of the overall acute care chain beyond the control of the ED.

It is clear from the findings obtained from the existing literature as well as those identified by this study that the turnaround time of CT scans in the ED has a definite and often severe influence on a patient’s length of stay, whether for admission or discharge purposes. It is recommended that the hospital management investigate strategies that will assist in the prevention of bottlenecks in the ED due to a delay in CT results and implement these to assist the medical personnel in achieving the predetermined goals within the ED and the hospital as a whole. Strategies may include the implementation of technology into the communication process between radiologists and doctors, which was proven to be an effective measure by the literature. The hospital management can ensure that the relevant technology is available and provide the necessary training and support. A dedicated triage team to direct the patients entering the ED will also be a valuable addition to the ED, as this may prevent bottlenecks within the ED.

Conclusion

The purpose of this quasi-experimental study was to investigate an intervention intended to facilitate faster and more efficient CT imaging in smaller urban hospitals by attempting to determine whether the presence of an RFA in the ED or other radiology expeditors in the ED could have an impact on the turnaround times for radiology imaging, leading to decreased lengths of stay and overall improvements in patient care. Emergency doctors rely heavily on CT scans when making diagnostic, treatment, and admission decisions (American Health Imaging, 2018). Croy (2020) stated that CT scanning capacity has not grown as quickly as the demand for these scans, which leads to lengthy turnaround times and bottlenecks at EDs.

The findings resulting from this study managed to address the initial aim thereof by determining whether the presence of an RFA in an ED at small urban hospitals impacts the turnaround times for CT scans through studying the existing literature and conducting empirical research by utilizing a quasi-experimental research design with inferential and descriptive data analysis. Results for RQ1 included that there was no significant turnaround time for patients with an RFA when compared to patients with an

RFA, though this finding may not be reliable due to limitations and other issues that resulted from the addition of the RFA position. Results for RQ2 and RQ3 indicated that there are significant and moderate, positive relationships between the times of admission and discharge relevant to CT turnaround times in the ED. ED triage procedures and technological communication strategies were identified as factors that could influence patient turnaround times by reducing the bottlenecks and long waiting times in the ED. The findings, recommendations, as well as opportunities for further research that were identified indicate that there is a definite need to develop strategies that can improve the turnaround time of CT scans for patients who visit the ED to ensure that there is an increase in positive patient outcomes and improved patient care in smaller urban hospitals.

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Appendix A

University Institutional Review Board Research Approval Letter

RADFORD UNIVERSITY

Research Compliance Office

Institutional Animal Care and Use Committee / Institutional Review Board

[Date]

TO:	Maxwell Baptiste
RE:	Not Human Subjects Research (NHSR) Determination
STUDY TITLE:	Evaluating the Impact of a Quality Improvement Initiative Designed to Decrease the Turnaround Time for CT scans in a Level 1 Trauma Center
IRB REFERENCE #:	NYU Langone IRB Project – Incident # 4808429
SUBMISSION TYPE:	Initial Submission
ACTION:	NHSR
DATE OF DETERMINATION:	January 18, 2023

The Radford University Institutional Review Board concurs with the NYU Langone IRB determination the above-referenced project is not human subjects research (NHSR).

This determination applies only to the activities described in the documents submitted to the Radford University IRB and does not apply should any changed be made. If changes are considered and there are questions related to whether or not IRB review is needed, please submit a protocol modification to the IRB for a determination.

If you have any questions, please contact the Research Compliance Office at 540.831.5290 or irb-iacuc@radford.edu. Please include your study title and reference number in all correspondence with this office.

Good luck with your project!

Radford University Institutional Review Board (IRB)
Research Compliance Office
540.831.5290
Irb-iacuc@radford.edu
https://www.radford.edu/content/research-compliance/home.html

Appendix B

Hospital Institutional Review Board Research Approval Letter

Dear Maxwell,

Thank you for sharing the project summary and completing the self-certifications. NYULH IRB only reviews and issues official determinations on the projects determined to be Human Subject Research.

This project does not meet the definition of human subjects research since the activities and data collected and analyzed **are not designed** to develop or contribute to **generalizable knowledge.** For the activities to contribute to generalizable knowledge, those have to be designed to draw general conclusions (i.e., knowledge gained from a study that may be applied to populations outside of the specific study population), inform policy, or generalize findings. To develop or contribute to generalizable knowledge requires that the results (or conclusions) of the activity are intended to be extended beyond a single individual or an internal program. In this specific project, the conclusions will not be extended beyond our institution.

Please use this email as an official statement that this project does not meet the definition of Human Subject Research. As a result, NYULH IRB will not review this project.

Feel free to share this email with any relevant parties overseeing the review and implementation of this project

Kindly

Marina Godina, MHA, RN, CIP
Director, Human Research Protections
IRB Operations, ESCRO, RDOC
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