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Strategies to Mitigate Inappropriate Test Utilization by Physicians to Improve Efficiency in a Healthcare Setting

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This is to certify that the doctoral study by

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Abstract

Inappropriate test utilization by physicians for clinical decision-making in patient care is a significant problem facing some healthcare leaders. Healthcare leaders are concerned about inappropriate test utilization because it can increase healthcare costs and degrade patient outcomes. Grounded in the complex adaptive system and Lean Six Sigma conceptual frameworks, the purpose of this qualitative single-case study was to identify strategies seven hospital leaders in Maryland and Washington, DC. who implemented successful test utilization strategies for physicians. Data were collected from semistructured virtual interviews and organizational reports and analyzed using Yin's 5 step process. Five themes emerged: (a) continuing physician education, (b) enforced accountability, (c) IT systems and EMR documentation training, (d) understanding financial ramifications, and (e) heightened resource stewardship. A key recommendation is for healthcare leaders to employ palliative care to mitigate physicians' inappropriate test utilization. The potential for positive social change includes the potential to reduce patient testing-related risks, improve patient satisfaction, and reduce healthcare costs, resulting in improved dignity and quality of life for individuals in local communities.

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Dedication

I dedicate this doctoral study to my husband, Bob, and children, Tim, Katie, and Ryan. I am thankful for their unwavering support and encouragement during my doctoral journey. I would also like to give special mention my father, Dr. Ned Clarke, who instilled the importance of education at an early age and encouraged me to pursue a doctorate degree and for being a mentor during my journey.

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Section 1: Foundation of the Study

Healthcare expenditures in the United States are approximately 18% of the gross domestic product (GDP), but about 30% of healthcare spending is categorized as waste (Shrank et al., 2019, p.1502). One component of wasteful expenditures is overtreatment or low value care, such as physicians' overutilization and underutilization of diagnostic laboratory tests (Shrank et al., 2019). Strategies to eliminate wasteful, low value, and non-value-added processes are critical for hospital leaders to facilitate high-quality care at lower costs. The objective of this qualitative case study was to explore the strategies healthcare leaders could use to reduce costs by decreasing the utilization of tests that are not medically necessary. The foundation of this research study will begin with the background of the problem.

Background of the Problem

Laboratory tests are an integral part of physicians' clinical decision-making process for diagnosing and treating patients' illnesses. For example, physicians use laboratory tests to diagnose myocardial infractions (troponin), diabetes mellitus (hemoglobin A1C), or infectious diseases (e.g., COVID-19). However, many physicians are uncertain about which laboratory tests to order and how to interpret the results, which leads to wrong, missed, or delayed diagnoses contributing to medical errors (the third leading cause of death in the United States), jeopardizing patient care and safety (Cadamuro et al., 2018, p. 6). In addition to patient care and safety risks, physicians' inappropriate test utilization practices cause financial consequences such as increased costs for healthcare institutions. Researchers have investigated physicians' inappropriate

test utilization; however, new research is warranted to aid healthcare leaders with strategies to mitigate physicians' inappropriate test utilization not meeting medical necessity to control organizational costs. The focus will now shift to the problem statement.

Problem and Purpose

Inappropriate selection of laboratory tests by clinicians impacts patient safety and healthcare spending (Cadamuro et al., 2018, p. 6). Healthcare spending in the United States is expected to increase at an average annual rate of 5.4% during the years 2019 to 2028 and projected to reach $6.2 trillion by 2028 (U.S. Centers for Medicare & Medicaid Services, 2020, p. 1). Of that total spending, laboratory tests will account for 3% of healthcare spending expenditures (Mize et al., 2019, p. 1) or approximately $1.2 trillion of the total healthcare spending in 2019 (U.S. Centers for Medicare & Medicaid Services [Press Release], 2020, p. 2). The general business problem is that inappropriate test utilization negatively impacts profitability for hospitals and adversely impacts the quality of care for patients. The specific business problem is that some hospital leaders lack strategies to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs.

The purpose of this qualitative single-case study was to identify strategies that some hospital leaders use to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs. The target population was hospital leaders from different hospitals within a single healthcare system in Maryland and Washington, D.C. I interviewed seven hospital leaders who had implemented successful

test utilization strategies for physicians. The prospective social change benefits include fewer testing-related risks for patients and reduced healthcare costs, resulting in improved dignity and quality of life for individuals in local communities and enhanced services' quality provided by hospitals.

Population and Sampling

Researchers should use samples of a population when data collection is impractical for an entire population, and the sample should represent the population that can best answer the research question (Saunders et al., 2019). I considered convenience sampling and purposive sampling methods for this research study. Some researchers use convenience sampling because the participants are easily accessible (Yin, 2018). However, convenience sampling is the least rigorous approach, and the data might result in low accuracy, poor representation, low credibility, and lack of transferability of results (Johnson et al., 2020). Purposive sampling allows researchers to obtain data from specific types of participants that could best answer the research question based on the participant's experience and expertise (Bougie & Sekaran, 2020). Additionally, the purposive sampling method is considered a best practice to increase qualitative research rigor and trustworthiness (Johnson et al., 2020) to provide an increased depth of understanding of the research topic (Campbell et al., 2020). Since the participants for this research study were selected intentionally for optimized data collection based on participants' experience and expertise with test utilization, I used purposive sampling.

The target population was hospital leaders from different hospitals within a single healthcare system in Maryland and Washington, D.C. Guest et al. (2020) discussed the

optimal number of interviews in qualitative research studies to achieve data saturation. Guest et al. (2020) stated that one approach to determining data saturation and the estimated sample size is related to the base size, run length, and new information threshold. Guest et al. (2020) found that the first five to six interviews produced the majority of new information in the dataset and that minimal new or valuable information was obtained as the sample size reached 20 interviews. I conducted a minimum seven interviews with selected participants to obtain the depth of information in the research process.

Data saturation is a crucial component of rigor in qualitative research (Guest et al., 2020). Data saturation is attained when there is no new or valuable information, enough information is available to replicate the study, and additional coding is not feasible (Fusch & Ness, 2015). For this single-case research design, I used semistructured interviews that include the same standard questions and interview format and test utilization performance reports to confirm and identify any variances from the interview findings to obtain more in-depth information.

Nature of the Study

Researchers choose among quantitative, qualitative, and mixed methods (Saunders et al., 2019). Quantitative researchers test hypotheses to investigate variables' characteristics and relationships (Saunders et al., 2019). Qualitative researchers use open-ended questions, such as *what*, *how*, and *why* questions to determine what is occurring or has occurred (Yin, 2018). Mixed method researchers use both the qualitative and quantitative methods (Saunders et al., 2019). To investigate appropriate test utilization

strategies employed by hospital leaders, I did not test hypotheses, which is part of a quantitative study or the quantitative segment of a mixed-methods study. I selected the qualitative method to explore and understand the phenomenon of effective strategies to minimize inappropriate test utilization to improve efficiency and reduce healthcare costs.

I considered four designs in this qualitative study: ethnography, narrative, phenomenology, and case study. The ethnography design involves studying the culture of one or more groups (Saunders et al., 2019). The ethnography design was not appropriate for my research study, because I did not research a group's culture. Researchers use the narrative design to collect information about participants' personal life stories based on an event or sequence of events (Saunders et al., 2019). The narrative design was not appropriate for my research study, as my research study was not focused on peoples' personal lived experiences through their life stories. Researchers use the phenomenological design to investigate the meanings of participants' lived experiences with a phenomenon (Patton, 2020). The phenomenological design was not appropriate for my research study because I did not investigate the personal meanings of participants' experiences with phenomena. Case study researchers use open-ended questions to answer *what, how,* and *why* questions to explore a current situation or event (Yin, 2018). I used an embedded single-case study design so I could interview hospital leaders at different levels and at different locations of a single organization of particular interest to enable me to garner a deeper understanding and more holistic view of how the organization's leaders developed and implemented effective strategies to reduce inappropriate test utilization by physicians.

Research Question

What strategies do some hospital leaders use to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs?

Interview Questions

1. What strategies are you using for assuring appropriate test utilization by physicians to improve efficiency?
2. How have you assessed the relative effectiveness of the strategies (metrics)?
3. What strategies did you find that work best for reducing inappropriate test utilization by physicians to improve efficiency in the system?
4. Regarding the process you use to assure testing appropriateness and efficiency, please describe the specific steps of the related quality control system?
5. How did you address the key barriers to implementing the strategies to reduce inappropriate test utilization by physicians?
6. What modifications would you make to the strategies to improve efficiency for appropriate test selection by physicians?
7. What additional information would you like to share about strategies used for reducing inappropriate test utilization by physicians to improve efficiency to reduce healthcare costs?

Theoretical or Conceptual Framework

The composite conceptual framework selected for this research study was the complex adaptive systems (CAS) theory and Lean Six Sigma (LSS). The CAS theory is based on the work of John Holland (1992). According to Holland, the CAS theory

consists of a network of diverse agents (components) responding in parallel by acting and reacting to adapt to the environment to function to achieve effective performance in the system. The interactions and relationships of different components simultaneously affect and are shaped by the system as a whole to improve performance. CAS has been applied in various industries to assist hospital leaders' understating of the dynamics of complex systems (Forrest & Mitchell, 2016).

The CAS theory's primary construct involves several individual elements interacting dynamically in the system that are affected by and affect several other systems (Holden, 2005). Complex systems have distinct properties that evolve from relationships with diverse agents, distributed control, emergence, adaptation, nonlinearity, and spontaneous order (Gomersall, 2018). These features need to be taken into consideration when identifying changes in systems such as healthcare. Holland (1992) discussed that it is essential for systems to balance exploration with exploitation for successful adaptation. Exploring involves gathering new information or capabilities, and exploitation involves efficiently using the information already existing (Holland, 1992). Change and adaptation are open-ended and continual, and systems develop with each other depending on resource availability and competition to help understand efficiency (Forrest & Mitchell, 2016). As a result, a state of equilibrium is never achieved within a CAS.

Lean Six Sigma (LSS) is one method that can align the diverse components to enhance the quality of a complex healthcare organization by reducing variation, waste, costs for creating a culture of continuous quality outcomes (Ahmed, 2019). The application of the LSS DMAIC (define, measure, analyze, improve, control) provides

healthcare leaders with the means to improve quality performance in a complex organization (Ahmed, 2019). Rathore and Srivastava (2020) explained that DMAIC is the framework for LSS. Define (D) is the phase where leaders identify and define the problem and develop the project charter. *Measure* (M) provides the measurement baseline data of the current state of a process. The data collected is used by leaders in the *analysi*s (A) phase to determine the root cause(s) and relationships with the selected problem. Leaders use the *contr*ol (C) phase to sustain and control the positive results.

Rathore and Srivastava (2020) discussed that Lean is a continuous quality improvement tool used by leaders to improve the value stream and patient flow, and to detect problems to eliminate waste. Leaders use the Six Sigma statistical tool to measure quality in defects per million opportunities (DPMO) to reduce variation in performance, minimize errors, and improve customer satisfaction separately. The combination of CAS and LSS DMAIC provides healthcare leaders with the framework to prevent and mitigate medical mistakes, decrease mortality rates, decrease the length of patient stays in hospitals, improve patient care, increase the quality of services, and reduce costs, which facilitates an enhanced continuous quality improvement methodology that Lean and Six Sigma cannot achieve. The CAS theory and LSS DMAIC models provided a composite lens for identifying and understanding the strategies the participants developed and used for reducing clinicians' inappropriate test utilization to improve workflow efficiency and reduce healthcare costs.

Operational Definitions

Clinical Decision Support System (CDSS): CDSS is a computer software system that physicians use while making complex decisions, including clinical knowledge procurement, patient information retrieval, and diagnostic test data (Leblow et al., 2020).

Computer Physician Order Entry (CPOE): CPOE is a computer software system that clinicians use to reduce prescribing and transcription errors and to manage medication-related problems in real time with alerts to the user (Tamburrano et al., 2020).

Electronic Health Record (EHR): EHR is a computer software system. Healthcare clinicians use the EHR to electronically document clinical activities regarding patient care, which eliminates paper documentation processes (Adelman et al., 2019).

Overutilization: Leblow et al. (2019) defined overutilization as tests ordered by physicians that are not clinically indicated for patient care.

Test utilization: According to Tamburrano et al. (2020), test utilization is the practice of clinicians ordering laboratory tests with the goal of providing high-quality, cost effective patient care.

Underutilization: Leblow et al. (2019) defined underutilization as tests that are clinically indicated for patient care but not ordered by physicians.

Assumptions, Limitations, and Delimitations

Assumptions

Assumptions are issues, ideas, or positions that the researcher takes for granted regarding the context of the research topic (Theofanidis & Fountouki, 2018). Researchers need to identify and address assumptions concerning the nature of the study (Theofanidis

& Fountouki, 2018). The first assumption was that I expected participants to be knowledgeable about test utilization. This assumption is essential for healthcare leaders to make improvements with reducing costs. The second assumption was that I expected the participants to answer the interview questions truthfully to support mitigating inappropriate test utilization and reducing costs. Researchers can conduct a more vigorous research study by identifying the assumptions to minimize potential barriers to the research.

Limitations

Limitations are potential weaknesses that are out of the researcher's control with the associated research study (Theofanidis & Fountouki, 2018). Limitations do not necessarily reduce the validity of the research study but depend on the researcher's expertise and experience with the subject matter (Akanle et al., 2020). Researchers could learn from the limitations of this study and formulate recommendations for further research. My research study was small in geographical scope and consisted of a small number of participants contributing to the limitations of this study. The findings of this research study may not apply to other healthcare institutions requiring additional research in the future.

Delimitations

The researcher determines the delimitations to set boundaries with the research study (Ross & Zaidi, 2019). One delimitation was that the hospital leaders I selected for this study were from the same healthcare system. Another delimitation was that the geographic area for this research study included different hospitals within a single

healthcare system located in Maryland and Washington D.C. Last, the participants in this study included healthcare executives who had a minimum of 3 years in their current roles or possessed similar experience.

Significance of the Study

The significance of this study could be to provide strategies for hospital leaders to improve test selection to improve patient care while reducing costs. According to Zare et al. (2020), laboratory testing accounts for 3% of all annual healthcare costs in the United States (p. 2). Also, an estimated 42% of laboratory tests are considered wasteful, contributing to approximately $200 billion in unnecessary treatments for patients in the United States (Freedman, 2015, p. 6). The selection of inappropriate laboratory tests starts with the ordering physician in the pre-analytical phase before a test is collected (Freedman, 2015). The consequences of physicians ordering wrong tests, duplicate tests, missed tests, over-utilization of tests, and underutilization of tests contribute to errors in patient diagnosis or treatments, delays, increased length of hospital stays, unnecessary blood loss, increased resource utilization, and patient safety concerns (Freedman, 2015). From a business perspective, the money saved by reducing inappropriate test selection could be utilized by hospital leaders to better treat and prevent actual illnesses.

The findings from this study may provide a means for positive social impacts on individuals and healthcare institutions. Improving test utilization reduces diagnostic errors, which will contribute to the right test selected at the right time for enhancing the quality of patients' care. For example, when patients receive appropriate diagnoses and treatment, their quality of life can be improved by reducing additional hospital stays and

medical errors from missed diagnoses. Another positive social change could be precluding pressure that patients might impose on physicians to run tests due to their research on the Internet for self-diagnosing or self-monitoring (Fryer & Smellie, 2013). Better collaboration among healthcare leaders, physicians, and patients can facilitate a partnership to improve appropriate test utilization strategies to enhance healthcare quality for individuals, communities, and society.

A Review of the Professional and Academic Literature

The purpose of the literature review was to analyze and synthesize various literature sources to achieve an in-depth examination related to the research topic. I accessed peer-reviewed scholarly journal articles through the Walden University Library database, including ProQuest Central, SAGE journals, Emerald Management journals, OVID, EBSCOhost, Google Scholar, government websites, and seminal scholarly books. The following review of the literature covers three areas: (a) the conceptual framework, (b) the foundation of the topic, and (c) the relationship between the research topic and the conceptual framework. I compiled scholarly research sources based on categorized sections for the literature review. This literature review consisted of 84 articles, journals, and seminal books. For this literature review, 84 out of 97 sources (89%) were within 5 years of my anticipated graduation date; 74 out of 84 sources were peer reviewed (88%). The entire doctoral study to date includes 109 out of 126 sources (86.5%) within 5 years of my anticipated graduation date and 118 out of 126 sources (93.7%) are peer reviewed sources (Note: Anticipated graduation date was 2023).

The healthcare industry is continuously changing, requiring business leaders to ensure quality patient care while reducing costs. One area that contributes to the diminishing quality of patient care and increased costs and waste is inappropriate laboratory test utilization. The negative consequences of physicians ordering inappropriate tests contribute to poor patient outcomes (Freedman, 2015). For example, some of the effects of overutilization of test orders by physicians include incorrect diagnosis and treatment, delays in diagnosis, increased length of hospital stays, unnecessary blood loss, and increased resource utilization (Freedman, 2015). Freedman (2015) discussed that physicians need to concentrate on improving test ordering practices for better clinical outcomes and changes to patient management in addition to reducing the number of tests ordered. Researchers can use the CAS conceptual framework as a lens to evaluate and better understand the behaviors exhibited by healthcare business leaders with inappropriate test utilization practices. Hospital leaders have opportunities to develop and implement strategies to improve quality patient care while controlling unnecessary expenditures such as medical test overutilization.

Although test utilization makes up only a small portion of overall healthcare spending, inappropriate test utilization contributes to a significant amount of waste that must be regulated with evidence-based best practices established for physicians to follow (Procop et al., 2014). However, changing the behavior of physician ordering practices is not without challenges. Jackups et al. (2017) explained that many physicians practice defensive medicine, which contributes to ordering unnecessary tests due to the fear of missing a serious diagnosis. Some clinicians use the defensive medicine approach, which

leads to medical errors resulting from false-positive testing and decreases in patient satisfaction due to multiple collections for additional tests (Jackups et al.).

Conceptual Framework – Complex Adaptive Systems (CAS)

Healthcare business leaders require distinct approaches for successful decision-making to improve test utilization. Healthcare leaders can use the CAS conceptual framework and LSS principles to adapt to changes in a fragmented system. Based on the literature, some researchers have not utilized CAS as a conceptual framework to apply to the healthcare industry. Still, healthcare leaders can use CAS to improve interconnections and relationships to create collaborative behaviors to improve test utilization and reduce costs as a network of diverse agents (components) acting in parallel (Holland, 1992). Cooperative actions are essential to generate positive outcomes for improved workflow processes and cost savings opportunities. As indicated in the literature, physician ordering practices are not standardized. Strategies for healthcare leaders to improve test utilization are a complicated issue throughout the healthcare industry. Hospital leaders should identify successful strategies to improve test utilization and develop tactics to improve the team dynamics to adapt best practices through the CAS theoretical lens and supplemental conceptual frameworks.

Van Beurden et al. (2013) discussed that a CAS is a dynamic network with multiple components that act and react to other entities' actions. Van Beurden et al. stated that Snowden's Cynefin framework could assist leaders as a supplemental framework with understanding CAS by categorizing issues and strategies. The Cynefin framework is a management problem-solving model for leaders to assess situations more accurately to

make decisions more appropriately based on cause-effect relationships (Van Beurden et al., 2013). The Cynefin framework is divided into five domains based on ordered or unordered situations. The five domains include complex (unordered), chaotic (unordered), complicated (ordered), simple (ordered), and a central domain of disorder in the center of the model. The relationships among the five domains could help hospital leaders identify best practices from simple to complex and chaotic issues (Van Beurden et al., 2013). Van Beurden et al. posited that CAS theory, in conjunction with the Cynefin framework, could assist hospital leaders in understanding a situation and selecting the most appropriate approach for better decision-making.

In another research study, Sturmberg and Bircher (2019) stated that CAS theory applies to healthcare systems with bottom-up leadership to improve patient care leading to improved cost reduction. Healthcare systems are based on purpose, goal, and value for operations, which serve as the driver with CAS (Sturmberg & Bircher, 2019). Traditionally, healthcare leaders have focused on a top-down structure consisting of command, power, and control (Sturmberg & Bircher, 2019). Healthcare leaders can apply the CAS conceptual framework to foster bottom-up organizational behaviors that empower front-line staff to respond to changing environments to focus on the patient's needs contrary to traditional top-down organizational leadership models (Sturmberg & Bircher, 2019).

Conversely, hospital leaders can apply the CAS theory with bottom-up organizational behaviors empowering front-line staff to respond to changing patient needs encouraging collaboration, respect, and learning (Sturmberg & Bircher, 2019).

Hospital leaders need to provide clear visions for teams and patients to deliver high-quality, low-cost medical care for patients and society (Sturmberg & Bircher, 2019). For example, Sturmberg and Bircher discussed that the Mayo Clinic is one healthcare institution that adopted a system driver where the patient's needs come first. The leaders at the Mayo Clinic have sustained a successful healthcare organization for over 100 years in a constantly changing environment while providing quality patient care. Sturmberg and Bircher stated that the Mayo Clinic is considered the benchmark for healthcare institutions delivering high-quality patient care for more efficient and cost-effective strategies. Hospital leaders could adopt the Mayo Clinic's best practices for effective test utilization stewardship.

To develop effective test utilization practices, Khan et al. (2018) analyzed the CAS theory and established six objectives to apply to health care systems. The objectives formulated by Khan et al. included leaders understanding the term "context" regarding outcomes and actions with performance; participants respond differently when a complex system is recognized; leaders need to manage uncertainty with new approaches; providers need to collaborate with patients for a patient-centered approach in a complicated situation; leadership is action-based and not traditionally role-based, and new innovative strategies require leaders to implement initiatives in complex systems (pp. 3-6). Khan et al. highlighted that healthcare systems' complex nature requires leaders to adapt to new organizational structures and social changes, since traditional methods are not suitable for complicated systems. Khan et al. posited that healthcare leaders should accept the

challenges with complex systems and adapt to the uncertainty in a complex environment, providing a more in-depth inquiry to improve clinicians' test utilization practices.

For example, in a multiple exploratory case study including physician assistants (PAs), Burrows et al. (2020) investigated the factors associated with successfully integrating PAs in healthcare systems as a solution to reduce physician shortages and provide team continuity and improve patient experiences. Burrows et al. evaluated the integration of PAs in 13 hospitals and six family medicine clinics in four specialty areas: family medicine, emergency medicine, general surgery, and inpatient medicine in Ontario, Canada. Burrows et al. used the lens of the CAS framework to identify that PAs perform an essential role and contribute to healthcare team member relationships that support effective communication between patients and the healthcare team, increases collaborative care, reduces workflow barriers allowing physicians more time for other patients, and understanding the patterns of healthcare team members' interactions with various stakeholders in relationship with team behavior dynamics. Burrows et al.'s study was significant because healthcare leaders could better understand the PA’s role to improve appropriate test utilization through the lens of CAS.

To further explain complex systems with team member relationships, Ryvicker (2017) discussed the behavioral-ecological perspective conceptual framework to address healthcare complexities and reduce inconsistencies in navigating the established social environment and healthcare infrastructure. Ryvicker theorized that healthcare is composed of an ecologically informed process consisting of the spatial distribution of healthcare services, individuals, and environmental factors that impact leaders’ decision-

making and behavior. Ryvicker stated that several healthcare and social dimensions (healthcare access, such as availability of services, affordability, transportation, education, communication skills with health care providers, and social support) must align with healthcare teams and patients to facilitate decision-making, the patients' compliance with treatment, and healthy behaviors for successful changes to reduce barriers. Besides healthcare leaders developing the required skill sets to manage healthcare complexities, consumers also need to build skillsets to navigate the complicated health care system, such as selecting providers, scheduling and following up with providers, and evaluating treatment options to improve patient care (Ryvicker, 2017).

Carmichael and Hadžikadić (2019) discussed that healthcare leaders facing complex problems do not have a specific theory that encompasses every situation. The authors addressed those hospital leaders could use the CAS in various changing environments to obtain results different from anticipated outcomes to explore complex phenomena (Carmichael & Hadžikadić, 2019). Carmichael and Hadžikadić stated that agents are used to describe a complex system's component with CAS, characterized as having one or more feedback levels, exhibiting emergent properties and self-organization, and producing non-linear dynamic behavior to describe phenomena in a diverse environment.

With other supplemental conceptual frameworks, multi-agent systems (MAS), agents compared to CASs possess simple rules and attributes that are primarily autonomous and operate with the knowledge available at the local level in the system

(Carmichael & Hadžikadić, 2019). The individual elements are flexible, easily replaced, and switched around with similar agents without interrupting the system's features as a whole (Carmichael & Hadžikadić, 2019). The agents in a MAS have a specific function and are not interchangeable. The MAS follows a strict hierarchy in the system, and the agents are distinct and not as flexible as CAS agents because they are heterogeneous (Carmichael & Hadžikadić, 2019). For example, the collection tubes required for laboratory testing are specific, and laboratorians use the designated tubes following strict guidelines where the specialized tubes are not interchangeable for testing. However, laboratory tests are constantly developed with flexible agents as new technology becomes available to diagnose and treat patients.

One method that can align the diverse components to enhance the quality of a complex healthcare organization for continuous improvement is LSS. In a qualitative analysis of 35 Six Sigma and LSS published papers, Honda et al. (2018) found that leaders could significantly improve organizational performance when implementing LSS principles. Honda et al. discussed that when healthcare leaders combined Six Sigma with LSS, there was a reduction in wait times, patient flow improvement, patient satisfaction increased, and a reduction in operating costs, leading to substantial savings. Honda et al. explained that removing waste is a principle of the lean philosophy and reducing variation is a tenet of Six Sigma focuses and combining the two methods are represented using the metric stages define (D), measure (M), analyze (A), improve (I), and control (C; Honda et al.). Although Honda et al. identified that LSS principles could help healthcare leaders positively impact organizational operations, the implementation of LSS requires

training and a multidisciplinary team approach, which can pose challenges for successful implementation because of the organization's leadership hierarchy and infrastructure. To further explain leaders' roles with operations, Martinez-Garcia and Hernandez-Lemus (2013) discussed that healthcare systems are complex and have historically been viewed as linear organizations. However, healthcare systems are complicated and diverse, requiring leaders to manage such organizations using an appropriate framework such as the CAS conceptual framework (Martinez-Garcia & Hernandez-Lemus, 2013). Martinez-Garcia and Hernandez-Lemus explained that healthcare leaders are under immense pressure and conflict from various sources when managing complex operations where systems are complicated, dysfunctional processes and one action can change another Area's dynamics even if the outcome was unintentional (Martinez-Garcia & Hernandez-Lemus, 2013). Martinez-Garcia and Hernandez-Lemus suggested that leaders could utilize Six-Sigma as one approach for healthcare leaders to improve organizational performance because the strategy incorporates the entire organization's processes instead of individual elements or personal agendas to improve complex healthcare systems, requiring functional areas to adapt to a cooperative environment with other departments and not operate individually.

Martinez-Garcia and Hernandez-Lemus provided a foundation for healthcare leaders to observe complex issues through the lens of CAS to manage organizations that could improve inappropriate test utilization efficiently.

Soliman and Saurin (2020) found there is a significant relationship between lean production and complexity. In an inductive case study, Soliman and Saurin (2020)

investigated responses to research questions with semistructured interviews from participants at an auto parts manufacturing plant to understand the gap between *lean-as-imagined* (how the system design should work) and *lean-as-done* (how the system works in practice). Soliman and Saurin identified several gaps between *lean-as-imagined* and *lean-as-done.* The gaps identified from complex interacting components in socio-technical systems included resilience, unexpected variability, varied elements such as a diverse workforce, technical diversity, and dynamically interacting factors, such as social interactions, which influence lean production and productivity. Although Soliman and Saurins' research study focused on an auto parts manufacturing plant, healthcare leaders could apply the results of this study to healthcare institutions as a framework to better understand the complexity of lean processes to make improvements.

In an effort to improve processes, Mrazek et al. (2020) discussed possible strategies to correct potential errors with the total testing process (TTP) from test selection to interpretation of tests. According to Mrazek et al., inappropriate test selection is the most frequent error by physicians. Physicians' improper test selection contributes to overutilization and underutilization of inappropriate test utilization. Mrazek et al. posited that the utilization of the Plan-Do-Check-Act tool, quality improvement programs, and Six Sigma could assist with reducing errors with the TTP. According to Mrazek et al., approximately 8% of primary care physicians are uncertain on how to interpret laboratory results leading to potential errors with patient care (p. 12). Mrazek et al. discussed that interpretation of the ordered test results has to be applied in conjunction with the patients' clinical history, symptoms, physical examination, and other diagnostic

disciplines for best outcomes. Mrazek et al. posited that in addition to quality improvement programs, physicians and other clinical areas need to collaborate with laboratorians with the TTP to identify any test utilization errors and improve test result interpretation to improve quality patient care.

To improve test result interpretation and improve quality patient care, Ninerola et al. (2020) evaluated Six Sigma publications in a systematic literature review from 1998 through 2017 to identify leaders' opportunities to apply this methodology to improve the healthcare industry. Ninerola et al. reviewed 196 articles from three different databases and found that healthcare institutions such as the Mayo Clinic and Mount Sinai Hospital in New York have implemented the Six Sigma methodology for continuous improvement initiatives. The author's research identified that leaders had used Six Sigma principles to improve patient care and safety in various specialties, with 26.5% of the articles revealing that leaders of organizations applied a combination of the Lean principles with Six Sigma methods to reduce waste and defects (Ninerola et al., 2020, p. 440). Ninerola et al. identified that Six Sigma principles could improve management processes and enhance patient care, which healthcare leaders could apply to improve physicians' test utilization.

The developers of Six Sigma focused on responsibility and performance, and Ho and Pursley (2021) stated that healthcare professionals must take responsibility for improving patient care value. The researchers identified several tools and recommendations to assist providers with improving value and efficiency with clinical decision-making. The first tool is the *Three Whys*, adapted from Toyota's lean manufacturing processes to identify the root cause of a problem or defect (Ho & Pursley,

2021). For example, the question *Why?* is asked by the healthcare leaders why something happened. Another *Why?* question is asked based on the response of the first *Why?* question and a third *Why?* question is asked based on the answer from the second *Why?* question until the root cause of a situation can be identified. A second tool is to "test the test," where providers ask the following questions when ordering diagnostic tests (Ho & Pursley, 2021, p. 4):

- What will the medical team do if the test is positive?
- What will the medical team do if the test is negative?
- Is the diagnostic test necessary at this time?

Other recommendations include appointing a value-added champion, using the electronic medical record (EMR) to alert clinicians to reconsider non-value-added tests, and random value audits (Ho & Pursley, 2021). Ho and Pursley explained that process flow diagrams and priority matrices are essential for leaders to understand complex systems to prioritize the order of changes associated with quality to reduce waste and overutilization of diagnostic tests.

Alternative Conceptual Frameworks

Similar to CAS, healthcare leaders can use other alternative conceptual frameworks to understand complex systems. Lartey (2020) discussed leaders of organizations deal with constant technological advancements and globalization efforts creating challenges with managing businesses. The chaos, complexity, and contingency theories are three conceptual frameworks that leaders can apply to understand and adapt to the evolving changes and challenges in the healthcare industry (Lartey, 2020). The

chaos, complexity, and contingency theories possess some similarities and distinct differences from CAS, providing different lenes for leaders to manage organizations more efficiently.

Chaos Theory

Karaman et al. (2019) discussed that Chaos theory is often difficult for leaders to understand and predict all the elements in a system. Such components include order, the butterfly effect, attractors, and fractal structures (Karaman et al., 2019). Chaos does not indicate disorder but represents unpredictability with systems' order (Lartey, 2020). Lorenz (1993) used a metaphor, the *butterfly effect,* to help explain unpredictable changes depicted in chaos theory, where small, simple changes in a system could lead to more significant changes in a later stage of the process. Henri Poincare, a mathematician, was an early supporter of the chaos theory with his work involving cross-sections of attractors to explain similarities and gaps with celestial mechanics (Lartey; Lorenz, 1993). Behaviors occurring in the system are not random, and an attractor causes unpredictable behavior. Lartey (2020) stated that patients' (attractors) unpredictable behaviors are present even in simple systems. For example, a physician's decision about managing a healthy patient can lead to unforeseeable outcomes for the patient in the later stages of their healthcare process. Lastly, in chaos theory, fractal elements (fragmented parts or patterns) are not the same and often behave chaotically; however, the fractals show some similarities to configure with the whole component (Karaman et al., 2019).

Demir et al. (2019) discussed that chaos theory continued to evolve based on the work of meteorologist Lorenz, who identified that small changes in a system could lead

to significant, unpredictable outcomes, as explained with the *butterfly effect* metaphor (p. 1226). Lorenz described that the *butterfly effect* starts with a butterfly flapping its wings (minor changes) in Beijing, China could cause unpredictable outcomes, such as hurricanes in Washington, D. C. (p. 1226). Demir et al. explained that behaviors occurring in systems are not random and are caused by an attractor. For example, a patient would be an attractor when seeking care from a healthcare professional. However, clinical treatments for individuals with the same illness can differ, demonstrating an unpredictable and non-linear system. Although the chaos theory is a conceptual framework that healthcare leaders can utilize to explain healthcare systems' complexities, in contrast to the CAS theoretical framework, healthcare leaders cannot adapt to changes with the chaos theory.

Raisio and Lundstrom (2017) further explained the chaos theory by analyzing three movies, *Chaos Theory, The Butterfly Effect*, and *Mr. Nobody.* Raisio and Lundstrom found that the movie *Chaos Theory* described chaos as uncontrollable, disorderly, and random, making future predictions impossible for individuals leading to making new choices causing path dependence, also known as bifurcation; *The Butterfly Effect* illustrated that chaos is so complex that control is impossible, and conflict is inevitable, and *Mr. Nobody* depicted individuals as part of the chaotic system and knowing when they should facilitate different choices. Based on the themes of the movies, Raisio and Lundstrom posited leaders should not try to control chaos as individuals must find ways to cope with the disorder because chaos is uncontrollable.

To understand ways to cope with chaos, Prestia (2020) discussed that healthcare organizations are settings for chaos, and leaders cannot assume that all individuals are working toward a common goal and must recognize when individuals could purposefully cause disruptions to team progress, adding a new dimension to chaos in healthcare (Prestia, 2020). Prestia explained that some individuals intentionally create turmoil and gain energy from generating chaotic situations, which could serve as a mechanism for such individuals to hide their lack of skills or inability to complete assignments and have little concern for the impact of their actions. Prestia posited leaders must be vigilant to detect contrived chaos, which applies to physician behavior, and engage other team members' help for support, such as human resource officers and chief medical officers.

In another research study, Saqr et al. (2020) applied the chaos theory using a naturally occurring chaotic system, physiologic vascular blood flow, utilizing the solution from Navier-Stokes's equation and Doppler ultrasound measurements of the carotid artery from healthy volunteers. Saqr et al. observed that the properties of physiologic blood flow are unstable and turbulent because of the cascade of kinetic energy, which is significant for researchers to understand the hemodynamic patterns with blood viscosity with peripheral and intracranial aneurysm blood flow. Saqr et al. explained that change is constant and produces unexpected results where leaders can evaluate situations from different perspectives using chaos theory; however, leaders need CAS theory to adapt to the changes.

Chaos is inevitable and often intensifies during crises. Postavaru et al. (2021) discussed that healthcare leaders face challenges with decision-making when confronted

with crises such as COVID-19. Postavaru et al. applied the chaos theory lens to develop a mathematical model based on patient's chaotic conditions of susceptibility, exposure, infectiousness, and removal (SEIR) to analyze the patient's complex and chaotic behaviors observed with the COVID-19 epidemic to calculate the number of infections as a mechanism for reliable information during times of disorder. Postavaru et al. posited that the mathematical model could provide vital information for healthcare leaders to support evidence-based decision-making in times of chaos.

Complexity Theory

Complexity theory is an alternative framework that leaders can use to simplify complex systems. The complexity theory is similar to the chaos theory by simplifying complex systems. However, the difference between the chaos and complexity theories is emergence (Lartey, 2020). In a complex system, emergence is described as new interactions of subcomponents creating new properties where decisions at the micro-level transmit to the macro-level (Lartey, 2020). Another difference between the chaos and complexity theories is that chaos systems are random, and complexity theory deals with non-random systems (Lartey).

To further explain complexity theory, Ferreira and Saurin (2019) investigated kaizen (continuous improvement) projects using lean principles influenced by the complexity theory in designing and assessing kaizen projects. Ferreira and Saurin conducted 13 semi-structured interviews and evaluated participant observations with kaizen projects involving preparing medications for patient administration at a large tertiary teaching hospital in Brazil. Ferreira and Saurin found that removing unnecessary

complex processes reduces waste, including the design of kaizen projects, such as slack in the design, allowing leaders to manage variability, assessing unintended consequences, and considering stakeholders' perspectives when making decisions that could increase disruption in the process. Transparency with personnel was an element that supported the detection of deviations and reduced the potential for disruption (Ferreira & Saurin, 2019). Although Ferreira and Saurin identified factors for a practical kaizen framework through the lens of the complexity theory, this study was limited to only five kaizen projects and did not assess the framework's long-term effects.

Long et al. (2018) discussed that the healthcare industry is complex and challenging for innovation. Long et al. stated that healthcare leaders could use the complexity theory and simulation modeling to explain the multifaceted components of healthcare systems to identify patterns of interactions with agents and between the agents and the environment to understand complicated settings. Long et al. identified that complexity theory deals with agent interactions and emergent system outcomes; however, there is a lack of knowledge surrounding the challenges of working within CASs. Long et al. argued that the only way for individuals to see the outcome of a CAS is to observe the system as a whole, rather than only evaluating the separate components. Long et al. posited similarities exist between pragmatism and complexity theory, such as sensitivity to the research background, a focus on applied research, and valuing the different forms of knowledge (p. 7). Long et al. suggested that a pragmatic complexity theory approach provides healthcare leaders with a flexible framework to apply to a continuously changing healthcare environment to enhance organizational operations.

To enhance organizational operations, Greenhalgh and Papoutsi (2018) reviewed five articles from the *British Medical Journal* related to complexity principles applied in healthcare systems. Greenhalgh and Papoutsi reviewed articles related to topics in complexity, including mental health services, respiratory conditions, medicine management, hospital-based rapid response teams, system-level accreditation mechanisms, and digital health solutions (Greenhalgh & Papoutsi, 2018). Greenhalgh and Papoutsi observed several central themes in the articles, such as researchers in healthcare services should use more diverse methods to research complex systems, researchers should develop new ways to work productively with insufficient data, and senior leaders could use simulation modeling to understand strategic decision support strategies to adapt to unpredictable situations. Greenhalgh and Papoutsi posited researchers and clinicians must learn to handle unknown, unpredictable, and emergent situations with a systems mindset to recognize changing interrelationships within a system and adapt to unexpected changes.

To understand changing interrelationships within a system, Horvat and Filipovic (2020) performed a quantitative study of 70 public, secondary, and tertiary health organizations in Serbia and analyzed the effectiveness of leadership styles using quality indicators in complex healthcare organizations through the lens of complexity leadership theory. Horvat and Filipovic evaluated the results from a survey conducted from a sample of 189 doctors in management positions measuring the differences in access to care and quality of care with administrative, adaptive, and enabling leadership styles. For example, leaders possessing the adaptive leadership style positively influenced the patients' length

of hospital stay, leaders possessing the enabling leadership style demonstrated a higher percentage of hospital readmissions, and leaders who exhibited the administrative leadership style effectively monitored the interactions with individuals in the organization and recognized barriers to workflow functions (Horvat & Filipovic, 2020). Horvat and Filipovic identified differences in leadership styles regarding quality indicators, which could be significant when leaders make workflow changes to improve test utilization by clinicians.

Contingency Theory

One of the contingency theory constructs is that there is a relationship between leaders' leadership styles and managing situations that arise based on the circumstances. Lartey (2020) explained that the contingency theory is an approach that depends on the situation, and there is not just one best way for leaders to solve a crisis. Leaders need the skills to assess conditions as decision-making is contingent on the circumstances.

Subri et al. (2020) described Fiedler's contingency theory as the relationship between leadership models and the situations to be handled that influence a leader's success. In a literature review, Subri et al. (2020) found that crises, such as COVID-19, require leaders to change leadership approaches and the tasks associated with planning, decision-making, goal setting, and maintaining relationships with other individuals in an organization. Subri et al. posited that leaders should make decisions based on the latest available facts, and planning is essential for the successful implementation of objectives.

Waters (2020) stated that healthcare providers should integrate theory and practice to facilitate best practices, especially nursing. The author reviewed several

theories; however, contingency theory was the most significant because group performance is contingent on leadership styles, situations, and the effectiveness of a leader's behavior and demonstrates the relationship between leadership actions and tasks to find the best approach to react to a situation contingent on the team (Waters, 2020). Waters explained that patient management teams can deliver various options for solutions that align with the nursing care teams for patient care delivery through the lens of the contingency theory. Although Waters focused on the nursing sector, integrating theory and practice, the information could apply to other healthcare professionals, such as physicians.

To support integrating theory and practice, Engelseth et al. (2020) evaluated three cases to assess information technology as a solution to support the logistics of healthcare services in a qualitative narrative case study. Engelseth et al. facilitated focus groups and semi-structured interviews through the lens of complex systems thinking. Engelseth et al. observed the logistics of workflow supplies at a hospital in Thailand, waiting list issues from an outpatient psychiatry clinic at a Norwegian Hospital Trust, and the workflow and effective communication with patients transferred between a hospital and home care facilities at a Norwegian municipality. Engelseth et al. found that combining the contingency theory with complex systems thinking provides leaders a framework to structure information technology systems to support the logistics of various complex healthcare services and improve the quality of information transmitted. Engelseth et al.'s study is significant because many solutions to improve physicians' test utilization include IT solutions.

Inappropriate Test Utilization

Vrijsen et al. (2020) identified physicians' overutilization of laboratory tests as an inappropriate practice. Some reasons for test overutilization were physicians not being aware of the issue (inappropriate test utilization) and the consequences of patient safety and financial impact. Vrijsen et al. stated that personal factors played a role in test overutilization. Several physicians in the study indicated that feelings of insecurity were a contributing factor when ordering tests. Another cause of overutilization discussed by Vrijsen et al. was the resident's preceptors' lack of feedback to provide constructive criticism as an educational opportunity to improve laboratory test selection.

Clouzeau et al. (2019) stated that few studies had provided long-term strategies for healthcare leaders to efficiently utilize diagnostic tests, as many laboratory tests are overused in hospitals, causing increased costs. Clouzeau et al. discussed that the multifaceted intervention included unbundling classic panel tests, education for junior residents, including asking questions such as “Do I really need it?” and positive encouragement included in daily physician round discussions would provide a strategy to allow necessary laboratory tests with sustainable results (p. 10). Clouzeau et al. studied two intensive care units (ICU) in a university teaching hospital with the same patient case mix. The ICU implemented the multifaceted intervention with new guidelines for appropriate test utilization, and the other ICU did not implement the multifaceted intervention. Clouzeau et al. (2019) found that multifaceted intervention guidelines for test utilization decreased ICU-patient days by 22 days, which led to a reduction in costs. The researchers stated that multifaceted interventions did not increase patient harm or

diagnostic delays, making the interventions safe and sustainable. The multifaceted interventions require physician commitment and other healthcare professionals involved in the patient's care to sustain results, and quarterly feedback with nursing and medical staff members with meaningful educational content to identify improvement opportunities were critical for sustainment (Clouzeau et al., 2019).

Harb et al. (2019) explained clinicians contribute to increasing health care costs because of laboratory testing overutilization compared to any other clinical service. The researchers examined several interventions at Yale New Haven Health to improve test utilization, including reducing obsolete or misused tests, duplicate orders, and daily routine lab testing. Harb et al. removed the obsolete or misused analytes from the testing formulary, installed electronic, hard stops, and a "No Labs Needed" alert to display on the computer to improve communication between shifts significantly reduced duplicate tests (p. 5). The researchers implemented weekly emails as a form of feedback to commend the clinicians who ordered tests the most wisely and monthly meetings to review test utilization metrics as an educational opportunity to change the culture of laboratory ordering practices. Furthermore, Harb et al. stated that the interventions generated cost savings of approximately $100,000 based on the results of appropriate test stewardship initiatives regarding ordering practices for medical decisions (p. 7). Other hospital leaders could adopt such interventions as an integrated approach with people, systems, and technology to improve overall laboratory test stewardship.

In addition to the research study by Harb et al. (2019), Nqeto et al. (2020) conducted an audit of laboratory test utilization practices by obstetricians over 2 months

in the obstetric unit at Inkosi Albert Luthuli Central Hospital Kwazulu-Natal, South Africa. Nqeto et al. analyzed laboratory tests performed on 39 patients admitted to the obstetric unit during the study. The authors found that when physicians selected tests to be analyzed, 51% were not clinically indicated, and in 27% of the laboratory tests indicated, the physicians chose the wrong priority (Nqeto et al., 2020, p. 37). Nqeto et al. (2020) discussed that most individual test orders placed by providers were clinically indicated for patient care compared to panel tests suggesting that physicians should order single tests when possible. Nqeto et al. (2020) identified a cost savings of 52.1% when physicians ordered clinically indicated tests during the research study (p. 38). The authors posited that physician orders should be based on the patient's condition and not on the clinician's routine preferences because physicians' increase in the selection of stat testing could increase costs compared to routine laboratory tests and lead to an overuse of the stat priority, where the urgent tests become handled as a regular priority (Nqeto et al.).

Along with Nqeto et al. (2020), Cadamuro et al. (2018) analyzed physicians' laboratory test ordering practices in the University Hospital of Salzburg, Austria, and survey responses from 299 healthcare employees regarding the reasons for not reordering any canceled tests. Cadamuro et al. focused on the causes of the number of canceled tests and not reordered for potassium, lactate dehydrogenase, aspartate-aminotransferase, activated partial thromboplastin time, and prothrombin time/INR. Cadamuro et al. concluded that 60-70% of the survey's focused tests were most likely inappropriate or produced debatable clinical importance (p. 91). Cadamuro et al. posited several strategies to improve the overutilization of test orders by physicians, including educational

programs, diagnostic algorithms, reflex testing, and demand management, developing re-testing intervals, standardizing test panels, and gate-keeping initiative. Cadamuro et al. suggested a new strategy to involve laboratorians to collaborate with clinicians regarding laboratory test utilization stewardship for improved patient and economic outcomes.

To improve test utilization stewardship, Morjaria and Chapin (2020) discussed that the number of clinical laboratory tests available for physicians to order has more than doubled in the past twenty years to > 3500 tests, and molecular tests are being used by physicians more often for infectious disease diagnoses (p. 1109). In a case study, Morjaria and Chapin found that a physician ordered expensive, unnecessary molecular tests on a patient that was not showing any improvement, and death was imminent in this situation. Morjaria and Chapin stated that many providers do not know what molecular tests to order or how to interpret the results, demonstrating that physicians must examine the patient's clinical condition and history in conjunction with laboratory results. Morjaria and Chapin suggested that healthcare leaders could implement a diagnostic stewardship program or committee as a strategy to reduce the number of unnecessary tests. A diagnostic stewardship program or committee would provide oversight, assist providers in prioritizing their decision-making, encourage physicians to be good stewards of expensive molecular testing, and improve patient care.

Wempe et al. (2020) further examined the financial impact of molecular testing with oncologists' use of diagnostic testing of patients with advanced non-small-cell lung cancer (NSCLC). Wempe et al. conducted a short survey with 150 oncologists and 815 patient chart reviews from patients with stage IV NSCLC. Wempe et al. found that 65%

of the oncologists indicated that the patient's insurance factored into their decision-making when ordering molecular diagnostic tests to assist with the diagnosis and treatment of patients with NSCLC (p. 116). Wempe et al. discovered that physicians are ordering molecular tests more often for cancer test screenings to assist with diagnoses, even though molecular tests are expensive. Wempe et al. identified two recommendations from their research. The first recommendation is for policymakers to improve the insurance regulatory system to benefit the patient (Wempe et al., 2020). The second recommendation is for the payers to develop a minimum set of diagnostic tests initially covered by insurance as early testing is critical for cancer diagnoses (Wempe et al., 2020). The research study by Wempe et al. identified a novel perspective regarding costs and insurance coverage as influencing oncologists' decision-making with molecular test utilization, which could be applied to other specialty physicians' test utilization.

In a cross-sectional descriptive study of 85 physicians at Upazila Health Complexes in Bangladesh, Islam and Awal (2020) analyzed data from participants' questionnaires regarding their clinical-decision making practices. Islam and Awal found several factors influencing physicians' clinical decisions regarding prescribing medications, ordering laboratory tests, lengths of visits, counseling patients, and referring patients to other providers or hospitals. Professional and personal social networks were the two primary factors influencing physicians' clinical decision-making processes (Islam & Awal, 2020). Other contributing factors influencing physicians' ordering practices for laboratory tests were the patient's economic condition, providers' workload, patients' demands, and physician knowledge (Islam & Awal).

In a qualitative review of databases, Lillo et al. (2021) examined 24 studies that included interventions to maximize physicians' use of laboratory tests. Lillo et al. found that 66% of the reviews consisted of a single intervention, while other studies were composed of a combination of high-quality interventions that maximized primary care physicians' test utilization (p. 11). The interventions included: administrative changes to test profiles, such as short cut menus, education, feedback reports, hard blocking that rejects clinicians' inappropriate test orders, and soft blocking consisting of alerts for test indications that could be overridden by providers with justification (Lillo et al., 2021). Although Lillo et al. identified several effective interventions to improve physicians' test utilization, more research is needed to evaluate the effectiveness of the hard and soft blocking of tests in combination with other interventions.

In a realist ethnographic study and a literature review, Duddy et al. (2021) evaluated primary care physicians' decision-making processes when selecting laboratory tests to understand how interventions work with healthcare stakeholders. Duddy et al. found that primary care physicians order laboratory tests for a variety of reasons. One significant reason is that some clinicians chose the efficiency-thoroughness trade-off (ETTO) by using laboratory tests as an easy intervention when managing heavy workloads with limited time to evaluate patients. Another reason for physicians' inappropriate test ordering practices included defensive medicine practices to minimize the risk of missing a diagnosis (Duddy et al.). Although Duddy et al. identified reasons for primary care physicians' decision-making influenced by ETTO for inappropriate test

utilization, future researchers need to consider the consequences of substituting efficiency for attention to detail with physicians' test utilization ordering practices.

Ziemba et al. (2018) discussed that laboratory test results should complement a patient's clinical condition as approximately 70% of laboratory tests assist providers with making clinical decisions (p. 2). Ziemba et al. analyzed the ordering patterns of providers grouped by specialties and patient population in a hospital, not named (p. 2). Ziemba et al. developed a utilization index (UI) formula based on the providers' ordering patterns and the results of the UI allow leaders to develop an illustrative heatmap to demonstrate improvement opportunities. The UI is derived by the formula [provider volume of a specific test/provider volume of all tests]/[cohort volume of a specific test/cohort volume of all tests] (Ziemba et al., p. 8). Although Ziemba et al. identified a useful tool to measure physicians' ordering patterns for improvement of inappropriate test utilization and reducing costs, the UI formula results should be evaluated by hospital leaders with caution since the results were based on physicians' variations with ordering practices and not on incorrect ordering patterns.

To review ordering practices, Rearigh et al. (2021) examined inpatient and outpatient negative or inconclusive COVID-19 rt-PCR test results at an academic medical center in Omaha, Nebraska. Rearigh et al. (2021) observed that 275 total patients, 94% demonstrated 94% negative results and 6% inconclusive results requiring at least one additional test (p. 338). Patients' repeat testing who initially tested negative provided minimal value because the 275 patients tested, only two patients tested positive after an initial negative test result (Rearigh et al., 2021). Rearigh et al. posited that one correctly

obtained sample within the first 7 days of a patient's illness is appropriate for testing to rule out COVID-19. Diagnostic stewardship is critical to improving the COVID testing process to conserve supplies that could apply to other testing practices.

Mohammed-Ali et al. (2021) discussed that revising laboratory test requisitions is one strategy to reduce unnecessary laboratory testing. Mohammed-Ali et al. conducted a laboratory requisition review with a steering committee that included family medicine physicians, a nurse practitioner, lab medicine specialists, and a quality improvement specialist evaluating laboratory tests used by the family medicine department from three healthcare institutions in Toronto, Canada. The steering committee evaluated 99,413 laboratory tests and removed laboratory tests from the requisition form based on evidence-based literature, including laboratory tests that were overutilized (aspartate aminotransferase, folate, urea, and erythrocyte sedimentation rate), outdated (amylase, creatine kinase), or infrequently needed in family medicine (Mohammed-Ali, 2021, p. 1). Mohammed-Ali et al. identified that revising the family medicine laboratory requisition was a simple strategy to improve family physicians' test utilization, which could be used in other specialty areas to promote appropriate test utilization and reduce costs.

Along with revised family medicine laboratory requisitions, physicians are receiving increased demands from patients for laboratory tests. Gamsızkan et al. (2020) stated that many family medicine physicians encounter patients' demands for laboratory tests even when the patients do not have any specific complaints. In a 6-month study of face-to-face interviews with 278 who requested laboratory tests in a family practice in Erzurum Palandöken Adnan Menderes Family Health Center located in Turkey,

Gamsızkan et al. found that the main reasons patients request laboratory tests included concerns about their health, such as non-specific symptoms, media warnings, and patients' high-stress levels. Family physicians often practice defensive medicine to avoid strained patient-physician relationships at the risk of laboratory test overutilization due to accommodating patients' requests for laboratory tests leading to increased unnecessary health information burdens for the patient (Gamsızkan et al.). Gamsızkan et al. posited that family medicine physicians should effectively communicate with their patients using an evidence-based approach for better health outcomes and balance the expectations of diagnostic tests.

Balancing test utilization with testing demands can present challenges. Nekkanti et al. (2020) discussed that COVID-19 had generated many changes and challenges for healthcare providers, such as testing every patient for COVID-19 for elective surgery procedures. In a 3 month study of 262 cancer patients in India, Nekkanti et al. found that 241 (92.1%) patients tested negative and underwent the scheduled surgery as planned, and 21(8.0%) of patients were asymptomatic but tested positive (p. 1289). The positive COVID-19 cancer patients were quarantined, and the elective surgery was postponed until the patients achieved two negative tests. Nekkanti et al. posited that the preoperative COVID-19 testing was beneficial in their institution; however, additional testing resources, such as COVID-19 tests and collection supplies, might not be available in other facilities, causing issues with test utilization.

Application of CAS with Test Utilization

The healthcare industry is complex, requiring healthcare leaders to deliver patient care in a more systematic and structured way that provides quality services while exercising good stewardship over healthcare expenses. Penney et al. (2018) performed a quantitative study utilizing a convenience sample with the CAS theoretical framework to evaluate if patient care transitions aligned with implemented complex processes led to better outcomes. The study consisted of extensive literature reviews that focused on hospital readmissions that met the systematic care criteria. The study revealed that almost all interventions involved a change in interconnections. For example, the highest responses were the CAS characteristics of learning and self-organization (Penney et al.). Changes to learning and self-organization require healthcare leaders to adapt to new organizational designs to improve complex systems.

According to Tang et al. (2017), healthcare systems operate under ineffective processes implemented by leaders and do not meet the industry's needs. New approaches need to be employed by healthcare leaders to adapt to the healthcare industry's changing environment. To be successful, government officials must acknowledge the complexities of the healthcare system and support the system's separate stakeholders (Tang et al., 2017). Tang et al. suggested that leaders in healthcare systems must balance the relationships between stakeholders and shift from top-down directives and be receptive to bottom-up feedback for organizations to adapt to complex systems. The research conducted by Fryer and Smellie (2013) supports the study by Tang et al. that local decisions should be based on national guidance and involve the key stakeholders,

including laboratory professionals. Tang et al. proposed to include the laboratory on the front end to improve communication from regulatory agencies and develop a relationship with all stakeholders when developing testing guidance for improved test utilization.

Team involvement is essential to improve diagnostic stewardship. Pype et al. (2018) used the CAS theoretical framework to understand team dynamics. The qualitative study consisted of interviews to evaluate team characteristics. Pype et al. interviewed three groups of nurses: palliative home-care nurses, community nurses, and nurse practitioners using deductive and inductive approaches in the research study. The deductive approach used the CAS coding principles, and the inductive approach identified the patterns of the codes for the CAS constructs to analyze the interviews from the participants (Pype et al.). The coding analysis demonstrated that team members functioned independently within specific guidelines to operate within their environment. However, when the team members did not work together cohesively, new undesirable behaviors emerged.

Pype et al. (2018) demonstrated how healthcare leaders could explain the patterns of the interactions between team members concerning team behavior using CAS. The CAS theoretical framework used in the study by Pype et al. also correlates with some barriers encountered with the lean philosophy, such as a lack of leadership support, commitment, participation, and professional skills, which affect team dynamics (Amran et al., 2020). The research study by Pype et al. provided awareness of how team members behave with structured processes, such as team members functioning with ground rules, and teams that operate based on history are more cohesive. However, the lack of unity

among individual team members produces undesirable effects (Pype et al.). The research utilizing CAS provides the lens for healthcare leaders to evaluate and better understand the behaviors exhibited by healthcare providers with test utilization practices as people management is a barrier with lean principles, as discussed by (Amran et al.). Healthcare leaders must commit to implementing lean principles to improve physicians' inappropriate test utilization issues for successful change management.

Some business and clinical leaders have difficulties implementing change management initiatives for integrated care (Harnett et al., 2020). One of the challenges is that the business and clinical leaders have other competing responsibilities when initiating new care models. Another challenge is that leaders fail to recognize the characteristics of a CAS. Harnett et al.'s research focused on utilizing a framework instead of care models to improve integrated healthcare with the elderly population. The researchers used an integrated literature review and a rapid review to investigate strategies that worked best for an integrated care program for older persons in Ireland. Harnett et al. stated that the framework approach builds commitment and ownership and includes evidenced-based pathways with best practices for an improved model for appropriate test utilization.

Werder and Maedche (2018) provided another practical application of CAS relating to teams and the healthcare arena with clinicians in responding to an ever-changing environment. The authors tested three hypotheses in a quantitative study regarding team dynamics to explain team agility as an emergent state, such as trust, cohesion, and emotions, using the CAS theoretical framework (Werder & Maedche,

2018, p. 833). Werder and Maedche (2018) described agility as a team-level phenomenon when responding to a crisis. Team agility is an emergent phenomenon, which helps to explain the characteristics of self-organizing teams. Werder & Maedche demonstrated that software could help identify the strengths and weaknesses of teams to assess a team's agility because software development teams are considered a form of CAS. According to Werder and Maedche, CAS involves three sectors: local, global, and contextual (Werder & Maedche, 2018). Werder & Maedche provided a practical application of CAS relating to teams and the healthcare arena with clinicians in responding to an ever-changing environment; however, more research is needed to investigate the relationships between systems.

The research study by Pype et al. (2018) correlates with Werder & Maedche's (2018) study. The team member's relationships impact the team's agility, education, and practice with appropriate test utilization practices in laboratory medicine. Teams must demonstrate self-organization as a vital component in the healthcare sector. Healthcare contains many unstructured relationships that can cause chaos. Holden (2005) described that the hospital staff serves as individual agents in a complex system. However, the individual staff members must adapt and work together within the system as defined by the CAS theoretical framework (Holden). The challenge is for individuals to not only convene in times of a crisis but during non-chaotic times (Holden). As discussed by Werder & Maedche, self-organization occurs at the local level. The study by Holden applies to the COVID pandemic crisis, where hospitals are continuously adjusting and

reforming their strategies regarding test utilization to serve the local community population in addition to the regular hospital patient populations.

Gomersall (2018) described that individual's behaviors in healthcare exhibited disorganized actions. According to Gomersall, the behavior of individuals is related to a causal chain reaction. For example, the beginning of the sequence starts with beliefs that develop from the stimulus situation or a person's past experiences (Gomersall). The team members' beliefs translate into an automatic and simultaneous attitude about a situation or event, guiding the involved participants (Gomersall). Gomersall examined the relationship between attitude and beliefs in a quantitative study to calculate behavior consequences. Gomersall discussed that the CAS theory impacts an individual's behavior and creates a response for actions within a system, creating adaption. The CAS theoretical framework agents are interconnected, and one step causes reactions from the next activity, which can generate unpredictable changes within the system.

Other researchers have investigated the dynamics of team behaviors and the relationship of individuals in a chaotic environment. For example, Diaz et al.'s (2017) qualitative research supports team members' self-organization with the CAS theory described by Holden (2015). The importance of stakeholders' relationships within healthcare systems cannot be overemphasized. As a result, the disconnected nature of healthcare system structures, the CAS theory can provide the framework to reduce the stress imposed in a chaotic environment. Another component to consider, as described by Diaz et al., is leadership. Leaders should be involved with adapting to situations to develop solutions for successful outcomes. Leadership involvement validates the research

conducted by Werder & Maedche (2018) as management support and development is essential in successfully influencing team dynamics.

To further explain the role of management support and team dynamics, Uhl-Bien and Arena (2018) conducted a theoretical analysis of leadership frameworks required for organizational adaptability in complex organizations. Uhl-Bien and Arena analyzed individuals' characteristics adapting to changing demands, dynamic capabilities, innovation, networks, and complex leadership frameworks. Uhl-Bien and Arena discussed new skills are required for leaders to challenge the status quo in CASs. In contrast, leaders in non-adaptive complex systems are focused on efficiency and control. Leaders who are adaptive in complex systems embrace new innovative ideas, which sometimes creates tension and conflict with risk-taking (Uhl-Bien & Arena). When leaders work collaboratively, a balance between innovation and conflict develops for more productive results (Uhl-Bien & Arena). Uhl-Bien and Arena's (2018) research is significant because leaders could use the leadership framework for implementing initiatives in complex organizations, such as strategies to improve physicians' test utilization ordering practices.

To improve physicians' test utilization ordering practices, Glover et al. (2020) discussed that innovation in the healthcare industry is challenging to implement because of the different clinical prevention methods, diagnoses, treatment options, increased interdisciplinary care, and team members being interdependent, which leads to unpredictable behavior requiring more adaptive solutions. The attitudes and motivations that influence teams and departments within CAS are different with complex systems

because team members are more interested in innovation when team members can demonstrate their capabilities (Glover et al., 2020). Glover et al. observed that complex working environments are different between units, and unit complexity is often associated with adverse patient and system outcomes influencing innovation performance. Hospital unit complexity was associated with higher innovation performance when autonomy is low (Glover et al.). Hospital leaders must provide direction and guidance for the leaders of hospital units and emphasize the intended innovation procedures to generate desired outcomes when complicated treatments are needed for patients; the staff should have less autonomy in such situations (Glover et al., 2020).

Strategies to Mitigate Inappropriate Test Utilization

There are many factors that contribute to physicians' inappropriate test utilization. Hall et al. (2019) discussed there is a worldwide demand to reduce unnecessary medical tests, treatments, and procedures. Physicians need to be involved with resource stewardship for test utilization, which begins with the residents. The authors stated that residents are often the first and last physician a patient encounters during hospital stays. Residents are often given autonomy when ordering tests with little oversight regarding appropriateness, resulting in a higher rate of inappropriate test utilization than practicing physicians (Hall et al.). Residents need to be educated as part of their curriculum on being good stewards of resources and ultimately developing appropriate ordering behaviors. The potential strategies discussed in this section are from the professional and academic literature available on the subject.

Sohail et al. (2020) discussed that frequent laboratory testing ordered by physicians for critically ill pediatric patients leads to test overutilization. However, repeated requests for laboratory tests can cause additional issues such as anemia, patient discomfort, and erroneous lab results contributing to incorrect diagnosis and treatments (Sohail et al.). The authors conducted a retrospective review of all children's medical records ranging in age from 1 month to 16 years admitted to the pediatric intensive care unit (PICU) for 6 months (Sohail et al.). Sohail et al. (2020) focused on three main categories: diagnostic/screening tests, hemostasis tests, and therapeutic monitoring tests to analyze the clinical indications and appropriateness for laboratory test orders and found that one-third of the tests performed were inappropriate. The researchers also stated no established standard guidelines existed for physicians to order laboratory tests for PICU patients contributing to improper decision-making practices. Sohail et al. (2020) found that most of the inappropriate tests ordered were biochemistry tests, specifically electrolytes.

Faisal et al. (2019) acknowledged that there is debate on what strategies achieve the best results to reduce healthcare spending. Inappropriate test utilization is an area of concern because the effects can lead to adverse patient effects and increase health care costs (Faisal et al.). The authors' quantitative study that spanned 8-weeks at a 1068-bed tertiary hospital in Grand Rapids, Michigan, indicated that residents order more unnecessary laboratory tests than more experienced doctors (Faisal et al.). The researchers implemented four interventions to educate internal medicine residents to be good stewards of laboratory testing. The four interventions included:

- A 30-minute presentation highlighting the benefits of reducing the number of routine blood tests
- At the beginning of each rotation, residents received a verbal reminder to justify the orders for blood tests
- A reminder email was sent halfway through the residents' 4-week rotation
- Posters were displayed in the residents' work areas included the price of a complete blood count (CBC), basic metabolic panel (BMP), comprehensive metabolic panel (CMP), renal function panel, and hemoglobin and hematocrit

Faisal et al. reviewed the median number of blood tests ordered by the residents with the interventions in place and found that the median number of CBCs and CMPs significantly decreased. Faisal et al. stated that the residents found the posters with laboratory test prices (94.1%) and encouragement from the attending physicians (82.4%) were the most effective strategies (p. 718). The authors observed that the number of routine blood tests ordered per day reduced by half, and hospital stays decreased by approximately one day.

de Wolff et al. (2020) examined another approach to improve test utilization. de Wolff et al. stated that physicians need to diagnose patients rapidly and reliably to diagnose COVID-19 and identify asymptomatic carriers. de Wolff et al. investigated six different simulation testing methods to determine the most efficient testing strategy for SARS-CoV-2 in laboratories with limited testing capabilities. de Wolff et al. found that testing personnel could analyze 10 times more samples than individual testing processes by pooling SARS-CoV-2 samples. de Wolff et al. explained that pooled-based specimens

also reduced the number of false-positive diagnoses, and this methodology could benefit public health measures as a testing strategy to increase testing capabilities.

Inappropriate test utilization is not limited to inpatient hospital environments. Song et al. (2021) discussed 12 billion medical laboratory tests are performed annually in the United States (p. 1674). Many of these tests are analyzed by out-of-network laboratories, generating additional costs and concerns regarding the appropriateness of the physicians' orders. In a review of 43 million people covered for at least one year in the IBM MarketScan Commercial Claims and Encounters Database, Song et al. found that out-of-network laboratory testing increased by 18.9% per year between 2008-2016, specifically for toxicology tests and the out-of-network prices exceeded the in-network prices (p. 1676). Song et al. posited that the increase in toxicology testing utilization could be attributed to patients with substance abuse disorders and treatment programs setting prices higher than the allowable insurer networks. The lack of guidance with physician ordering practices may be another factor contributing to inappropriate test utilization causing increased costs.

As laboratory tests are continually being developed, consumers can utilize over-the-counter tests for self-testing, adding a new dimension to test utilization without licensed provider supervision. Pettengill and McAdam (2020) provided an example of test utilization where some healthcare officials had proposed universal, frequent, low-cost testing, such as self-testing with home tests, to detect the coronavirus disease to identify and quarantine individuals with positive test results to reduce the spread of the disease throughout communities. Pettengill and McAdam (2020) explained that there are

challenges in using inexpensive paper strips for self-testing from a technical and practical perspective. For example, individuals who self-test may not report the results to their physician or public health officials, while asymptomatic people who test positive may not self-quarantine, and home tests could produce false positive or negative results because of reduced specificity and sensitivity. Pettengill and McAdam's research highlights that in addition to physicians' test utilization, patients are performing testing more often without the guidance of a licensed provider, potentially causing additional safety issues.

Feedback Initiatives

One potential strategy is feedback initiatives for clinicians. Vrijsen et al. observed that personal factors played a role in test overutilization. Several physicians in the study indicated that feelings of insecurity were a contributing factor when ordering tests. Another cause of overutilization detected by Vrijsen et al. was the resident's preceptor's lack of feedback to provide constructive criticism as an educational opportunity to improve laboratory test selection.

Baird (2014) discussed that healthcare leaders must correlate laboratory test utilization with patient data regarding diagnosis. For leaders to effectively manage test utilization, metrics are required. Health information databases can assist with utilization management and interventions (Baird). One method to measure appropriate test utilization is a computerized clinical decision support (CDS) system. A CDS system can provide more automated processes to evaluate test utilization and the patient's acuity (severity of the illness). The research performed by Behling and Bierl (2019) aligns with the outcomes from the research study conducted by Baird and Procop et al. (2014).

Behling and Bierl enhanced the CDS system by including the inpatient test/case-mix (acuity) to evaluate the test volume and cost/case mix index to analyze the relationship between discharge and hospital days to assess the financial impact (Behling & Bierl).

Bindraban et al. (2019) discussed the overutilization of tests ordered by physicians is a challenging problem, which is related to an estimated 20% rate (p. 2). The researchers conducted a qualitative improvement before and after the study with the internal medicine departments in four large teaching hospitals in the Netherlands. Bindraban et al.'s research question was: *What is the association of a multifaceted intervention aimed at changing caregivers' mindset with the amount of unnecessary testing?* Bindraban et al. collected data for the volume of tests associate with the duration of hospital stays, repeated outpatient visits, 30-day readmission rates, and the rate of prolonged hospital stays for patients admitted with pneumonia. The most beneficial outcomes identified by Bindraban et al. were physician education, feedback, and residents' involvement to reduce overutilization of laboratory tests and inappropriate ordering practices. Bindraban et al. posited that the sustainability of long-term interventions requires new hire education, continuous education, and visual reminders, such as mouse pads and posters in the work areas with reminders about appropriate ordering practices.

Hauser and Shirts (2014) discussed that test utilization is a component of quality improvement; however, there is a lack of consensus about who should oversee appropriate test selection, such as the pathologists or the clinicians. Hauser and Shirts conducted a qualitative research study that consisted of audits from database queries,

chart reviews, surveys, and questionnaires, in addition to a literature review. The authors suggested that the pathologists need to oversee test utilization by clinicians. Clinicians also have a responsibility to make accurate referrals to decrease false-positive results due to unnecessary tests' overutilization (Hauser & Shirts). The authors suggested a team approach to observe ordering patterns, develop interventions, and modify clinicians' ordering behaviors as part of continuous quality improvements. Hauser and Shirts posited there is a lack of leadership regarding the oversight of test utilization, which supports the research of Harnett et al. (2020) that some leaders lack the needed leadership skills needed to manage test utilization programs.

To enhance leadership skills, Ducatman et al. (2020) evaluated clinical scenarios demonstrating the effects of clinicians' orders that resulted in test overutilization and underutilization of orders. Ducatman et al. found that pathologists could serve as liaisons in the medical community as a strategy to improve test utilization gaps. Ducatman et al. stated there is an opportunity for pathologists to be engaged in test utilization stewardship at healthcare institutions and population health initiatives since pathologists have comprehensive medical laboratory knowledge and can provide real-time education with clinicians' ordering practices (Ducatman et al.). The authors posited that pathologists need to educate other stakeholders about test utilization to improve quality and cost-effectiveness when shifting to value-based payment structures for physicians (Ducatman et al.).

To improve value-based payment structures, Naugler and Wyonch (2019) researched test utilization and associated costs in the Canadian health care industry. The

authors discussed that laboratory tests are essential to aid clinicians in diagnosing patient conditions and quality improvement. Inappropriate laboratory testing included both overutilization and underutilization, leading to unnecessary testing, inaccurate diagnoses, delayed decisions and treatment, and the deterioration of a patient's condition adding to the waste of resources and increasing expenses. The researchers proposed three metrics to measure clinicians' ordering practices. These metrics included: peer-to-peer variation, the mix of tests ordered, and abnormal test rates (Naugler & Wyonch). The authors discussed other strategies to reduce inappropriate test utilization. These strategies included:

- Making physicians aware of the problem with inappropriate test utilization
- Implementation of capitation for physicians
- Requiring physicians to justify ordering tests outside the guidelines
- Develop formularies that indicate reimbursement for public insurance and purposes
- Electronic restricted access for inappropriate tests

Naugler and Wyonch stated that combining these strategies could be more effective than just feedback from audits. The authors posited that the interventions that impose restrictions, such as electronic, hard stops, are the most effective approaches to reduce inappropriate test utilization. The research conducted by Naugler and Wyonch reinforced the study undertaken by Harb et al. (2019) regarding physician awareness and technology restrictions.

To enhance physician awareness with test utilization, Brady et al. (2018) focused their research on clinician ordering practices with geriatric patients in an Irish tertiary

hospital. The authors trialed five interventions: poster education, presentation education during Grand Rounds to highlight inappropriate duplicate testing, lab information system review, patient empowerment, and modification of the transfer documentation, including discharge, transfer, and referral communication (Brady et al.). Brady et al. found that many patients did not understand or receive communication from clinicians regarding collecting laboratory tests. Another outcome was the lack of a standardized integrated information technology (IT) system, which generated new medical record numbers with patient admissions leading to duplicate laboratory orders (Brady et al.). The authors observed that combining educational activities and modifications to the lab information system generated a 40% reduction in test overutilization (Brady et al., 2018, p. 31). Brady et al. posited that poster education and presentation education with Grand Rounds caused an initial decrease in unnecessary laboratory tests, which could be applied worldwide to reduce laboratory costs associated with inappropriate laboratory testing in hospitals.

Information Technology (IT)

Another strategy to reduce inappropriate test utilization is information technology (IT) solutions. Leaders need to incorporate the CAS framework with technology to support multifaceted decision-making with test utilization practices, which could benefit leaders to change the behavioral patterns of clinicians, leading to improved test utilization (Heino et al., 2021). Heino et al. (2021) discussed that people are complex systems who are part of interdependent elements without control, whose interactions increase with emergent behaviors. Individuals' future behaviors in complex systems depend on the interactions based on past experiences and adapt to the environment to coevolve with

behavioral changes (Heino et al., 2021). IT solutions provide a mechanism to standardized and adjust physician behaviors to assist with test utilization decisions.

According to Patel et al. (2019), more than 25% of laboratory tests ordered by physicians are not necessary. For example, laboratory testing in the intensive care unit (ICU) can contribute up to 10% of the costs for a hospitalization stay (Patel et al., 2019, p. 4). The authors discussed that physicians failing to follow-up on correctly ordered tests, a lack of physician awareness, and repeat testing despite an established diagnosis significantly contributes to physicians ordering unnecessary laboratory tests. Patel et al. identified that physicians' inappropriate ordering practices decreased in an ICU when a list of patient charges was available for physicians when ordering diagnostic tests. Patel et al. recommended computer-based programs as a best practice to detect duplicate tests and foster clinical education when ordering laboratory tests. The findings presented by Patel et al. support the importance of computer-based solutions and physician education to reduce the financial burdens associated with inappropriate test utilization.

Kobewka et al. (2015) discussed that 95% of tests ordered by physicians are not appropriate, including duplicate tests, which are non-value-added for patient care (p. 157). The research conducted by Procop et al. (2014) demonstrated that computerized physician order entry (CPOE,) a form of CDS, information technology with hard stops, provided a viable strategy to minimize duplicate test orders. Duplicate test selection occurs for a variety of different reasons. One cause was that physicians were too busy to review pending orders (Procop et al.). Other issues are disruptions with clinical workflows leading to inadequate patient care decisions (Jackups et al., 2017). The

qualitative research study conducted by Vrijsen et al. (2020) supports the findings of CDS from Procop et al. and Jackups et al. technical solutions with "pop-up" alerts and hard-stops are one potential solution to minimize physicians' overutilization of tests (Vrijesn et al. p. 52). Although CDS has proven successful, there are some limitations with this information technology solution (Jackups et al.). One limit is alert fatigue, resulting in numerous notifications because they are often ignored or not determined to be necessary by the physician, leading to harmful patient care issues.

In addition to alert fatigue, Adelman et al. (2019) discussed that the number of electronic records open at one time could contribute to the selection of wrong-patient orders. Adelman et al. conducted a randomized clinical trial performed for 18 months at a large academic medical center that included four hospitals (total of 1536 beds), five emergency departments, and 144 outpatient facilities. Adelman et al. tested the hypothesis that limiting physicians' access to open one patient at a time would result in significantly fewer wrong-patient orders compared to unrestricted access to up to four open records. The researchers found no significant statistical difference between the two groups with wrong-patient orders. However, Adelman et al. posited that multiple records opened simultaneously creates a significant risk factor with patient identification and incorrect test choices from a patient safety perspective**.**

To mitigate risk factors with patient identification, Krasowski et al. (2015) conducted a qualitative case study spanning 3 years using electronic medical record (EMR) strategies to improve laboratory test utilization. Krasowski et al. focused on high-cost reference laboratory tests, duplicate tests, high-volume automated tests, and similar-

looking tests. The qualitative research by Krasowski et al. revealed that adding restrictions to the EMR and computerized provider order entry (CPOE) systems reduced high-cost reference tests by 23% and demonstrated a decrease in similar and duplicate tests, which could improve significant patient care issues, such as blood loss, invasive procedures, follow-up testing, and unnecessary specialist referrals (p. 3). The research conducted by Krasowski et al. supports the research conducted by Adelman (2019) using technology to manage physician ordering practices.

To manage physician ordering practices using technology, Chami et al. (2021) evaluated the association between a laboratory electronic medical record (EMR) system and the rate of inappropriate testing with hemoglobin A1c (HbA1c), lipid and thyroid-stimulating selected HbA1c, lipid, and TSH tests because primary care physicians routinely ordered these tests to screen patients with chronic illnesses. Chami et al. observed an association between a laboratory EMR system and a reduction in the rate of test utilization by primary care physicians with HbA1c, lipid, and TSH tests when the EMRs alerted physicians of tests ordered before the recommended timeframe. Chami et al. posited physicians should be encouraged to use EMR systems to improve test utilization and lower unnecessary healthcare costs for better patient care.

The researchers used a literature review and questionnaires to develop a Choose Wisely Canada (CWC) resource stewardship list (Hall et al., 2019). From the questionnaires, five recommendations were identified from the feedback to improve test utilization. The recommendations by Hall et al. included:

- Do not order investigations that will not change your patient management plan.

- Do not order repeat laboratory investigations on clinically stable inpatients.
- Do not order intravenous (IV) when an oral (PO) option is appropriate and tolerated.
- Do not order non-urgent investigations or procedures that will delay the discharge of hospital inpatients, and
- Do not order invasive studies if less invasive options are available and as effective.

These top-ranking recommendations demonstrated the customization component with the CWC program to improve test utilization and resource management, which could apply to other health care institutions. The CWC program provides an opportunity to bridge the gap between inconsistent ordering practices into a standardized algorithm to prevent inappropriate test utilization.

Born et al. (2019) discussed that with the inception of the CWC system, adjustments need to be made to this program as physicians are not the only ones ordering tests. Physicians developed an awareness of inappropriate test utilization with the CWC program, but recognition is not enough for physicians to change their ordering practices. Born et al. stated that other health professionals such as nurses, dentists, and pharmacists order tests and collaborate with physicians. The researchers discussed that patients also need to be included in the alliance with medical professionals with clinical decisions as communication is a central element of the CWC program. Physicians face additional challenges, such as getting patients to accept evidence-based practices against unnecessary tests (Born et al.). The CWC programs in Canada, New Zealand, England,

and Australia developed a set of questions in partnership with *Consumer Reports* for patients to ask their doctors about unnecessary tests to improve unnecessary testing. These questions include:

- Do I really need this test or procedure?
- What are the risks?
- Are there simpler, safer options?
- What happens if I do nothing?
- How much does the test cost?

Born et al. (2019) discussed that including the patient is a strategy to bridge the knowledge gaps with test overutilization. Physicians need to include patients in the plan of care regarding decision-making processes instead of being excluded. Improved communication between the patients and physicians will provide new opportunities for programs such as CWC (Born et al., 2019).

Aziz and Alshekhabobakr (2017) discussed that improper test utilization by physicians leads to wasting financial resources in the health care industry. Aziz and Alshekhabobakr categorized inappropriate test utilization into three categories: overuse, underuse, and misuse. Based on the authors' research, some physician ordering practices tend to be personal preference and not for better patient outcomes. Aziz and Alshekhabobakr discussed that routine and simple tests account for most orders, and physicians contributed to inappropriate ordering practices for the same diagnosis without considering the costs. The authors stated electronic health records (EHR) in combination with three other electronic systems: clinical decision support system (CDSS),

computerized provider order entry (CPOE), and laboratory information system (LIS) could be used as a health information exchange strategy to improve that the lack of standardization with physician ordering practices. For example, CDSS provides physicians information based on clinical practice guidelines, including alerts and reminders to avoid unnecessary tests. CPOE reduces errors attributed to illegible laboratory test orders and improves physician variations in care. LIS manages the data received for orders and the output of results. Aziz and Alshekhabobakr stated that combining the three electronic systems helps standardize patient care, significantly improve test utilization practices, increasing patient satisfaction, and improving health care processes.

Zare et al. (2021) stated that clinicians' inappropriate laboratory test orders contribute to 20% of over-utilized tests, and 45% of tests are underutilized, causing increased waste (p. 1). In a quantitative, quasi-experimental design research study, Zare et al. evaluated clinical decision support systems (CDSS) as an intervention with physicians' ordering laboratory practices and literature evaluations with CDSS regarding laboratory tests, physician, and patient outcomes. Zare et al. observed that CDSSs support improving physicians' ordering test utilization practices by reducing duplicate test orders and improving evidence-based decision-making. Zare et al. highlighted the positive effects of CDSSs regarding physicians' laboratory test ordering practices. However, more research is needed to identify the adverse effects and potential patient harm with canceling tests using CDSSs.

Sutton et al. (2020) examined the benefits and risks with clinical decision support systems (CDSS) to improve physicians' medical decisions for better test utilization. The authors discussed that CDSSs are endorsed by the U.S. Government's Health and Medicare acts and utilized by other countries such as Canada, Denmark, Estonia, Australia, etc. (Sutton et al., 2020). The benefits of CDSSs for diagnostic laboratory support included standardized interpretation of laboratory results, improved patient safety, clinical management, diagnostic support, better physician documentation, improved clinician workflow, and cost containment (Sutton et al., 2020).

Conversely, Sutton et al. identified several risks of CDSSs, including increased physician dependence on CDSSs, leading to reduced critical thinking skills and computer alert fatigue impacting clinical decision-making and patient safety (Sutton et al.). CDSSs can also be expensive to implement, and the benefits of cost containment can be prolonged and are not guaranteed (Sutton et al.). Implementing CDSSs by hospital leaders can provide several opportunities to improve physician decision-making support with diagnostic test utilization. However, hospital leaders must take precautions when designing, implementing, and maintaining CDSSs to optimize the benefits with minimal risk (Sutton et al.).

Physicians’ inappropriate test utilization ordering practices contribute to the rising costs of healthcare, which is not limited to the United States (Delvaux et al., 2020). The increase in physicians’ ordering practices does not signify that more tests are better and often represent overused, underused, or misused tests, creating increased costs and delayed or inaccurate diagnoses (Delvaux et al.). In a cluster-randomized, controlled

clinical trial study with general practitioners, Delvaux et al. analyzed 288 general practitioners' laboratory test practices from 72 primary care practices in Belgium. Delvaux et al. found that when a clinical decision support system (CDSS) combined with the computerized physician order entry (CPOE) system, physicians' laboratory test ordering practices improved with 17 routinely ordered tests. The combination of a CDSS for order sets with CPOE not only improved the number of appropriate laboratory tests ordered by physicians but demonstrated that this intervention was also safe for diagnostic decision-making because there was no increase in diagnostic errors. Although Delvaux et al. identified an effective intervention to improve inappropriate physicians' ordering practices, more research is needed to determine if the strategy could apply to more complex systems and other physician specialties with the same effects.

Leblow et al. (2019) discussed that improper test utilization management is not a new problem in the healthcare industry. Leblow et al. conducted a study analyzing the claims or physicians' orders from a reference laboratory and a small insurance provider that managed self-pay organizations using the Laboratory Decision System (LDS). Leblow et al. observed significant improvements with test ordering and test utilization management with the LDS, which detected 43.3% of test orders failed to meet ICD10 criteria, and 50% of submitted orders did not meet medical necessity with the LDS program (p. 4). Leblow et al. discussed that many healthcare institutions had implemented other computer systems such as computerized provider order entry (CPOE) and Medical Database, Inc. (MDS) as strategies to improve inappropriate test utilization. Leblow et al. stated that the LDS included appropriate ICD10 codes, identified the

correct initial test before physicians ordered a reflex test, included reference ranges, sample collection and handling requirements, and test methodology to assist providers with selecting the most relevant test for a patient's condition and treatment, where these elements were not all included in CPOE, and MDS Inc. Leblow et al.'s study supports the research study performed by Aziz and Alshekhabobakr (2017) and Krasowski et al. (2015) using technology as a strategy to manage physician ordering practices with clinical decision support to meet the insurance payer's medical necessity requirements not found in other systems.

Physicians' test utilization ordering practices in emergency departments contribute to the rising costs of healthcare and demonstrate a link to over-utilization of coagulation tests (Tawadrous et al., 2020). Tawadrous et al. (2020) analyzed the results of a prospective pre and post-study of all emergency department visits over a 2 year period at two academic hospitals: London Health Sciences Centre's Victoria Hospital and University Hospital in Canada with coagulation tests: international normalized ratio (INR) and activated partial thromboplastin time (aPTT). Tawadrous et al. found that when physicians ordered coagulation tests separately using an online education module and a clinical decision support system, the coagulation test orders and associate costs were reduced by 45% without causing harm to patients based on the difference between the pre and post data (p. 534). Tawadrous et al. posited that a multi-dimensional strategy could significantly decrease unnecessary coagulation test utilization reduce costs. Although Tawadrous et al. identified a model to improve physicians' ordering practices in emergency departments, the study was limited to one order set. Additionally, the data

may not represent all physicians' ordering practices with laboratory order sets for all emergency departments.

Although technology can improve physician ordering practices, in an observational study of physicians' laboratory orders at a 1,526-bed university hospital in Rome, Italy, Tamburrano et al. (2020) examined the number of violations encountered with 43 commonly ordered tests using a clinical decision support system (CDSS). Tamburrano et al. observed a 14.2% (+/-3%) overutilization rate with physician ordering practices (p. 6). The increased overutilization costs included the following tests: complete blood count, fibrinogen, and total serum protein (Tamburrano et al.). Tamburrano et al. posited that CDSSs, combined with physician education, feedback, audits, and test panel modifications, can provide effective interventions to improve inappropriate test utilization. While Tamburrano et al. identified viable interventions, more research is needed with international medical organizations to develop standardized rules for physicians most commonly ordered tests to improve ordering practices and reduce costs.

Summary

One area contributing to the diminishing quality of patient care and increased costs and waste in the healthcare industry is clinicians' inappropriate laboratory test utilization. The literature review was assessed through the lens of the CAS conceptual framework based on the theory by John Holland and LSS to understand the concepts necessary to improve physician's test utilization ordering practices and the significance of the study: (a) foundation of inappropriate test selection by clinicians, (b) relationship between inappropriate test selection and CAS and LSS, (c) and strategies to improve

inappropriate test utilization. These components provide the foundation for formal strategies used to improve physicians' inappropriate test utilization.

Transition

In Section 1, I discussed the foundation of the study, including the problem, purpose of the research, the significance of the study, and the research question. Healthcare leaders can use the CAS conceptual framework to understand the concepts necessary for successfully implementing strategies to improve physicians' test utilization ordering practices to reduce healthcare costs. I provided an in-depth analysis and synthesis of multiple scholarly sources related to the research study, with the literature review as the foundation of this research study. In Section 2, I will discuss the purpose of the study, the role of the researcher, the participants in the study, the research method, the research design, population and sampling, the ethical research elements, the data collection instruments, the data collection technique, the data organization techniques, data analysis, reliability and validity, and the transition and summary.

Section 2: The Project

In Section 2, I restate the purpose of the study. I then discuss the role of the researcher, the participants in the study, the research method, the research design, population and sampling, and the ethical research elements. Last, I address the data collection instruments, the data collection technique, the data organization techniques, data analysis, reliability and validity, and provide a transition and summary.

Purpose Statement

The purpose of this qualitative single-case study was to identify strategies that some hospital leaders use to minimize inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs. The target population was hospital leaders from different hospitals within a single healthcare system in Maryland and Washington, D.C. I interviewed seven hospital leaders who had implemented successful test utilization strategies by physicians. The prospective social change benefits include fewer testing-related risks for patients and reduced healthcare costs, resulting in improved dignity and quality of life for individuals in local communities and enhanced services' quality provided by hospitals.

Role of the Researcher

In this qualitative research study, I was the primary data collection instrument, which required me to identify beliefs, assumptions, and biases. The researcher is responsible for establishing and maintaining the rigor in data collection while reliably and accurately representing the participants' responses (Saunders et al., 2019). Additionally, researchers are bound by ethics rules and must be conscious of their relationships with

the research topic and participants with biomedical and behavioral research (Earl, 2020). Researchers can use the Belmont Report to understand the basic ethical principles when working with human subjects. The Belmont Report was established to prevent misconduct and abuse of research subjects by instituting three basic ethical principles to protect human subjects: respect for individuals, beneficence, and justice (U.S. Department of Health & Human Services, 2018). The Belmont Report also addresses documentation with informed consent, assessment of risk and benefits, and selecting subjects for the research study (U.S. Department of Health & Human Services, 2018).

To strengthen the rigor of my research study, I used semistructured interviews and was open-minded with exploring the participant's experiences to discover information not previously reported. The researcher must develop the conceptual framework applied to the research study to ensure the rigor and credibility of the research design to minimize bias (Johnson et al., 2020). Personal or interviewer bias could affect participants' responses by influencing the participant to respond based on the interviewer's beliefs and should be minimized as much as possible. Interviewee bias is another form of bias that the researcher must recognize. Interviewees may possess bias towards the interviewer and may not respond honestly. Last, researchers need to acknowledge participation bias with the interviewees or organizational participants (Saunders et al., 2019). Participation bias could be affected by the time required for an interview and cultural differences between the interviewer and interviewee, impacting the interactions for a successful interview. The researcher must remain neutral and focus on the data collected and avoid influencing the results of the research findings (Chivanga & Monyai, 2021).

As a healthcare professional working in several hospital clinical laboratories, my perceptions of laboratory test utilization have shaped my personal experiences with physician ordering practices. I have observed the ordering practices of numerous physicians in different healthcare institutions in my career. My experiences over the years enhanced my awareness, knowledge, and understanding of the many challenges and issues surrounding physicians' ordering practices related to test utilization. Because of my personal experiences in the clinical laboratory, I brought certain biases to this study. Researchers must be aware of personal bias and mitigate threats to the reliability of a research study (Saunders et al., 2019). To reduce potential personal bias, I refrained from judgments based on my experience, limited sources that would only support my initial understanding of inappropriate test utilization, and remained open-minded regarding data collected from multiple perspectives contrary to my beliefs and assumptions. The goal of the interview protocol was to explore participants' experiences and discover information not previously reported. I applied different validity strategies and tools such as member checking for transcript validation, data saturation, carefully constructed interview questions, and kept a diary documenting any personal bias to mitigate personal bias in my research study. Researchers have a responsibility to protect the rights of the participants at all times (Wendler, 2020). I was conscious of the ethical implications of my research study and protected the rights of the participants at all times and minimized any potential harm to the participants, even after the conclusion of the study.

Participants

Researchers must determine the eligibility of the participants to collect data in a research study (Yin, 2018). The participants were hospital leaders from different hospitals within a single healthcare system in Maryland and Washington, D.C. I interviewed seven hospital leaders, such as vice presidents, chief operating officers, and chief financial officers, who had implemented successful test utilization strategies. Participants were selected based on their ability to provide detailed knowledge regarding test utilization and the desire to improve the performance of the organization using the CAS conceptual framework and standardized LSS principles. Targeting organizational leaders with interest in the focus of the study minimized the rejection of access to the organization. In addition to the hospital leader's willingness to participate in the study, participants had a minimum of 3 years of service in their current or similar leadership role. I first inquired with individual hospital leaders in the system if the organization required formal approval for the potential participants to take part in the research study. Once permission was granted, access to the healthcare leaders was accomplished through a gatekeeper. I allowed at least 2 hours to follow up with potential participants through email correspondence, telephone calls, and Microsoft Teams meetings.

As a result of COVID-19 pandemic, face-to-face interviews were not appropriate. Additionally, establishing credibility and rapport with the participants is critical to gain access and cooperation to conduct the research study (Saunders et al., 2019). The researcher needs to identify the benefits to the participants, address anonymity and

confidentiality concerns, and explain the efficiency of the interview process to minimize any apprehensions regarding the sensitivity of the topic (Saunders et al.).

Research Method and Design

The research method and design are described in this section. Researchers correlate the subjective meanings of the research topic studied by carefully identifying the problem and collecting, analyzing, and interpreting the data (Saunders et al., 2019). Accounts from organizational members provide the specialization needed to understand the dynamics affecting the stakeholders affiliated with the research problem (Shufutinsky, 2020). Researchers use qualitative research to explain questions to understand the issue where a quantitative method of manipulating variables are not appropriate (Nassaji, 2020). The purpose of this qualitative case study was to explore the strategies hospital leaders use to improve test utilization, which allowed me to explore and understand the phenomenon of effective strategies to minimize inappropriate test utilization to improve efficiency and reduce healthcare costs. I conducted semistructured interviews with hospital leaders from a health system in Maryland and Washington, D.C.

Research Method

I selected qualitative method for this study. Researchers choose among quantitative, qualitative, and mixed methods (Saunders et al., 2019). Quantitative researchers test hypotheses to investigate variables' characteristics and relationships (Saunders et al., 2019). Qualitative researchers use open-ended questions, such as "what," "how," and "why" questions to determine what is occurring or has occurred (Yin, 2018). Mixed method researchers use both the qualitative and quantitative methods (Saunders et

al., 2019). To understand the appropriate test utilization strategies employed by hospital leaders, I did not test hypotheses, which is part of a quantitative study or the quantitative segment of a mixed-methods study. I selected the qualitative method to explore and understand the phenomenon of effective strategies to minimize inappropriate test utilization to improve efficiency and reduce healthcare costs.

Research Design

I considered four designs in this qualitative study: ethnography, narrative, phenomenology, and case study. The ethnography design involves studying the culture of one or more groups (Saunders et al., 2019). The ethnography design was not appropriate for my research study, because I did not research a group's culture. Researchers use the narrative design to collect information about participants' personal life stories based on an event or sequence of events (Saunders et al., 2019). The narrative design was not appropriate for my research study, as my research study was not focused on peoples' personal lived experiences through their life stories. Researchers use the phenomenological design to investigate the meanings of participants' lived experiences with a phenomenon (Soule & Freeman, 2019). The phenomenological design was not appropriate for my research study because I did not explore the personal meanings of participants' experiences with phenomena. Case study researchers use open-ended questions to answer *what, how,* and *why* questions to explore a current situation or event (Yin, 2018). I used an embedded single-case study design so I could interview hospital leaders at different levels at different locations of a single organization of particular interest to enable me to garner a deeper understanding and more holistic view of how the

organization's leaders developed and implemented effective strategies to reduce inappropriate test utilization by physicians.

I collected data through interviews for the single-case study and hospital documents such as policies. Researchers need to ensure data saturation when conducting qualitative research to demonstrate the rigor and validity of the content. Fusch and Ness (2015) defined data saturation as no new information acquired, there is enough information available to replicate the study, and additional coding is not feasible. Adequate sample size varies with research studies. Mthuli et al. (2021) stated that in some cases, data saturation could be accomplished in as few as six interviews, where other research studies could require a larger sample size with additional interviews (p. 2). When researchers can no longer obtain new themes or insights, adequate sample size is achieved for data saturation (Yin, 2018).

Population and Sampling

Researchers should use samples of a population when data collection is impractical for an entire population, and the sample should represent the population that can best answer the research question (Saunders et al., 2019). I considered convenience sampling and purposive sampling methods for this research study. Some researchers use convenience sampling because the participants are easily accessible (Yin, 2018). However, convenience sampling is the least rigorous approach, and the data might result in low accuracy, poor representation, low credibility, and lack of transferability of results (Johnson et al., 2020). Purposive sampling allows researchers to obtain data from specific types of participants that could best answer the research question based on the

participant's experience and expertise (Bougie & Sekaran, 2020). Additionally, the purposive sampling method is considered a best practice to increase qualitative research rigor and trustworthiness (Johnson et al., 2020) to provide an increased depth of understanding of the research topic (Campbell et al., 2020). Since the participants for this research study were selected intentionally for optimized data collection based on participants' experience and expertise with test utilization, I used purposive sampling.

The target population is hospital leaders from different hospitals within a single healthcare system in Maryland and Washington, D.C. Guest et al. (2020) discussed research studies to determine how many interviews are enough in qualitative research to achieve data saturation. Guest et al. (2020) stated that one approach to determining data saturation and the estimated sample size is related to the base size, run length, and new information threshold. Guest et al. (2020) found that the first five to six interviews produced the majority of new information in the dataset and that minimal new or valuable information was obtained as the sample size reached 20 interviews (p. 2). I conducted a minimum of six interviews with selected participants to obtain the depth of information in the research process.

Data saturation is a crucial component of rigor in qualitative research (Guest et al., 2020). Data saturation is attained when there is no new or valuable information, enough information is available to replicate the study, and additional coding is not feasible (Fusch & Ness, 2015). For this single-case research design, I used semistructured interviews that include the same standard questions and interview format and test

utilization performance reports to confirm and identify any variances from the interview findings to obtain more in-depth information.

Ethical Research

Ethical considerations are essential for a research study. The researcher has the responsibility to protect the participants from harm, and individuals have the right to privacy. Participants should not be pressured or coerced into participating in a research study (Saunders et al., 2019). The Belmont Report was established as one mechanism to protect participants from malfeasance, including three basic principles to protect human subjects: respect for individuals, beneficence, and justice (U.S. Department of Health & Human Services, 2018). Many research studies offer incentives to attract participants. However, I did not offer any incentives for the participants, but shared the summary of the final results with the participants and sent them a thank you note for their time to participate.

Obtaining informed consent from the participants is a critical principle in ethical research to provide sufficient information about the research study. Participants can ask questions about the research study to ensure they are fully informed, including the right to withdraw from the research study at any time (Saunders et al., 2019). I obtained informed consent from all participants before conducting any interviews. Researchers also have the responsibility to respect the privacy and anonymity of each participant to protect them from harm (Favaretto et al., 2020). I explained to the participants that their interviews would be strictly confidential. I achieved the anonymity of the participants by assigning participants a numeric code, such as P1 so that the participants cannot be traced

back to their respective institution or position. I had the conversation with the participants that they have the right to withdraw from the study at any time. Data collected from the interviews will be secured for 5 years using encryption codes for electronic media and discarded after 5 five years to protect the rights of the participants. Once my proposal was submitted, I completed the Institutional Review Board (IRB) forms for the participating organization and Walden University to start the approval process. The final doctoral manuscript included the approval letter from the participating organization (STUDY00005092) and the Walden IRB approval number (06-08-22-1026341) . Participant names or any other identifying information of individuals or organizations were not included in the final document to uphold the ethical standards of this research study. Additionally, I completed the CITI Doctoral Student Researchers basic course training - record number 38397103 and 48739158, responsible conduct of research for administrators – record number 48739155, and GCP – social and behavioral research best practices for clinical research – record number 48739159 to understand the ethical research requirements and guidelines involving human subjects.

Data Collection Instruments (Qualitative Only)

The researcher is the primary data collection instrument in qualitative studies. Researchers should use more than one source of data when conducting qualitative research studies to increase the validity of a study. Secondary data sources include but are not limited to organizational documentation, such as performance reports, and observations (Yin, 2018). Nassaji (2020) explained that good qualitative research is robust, well-informed, and well documented. Researchers follow a vigilant process of

identifying the problem, collecting, analyzing, presenting, evaluating, and interpreting the data (Nassaji, 2020). I used multiple data sources throughout this research study, including semistructured interview questions, organizational performance reports, and keeping a journal of observations to assist with mitigating bias as the primary data collection instrument.

Researchers can obtain reliable data from semistructured interviews with open-ended questions to obtain responses from the participants (Yin, 2018). However, during a semistructured interview, researchers need to ask specific questions and not lead participants to answers to mitigate bias with the information obtained. The data collection process ends when saturation is achieved (Busetto et al., 2020). I used a standardized interview protocol during the interviews, including seven interview questions. I also asked probing questions to extract more information from the participants depending on the subjects' responses. For example, I asked, "Tell me more," "Could you explain your response?" and "What does this mean?" (Creswell & Creswell, 2023, p. 205). Additionally, I limited the interview sessions to 30 to 45 minutes to respect the participants' time. The interviews were recorded with the participants' approval to encourage collaboration between the participants and the researcher.

Data Collection Technique

The data collection techniques for this study included semistructured, open-ended questions to interview participants from a single healthcare system in Maryland and Washington, D.C. I also reviewed organizational performance reports and observations. Researchers can use semistructured interviews to collect new data by exploring the

participant's personal experiences, attitudes, perceptions, and beliefs related to the specific research topic (DeJonckheere & Vaughn, 2020). The semistructured interviews allowed me to obtain in-depth information from hospital leaders to identify strategies that some hospital leaders use to minimize inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs. I also performed member checking and triangulation with the data sources to validate the findings.

Since interview questions are an influential component of a qualitative research study, researchers often follow interview protocols when conducting interviews. Researchers first identify the participants in the study. Researchers must develop a rapport with the participants, inform the participants about the ethical issues regarding the study, such as informed consent and protecting the interviewees' information from harm (DeJonckheere & Vaughn, 2020). I initially contacted the participants through telephone calls or email and performed the interviews using Microsoft Teams application to comply with the COVID-19 pandemic protocols. I recorded the participant interviews using Microsoft Teams and a tape recorder as a backup. Before conducting the interviews, I performed an equipment check of all the devices before recording the interviews to ensure the functionality of the equipment to minimize delays with the interviews and be respectful of the participant's time. I also took notes during the interviews to assist with identifying themes from the participants. After the interviews, I transcribed the information verbatim from the audio recording. I sent the completed transcripts and list of potential themes identified to the corresponding participant validating the researcher's interpretation of the participant's responses.

Although semistructured interviews can provide in-depth information about a specific topic of interest, researchers need to be aware of the benefits and limitations of conducting semistructured interviews. Researchers can effectively extract valuable data from participants. Researchers have the opportunity to develop a rapport with the participants, ask clarifying questions, and observe non-verbal communication queues (Bougie & Sekaran, 2020). Interview methods are also inexpensive to obtain data about the research topic (Bougie & Sekaran, 2020). However, semistructured interviews have limitations. One limitation is that not all interviewees make good participants (DeJonckheere & Vaughn, 2020). Some interviewees are challenging to engage in conversation or are reluctant to discuss the topic because of potential confidentiality concerns or other reasons affecting the data collection. Researchers can also have difficulty asking probing questions and not exercising active listening in such situations (DeJonckheere & Vaughn, 2020). Additionally, smaller sample sizes used for interviews could raise the issue of generalizability to an entire population (Rahman, 2017). Researchers must be aware of such potential limitations and develop backup plans to achieve the best interviews possible. Additionally, I followed all IRB requirements for ethical research data collection.

Data Organization Technique

Researchers need to organize the data collected from a research study to interpret the findings correctly and build logical themes to demonstrate validity (Creswell & Creswell, 2023). There are several organizational techniques I employed to categorize the data. I coded all participants' names to ensure confidentiality before conducting the

interviews, such as P1 for the first participant. I immediately transcribed the recordings of the participant interviews using the Teams transcribe application and categorized them in a Microsoft Word document creating the transcript for member checking with the appropriate participant. I used NVivo software to code and analyze the interview data. I organized my field notes and observations by the interview questions for each participant into a corresponding Microsoft Word document, including the interview date, participant code, major themes noted, and participant behavioral observations. I incorporated the organizational performance reports and observations in the Microsoft Word document as an electronic link, if available, or the data manually. Having all the data in one central location makde it easily accessible for the researcher and provide a clear chain of evidence (Yin, 2018). Protecting the data is essential in ethical research. I was the only person who had access to the data. Electronic data was password protected for access to the hard drive. I stored physical copies of other data sources in a secure, locked box in my personal dwelling. I deleted all electronic files and shred all paper documents 5 years after the approval of this study.

Data Analysis

Researchers can use multiple methods of data analysis for qualitative research studies. Yin (2018) discussed that researchers use data to discover patterns, insights, or concepts. Yin explained four general strategies to analyze case study data: (a) use the conceptual framework, (b) develop a detailed description of the case, (c) examine divergent explanations, and (d) identify emergent themes. According to Castleberry and

Nolen (2018), data analysis consists of five steps: compiling, disassembling, reassembling, interpreting, and concluding.

When compiling the data, some experts recommend the researcher manually perform the transcription of the interviews to become thoroughly familiar and develop a greater understanding of the data (Castleberry & Nolen, 2018). However, manual transcription is more time-consuming, and extra time was allocated for this step. In addition to manual transcription, I used computer-assisted software programs such as NVivo and word processing tools such as Word and Excel to categorize and code the raw data to identify themes that correlate with answering the research question.
Thematic analysis is a flexible tool that can assist researchers in identifying, analyzing, and reporting themes for an in-depth account of the data where researchers follow the process of discovering repeated patterns of meaning from the datasets. (Braun & Clarke, 2006). Coding occurs in the disassembling step and is an essential element in thematic analysis (Castleberry & Nolen, 2018). Coding is the process of exploring patterns and meanings from the datasets, including developing codes and applying code labels to specific segments of each data item (Braun & Clarke, 2022). The thematic analysis approach allowed me to identify and analyze themes from the data collected to answer the research question.

Yin (2018) suggested that researchers should interpret the data as it is being collected and recognize immediately if several sources of information contradict each other, requiring the researcher to collect additional data. To assist with data interpretation, Yin (2018) described five qualities of interpreting data. First,

interpretations should be complete. Second, the interpretations should be fair, so other researchers should reach the same interpretation with the same data. Third, the interpretations should be accurate and representative of the raw data. Fourth, the study will add value to understanding the topic in context with the current literature. Lastly, data methods and interpretations should be credible and gain the respect of other scholars. These data interpretation qualities assisted me with my data analysis to obtain accurate conclusions.

In addition to Yin's qualities of interpreting data, Creswell and Creswell (2023) discussed that researchers should check the findings for accuracy using validity strategies, such as methodological triangulation. The purpose of methodological triangulation involves analyzing multiple data sources, increasing the validity of the data, analysis, and interpretation of the findings (Bougie & Sekaran, 2020). I used the methodological triangulation approach to analyze the data collected from multiple sources, including semistructured interviews, and organizational performance reports to increase the validity of my research study.

Reliability and Validity

Reliability

Researchers must demonstrate that research study findings are reliable so other researchers can perform data collection procedures and obtain the same results. Reliability refers to the consistency and repeatability of a case study's findings (Yin, 2018). In qualitative research, trustworthiness or rigor is essential to attain scholar's confidence in the accuracy of data, interpretation, and methods used to ensure a quality

study (Connelly, 2016). Yin (2018) discussed that the goal of reliability is to minimize errors and biases with the research study. To achieve reliability, Yin (2018) discussed two techniques: a case study protocol and a case study database. The case study protocol described by Yin (2018) consists of four sections: an overview of the case study, data collection procedures, protocol questions, and an outline for the case study report. Researchers can increase the trustworthiness of a case study database by performing an audit trail to document the processes throughout the research study for other researchers to follow. Other techniques I utilized to increase the trustworthiness of my research study were triangulation with multiple sources of data, member checking, and data saturation - where no new information is obtained from additional data sources (Fusch et al., 2018).

Validity

Researchers should incorporate validity strategies into their research study. Yin (2018) discussed three types of validity tests to strengthen a case study: internal, external, and construct. Internal validity is used for experimental and quasi-experimental research and explanatory case studies (Yin, 2018). In this study, I followed Yin's (2018) recommendations that using multiple data sources can enhance assurance of data saturation, increase internal validity and construct validity, and strengthen the reliability of research results. External validity generalizes the findings from organizations outside of the research study. To establish external validity, I used *what*, *how*, and *why* questions for the semistructured interviews. The standardized interview questions increased a deeper understanding of the phenomenon from the participants. I achieved construct validity by using multiple data sources of evidence and operational sources that matched

the concepts to correlate with the original objectives of this study. In qualitative research, trustworthiness or rigor is essential for scholars to attain the confidence in data, interpretation, and methods used to increase the integrity of a quality study (Connelly, 2016). Connelly (2016) discussed that trustworthiness is essential in qualitative research integrity and consists of several criteria: credibility, dependability, confirmability, and transferability.

Credibility

Credibility is associated with the truthfulness of the research findings and conclusions (Nassaji, 2020). Researchers can gain credibility with the participants by building trust and rapport and achieving more profound responses to the interview questions (Saunders et al., 2019). Credibility ensures that the research participants' experiences match what the participants intended. Member checking is a technique to ensure the credibility of the participant's responses to the interview questions. I sent each participant a copy of the draft findings, which helped to corroborate findings and evidence as well as produced new evidence the participant may not have provided in the interviews. Triangulation is another technique that I used to increase the credibility of a research study and gained an in-depth understanding of the phenomenon (Yin, 2018).

Confirmability

Confirmability is the principle where the accuracy of a researcher's findings and conclusions are confirmed by others (Nassaji, 2020). Researchers can establish confirmability by analyzing the research study's findings based on the data, not personal opinions, thus reducing personal bias. Audit trails, member checking, and

methodological triangulation support the confirmability of a research study. For example, an audit trail allows researchers to record all the steps and decisions made during data coding and analysis that others can evaluate (Nassaji, 2020). Additionally, asking probing questions during the participant interviews allows the researcher to clarify the confirmability of the participant's responses (Fusch et al., 2018). For this study, I established confirmability through data saturation, where I did not obtain any new information, themes, or codes from the semistructured interviews. I asked the participants probing questions during the interviews to clarify the participants' responses. I engaged the participants in member checking after the interviews to ensure their responses were accurate, and I triangulated the identified themes using multiple data sources. Additionally, I created an electronic research database for my audit trail and recorded my field notes in a hard-copy journal.

Transferability

Transferability is linked to external validity, demonstrating the ability to replicate future research studies in another context (Fusch et al., 2018). The researcher is not responsible for the transferability of research findings but should present in-depth information supporting other research studies (Fusch et al., 2018). Since sample sizes are often small and do not represent all populations, transferability should not be used to make generalizations about the study (Nassaji, 2020). For this study, I achieved transferability by utilizing member checking and an audit trail central to the research context to support other researchers with transferability. I also presented a comprehensive

description and findings of the research context and assumptions fundamental to the research topic, as Nassaji (2020) recommended.

Transition and Summary

In Section 2, I discussed the purpose statement, the role of the researcher, participant selection criteria, research methodology and design, population and sampling method, ethical research practices, data collection instruments, techniques, and organization. I concluded Section 2 with a discussion of reliability and validity practices and principles. In Section 3, I will begin with an introduction and discuss the presentation of the findings, application to professional practice, implications for social change, recommendations for action, recommendations for further research, reflections, and an overall conclusion

Section 3: Application to Professional Practice and Implications for Change

The purpose of this qualitative single-case study was to explore strategies used by some hospital leaders to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs. Seven executive-level healthcare business leaders with test utilization expertise and experience participated in this study. All participants met the criteria for inclusion in the study, and no participants withdrew. Each participant answered seven questions plus any necessary clarifying questions pertaining to strategies used to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs. The questions included issues and topics about metrics used to assess the effectiveness of strategies, successful strategies, steps used related to the quality control system, key barriers to implementing strategies, and modifications to the strategies to improve test utilization by physicians to improve efficiency and reduce healthcare costs.

Based on the research findings from this study, hospital leaders used various strategies to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs but also encountered several barriers. The barriers hospital leaders encountered are factors within their facility and elements outside their control at a system level. The major themes identified from the qualitative semistructured interviews and organizational reports are (a) continuing physician education, (b) enforced accountability, (c) IT system and EMR documentation training, (d) understanding financial ramifications, and (e) heightened resource stewardship. The major themes of the

study demonstrate commonalities with participants and are suggestive of a complex system supporting the conceptual framework, CAS, and LSS methods.

Presentation of the Findings

The overarching research question for this study was: What strategies do some hospital leaders use to mitigate and inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs? The target population included seven hospital leaders with a minimum of 3 years of service in their current or similar leadership roles (President, VPMA, VP, and AVP) from different hospitals within a single healthcare system in Maryland and Washington, D.C. I used seven semistructured interviews and reviewed organizational documents from the system for data triangulation. The organizational documents included pre-analytical order issues, reference laboratory test utilization, and a cost comparison of a palliative care initiative, which supported the findings of the semistructured interviews.

I used qualitative data analysis to identify five themes regarding strategies to mitigate inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs, which include (a) continuing physician education, (b) enforced accountability, (c) IT system and EMR documentation training, (d) understanding financial ramifications, and (e) heightened resource stewardship. The seven participants signed informed consent forms before participating in the interviews and answered seven semistructured interview questions and additional follow-up questions. The participants shared their strategies and experiences regarding mitigation and inappropriate test utilization by physicians to improve efficiency and reduce healthcare costs from each of

their respective healthcare organizations. I transcribed the interviews verbatim and identified common themes throughout the interview transcripts. I discussed the process of member checking with all participants to ensure the accuracy of my interpretations of the interviews. I sent the transcribed interviews and a list of identified themes to each participant via email for the member checking process. Three out of the seven participants responded to the request to check the documents for accuracy with no issues with the content collected. Despite multiple follow-up attempts with four participants, these individuals did not respond to the member checking process. None of the participants provided any revisions to transcript review content. Table 1 is the participant coding for the study.

Table 1

Participant Coding

Participant	Hospital	Title	Code
1	H8	Assistant vice president	P1H8
2	H7	President	P2H7
3	H1	Vice president medical affairs	P3H1
4	H7	Vice president medical affairs	P4H7
5	H9	Vice president	P5H9
6	H2	Vice president medical affairs	P6H2
7	H5	Vice president	P7H5

From the data collected, I identified five major themes. The major themes of the study are (a) continuing physician education, (b) enforced accountability, (c) IT system and EMR documentation training, (d) understanding financial ramifications, and (e)

heightened resource stewardship. I verified data credibility through methodological triangulation by analyzing and cross-checking the reliability of data collected during interviews, member checking, organizational reports, and field notes related to my study. Table 2 shows the major themes and core strategies identified for the study.

Table 2

Major Themes and Core Strategies

Major theme	Core strategies
Continuing physician education	Physician education Defensive medicine Multidisciplinary approach, communication, peer review feedback
Enforced accountability	Leadership engagement Metrics to trend improvement Self-reporting
IT system and EMR documentation training	Clinical decision systems EMR guidelines Choosing Wisely
Understanding financial ramifications	Palliative Medicine Physician ordering practices (reference laboratory tests) Governance committee
Heightened resource stewardship	Supply chain constraints Conservation initiatives

The conceptual framework for the study was the CAS theory and LSS. Healthcare leaders can use CAS to understand their organizations and the environment as complex systems, which have distinct properties that evolve from relationships with diverse

agents, distributed control, emergence, adaptation, nonlinearity, and spontaneous order (Gomersall, 2018). Munro et al. (2020) discussed that individuals, organizations, and other agents can act unpredictably. The actions of such constituents are interconnected, where one individual's actions change the course for others, which aligns with mitigation and inappropriate test utilization by physicians.

Non-value activities in healthcare organizations can affect the quality of patient care (Prasad et al., 2020). LSS is a quality improvement methodology that healthcare leaders can use to align the diverse components of complex healthcare organizations by reducing variation, waste, and costs to create a culture of continuous quality outcomes to improve performance in a complex organization (Ahmed, 2019). CAS and LSS are appropriate for the complex nature of the healthcare industry, related business problems, and the major themes identified.

Major Theme 1: Continuing Physician Education

Continuing Physician Education

Continuing physician education is the first major theme of the study. Based on the literature, physician education is an ongoing strategy that healthcare leaders have employed to help improve inappropriate test utilization by physicians. However, there are some core strategies that healthcare leaders can use to mitigate inappropriate test utilization. Healthcare leaders should first understand physician practice behaviors. P5H9 discussed that physicians are taught in medical school to do the same thing repeatedly for a meticulously thorough approach, so nothing is missed. Most physicians want to do the right thing and avoid standing out from their peers with test utilization. As a result,

physicians develop habits with test ordering practices, which could be contrary to best practices. For example, according to P3H1, some physicians continue to order routine tests daily without question because they can, which presents a barrier to appropriate test utilization. A philosophical change for providers would have to occur, requiring providers to go through the mental exercise of reordering tests every day because it ensures the reordered tests are needed daily and not just ordered automatically for several days because of convenience.

Defensive Medicine

Physicians' inappropriate test utilization can also be attributed to behaviors related to defensive medicine, so nothing is missed. P6H2 discussed that residents contribute to an itinerant workforce making appropriate physician ordering practices challenging to hardwire since the residents do not want to miss anything. Kakemam et al. (2022) discussed that the practice of defensive medicine reflects the behavior of healthcare providers to prevent malpractice from administrative, legal, criminal, and ethical penalties (p.2). Defensive behaviors are categorized into two themes: assurance (not detrimental to patients) and avoidance (harmful to patients) (Kakemam, 2022). The most common type of assurance defensive behavior included unnecessary services, such as medications, laboratory tests, and imaging exams. The most common type of avoidance defensive behavior is avoiding performing high-risk procedures and interventions and using non-invasive procedures, avoiding care for high-risk performing unnecessary intervention surgery. Kakemam et al. posited that providers practice defensive medicine for patient-related reasons, such as increased lawsuits against physicians and potential

conflict with patients. Kakemam et al. proposed structured training and education to improve physicians' training and education about appropriate care in clinical settings. The curriculum should include more problem-solving techniques, implement defensive medicine techniques, support the regular use of evidence-based medicine and structured care, and education should address litigation issues (Kakemam et al.).

Multidisciplinary Approach, Communication, Peer-Review Feedback

Jackups (2020) discussed that service-wide educational initiatives could reach multiple providers and lead to procedural changes compared to direct one-to-one conversations. P4H7 discussed grand round sessions as a proactive strategy to ensure physicians understand how to utilize laboratory resources appropriately.

Braithwaite et al. (2020) opined that healthcare performance has flatlined: 60% of care on average is in-line with evidence or consensus-based guidelines, 30% of care is wasteful or has minimal value, and 10% is related to adverse effects or harm (p. 1). The culture of learning organizations in healthcare allows leaders to create the foundation to meet systemwide relevant patient delivery targets in adaptive learning systems. As found in the literature, P4H7 discussed the concept of learning organizations with the correct stakeholders, including multidisciplinary teams and councils committed to improving processes as a strategic initiative optimizes the organizational culture and the importance of continuous improvement to communicate and achieve buy-in as an educational tool for providers. Additionally, P3H1 stated that signage flyers at the workstations can serve as simple public service announcements for providers to think twice before ordering routine lab tests to ensure they are necessary.

Major Theme 2: Enforced Accountability

Leadership Engagement

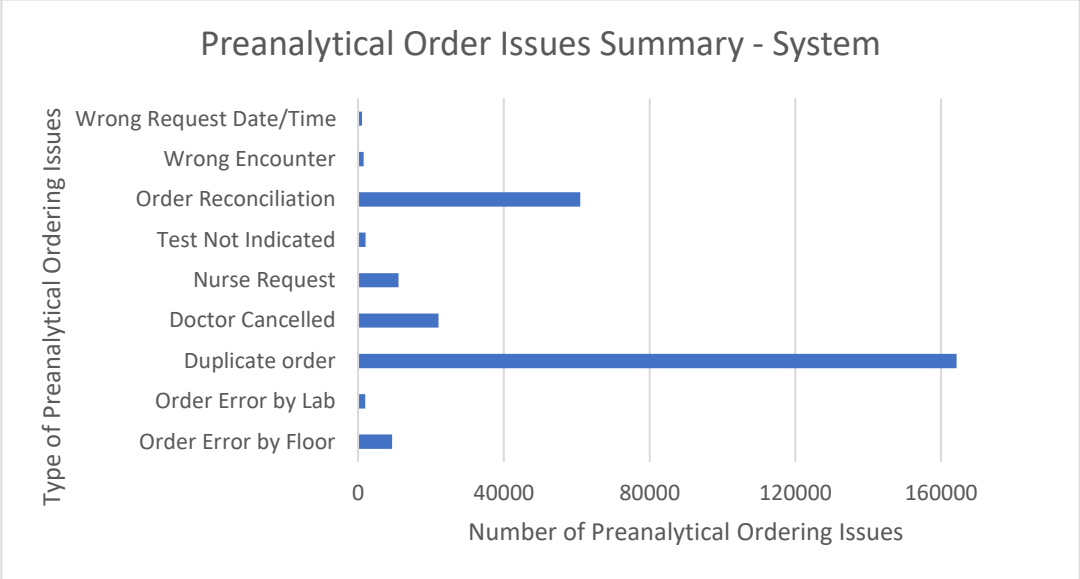
Enforced accountability is the second major theme identified. Naugler and Guo (2016) discussed that a common challenge with reducing unnecessary laboratory tests is quantifying physicians' redundant test ordering practices and not following published clinical practice guidelines. From the literature review, Naugler and Wyonch (2019) proposed three metrics to measure clinicians' ordering practices. These metrics included: peer-to-peer variation, the mix of tests ordered, and abnormal test rates. Several participants discussed that leadership engagement was essential, with direct oversight regarding peer-to-peer variation to hold physicians accountable. P2H7 stated that physicians know their patients, and the facts (metrics) must be accurate with physician non-conformance. Senior leadership must be prepared to provide sound evidence constructively. P7H5 discussed that providers are competitive and want to know their metrics similar to baseball statistics, which can be a good motivator to improve behavior. According to P7H5, senior leadership should report metrics at the individual level; such examples could include how many tests a provider orders per worked hour or patient, how many tests one doctor orders versus another provider, and compare the results to get an accurate benchmark of providers' test ordering practices. Based on the organizational reports, the most common physician preanalytical ordering issue was duplicate orders followed by order reconciliation.

Metrics to Trend Improvement

P6H9 stated that physicians respond to data performance and feedback. System data were collected from September 2021 through August 2022. Based on the data collected, senior leaders have an opportunity to address duplicate orders to hold physicians accountable to improve efficiency. Figure 1 illustrates the preanalytical order issues identified for the study.

Figure 1

Preanalytical Order Issues Summary



Self-Reporting

Another strategy to measure and track non-conformance by physicians is self-reporting in the system-wide variance application system. The healthcare system in this study adopted a safety culture of a high-reliability organization (HRO). As discussed by P4H7, self-reporting is encouraged by all associates, including physicians, to make improvements in the system, so errors do not continue to occur. Table 4 illustrates

providers' self-reporting with ordering issue details. Based on the data in Table 4, healthcare leaders are making small strides in encouraging providers to self-report order issues to improve physicians' inappropriate test utilization. P4H7 also stated that leadership and quality councils track trends to identify areas of improvement, such as wasted blood products or transfusion orders not clinically indicated.

Table 3

CY2021 Providers' Self-Reporting with Specific Order Issues

Job Position	Wrong/Extra Test Ordered	Test Ordered on Wrong Patient	Total
Physician/Attending Staff	1		1
Physician Assistant	2	2	4

Major Theme 3: IT System and EMR Documentation Training

Clinical Decision Systems

IT system and EMR documentation training is the third major theme identified. From the literature, Engelseth et al. (2020) found that leaders can develop a structure for information technology systems to support the logistics of various complex healthcare services and improve the quality of information transmitted. Atasoy et al. (2019) posited that there is empirical evidence supporting a relationship between electronic health records and healthcare quality (p. 490). The most general CDSs are designed to prevent medical errors (Atasoy et al., 2019). Many healthcare leaders utilize CDS algorithms assisting clinicians with test utilization practices. Most participants agreed that IT strategies work the best. P1H8 discussed that better documentation in EMRs leads to physicians selecting clinically appropriate laboratory tests.

EMR Guidelines

However, IT solutions are difficult to design. P5H9 stated that the design needs to develop a balance between reminding physicians and patient care. Alerts are helpful to remind physicians about appropriate test orders. However, many physicians experience alert fatigue and too many pop-up messages creating challenges and frustrations. For example, P6H2 discussed that EMRs need to be designed with principled guardrails for effective outcomes. One strategy implemented at H9 was limiting how many consecutive days blood draws could be ordered by the residents (house medical staff). However, this strategy was not very effective and was removed. At H9, residents write orders because they do not want to be the one who did not find a patient's problem and are very busy. Therefore, residents take the path of least resistance with their ordering practices. Later, this strategy was reinstated at H9 when the healthcare system was facing supply constraints due to COVID to conserve blood collection tubes. The tactic of limiting the number of blood draws was not very effective to change physicians' behavior because providers were discovering workarounds to order whatever laboratory tests they wanted, which was a barrier to IT solutions.

Choosing Wisely

Several participants discussed IT programs such as Choosing Wisely and CDS tools to improve physician ordering practices, including the cost. The Choosing Wisely program is not currently in place in the healthcare system in the study. CDS tools have been implemented to help mitigate the challenges of physicians' inappropriate test

utilization but only partially prevent non-compliance. Choosing Wisely applications could minimize physicians' non-compliance in relation to cost per test.

Major Theme 4: Understanding Financial Ramifications

Palliative Medicine

Understanding financial ramifications is the fourth major theme identified. With the growing need to improve the quality of patient care with advancements in medical treatments allowing people to live longer, palliative medicine is an area that includes a holistic approach to better serve patients facing the consequences of serious illnesses. Palliative medicine is one area healthcare providers can utilize to improve test utilization and patients' quality of life, leading to lower total healthcare costs. According to Finn and Malhotra (2019), palliative medicine is not limited to end-of-life care but includes specialized care for people with serious illnesses (p. 1). Healthcare providers specializing in palliative medicine provide pain and symptom management, communication expertise, emotional, spiritual, and psychosocial support, including end-of-life care when appropriate (Finn & Malhotra, 2019).

According to P1H8, decreased lab utilization is a byproduct of palliative care to provide patient-centered care. Physicians do not need to continually order laboratory tests based on convenience, assisting with improving the patient's quality of life by minimizing hospital-acquired anemia and enhancing patient satisfaction. P1H8's team performed a study to quantify reduced utilization attributed to the de-escalation of care related to supporting patients in creating a plan to change the goals of care and managing symptoms. The cost savings formula was the difference of direct variable costs per day

between pre-consultation and post-consultation x total palliative care days. Direct variable costs = 12% of drugs and lab charges. Total palliative care days = the number of total patient days post palliative care consultation to discharge. Pre-consultation included days of palliative care consultation. Table 4 is the palliative medicine cost savings methodology chart. Table 5 illustrates the palliative care laboratory charges.

Table 4

Palliative Medicine Cost Savings Methodology

Hospital	Avg drugs & labs daily charges, PRE-PC	Avg drugs & labs daily charges, POST-PC	Δ/Day	Total PC days post consult	Subtotal of total savings (charges)	Total savings (costs)
H1	$708	$215	$493	1,755	$865,215	$103,826
H2	$3,613	$2,320	$1,293	8,107	$10,482,351	$1,257,882
H3	$1,332	$626	$706	1,716	$1,211,496	$145,380
H4	$1,686	$481	$1,205	2,200	$2,651,000	$318,120
H5	$1,004	$304	$700	729	$510,300	$61,236
H6	$578	$232	$346	972	$336,312	$40,357
H7	$1,227	$450	$777	2,430	$1,888,110	$226,573
H8	$1,205	$440	$765	8,107	$6,201,855	$744,223
H9	$3,492	$1,782	$1,710	14,337	$24,516,270	$2,941,952
				System Total	**$48,662,909**	**$5,839,550**

Table 5

Palliative Care Laboratory Charges

Hospital	Lab Charges[a]		
	Pre-PC	Post-PC	Δ Pre-PC & Post-PC
H1	$450	$116	$334
H2	$2,122	$1,125	$997
H3	$543	$180	$363
H4	$945	$218	$727
H5	$586	$132	$454
H6	$400	$115	$285
H7	$590	$169	$421
H8	$788	$211	$577
H9	$2,341	$1,016	$1,325
Total	**$8,765**	**$3,282**	**$5,483**

Note. [a] FY18 Pre-Post charge data used by category.

Physician Ordering Patterns (Reference Laboratory Tests)

Analyzing physician test ordering patterns with reference laboratory tests is another financial opportunity to improve inappropriate test utilization. Many physicians order laboratory tests for in-patients that cannot be performed in hospital laboratories requiring such tests to be sent to more specialized reference laboratories. Many tests sent to reference laboratories take at least 1 to 2 days for results after arriving at the reference laboratory facility and can generate increased expenditures. Hospital leaders should review reference laboratory business analytics for send out laboratory tests and work with the reference laboratory business partners to collaborate on strategies to reduce clinical variation, manage test utilization according to evidence-based guidelines, contain laboratory testing costs, and improve patient care. Many physicians do not order the correct reference laboratory tests resulting in increased laboratory costs for the laboratory

and patient. Table 6 shows the reference laboratory cost analysis for the healthcare system with opportunities for cost savings.

Table 6

Reference Laboratory Cost Analysis and Recommendations

Reference Laboratory Test (System)	Volume	Cost per Test	Total Annual Cost	Recommendation
Vitamin K1	115	$43.50	$5,002.50	Vitamin K deficiency is very rare, and results in prolonged prothrombin time (PT) and elevated international normalized ratio (INR) when it does occur. Vitamin K1, Serum, is indicated if the patient has an abnormal INR and does not respond to Vitamin K therapy. It is not recommended to screen for deficiency or as a prerequisite for starting Vitamin K therapy.
Aldolase	548	$7.69	$4,214.12	Aldolase is a nonspecific marker for muscle or liver damage. Aldolase testing has largely been replaced by other enzyme tests such as creatine kinase (CK), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) as markers of muscle or liver damage. Aldolase, Serum is not recommended as a standalone test.
HSV Type 1and/or 2 Antibodies IgM by ELISA	227	$13.29	$3,016.83	Herpes Simplex Virus Type 1 and/or 2 Antibodies, IgM by ELISA lacks adequate predictive value for acute infection and therefore is not recommended. If pursuing antibody testing, refer to Herpes Simplex Type1 and Type 2 Glycoprotein G-Specific Antibodies, IgG by CIA. If acute HSV infection is suspected, molecular testing is preferred refer to Herpes Simplex Virus by PCR.
Myelin Basic Protein	65	$29.25	$1,901.25	Oligoclonal Band Profile is the preferred test in the workup of multiple sclerosis (MS). Myelin Basic Protein is not recommended because it is a nonspecific marker for central nervous system (CNS) inflammation.
Triiodothyronine, Free (Free T3)	177	$9.19	$1,626.63	For initial thyroid function screening in nonpregnant individuals, order Thyroid Stimulating Hormone with reflex to Free Thyroxine. For pregnant women, the optimal method of thyroid screening is Thyroxine, Free (Free T4), rather than TSH/free T4 combination. Triiodothyronine, Free (Free T3), and Triiodothyronine, Total (Total T3), should be ordered only for specific circumstances (e.g, abnormal TSH/normal Free T4 and suspicion of thyroid disease). Thyroid panels containing obsolete tests such as T3 Uptake and total T4 should not be ordered. Recommend utilizing Free T3 only in cases of abnormal TSH/normal Free T4 and suspicion of thyroid disease.
Financial opportunities for improved test ordering			$15,761.33	(Data from July 2020 through July 2021)

Governance Committee

One core strategy is for hospital leaders to establish an effective governance committee to prioritize and implement intervention strategies. Test utilization interventions can be built for specific outcomes with immediate impact and include IT based resources that are automated and control variations with ordering patterns by physicians. A governance committee should include multidisciplinary members to best understand laboratory testing practices by physicians and identify variances from practice to effectively apply appropriate intervention strategies. Interventions can be grouped into categories based on the level of impact promoting change and proper utilization. Figure 2 illustrates the intervention impact with a reference laboratory.

Figure 2

Reference Laboratory Intervention Impact

LOW IMPACT	MODERATE IMPACT	HIGH IMPACT
• Displaying test costs • Creating duplicate testing alerts • Creating best practice alerts • Educating physicians	• Displaying turnaround times • Creating physician report cards • Creating reflex testing pathways • Providing decision support • Changing test names	• Modifying order sets • Establishing a laboratory formulary • Limiting standing orders • Using pathology review to restrict tests

Major Theme 5: Heightened Resource Stewardship

Supply Chain Constraints

The fifth major theme is heightened resource stewardship. In June 2021, the Federal Drug Administration (FDA) and the College of American Pathologists (CAP)

notified United States laboratories of supply shortages for 3.2% sodium citrate tubes due to severe tube recalls in addition to the unprecedented levels of demand (Gosselin et al., 2021, p. 1). Sodium citrate tubes are required for the evaluation of coagulation functions in patients. The COVID-19 pandemic disrupted standard vendor manufacturing and supply chains in various aspects of laboratory supplies. A significant increase in coagulation testing compounded the manufacturing and supply chain issues because of increased thrombotic events in patients infected with COVID-19 (Schuett et al., 2022).

Conservation Initiatives

In response to the sodium citrate tube shortage, the FDA endorsed the same conservation practices recommended by CAP for the stewardship of resources. CAP recommended several core strategies. Gosselin et al. (2021) stated the core strategies included: reducing physician standing orders for coagulation testing; reducing routine (non-essential) coagulation testing; avoiding using sodium citrate tubes as discard tubes for blood draws; reserving smaller volume sodium citrate tubes for specific patient populations and considering point-of-care testing when suitable and available as an alternative for coagulation testing (See Figure 3). P6H2 expressed that limited test orders due to supply chain constraints to avoid running out of blood collection tubes was not a tactic to affect physician behavior regarding ordering practices.

Figure 3

Example of SBAR Communication for the System Regarding the National Shortage of Multiple BD Vacutainer Tubes

National Shortage of Multiple BD Vacutainer Tubes used in Blood Collection for Laboratory Testing
January 21, 2022

Situation: The supply level of BD Vacutainer tubes and those from other manufacturers used for laboratory testing is critically low due to supply constraints and high clinical demand. All tubes are now impacted.

Background: BD, the manufacturer of the blood collection tubes, has had unprecedented levels of demand due to the surges in COVID-19 infection rates, COVID-19 vaccine and treatment development and alternative vendor supply challenges.

Assessment: The Supply Chain has been working tirelessly with Cardinal Health and BD leadership over the past several months to obtain enough product to supply the testing needs of MedStar on a week-to-week basis. There will be a need at times to substitute similar BD tubes for sample collection. These substitute tubes may vary in size and the quantity of blood they collect. Be assured that all tubes distributed in MedStar facilities will be FDA approved and will have been evaluated and validated by the Clinical Laboratories.

Recommendations:

(1) Use the BD vacutainer tubes for ***ordered*** diagnostic testing only
(2) Do not collect extra tubes for “just in case” orders in the Emergency Department or any other location
(3) Minimize use of a discard tube when collecting blood from an IV
(4) Removal of the ‘Extra’ order in First Net so tubes will not be collected in the rainbow set
(5) Most inpatients DO NOT require daily Hematology and Chemistry testing after two days of stable results in the absence of significant clinical change. Do not order routine laboratory testing every day on inpatients.

If you have additional questions or concerns, please contact your site Laboratory Administrative Director.

P4H7 provided a different perspective regarding the stewardship of resources. P4H7 discussed that physical resource challenges are overrated as barriers. There will always be staffing challenges and financial constraints with purchasing new equipment. Leaders must commit to optimizing time and focus on efficiency, such as how to use the staff efficiently. How is time being used?

Applications to Professional Practice

Physicians use laboratory tests to support clinical decisions regarding screening, prognosis, and management of diseases. Physicians' inappropriate test utilization (overutilization and underutilization) is problematic for healthcare systems causing increased costs to healthcare organizations and negatively impacting patient care and patient dissatisfaction (Alshekhabobakr et al., 2022). Hospital leaders need to ensure strategies minimize physicians' inappropriate test utilization so providers choose the correct test for the right patient and prevent unnecessary sample collections, and testing is deemed essential (Alshekhabobakr et al., 2022). Additionally, hospital leaders can use the results of this study to develop strategic partnerships with multidisciplinary teams to reduce the financial burden of unnecessary testing and deliver optimum patient care.

I identified five major themes to mitigate and improve physicians’ inappropriate test utilization: (a) continuing physician education, (b) enforced accountability, (c) IT systems and EMR documentation training, (d) understanding financial ramifications, and (e) heightened resource stewardship. Alshekhabobakr et al. (2022) found that 91% of physicians used electronic ordering to select the appropriate tests, 95.5% of physicians preferred to receive feedback about inappropriate tests, while 51.1% were not receiving

feedback, and 67.4% of physicians were not aware of test costs; however, 63.6% demonstrated a willingness to reduce their orders if the cost was high and unnecessary (p. 413). Gardner and Childs (2022) found that hospital leaders achieved accountability through utilization review processes to create a system for addressing inappropriate test utilization related to cost information and patient care data as safeguards against unnecessary and improper medical care. Physicians' test selection for clinical decision-making about patient care plays a vital role in healthcare costs and optimizing quality patient care. Monitoring physicians' inappropriate test utilization by implementing and managing the identified test utilization strategies is critical for healthcare leaders to reduce waste, unnecessary spending, and costs and improve the quality of patient care to achieve successful organizational efficiency. Hospital leaders should consider evaluating their current strategies with the recommended strategies identified in this study to mitigate and improve physicians' inappropriate test utilization to align with their organizational operations.

Implications for Social Change

Physicians' inappropriate test utilization for clinical decision-making for patient care is a significant problem facing healthcare leaders. Hospital leaders may use this study to improve fewer testing-related risks for patients and reduce healthcare costs, resulting in improved dignity and quality of life for individuals in local communities and enhanced quality of hospital services. For example, Bressman et al. (2021) discussed that repetitive blood collections for diagnostic tests contribute to hospital-acquired anemia (HAA) caused by blood loss during a hospital stay based on increased blood draws and

the total volume taken for each test. Additionally, HAA is often associated with poor patient outcomes (Bressman et al., 2021). Understanding the ramifications of physicians' inappropriate test utilization, such as HAA, hospital leaders have an opportunity to improve patient's quality of life and experience. Identifying and implementing strategies to reduce physicians' inappropriate test utilization may enable hospital team members to focus on other areas beyond clinical care, such as patient satisfaction, which is associated with financial reimbursement. Hospital leaders who focus on improving physicians' test utilization can position their organizations to contribute to positive social changes for their patients and community.

Recommendations for Action

I identified five effective strategies to mitigate and improve physicians' inappropriate test utilization, including (a) continuing physician education, (b) enforced accountability, (c) IT systems and EMR documentation training, (d) understanding financial ramifications, and (e) heightened resource stewardship. Hospital leaders may consider evaluating their current strategies with the recommended strategies identified in this study to mitigate and improve physicians' inappropriate test utilization to align with their organizational operations. Not all the strategies identified in the study are appropriate for all healthcare leaders, depending on their organization's current state of operations. However, some hospital leaders who face challenges with controlling physicians' inappropriate test utilization should develop partnerships with multidisciplinary teams to select and adopt new strategies to minimize waste, reduce costs, and improve patient care.

The results of the study are significant to hospital leaders, such as senior leadership, providers, managers, and front-line team members. Implementing strategies to minimize physicians' inappropriate test utilization is a collaborative effort requiring the right stakeholders and an organizational culture committed to continuous improvement to improve processes. I will disseminate my findings to the participants by summarizing the results and sending the information via email. Additionally, I will share the findings via scholarly journals, meetings, and conferences.

Recommendations for Further Research

Other researchers and scholars can augment the results of this study with further research. I identified some limitations with this research study. One limitation was the size of my research study. This study was small in geographical scope and consisted of a small number of participants contributing to the limitations of this study. The findings of this research study may not apply to other healthcare institutions requiring additional research in the future. A recommendation for further action would be to increase the sample size of participants from different geographical regions to allow for greater generalizability and transferability to strengthen the reliability and validity of the data. Another limitation was that the study participants only included senior healthcare leaders of organizations within a single healthcare system. A recommendation for further would be to include other participants in lesser leadership roles who possess the expertise and experience with physicians' inappropriate test utilization. Lastly, there is scant literature and research context regarding standardized key performance indicators (KPI) to measure physicians' inappropriate test utilization. One recommendation for future researchers is

to explore data analytics utilized by healthcare leaders from other organizations to establish best practices for improved outcomes.

Reflections

The DBA journey was the most challenging yet rewarding academic experience I have ever encountered. The research process proved to be rigorous both academically and personally. I started my DBA journey two months before the COVID-19 pandemic commenced. Professionally, I was at the center of COVID-19 testing, which required long hours at work to care for patients in my community. I persevered with the challenges encountered professionally and academically despite the unprecedented times with COVID-19, testing my time-management skills. During my journey, I recognized my academic growth as a researcher with the support of Walden University's faculty members. I have gained much knowledge about scholarly writing and the overall research process. I am genuinely grateful for Walden University faculty's expertise, detailed assistance, and encouragement so I could successfully achieve this academic endeavor.

I believe my research findings could provide new strategies and best practices for healthcare leaders to improve physicians' inappropriate test utilization. I am grateful to all the participants in this study for their time and extensive knowledge on this vital topic. Their guidance and expertise conveyed unknown knowledge to me, minimizing researcher bias, which I used to expand my understanding of physicians' inappropriate test utilization. Several participants discussed numerous factors affecting physicians' inappropriate test utilization outside their control. The participants described a complex

situation with no one specific answer to the research question aligning with the CAS and LSS conceptual frameworks.

Conclusion

The findings of this research study revealed that physicians' inappropriate test utilization is a large-scale and complex issue affecting many healthcare organizations. All participants in this study agreed that physicians' inappropriate test utilization is an issue. Based on the literature and research context, there is no one specific strategy that healthcare leaders can use to mitigate physicians' inappropriate test utilization. Healthcare leaders also have an opportunity to evaluate other service lines associated with physicians' inappropriate test utilization, such as palliative medicine, to employ strategies to make improvements, as there is a literature cap regarding this topic, and this study can facilitate the filling of that gap.

Healthcare leaders should consider combining initiatives to improve physicians' inappropriate test utilization in their organizations. I have shared the expertise and experiences of seven participants in this research study. Based on the research of this study, five major themes were identified, which included (a) continuing physician education, (b) enforced accountability, (c) IT systems and EMR documentation training, (d) understanding financial ramifications, and (e) heightened resource stewardship. Within the major themes are core strategies that healthcare leaders use to mitigate physicians' inappropriate test utilization and reduce healthcare costs. The major themes and core strategies reflect the complex nature yet connection to a healthcare issue, which is suggestive of the CAS and LSS conceptual frameworks.

References

Adelman, J. S., Applebaum, J. R., Schechter, C. B., Berger, M. A., Reissman, S. H., Thota, R., Racine, A. D., Vawdrey, D. K., Green, R. A., Salmasian, H., Schiff, G. D., Wright, A., Landman, A., Bates, D. W., Koppel, R., Galanter, W. L., Lambert, B. L., Paparella, S., & Southern, W. N. (2019). Effect of restriction of the number of concurrently open records in an electronic health record on wrong-patient order errors: A randomized clinical trial. *JAMA*, *321*(18), 1780-1787. https://doi.org/10.1001/jama.2019.3698

Ahmed, S. (2019). Integrating DMAIC approach of Lean Six Sigma and theory of constraints toward quality improvement in healthcare. *Reviews on Environmental Health*, *34*(4), 427-434. https://doi.org/10.1515/reveh-2019-0003

Akanle, O., Ademuson, A. O., & Shittu, O. S. (2020). Choosing research topic. In A. S. Jegede & U. C. Isiugo-Abanihe (Eds.), *Contemporary issues in social research* (p. 841). Ibadan University Press.

Alshekhabobakr, H. M., AlSaqatri, S. O., & Rizk, N. M. (2022). Laboratory test utilization practices in Hamad medical corporation; Role of laboratory supervisors and clinicians in improper test utilization; A descriptive pilot study. *Journal of Multidisciplinary Healthcare*, *15*, 413-429. https://doaj.org/article/e1c4db652b504c7b9da9907535cdd38a

Amran, M. D. M., Januddi, F., Nuraina, S., Ikbar, A. W. M., & Khairanum, S. (2020). The barriers in lean healthcare implementation. *Test Engineering & Management*, *82*(January-February), 1972-1981.

https://www.researchgate.net/profile/Mohd_Amran_Mohd_Daril/publication/338594955_The_Barriers_in_Lean_Healthcare_Implementation/links/5e1eb2bba6fdcc904f70579c/The-Barriers-in-Lean-Healthcare-Implementation.pdf

Atasoy, H., Greenwood, B. N., & McCullough, J. S. (2019). The digitization of patient care: A review of the effects of electronic health records on health care quality and utilization. *Annual Review of Public Health*, *40*, 487-500. https://doi.org/10.1146/annurev-publhealth-040218-044206

Aziz, H. A., & Alshekhabobakr, H. M. (2017). Health information tools to improve utilization of laboratory tests. *Laboratory Medicine*, *48*(2), 30-35. https://doi.org/10.1093/labmed/lmw066

Baird, G. (2014). The laboratory test utilization management toolbox. *Biochemia Medica*, *24*(2), 223-234. https://doi.org/10.11613/BM.2014.025

Behling, K. C., & Bierl, C. (2019). Cost per case mix index–adjusted hospital day as a measure of effective laboratory utilization efforts in a growing academic medical center. *American Journal for Clinical Pathology*, *151*(4), 371-376. https://doi.org/10.1093/AJCP/AQY152

Bindraban, R. S., van Beneden, M., Kramer, M. H. H., van Solinge, W. W., van de Ven, P. M., Naaktgeboren, C. A., Al-Dulaimy, M., van er Wekken, L. C., Bandt, Y. C., Stam, F., Neppelenbroek, S. I. M., Griffioen-Keijzer, A., Castelijn, D. A. R., Wevers, B. A., Boerman, A. W., van Wijnen, M., ten Berg, M. J., & Nanayakkara, P. W. B. (2019). Association of a multifaceted intervention with ordering of unnecessary laboratory tests among caregivers in internal medicine

departments. *JAMA Network Open*, *2*(7), 1-11. https://doi.org/10.1001/jamanetworkopen.2019.7577

Born, K., Kool, T., & Levinson, W. (2019). Reducing overuse in healthcare: Advancing Choosing Wisely. *BMJ*, *367*(16317). https://doi.org/10.1136/bmj.l6317

Bougie, R., & Sekaran, U. (2020). *Research methods for business: A skill building approach* (8th ed.). Wiley.

Brady, H., Piggott, L., Dunne, S. S., O'Connell, N. H., & Dunne, C. P. (2018). Clustered interventions to reduce inappropriate duplicate laboratory tests in an Irish tertiary hospital. *Clinical Biochemistry*, *52*, 26-32. https://doi.org/10.1016/j.clinbiochem.2017.10.012

Braithwaite, J., Glasziou, P., & Westbrook, J. (2020). The three numbers you need to know about healthcare: The 60-30-10 challenge. *BMC Medicine*, *18*(1), 1-8. https://doi.org/10.1186/s12916-020-01563-4

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. SAGE.

Bressman, E., Jhang, J., McClasky, J., & Ginzburg, Y. Z. (2021). Tackling the unknowns in understanding and management of hospital acquired anemia. *Blood Reviews*, *49*(100830), 1-8. https://doi.org/10.1016/j.blre.2021.100830

Burrows, K. E., Abelson, J., Miller, P. A., Levine, M., & Vanstone, M. (2020). Understanding health professional role integration in complex adaptive systems:

A multiple-case study of physician assistants in Ontario, Canada. *BMC Health Services Research*, *20*(365), 1-14. https://doi.org/10.1186/s12913-020-05087-8

Busetto, L., Wick, W., & Gumbinger, C. (2020). How to use and assess qualitative research methods. *Neurological Research and Practice*, *2*(14), 1-10. https://doi.org/10.1186/s42466-020-00059-z

Cadamuro, J., Gaksch, M., Wiedemann, H., Lippi, G., von Meyer, A., Pertersmann, A., Auer, S., Mrazek, C., Kipman, U., Felder, T. K., Oberkofler, H., & Haschke-Becher, E. (2018). Are laboratory tests always needed? Frequency and causes of laboratory overuse in a hospital setting. *Clinical Biochemistry*, *54*(1), 85-91. https://doi.org/10.1016/j.clinbiochem.2018.01.024

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sample: Complex or simple? Research case examples. *Journal of Research in Nursing*, *25*(8), 652-660. https://doi.org/10.1177/1744987120927206

Carmichael T., Hadžikadić M. (2019) The Fundamentals of Complex Adaptive Systems. In: Carmichael T., Collins A., Hadžikadić M. (eds) Complex Adaptive Systems. Understanding Complex Systems. Springer International Publishing. https://doi.org/10.1007/978-3-03020309-2_1

Castleberry, A., & Nolen, A. (2018). Thematic analysis of qualitative research data: Is it easy as it sounds? *Currents in Pharmacy Teaching and Learning*, *10*(6), 807-815. https://doi.org/10.1016/j.cptl.2018.03.019

Chami, N., Mathew, S., Weir, S., Wright, J. G., & Kantarevic, J. (2021). Adoption of a laboratory EMR system and inappropriate laboratory testing in Ontario a cross-sectional observational study. *BMC Health Services Research*, *21*(307), 1-10. https://doi.org/10.1186/s12913-021-06296-5

Chivanga, S. Y., & Monyai, P. B. (2021). Back to basics: Qualitative research methodology for beginners. *Journal of Critical Reviews*, *8*(2), 11-17. http://www.jcreview.com/fulltext/197-1616242095.pdf

Clouzeau, B., Caujolle, M., San-Miguel, A., Pillot, J., Gazeau, N., Tecaille, C., Dousset, V., Bazin, F., Vargas, F., Hilbert, G., Molimard, M., Gruson, D., & Boyer, A. (2019). The sustainable impact of an educational approach to improve the appropriateness of laboratory test orders in the ICU. *PloS One*, *14*(5), 1-8. https://doi.org/10.1371/journal.pone.0214802

Connelly, L. M. (2016). Trustworthiness in qualitative research. *Medsurg Nursing*, *25*(6), 435-436. https://pubmed.ncbi.nlm.nih.gov/30304614/

Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications.

DeJonckheere, M., & Vaughn, L. M. (2019). Semistructured interviewing in primary care research: A balance of relationship and rigour. *Family Medicine and Community Health*, *7*(2), 1-8. https://doi.org/10.1136/fmch-2018-00005

Delvaux, N., Piessens, V., De Burhgraeve, T., Mamouris, P., Vaes, B., Stichele, R. V., Cloetens, H., Thomas, J., Ramaekers, D., De Sutter, A., & Aertgeerts, B. (2020). Clinical decision support improves the appropriateness of laboratory test ordering

in primary care without increasing diagnostic error: The ELMO cluster randomized trial. *Implementation Science, 15*(100), 1-10. https://doi.org/10.1186/s13012-020-01059-y

Demir, M. S., Karaman, A., & Oztekin, S. D. (2019). Chaos theory and nursing. *International Journal of Caring Sciences*, *12*(2), 1225-1228. http://www.internationaljournalofcaringsciences.org/docs/72_karaman_special_12_2_2.pdf

de Wolff, T., Pfluger, D., Rehme, M., Heuer, J., & Bittner, M. I. (2020). Evaluation of pooled-based testing approaches to enable population-wide screening for COVID-19. *PloS One*, *15*(12), 1-14. https://doi.org/10.1371/journal.pone.0243692

Diaz, C. A., Castilla, R. A., & Lebersztein, G. (2017). The hospital: A complex adaptive system. *Asian Journal of Medicine and Health*, *5*(1), 1-5. https://doi.org/10.973A/AJMAH/2017/34421

Ducatman, B. S., Ducatman, A. M., Crawford, J. M., Laposata, M., & Sanfilippo, F. (2020). The value of proposition for pathologists: A population health approach. *Academic Pathology*, *7*(January), 1-2. https://doi.org/10.1177/2374289519898857

Duddy, C., & Wong, G. (2021). Efficiency over thoroughness in laboratory testing decision making in primary care: Findings from a realist review. *British Journal of General Practice (BJGP) Open*, 1-12. https://doi.org/10.3399/bjgopen20X101146

Earl, J. (2020). The Belmont Report and innovative practice. *Perspectives in Biology and Medicine*, *63*(2), 313-326. https://doi.org/10.1353/pbm.2020.0021

Engelseth, P., White, B. E., Mundal, I., Eines, T. F., & Kritchanchai, D. (2020). Systems modelling to support the complex nature of healthcare services. *Health and Technology*, *11*, 193-209. https://doi.org/10.1007/s12553-020-00504-8

Faisal, A., Andres, K., Kkan Rind, J. A., Das, A., Alter, D., Subramanian, J., Koehler, T. J., Parker, J., & Bernicchi, N. (2018). Reducing the number of unnecessary routine laboratory tests through education of internal medicine residents. *Postgraduate Medical Journal*, *94*(1118), 716-719. https://doi.org/10.136/postgradmedj-2018-135784

Favaretto, M., De Clercq, E., Gaab, J., & Elger, B. S. (2020). First do no harm: An exploration of researchers' ethics of conduct in Big Data behavioral studies. *PloS One*, *15*(1), 1-23. https://doi.org/10.1371/journal.pone.0241865

Ferreira, D. M. C., & Saurin, T. A. (2019). A complexity theory perspective of kaizen: A study in healthcare. *Production Planning & Control*, *30*(16), 1337-1353. https://doi.org/10.1080/09537287.2019.1615649

Finn, L., & Malhotra, S. (2019). The development of pathways in palliative medicine: Definition, models, cost, and quality impact. *Healthcare*, *7*(22), 1-10. https://doi:10.3390/healthcare7010022

Forrest, S., & Mitchell, M. (2016). Adaptive computation: The multidisciplinary legacy of John H. Holland. *Communications of the ACM*, *59*(8), 58-63. https://doi.org/10.1145/2964342

Freedman, D. B. (2015). Towards better test utilization - strategies to improve physician ordering and their impact on patient outcomes. *The Journal of International*

Federation of Clinical Chemistry and Laboratory medicine (EJIFCC), *26*(1), 15-30. https://www.ifcc.org/media/331927/eJIFCC2015Vol26No1pp015-030.pdf

Fryer, A. A., & Smellie, W. S. A. (2013). Managing demand for laboratory tests: a laboratory toolkit. *Journal of Clinical Pathology*, *66*(1), 62-72. https://doi.org/10.1136/jclinpath-2011-200524

Fusch, P., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: Revisiting triangulation in qualitative research. *Journal of Social Change*, *10*(1), 19-32. https://doi.org/10.5590/JOSC.2018.10.1.02

Fusch, P. I., & Ness, L. R. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report*, *20*(9), 1408-1416. http://www.nova.edu/ssss/QR/QR20/9/fusch1.pdf

Gamsızkan, Z., Sungur, M. A., & Cayir, Y. (2020). Blood analysis requests of patients' and clinical reflections in primary care. *Euras Journal of Family Medicine*, *9*(2), 96-102. https://doi.org/10.33880/ejfm.2020090205

Gardner, J. W., & Childs, S. (2022). Managing the waste of over processing in healthcare using accountability through utilization reviews and information technologies. *Quality Management Journal*, *29*(2), 82-103. https://doi.org/10.1080/10686967.2022.2034492

Glover, W. J., Nissinboim, N., & Naveh, E. (2020). Examining innovation in hospital units: A complex adaptive systems approach. *BMC Health Services Research*, *20*(1), 1-12. https://doi.org/10.1186/s12913-020-05403-2

Gomersall, T. (2018). Complex adaptive systems: A new approach for understanding health practices. *Health Psychology Review*, *12*(4), 405-418. https://doi.org/10.1080/17437199.2018.1488603

Gosselin, R. C., Bowyer, A., Favaloro, E. J., Johnson, J. M., Lippi, G., Marlar, R. A., Neeves, K., & Rollins-Raval, M. A. (2019). Guidance on the critical shortage of sodium citrate coagulation tubes for hemostasis testing. *Journal of Thrombosis and Haemostasis*, *19*, 2857-2861. https://doi.org/10.1111/jth.15514

Greenhalgh, T., & Papoutsi, C. (2018). Studying complexity in health services research: Desperately seeking an overdue paradigm shift. *BMC Medicine*, *16*(95), 1-6. https://doi.org/10.1186/s12916-018-1089-4

Guest, G., Namey, E., & Chen, M. (2020). A simple method to assess and report thematic saturation in qualitative research. *PLoS One*, *15*(5), 1-17. https://doi.org/10.1371/journal.pone.0232076

Hall, J., Mirza, R., Quinlan, J., Chong, E., Born, K., Wong, B., & Hillis, C. (2019). Engaging residents to choose wisely: Resident doctors of Canada resource stewardship recommendations. *Canadian Medical Education Journal*, *10*(1), 39-55. http://www.cmej.ca

Harb, R., Hajdasz, D., Landry, M. L., & Sussman, L. S. (2019;8:e000689). Improving laboratory test utilization at the multihospital Yale New Haven Health System. *BMJ Open Quality*, *8*(3), 1-9. https://doi.org/10.1136/bmjoq-2019-000689

Harnett, P. J., Kennelly, S., & Williams, P. (2020). A 10 step framework to implements integrated care for older persons. *Ageing International*, *45*(3), 288-304. https://doi.org/10.1007/s12126-019-09349-7

Hauser, R. G., & Shirts, B. H. (2014). Do we now know what inappropriate laboratory utilization is? An expanded systematic review of laboratory clinical audits. *American Journal of Clinical Pathology*, *141*(6), 774-783. https://doi.org/10.1309/AJCPX1HIEM4KLGNU

Heino, M. T. J., Knittle, K., Noone, C., Hasselman, F., & Hankonen, N. (2021). Studying behavioral change mechanisms under complexity. *Behavioral Sciences*, *11*(5), 1-22. https://doi.org/10.3390/bs11050077

Ho, T., & Pursley, D. M. (2021). Economics at the frontline: Tools and tips for busy clinicians. *Seminars in Perinatology*, *(January)*, 1-9. https://doi.org/0.1016/j.semperi.2021.151396

Holden, L. M. (2005). Complex adaptive systems: Concept analysis. *Journal of Advanced Nursing*, *52*(6), 651-657. https://doi.org/10.1111/j.1365-2648.2005.03638.x

Holland, J. H. (1992). *Adaptation in natural and artificial systems: An introductory analysis with applications to biology, control, and artificial intelligence*. Bradford Books.

Honda, A. C., Bernardo, V. Z., Gerolamo, M. C., & Davis, M. M. (2018). How Lean Six Sigma principles improve hospital performance. *Quality Management Journal*, *25*(2), 70-82. https://doi.org/10.1080/10686967.2018.1436349

Horvat, A., & Filipovic, J. (2020). Healthcare system quality indicators: The complexity perspective. *Total Quality Management & Business Excellence*, *31*(1-2), 161-177. https://doi.org/10.1080/14783363.2017.1421062

Islam, M. A., & Awal, M. A. (2020). Factors influencing physicians' clinical decision-making at Upazila Health Complexes in Bangladesh. *Global Journal on Quality and Safety in Healthcare*, *3*(4), 125-133. https://doi.org/10.36401/JQSH-20-7

Jackups, R., Jr. (2020). Clinical decision support tools for microbiology laboratory testing. *Clinical Microbiology Newsletter*, *42*(5), 35-44. http://www.cmnewsletter.com

Jackups, R., Jr., Szymanski, J. J., & Persaud, S. P. (2017). Clinical decision support for hematology laboratory test utilization. *International Journal of Laboratory Hematology*, *39*(128), 128-135. https://doi.org/10.1111/ijlh.12679

Johnson, J. L., Adkins, D., & Chauvin, S. (2020). Qualitative research in pharmacy education: A review if the quality indicators of rigor in qualitative research. *American Journal of Pharmaceutical Education*, *84*(1), 138-146. https://doi.org/10.5688/ajpe7120

Kakemam, E., Arab-Zozani, M., Raeissi, P., & Albelbeisi, A. H. (2022). The occurrence, types, reasons, and mitigation strategies of defensive medicine among physicians: a scoping review. *BMC Health Services Research*, *22*(800), 1-11. https://doi.org/10.1186/s12913-022-08194-w

Karaman, A., Demir, M. S., & Oztekin, S. D. (2019). Chaos theory and nursing. *International Journal of Caring Sciences*, *12*(2), 1223-1227.

http://internationaljournalofcaringsciences.org/docs/72_karaman_special_12_2-22.pdf

Khan, S., Vandermorris, A., Shepherd, J., Begun, J. W., Lanham, H. J., Uhl-Bien, M., & Berta, W. (2018). Embracing uncertainty, managing complexity: Applying complexity thinking principles to transformation efforts in healthcare systems. *BMC Health Services Research, 18*(192), 1-8. https://doi.org/10.1186/s12913-018-2994-0

Kobewka, D. A., Ronksley, P. E., McKay, J. A., Forster, A. J., & van Walraven, C. (2015). Influence of educational, audit and feedback, system based, and incentive and penalty interventions to reduce laboratory test utilization: A systemic review. *Clinical Chemistry Laboratory Medicine*, *53*(2), 157-183. https://doi.org/10.1515/cclm-2014-0778

Krasowski, M. D., Chudzik, D., Dolezal, A., Steussy, B., Gailey, M. P., Koch, B., Kilborn, S. B., Darbro, B. W., Rysgaard, C. D., & Klesney-Tait, J. A. (2015). Promoting improved utilization of laboratory testing through changes in an electronic medical record: experience at an academic medical center. *BMC Medical Informatics and Decision Making*, *15*(11), 1-10. https://doi.org/10.1186/s12911-015-0137-7

Lartey, F. M. (2020). Chaos, complexity, and contingency theories: A comparative analysis and application to the 21st century organization. *Journal of Business Administration Research*, *9*(1), 44-51. https://doi.org/10.5430/jbar.v9n1p44

Leblow, L., Hamill, T., & Beqaj, S. H. (2019). Use of laboratory decision system as a test utilization management tool in clinical settings, current and future perspectives. *Journal of Clinical and Laboratory Medicine*, *4*(1), 1-5. https://doi.org/10.16966/2572-9578.128

Lillo, S., Larsen, T. R., Pennerup, L., & Antonsen, S. (2021). The impact of interventions applied in primary care to optimize the use of laboratory tests: A systematic review. *Clinical Chemistry and Laboratory Medicine*, (February), 1-17. https://doi.org/10.1515/cclm-2020-1734

Long, K. M., McDermott, F., & Meadows, G. N. (2018). Being pragmatic about healthcare complexity: Our experiences applying complexity theory and pragmatism to health services research. *BMC Medicine*, *16*(94), 1-9. https://doi.org/10.1186/s12916-018-1087-6

Lorenz, E. N. (1993). *The essence of chaos*. University of Washington Press.

Martinez-Garcia, M., & Hernandez-Lemus, E. (2013). Health systems as complex systems. *American Journal of Operations Research*, *3*(1A), 1-14. https://doi.org/10.4236/ajor.2013.31A011

Mize, R., Hunt, S. D., & Redman, W. (2019). The issue of test utilization within the clinical laboratory. *Journal of Business and Behavioral Sciences*, *31*(2), 70-79. http://asbbs.org/files/2019/JBBS_Vol_31.2_Fall_2019.pdf#page=70

Mohammed-Ali, Z., Bhandarkar, S., Tahir, S., Handford, C., Yip, D., Beriault, D., & Hicks, L. K. (2021). Implementing effective test utilization via team-based

evaluation and revision of a family medicine laboratory test requisition. *BMJ Open Quality*, *10*(e001219), 1-3. https://doi.org/10.1136/bmjoq-2020-001219

Morjaria, S., & Chapin, K. C. (2020). Who to test, when, and for what: Why diagnostic stewardship in infectious diseases matters? *The Journal of Molecular Diagnostics*, *22*(9), 1109-1113. https://doi.org/10.1016/j.jmoldx.2020.06.012

Mrazek, C., Lippi, G., Keppel, M. H., Felder, T. K., Oberkofler, H., Haschke-Becher, E., & Cadamuro, J. (2020). Errors within the total laboratory testing process, from test selection to medical-decision making - A review of causes, consequences, surveillance and solutions. *Biochemia Medica*, *30*(2), 1-19. https://doi.org/10.11613/BM.2020.020502

Mthuli, S. A., Ruffin, F., & Singh, N. (2021). 'Define, explain, justify, apply' (DEJA): An analytic tool for guiding qualitative research sample size. *International Journal of Social Research Methodology*, (June 25), 1-13. https://doi.org/10.1080/13645579.2021.1941646

Nassaji, H. (2020). Good qualitative research. *Language Teaching Research*, *24*(4), 427-431. https://doi.org/10.1177/1362168820941288

Naugler, C. T., & Guo, M. (2016). Proof of concept of a new metric for benchmarking selectivity in laboratory test ordering. *American Journal of Clinical Pathology*, *Apr;145*(4), 568-573. https://doi:10.1093/ajcp/aqw041

Naugler, C., & Wyonch, R. (2019). What the doctor ordered: improving the use and value of laboratory testing (February 14, 2019). C.D. Howe Institute Commentary 533. http://dx.doi.org/10.2139/ssrn.3338061

Nekkanti, S. S., Nair, S. V., Parmar, V., Saklani, A., Shrikhande, S., Shetty, N. S., Joshi, A., Murthy, V., Patkar, N., Khattry, N., & Gupta, S. (2020). Mandatory preoperative COVID-19 testing for cancer patients-Is it justified? *Journal of Surgical Oncology*, *122*(7), 1288-1292. https://doi.org/10.1002/jso.26187

Ninerola, A., Sanchez-Rebull, M.-V., & Hernandez-Lara, A.-B. (2020). Quality improvement in healthcare: Six Sigma systematic review. *Health Policy*, *124*(4), 438-445. https://doi.org/10.1016/j.healthpol.2020.01.002

Nqeto, A., Budhram, S., & Gubu-Ntaba, C. N. (2020). An audit of laboratory test utilization practices in a high care obstetric unit - Is it appropriate and what are the cost implications? *Obstetrics & Gynaecology Forum*, *30*(3), 35-38. https://journals.co.za/doi/pdf/10.10520/ejc-medog-v30-n3-a08

Patel, T., Karle, E., & Krvavac, A. (2019). Avoiding unnecessary repeat laboratory testing. *Cureus*, *11*(10), 1-5. https://doi.org/10.7759/cureus.5872

Patton, C. M. (2020). Phenomenology for the holistic nurse researcher underpinnings of descriptive and interpretive traditions. *Journal of Holistic Nursing American Holistic Nurses Association*, *38*(3), 278-286. https://doi.org/10.1177/0898010119882155

Penney, L. S., Nahid, M., Leykum, L. K., Lanham, H. J., Noel, P. H., Finley, E. P., & Pugh, J. (2018). Interventions to reduce readmissions: Can complex adaptive system theory explain the heterogeneity in effectiveness? A systematic review. *BMC Health Services Research*, *18*(894), 1-10. https://doi.org/10.1186/s12913-018-3712-7

Pettengill, M. A., & McAdam, A. J. (2020). Can we test our way out of the COVID-19 pandemic? *Journal of Clinical Microbiology*, *58*(11), 1-5. https://doi.org/10.1128/JCM.02225-20

Postavaru, O., Anton, S. R., & Toma, A. (2021). COVID-19 pandemic and chaos theory. *Mathematics and Computers in Simulation*, *181*(March), 138-149. https://doi.org/10.1016/j.malcom.2020.09.029

Prestia, A. S. (2020). Recognizing, managing. and leading through manufactured chaos. *Nurse Leader*, *18*(1), 82-84. https://doi.org/10.1016/j.mnl.2019.07.013

Procop, G. W., Yerian, L. M., Wyllie, R., Harrison, A. M., & Kottke-Marchant, K. (2014). Duplicate laboratory test reduction using a clinical decision support tool. *American Journal of Clinical Pathology*, *141*(5), 718-723. https://doi.org/10.1309/AJCPOWHOIZBZ3FRW

Pype, P., Mertens, F., Helewaut, F., & Krystallidou, D. (2018). Healthcare teams as complex adaptive systems: Understanding team behavior through team members' perception of interpersonal interaction. *BMC Health Services Research*, *18*(570), 1-13. https://doi.org/10.1186/s12913-018-3392-3

Rahman, M. S. (2017). The advantages and disadvantages of using qualitative and quantitative approaches and methods in language "testing and assessment" research: A literature review. *Journal of Education and Learning*, *6*(1), 102-112. https://doi.org/10.5539/jel.v6n1p102

Raisio, H., & Lundstrom, N. (2017). Managing chaos: Lessons from movies on chaos theory. *Administration & Society*, *49*(2), 296-315. https://doi.org/10.1177/0095399714541269

Rathore, R., & Srivastava, A. K. (2020). A decade of lean six sigma (LSS) in healthcare: Past review, current state and future perspective. *International Journal of Engineering Research & Technology*, *9*(06-June), 1310-1319. http://www.ijert.org

Rearigh, L. M., Hewlett, A. L., Fey, P. D., Broadhurst, J., Brett-Major, D. M., Rupp, M. E., & Van Schooneveld, T. C. (2021). Utility of repeat testing for COVID-19: Laboratory stewardship when the stakes are high. *Infection Control & Hospital Epidemiology*, *42*(3), 338-340. https://doi.org/10.1017/ice.2020.397

Ross, P. T., & Zaidi, N. L. B. (2019). Limited by our limitations. *Perspectives on Medical Education*, *8*(4), 261-264. https://doi.org/10.1007/s40037-019-00530-x

Ryvicker, M. (2017). A conceptual framework for examining healthcare access and navigation: A behavioral-ecological perspective. *Social Theory & Health, 16*(3), 224-240. https://doi.org/1057/s41285-017-0053-2

Saqr, K. M., Tupin, S., Rashad, S., Endo, T., Niizuma, K., Tominaga, T., & Ohta, M. (2020). Physiologic blood flow is turbulent. *Scientific Reports*, *10*(1), 1-12. https://doi.org/10.1038/s41598-020-72309-8

Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research methods for business students* (8th ed.). Pearson.

Schuett, H. G., Volod, O., Berg, A. H., Rhee, K., Torbati, S., Riggs, R. V., & Frishberg, D. P. (2022). Changes in coagulation testing during a national shortage of blue-top tubes - A laboratory stewardship opportunity. *American Journal of Clinical Pathology*, *aqac121*, 1-10. https://doi.org/10.1093/ajcp/aqac121

Shrank, W. H., Rogstad, T. L., & Parekh, N. (2019). Waste in the US health care system: Estimated costs and potential for savings. *JAMA 322*(15), 1501-1509. https://doi.org/10.1001/jama.2019.13978

Shufutinsky, A. (2020). Employing the use of self for transparency, rigor, trustworthiness, and credibility in qualitative organizational research methods. *Organizational Development Review*, *52*(1), 50-58. https://www.researchgate.net/publication/340539936_Employing_Use_of_Self_for_Transparency_Rigor_Trustworthiness_and_Credibility_in_Qualitative_Organizational_Research_Methods

Sohail, H., Bibi, S., Hakeem, M., ul Haque, A., & Abbas, Q. (2020). Laboratory blood testing in paediatric intensive care unit of a university hospital: are we doing it appropriately? *Journal of Ayub Medical College Abbottabad*, *32*(3), 422-424. http://www.jamc.ayubmed.edu.pk

Soliman, M., & Saurin, A. (2020). Lean-as-imagined differs from lean-as-done: The influence of complexity. *Production Planning & Control*, (November), 1-18. https://doi.org/10.1080/0953787.2020.1843729

Song, Z., Lillehaugen, T., & Wallace, J. (2021). Out-of-network laboratory test spending, utilization, and prices in the US. *JAMA*, *325*(16), 1674-1676. https://doi.org/10.1001/jama.2021.0720

Soule, K. E., & Freeman, M. (2019). So you want to do post-intentional phenomenological research? *The Qualitative Report*, *24*(4), 857-872. https://nsuworks.nova.edu/tqr/vol24/iss4/15

Sturmberg, J. P., & Bircher, J. (2019). Better and fulfilling healthcare at lower costs: The need to manage health systems as complex adaptive systems [version1;peer review: 2 approved]. *F1000Research*, *8*(789), 1-13.https://doi.org/10.12688/11000reserach.19414.1

Subri, S. A. M., Shukri, S. N., & Wahab, S. (2020). Leadership theories in COVID-19 outbreak management. *Asian Journal of Behavioral Sciences*, *2*(4), 18-25. http://myjms.mohe.gov.my/index.php/ajbs/article/view/11676>

Sutton, R. T., Pincock, D., Baumgart, D. C., Sadowski, D. C., Fedorak, R. N., & Kroeker, K. I. (2020). An overview of clinical decision support systems: Benefits, risks, and strategies for success. *Nature Partner Journals Digital Medicine*, *3*(17), 1-9. https://doi.org/10.1038/s41746-020-0221-y

Tamburrano, A., Vallone, D., Carrozza, C., Urbani, A., Sanguinetti, M., Nicolotti, N., Cambieri, A., & Laurenti, P. (2020). Evaluation and cost estimation of laboratory test overuse in 43 commonly ordered parameters through a Computerized Clinical Decision Support System (CCDSS) in a large university hospital. *PloS One*, *15*(8), 1-11. https://doi.org/10.1371/journal.pone.0237159

Tang, W., Wei, L., & Zhang, L. (2017). Analysing a Chinese regional integrated healthcare organisation reform failure using a complex adaptive system approach. *International Journal of Integrated Care*, *17*(2), 1-11. https://doi.org/10.5334/ijic.2420

Tawadrous, D., Detombe, S., Thompson, D., Columbus, M., Van Aarsen, K., & Skoretz, T. (2020). Reducing unnecessary testing in the emergency department: The case for INR and aPTT. *Canadian Association of Emergency Physicians*, *22*(4), 534-541. https://doi.org/10.1017/cem.2019.493

Theofanidis, D., & Fountouki, A. (2018). Limitations and delimitations in the research process. *Perioperative Nursing*, *7*(3), 155-163. https://doi.org/10.5281/zenodo.2552022

Uhl-Bien, M., & Arena, M. (2018). Leadership for organizational adaptability: A theoretical synthesis and integrative framework. *The Leadership Quality*, *29*(1), 89-104. https://doi.org/10.1016/j.leaqua.2017.12.009

U.S. Centers for Medicare & Medicaid Services (CMS). (2020, December 16). *CMS office of the actuary releases 2019 national health expenditures* [Press Release]. https://www.cms.gov/newsroom/press-releases/cms-office-actuary-releases-2019-national-health-expenditures

U. S. Centers for Medicare & Medicaid Services (CMS). (2020, March 24). *NHE fact sheet*. U. S. Centers for Medicare & Medicaid Services. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet

U.S. Department of Health & Human Services. (2018, January 15). *The Belmont Report*. HHS.gov. https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html

Van Beurden, E. K., Kia, A. M., Zask, A., Dietrich, U., & Rose, L. (2013). Making sense in a complex landscape: How the Cynefin Framework from Complex Adaptive Systems Theory can inform health promotion practice. *Health Promotion International*, *28*(1), 73-83. https://doi.org/10.1093/heapro/dar089

Vrijsen, B. E. L., Naaktgeboren, C. A., Vos, L. M., van Solinge, W. W., Kaasjager, H. A. H., & ten Berg, M. J. (2020). Inappropriate laboratory testing in internal medicine inpatients: Prevalence, causes and interventions. *Annals of Medicine and Surgery*, *51*(March), 48-53. https://doi.org/10.1016/j.amsu.2020.02.002

Waters, V. L. (2020). Theory, nurse decision-making, and practice: What's all the fuss? *Nursing Management*, *51*(2), 22-28. https://doi.org/10.1097/01.NUMA.0000605164.72940.25

Wempe, M. M., Stewart, M. D., Glass, D., Lasiter, L., Vega, D. M., Ramamurthy, N., Allen, J., & Sigal, E. V. (2020). A national assessment of diagnostic test use for patients with advanced NSCLC and factors influencing physician decision-making. *American Health and Drug Benefits*, *13*(3), 110-119. http://www.AHDBonline.com

Wendler, D. (spring 2020). Minimizing risks is not enough: The relevance of benefits to protecting research participants. *Perspectives in Biology and Medicine*, *63*(2), 346-358. https://doi.org/10.1353/pbm.2020.0023

Werder, K., & Maedche, A. (2018). Explaining the emergence of team agility: A complex adaptive systems perspective. *Information and Technology & People*, *31*(3), 819-844. https://doi.org/0.1108/TTP-04-20170125

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE.

Zare, S., Meidani, Z., Shirdeli, M., & Nabovati, E. (2021). Laboratory test ordering in inpatient hospitals: A systematic review on the effects and features of clinical decision support systems. *BMC Medical Informatics and Decision Making*, *21*(20), 1-20. https://doi.org/10.1186/s12911-020-01384-8

Ziemba, Y. C., Lomsadze, L., Jacobs, Y., Chang, T. Y., & Haghi, N. (2018). Using heatmaps to identify opportunities for optimization of test utilization and care delivery. *Journal of Pathology Informatics*, *9*(31), 1-10. https://doi.org/10.4103/jpi.jpi_7_18

Appendix A: Interview Questions

1. What strategies are you using for assuring appropriate test utilization by physicians to improve efficiency?
2. How have you assessed the relative effectiveness of the strategies (metrics)?
3. What strategies did you find that work best for reducing inappropriate test utilization by physicians to improve efficiency in the system?
4. Regarding the process you use to assure testing appropriateness and efficiency, please describe the specific steps of the related quality control system?
5. How did you address the key barriers to implementing the strategies to reduce inappropriate test utilization by physicians?
6. What modifications would you make to the strategies to improve efficiency for appropriate test selection by physicians?
7. What additional information would you like to share about strategies used for reducing inappropriate test utilization by physicians to improve efficiency to reduce healthcare costs?