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A Conceptual Framework for Total Quality Management and Productivity Post-LIMS: The Moderating Role of Employee Resistance in Forensic Laboratories

Salim Obaid Mohamed Alkhayyal, Raja Zuraidah Binti Raja Mohd Rasi*

Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia

Email: Salimsfl@outlook.com

*Corresponding Author Email: rzuraida@uthm.edu.my

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Abstract

Forensic laboratories are vital to criminal investigations and the judicial process, demanding accuracy, efficiency, and compliance with regulatory standards. Key Total Quality Management (TQM) determinants, such as dedicated leadership, commitment to continual improvement, employee training and performance evaluation emerged as vital drivers of productivity and service quality. These key drivers are particularly significantas forensic institutions transition to digital environment. This article creates a conceptual framework combining concepts from TQM Theory, Resource-Based View (RBV), and Change Management Theory to explore how forensic institutions can increase productivity and handle employee resistance to change. Although, there have been comprehensive studies of the effects of TQM on manufacturing, healthcare and the service industries, there is not much study has been given to TQM effects on forensic science institutions within post-Laboratory Information Management Systems (LIMS) environments. The article finds a substantial gap in literature in reference to employee resistance and how does this impact on the TQM driven, quality improvements in the forensic laboratories. The study emphasizes the need for additional empirical research to test the framework described here via case studies and longitudinal studies that show the long-term impact of TQM on forensic productivity. Cross-national studies of forensic practice could shine further light on how resistance to change is reflected in various forensic settings, as they will scrutinize different forensic institutions, legal jurisdictions, and cultural contexts. This way, forensic institutions may fill the gaps with effective quality management approaches, regulatory compliance, and forensic service delivery. Furthermore, implementing TQM with digital forensic advancements as a method of addressing the concerns of employees via improved

communication will guarantee that forensic institutions could harness the full potential of quality initiatives in post-LIMS environments.
Keywords: Total Quality Management, Forensic Productivity, Employee Resistance, Laboratory Information Management Systems, Change Management

Introduction

Guaranteeing the accuracy, reliability, and efficiency of forensic analyses utilized in investigations and legal proceedings is one of the important roles the forensic laboratories play in the criminal justice system. Forensic institutions have gradually adopted Laboratory Information Management System (LIMS) for operational efficiency and data management. LIMS also enables tracking of samples, automates workflows, assures accuracy of data, and performs quality control to streamline forensic case processing (Olsen et al., 2020). Despite the overall potential of LIMS to improve productivity, the application of LIMS is often met with resistance during its implementation by employees, which reduces the effectiveness of quality management initiatives (Al-Kahtani and Al-Muhaisen, 2021). A popular employee resistance eliminator is Total Quality Management (TQM), which helps the organization to function better. It is an all-inclusive system that emphasizes continuous improvement, organizational leadership, workforce training, customer satisfaction, and performance measurement as mechanisms for ongoing quality improvement (Prashar, 2023). TQM principles can maximize LIMS implementation in forensic laboratories and improve overall productivity in forensic workflows (Ahmed & Sajid, 2023). However, the reluctance of employees to change is still a major issue that may moderate the nexus of TQM implementation and productivity (Abbas & Kumari, 2023).

Despite the proven benefits of LIMS adoption and TQM implementation, forensic laboratories often struggle with productivity challenges due to employee resistance to change. Resistance may stem from fear of job displacement, lack of familiarity with digital forensic systems, or preference for traditional forensic methodologies. Existing research highlights the importance of top management support, continuous improvement, and employee training in mitigating resistance (Al-Dhaafri et al., 2021), but there is a limited understanding of how employee resistance moderates the impact of TQM factors on forensic productivity (Nguyen et al., 2021). This gap underscores the need for a conceptual framework that explores the interplay between TQM, employee resistance, and productivity in forensic laboratories. The central research question guiding this study is: How do TQM factors influence forensic laboratory productivity, and to what extent does employee resistance moderate this relationship? Based on existing literature, the study hypothesizes that TQM factors (top management support, continuous improvement, training, customer focus, and performance assessment) positively impact forensic laboratory productivity (H1), while employee resistance negatively moderates this relationship (H2).

The primary objective of this paper is to develop a conceptual framework that examines the relationship between TQM practices and forensic laboratory productivity, considering the moderating role of employee resistance. Specifically, this study aims to analyze the impact of TQM principles (top management support, training, continuous improvement, customer focus, and performance assessment) on forensic laboratory productivity. Additionally, it seeks to evaluate how employee resistance affects the successful adoption of LIMS and TQM initiatives while proposing a structured framework for forensic laboratories to optimize

quality management strategies and productivity outcomes. The study also provides practical recommendations for mitigating employee resistance and improving LIMS implementation in forensic institutions. This study argues that TQM factors significantly enhance forensic laboratory productivity following LIMS implementation; however, employee resistance serves as a moderating factor that can either facilitate or hinder these improvements. By addressing workforce concerns and fostering a culture of continuous improvement, forensic institutions can enhance LIMS adoption, improve case processing efficiency, and optimize forensic service delivery. This paper is structured as follows: Section 2 introduces the Resource-Based View (RBV) theory as the conceptual foundation and explores TQM as a strategic resource that enhances forensic productivity. Section 3 presents the proposed research model, illustrating the relationship between TQM factors, employee resistance, and productivity outcomes. Section 4 discusses the research hypotheses and justifies their theoretical basis. Section 5 explores the theoretical and practical contributions of the study, providing insights into forensic institutions and policymakers. Finally, Section 6 summarizes the key findings, limitations, and recommendations for future research.

Literature Review

Total Quality Management (TQM)

Total Quality Management (TQM) is a strategic management approach that focuses on continuous improvement, customer satisfaction, and employee participation in enhancing organizational performance (Abbas & Kumari, 2023). TQM is a theoretical background for TQM is based on the quality-improvement philosophies of Deming, Jura, and Crosby emphasizing the importance of top management, standardized methods, and controlling quality by prevention (Al-Dhaafri et al., 2021). The principle behind total quality management (TQM) is that organizations using TQM want to maximize consistency in processes, eliminate waste, and make quality a part of the national culture at every level of the organization. Forensic science consists of crucial evidence handling, digital forensics, and providing legal support for the case, therefore the quality standards of forensic investigations are essential to their credibility and effectiveness. Although the adoption of LIMS has brought automation, electronic monitoring, and process standardization, how efficient these systems are, however, is driven by the ability of forensic institutions to integrate TQM practices (Al-Kahtani & Al-Muhaisen, 2021). The lack of a quality management framework can result in challenges with LIMS adoption including resisting change from employees, inconsistent implementation of the system, and the lack of continuous quality improvement initiatives. The key principles of TQM that enhances forensic laboratory efficiency are:

Leadership and Top Management Commitment

Strong leadership commitment to quality management principles is critical for successful implementation of TQM initiatives. The role of effective top management is that it makes forensic institutions focus more on quality improvement, maintain quality resources, and maintains a culture of accountability (Ahmed & Sajid, 2023). Proper testing and training for staff as well as the integration of quality control into forensic workflows are centralized under LIMS and takes company leadership to spearhead the adoption of this technology. The nonexistence of managerial backing is a significant hurdle that organizations face when implementing TQM, as this lack of support may lead to resistance to change, low motivation as well as insufficient enforcement of quality standards (Verma, Sharma, & Gupta, 2022).

Continuous Improvement (Kaizen) and Process Optimization

TQM revolves around continuous improvement, where managers constantly identify inefficiencies, streamline processes, and improve the delivery of forensic services (Al-Dhaafri, Al-Swidi, & Yusoff, 2021; Akanmu et al., 2023). A thoughtful and systematic approach to reducing error, streamlining forensic workflow, and standardizing case processing are also needed in forensic laboratories. This is where the principle of continuous improvement is relevant, with forensic institutions required to have the facilities to upgrade and adapt forensic technologies, regulatory updates, and changing forensic methods. The guidelines demonstrate that forensic laboratories where continuous improvement strategies are employed will triumph in having higher accuracy rates, reduced case backlogs and improved turnaround times (Fraihat et al., 2023).

Employee Involvement and Training

In order to be precise and adhere to forensic quality standards, a well-trained forensic workforce is needed. TQM emphasizes the importance of employee training programs that enable personnel to become knowledgeable on digital forensic tools, LIMS capabilities, and forensic data management methods (Nguyen, Pham, & Tran, 2021). Training is also crucial in overcoming employee resistance to new forensic technologies as it provides employees with the knowledge and confidence to embrace change. Continuous training and professional development of staff in institutions leads to better engagement, enhanced forensic, and lower resistance to LIMS (Akanmu et al., 2023).

Customer Focus and Stakeholder Satisfaction

In total, quality management (TQM) emphasizes the vital blend of customer-centeredness ensuring that when forensic services achieve the expectations of significant stakeholders (mainly law enforcement agencies, judiciary institutions and policymakers) (Abbas & Kumari, 2023). In order to ensure their reliability in the criminal justice system, forensic laboratories are required to provide credible and timely analyses (Ahmed & Sajid, 2023). The implementation of TQM principles allows forensic institutions to develop processes that correlate with stakeholder expectations, best forensic practices, and regulatory compliance (Alzoubi, Alshurideh & Kurdi 2019). The focus should be on sustaining leadership commitment to continuously scrutinize the quality expectations of serviced-by organizations and adjusting its approach in forensics organizations to provide better services (Al-Dhaafri, Al-Swidi, & Yusoff, 2021; Akanmu et al., 2023).

Performance Measurement and Quality Control

Validity of TQM framework depends on data available to the forensic institutions and hence, the performance monitoring systems should be evaluated constantly and their processes updated (Abbas & Kumari, 2023). Some of the key performance indicators (KPIs) used to evaluate forensic laboratory efficiency are the turnaround time for forensic reports, accuracy rates, growing error rates, and international forensic standards compliance (Ahmed & Sajid, 2023). Achieving ISO 17025 accreditation and regularly performed forensic quality audits are vital to meeting industry benchmarks for both productivity and the delivery of high-quality services (Alzoubi et al., 2019).

Firm Productivity

One main indicator to showcase an organization's capability in optimizing (labor, technology, capital) while ensuring quality standards is firm productivity (Abbas & Kumari, 2023). Forensic laboratories measure productivity across several axes, including the efficiency of case processing, the accuracy of forensic analyses, the speed of evidence examination, and adherence to regulatory standards. A high productivity leads to prompt investigations, judicial verdicts and better case resolution as they are based on reliable forensic evidence. This differs from traditional business productivity measures including revenue, cost-efficiency, and economies of scale, service, accuracy, and compliance with the standards of law and science. Such processing inefficiencies can affect the integrity of evidence and cause considerable delays in forensic services to judicial stakeholders, for example, significant case backlogs and evidence disclosures (Al-Kahtani & Al-Muhaisen, 2021). TQM practices play an important role in how the forensic institutions operate on a daily basis and the better, or worse they do in terms of productivity. Adoption of structured quality management frameworks, improved forensic processes and advanced tools such as Laboratory Information Management Systems (LIMS) can boost their operational capability at the same time as complying with international standards in forensic practices (Fraihat et al., 2023).

Employee Resistance as a Moderator

As a result, replacing manual systems with TQM, digital forensic tools and LIMS suffers employee resistance to change is seen as a major barrier to implementation. There is also evidence to support that employee resistance can also act as a moderating variable and affect the link between organizational changes initiatives and organizations productivity (Nguyen, Pham, & Tran, 2021). To enhance productivity through improving workflow efficiency, case processing, and greater forensic quality, forensic laboratories can apply Total Quality Management (TQM) strategies particularly, given the rigorous demands around accuracy, rapid turnaround times, and responding to specific input requirements of the legal system. However, the success of these strategies relies upon how employees act. Resistance reflected in refusal to adopt new ways of doing things, slow acceptance of change, and lack of participation in training can dilute the power of TQM to improve productivity. On the contrary, when resistance is better handled, the employees have more reception to the quality management initiatives, and its effectiveness. In this section, we discuss the role of employee resistance in the TQM productivity relationship within forensic institutions. This knowledge on this role can allow organizations to develop structured systems that mitigate resistance, engage employees, and move people more towards the adoption of this new forensic methods (Nguyen et al., 2021).

Leadership and Employee Resistance

The role of strong leadership in organizational performance strongly contributes to the successful implementation of TQM by creating a culture of quality, establishing accountability, and ensuring high levels of employee engagement (Ahmed & Sajid, 2023). This is crucial, as effective leadership is vital to communicating the need for quality improvement initiatives and can help reduce employee resistance to it. A failure to communicate the purpose and advantages of TQM by leaders can cause resistance to increase, and can result in delays in quality improvements, a reluctance to adopt new forensic methodologies to prevent errors, and noncompliance with standardized processes. Active Leadership initiatives in quality management, in forensic laboratories, with employees who

are more amenable to change enables optimization of human resources in forensic laboratories ensuring forensic accuracy and elimination of backlogs in cases, thus enabling higher efficiency of operations. On the other hand, high resistance can remove the positive effect of leadership on productivity, and the improvement in the TQM model will be limited (Alzoubi, Alshurideh, & Kurdi, 2019).

Training, Skill Development, and Employee Resistance

TQM training promotes continuous learning for employees to develop their forensic competencies, especially for the adoption of LIMS, digital forensic tools, and AI-based forensic analytics (Nguyen et al., 2021). However, if employees feel that their training is unnecessary, disruptive, or outside their technical skill set, resistance builds resulting in ineffective training programs. Forensic professionals are more open to adopting new training methodologies, adopting forensic automation tools, and applying advanced forensic techniques when resistance is low. This leads to increased efficiency, less forensic fallibility, and improved observance of forensic quality standards. On the contrary, high resistance may lead to employee disengagement in training programs, hindering the TQM effect on productivity and delaying the uptake of critical forensic innovations (Verma, Sharma, & Gupta, 2022).

Continuous Improvement and Employee Resistance

One of the most important theories in Total Quality Management (TQM) is continuous improvement, which can be used to improve forensic workflows, the process of an actual error reduction, and the process of handling cases more efficiently. But resistance from employees on workflow transformations can impede these initiatives, which causes more inefficiencies and implementation delays (Khan et al., 2020). Continuous quality improvement helps forensic laboratories maintain efficiency when processing cases, ensure accurate documentation of evidence, and adopt the best forensic practices. Less resistance from the employees leads to faster adoption of continuous improvement initiatives, resulting in substantial productivity improvements and substantial decreases in the forensic case backlog. In reverse, the level of resistance very high can impede this effort, resulting in stagnation of forensic practices that may lead to the existing inefficiency (Nguyen et al., 2021).

Theoretical Framework

The current study proposes an extensive theoretical framework with distinct relationships between key research variables. It studies the impact of Total Quality Management (TQM) factors on forensic laboratories firm productivity, with employee resistance as a moderator. While highlighting the impact of employee resistance on the success of quality management practices, this framework also delineates the pathways through which such practices catalyse forensic productivity. The framework formed a global fundamental of TQM theory combined with the Resource-Based View (RBV) theory with Change Management theory. But adopting principles of TQM leadership commitment, continual improvement, employee training and development, and quality assessment does not in itself mean productivity will improve. These practices are heavily reliant on employee ability adjust to new technologies, quality control processes, and digital workflows (Nguyen, Pham & Tran, 2021).

It is grounded by various theoretical perspectives and provides a systematic approach for forensic laboratories to explore and implement strategies to improve efficiency,

effectiveness, and service delivery. As defined by Khan et al., (2020) effective change management strategies are needed to eliminate employee resistance to change allowing for smoother transitions and high productivity. The study is constructed on three main theories. However, TQM theory describes a chain of reasoning from systematic practices of quality management to higher organizational performance. Component of Resource Based View (RBV) theory that posits Human capital, management (leadership and quality control) as a strategic asset integral to long-term competitive differentiation. Lastly, Change Management theory provides insights into employee resistance and its impact on the success of organizational change initiatives. It discusses resistance and management strategies to manage resistance effectively (Abbas & Kumari, 2023). And so on, providing for these institutions the key sense of how to provide an optimal performance to the system of minimizing the resistance to change and encouraging at the same time a continuous improvement culture.

Total Quality Management (TQM) Theory

TQM is a detailed initiative to improve the organizational performance as a whole, with high process / product standards and emphasis toward the customer satisfaction (Al-Dhaafri, Al-Swidi, & Yusoff, 2021). The core of TQM is the concept that quality should be integrated into all facets of the organization from the outset, creating effectiveness, uniformity, and compliance with regulations. The deployment of Total Quality Management (TQM) principles in forensic laboratories is believed to enhance the quality of forensic analyses, streamline case-processing procedures and better fulfil forensic accreditation requirements (Alzoubi, Alshurideh, & Kurdi, 2019).Commitment from leaders, active participation is the basic need to develop a culture of quality, dedicate human and material resources to quality enhancement and handle risks as per forensic standards best practices (Ahmed & Sajid, 2023). As aforementioned, continuous quality improvement is indispensable to minimize inefficiencies and corrective actions undertaken to bolster the reliability of forensic services (Fraihat et al., 2023). Not only do they need to have the required personnel but also such personnel should undergo training and development so that they could utilize the digital forensic tools in the best possible manner, avoid errors and ensure consistency in their case evaluations (Nguyen et al., 2021).

Performance evaluation and quality assurance processes embedding key performance indicators (KPIs) and regular forensic audits enable institutions to track and enhance service delivery. TQM practices are considered among the most powerful means of achieving higher organisational productivity, but their effectiveness relies heavily on the extent of employee engagement with quality management practices and the organisation's effectiveness in promoting such management changes. This means that high employee resistance can significantly reduce the effectiveness of TQM initiatives, indicating that it is a central moderating variable in the TQM–firm productivity relationship (Prashar, 2023).

Resource-Based View (RBV) Theory

The Resource-Based View (RBV) is a theory that explores the competitive advantage organizations or firms maintain through their internal resources (Barney, 1991). Theoretical Underpinning: Resource Based View (RBV) postulates that for resources to lead to sustained organizational success, these resources should be valuable, rare, inimitable, and non-substitutable (VRIN). Total Quality Management (TQM) has evolved as a strategic resource in

forensic laboratories that increases efficiency and service quality, stimulates compliance with the expected aptitudes and regulations, and enhances the forensic quality of results. Laboratory Information Management Systems (LIMS), forensic automation, and quality management systems are some benefits offered to forensic operations that can provide a sustainable competitive advantage (Prashar, 2023) through the improvement of processing speed, error rates, and lack of analysis reporting.

RBV further identifies human capital as a resource that must be effectively managed, suggesting that employee engagement is critical for the effective implementation of TQM practices. A high level of employee resistance, though, can derail the potential impact of TQM-based reform initiatives. Accordingly, the success of quality management initiatives, including the management of people and facilitating the acceptance of organizational change is critical (Alzoubi, Alshurideh, & Kurdi, 2019).

Change Management Theory

Change Management Theory is one of the theories relevant to this study, and it concerns how to manage employee responses and resistance to organizational change. The theory also elaborates on how to manage the small but critical steps in introducing and sustaining change to be more successful. Although many benefits are provided by technological advancements in the area of digital forensics like improved evidence management and automated processes, lack of trust in digital forensic technologies, underutilization of LIMS, and poor adoption of structured quality framework adversely affects the productivity and service continuity of forensic laboratories. Aspects that make a person resistant to change may include fear of job loss, distrust in new processes, non-familiarization with technologies, or preference to stick to old forensic practices (Nguyen et al., 2021). To address these challenges, organizations should take a structured change management approach. Methods such as employee engagement, leaders offering inspirational motivation, and phased rollouts can help foster constructive change that is sustainable and minimize resistance (Prashar, 2023). Integrating Change Management Theory into this framework illustrates that employee resistance is not just a hindrance but rather one of the critical factors affecting the extent of effectiveness in forensic institutions in successfully implementing TQM and boosting productivity. Resistance, if managed well, can become an opportunity to increase employee engagement and stimulate long-term enhancements.

Gap in Literature

This paper contributes to the existing body of knowledge by identifying a number of research gaps in the available literature on Total Quality Management (TQM), firm, productivity, and employee resistance, in the context of forensic laboratories. Despite an abundance of studies focusing on TQM's impact on overall organizational performance (Abbas & Kumari, 2023), few have analyzed its effect on efficiency specifically in forensic institutions post-implementation of a Laboratory Information Management System (LIMS). Additionally, while the association between TQM and productivity is well-established, the process by which TQM impacts productivity through the mechanism of employee resistance is yet to receive significant attention, despite evidence of employee resistance as a critical component in the success of organizational change efforts (Nguyen, Pham, & Tran, 2021). In forensic science institutions, the challenges faced are notably more pronounced than in other sectors due to the increased need for accuracy, operational efficiency, and compliance with regulatory

standards. TQM in manufacturing and healthcare sectors has been extensively studied, however the relationship between its implementation with forensic laboratory productivity prior to, and post, LIMS implementation is less well understood. Furthermore, resistance has been recognized as a normal reaction to transformations; however, empirical studies have shown that it can attenuate or mediate the effect of TQM on forensic productivity (Prashar, 2023).

Research on Total Quality Management (TQM) is largely limited to production, healthcare and services that establish and widely apply continuous quality improvement (Al-Dhaafri et al., 2021; Fraihat et al., 2023). Forensic laboratories instead operate within tightly regulated frameworks and legal mandates, which create challenges that differ from a normal business environment. TQM has not yet undergone successful implementation in forensic science, and only a few research attempts have been made in areas of case processing efficiency, forensic analysis accuracy, and laboratory productivity. While forensic institutions are adopting Laboratory Information Management Systems (LIMS) to automate workflow and improve evidence tracking, the integration of TQM as a supportive strategy with these digital solutions has not been fully studied. Most studies show relevance to advancements rather than systematic quality management in forensic laboratory performance. Moreover, it accentuates an obvious research gap about the contribution of TQM concepts like continuous improvement, employee education, and top management commitment in bolstering forensic effectiveness in a post-LIMS era (Prashar, 2023).

Employee resistance is recognized as a significant factor that can hinder the successful implementation of quality management programs and technical innovations. Resistances could lead to several organizations not adapting changes, leading to greater technical inefficiencies and a culture of disengagement (Malik, Saleem, & Ahmad, 2018; Nguyen et al., 2021). Nevertheless, past studies tend to view employee resistance as an obstacle of productivity rather than a moderating factor that impacts TQM practices. The assumption made by most TQM studies is that quality management practices are instruments that automatically generate more productivity, but they do not take into account how employee attitudes towards change are a factor in that relationship. The implementation of such a model in forensic laboratories must be analyzed taking into account that in these environments, where accuracy, speed, and compliance with established regulations are critical, there may be resistance to adhering to new quality control procedures or automated systems, which can drastically change the expected gains with the TQM implementation (Al-Kahtani & Al-Muhaisen, 2021). There is no research on how varying degrees of resistance from passive to active opposition affect the adoption of quality management strategies in forensic institutions.

Additionally, some studies examined employee resistance in various sectors such as manufacturing and healthcare, but very few studies have considered the impact of employee resistance in forensic science institutions, where professionals may be more resistant because of the highly specialized natures of their work, legal accountability, and well-established forensic traditions (Al-Kahtani & Al-Muhaisen, 2021). Fully bridging this research gap can shed light on how forensic institutions can formulate change management strategies to minimize resistance and increase TQM efficacy in productivity improvements. Existing TQM and productivity literature has generally been applicable to many industries, but tends to neglect

the fundamental operational, regulatory, and technological differences found in forensic laboratories. Forensics tech adoption shouldnt just be about productivity. The TQM framework, instead, allows to shed lights about how some of its main characteristics (i.e., adaptability of the work force, regulatory compliance and efficiencies of the service) interact with each other in the context of forensic institutions (Alzoubi, Alshurideh, & Kurdi, 2019). Forensic laboratories vary widely in the cases they process, the accreditation they must maintain, and the legal contexts they operate under. Nevertheless, TQM literature fails to provide comparative studies on forensic institutions integrating LIMS and their counterparts relying on manual processes (Prashar, 2023). Additionally, much of the research related to forensic productivity has primarily concentrated on North American and European forensic laboratories and there is limited literature with respect to Middle Eastern institutions.

Forensic laboratories in the specific work lines, laboratory staff types, and laboratory governing laws, which are different from regions, may be barriers or facilitate TQM implementation. However, this emphasizes the pressing need for local studies that examine forensics quality management practices at the regional level to assess how specific factors at this level can affect overall realization of TQM (Nguyen et al., 2021). The specific work settings, staff dynamics, and governing laws of forensic laboratories across different regions can either act as barriers or facilitators for TQM implementation. This highlights the urgent need for region-specific investigations into forensic quality management practices to better understand how local factors influence TQM's effectiveness (Nguyen, Pham, & Tran, 2021). Also, another gap in the literature is that there are few longitudinal studies showing the long-term results of implementing TQM on productivity and service quality in forensics. Hence, several studies have analyzed TQM effectiveness through short-term cross-sectional approaches (Verma, Sharma, & Gupta, 2022) which precludes ascertaining how forensic institutions develop quality management strategies in the long run. Longitudinal studies would enable researchers to investigate the ways in which forensic institutions maintain TQM in the long-term, to track when employee resistance peaks across the implementation process, and whether productivity gains are sustained or diminished after initial implementation (Nguyen et al., 2021).

Conceptual Framework Development

Conceptual framework: A representation of the relationships between the key variables in the research, which might be thought to guide the study in, the conceptual foundation for the research that is being analyzed. This study includes the conceptual framework that outlines the relationship between TQM factors and forensic laboratory productivity, with employee resistance as a moderating variable. This framework synthesizes existing theories such as TQM Theory, RBV, and Change Management Theory to provide an integrated framework stating how forensic institutions can improve their operational efficiency after the implementation of LIMS systems. Previous studies have highlighted the positive impacts of TQM practices, including top management commitment, continuous improvement, training, and performance evaluation, on increasing productivity (Abbas & Kumari, 2023; Zahedi, Hashemi, & Akhavan, 2020). However, in forensic institutions where the accuracy and adherence to legal standards is critical, the success of TQM is highly dependent on employees' readiness to implement new quality management procedures and tools for digital forensics (Nguyen, Pham, & Tran, 2021). While employee resistance has been now widely accepted as a barrier to change, as a moderating variable in the relationship between TQM

and productivity is yet to be broadly investigated (Al-Dhaafri et al, 2021). The absence of such a conceptual framework gives rise to the current research which illustrates how employee resistance affects the success of TQM initiatives in forensic laboratories.

The visual representation of the model in figure 1 Demonstrates the relationships among TQM factors, forensic productivity and the employee might be resisted as a moderating variable. The independent factors, TQM factors such as leadership, commitment to continuous improvement, employees' training and performance evaluation lead to productivity improvement (Abdullah, A.H., 2020). Employee resistance is a key factor that moderates the effect of these quality management efforts on improved productivity. At the leadership level, commitment to a culture of quality needs to come from the management and higher authorities in forensic laboratories, who are responsible for justifying quality-improvement efforts, effective allocation of resources, prioritization of employees in change processes and so on (Ahmed & Sajid, 2023). In effect, this form of continuous improvement involves determining the most effective approach to minimizing errors, implementing appropriate remedial solutions, and further improving service delivery through integration of modern forensic technologies and processes (Zahedi et al., 2020). TQM places importance on training and the development of employees; in this context, forensic professionals until have the skills needed to accept new forensic technology, fulfill the regulatory compliance requirements, and utilize LIMS effectively (Nguyen et al., 2021). In contrast, performance assessment and quality control mechanisms such as key performance indicators (KPIs) and forensic audits provide a systematic approach to ensuring high-quality services from laboratories and adherence to regulations (Nguyen, Pham, & Tran, 2021).

Forensic productivity as a dependent variable includes factors such as decreased case processing time, accuracy of forensic analysis, compliance with regulatory standards, as well as improved evidence tracking and management (Zahedi et al., 2020). The success of these outcomes heavily relies on the ability of forensic institutions to adopt TQM approaches while dealing with employee resistance. It plays a moderating role between TQM and forensic productivity within organizations and organizations' coherent ability to manage its human resources. The limitations to adoption can come in the form of concerns for lost jobs as a result of LIMS automation, scepticism towards the new forensic protocol, or simply unwillingness to use digital forensic tools because of the unfamiliarity with the technology (Malik, Saleem, & Ahmad, 2018). TQM initiatives can improve workflow efficiency, forensic accuracy and case processing speed when resistance is low. Alternatively, too much resistance from workers may impede or return the benefits associated with TQM, demonstrating how crucial it is for organizations to manage their human resource in order to realize productivity improvements (Al-Dhaafri et al, 2020).

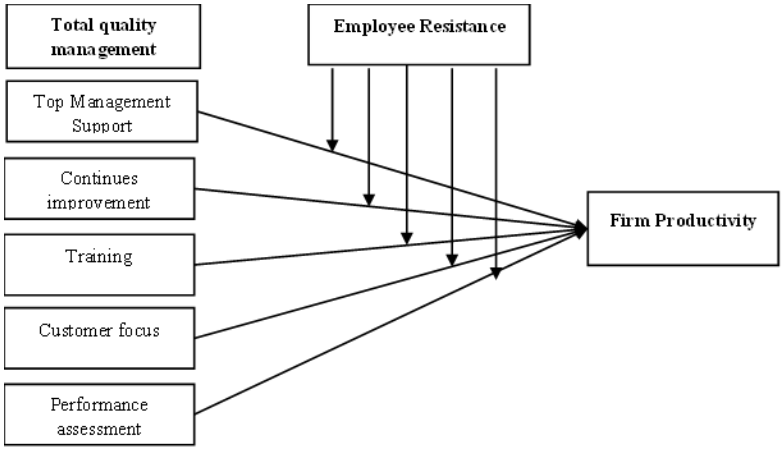

Figure1: Conceptual Framework

Research Implications

This study contributes theoretically and practically to forensic laboratories, policy makers, and quality management practitioners. This study contributes to academic knowledge on forensic laboratory efficiency through its examination of the relationship between Total Quality Management (TQM) steps and forensic laboratory productivity; the moderating role of employee resistance in that relationship discusses the implications of the study for both academic literature and practical forensic cases. Studying the impact of TQM practices on the productivity of forensic institutions, especially in the case of incorporation of technology such as Laboratory Information Management Systems (LIMS) has several implications for making them more tech-savvy and productive. From a theoretical perspective, this research builds on the Resource-Based View (RBV) theory by positioning TQM as an internal strategic asset that increases forensic laboratory productivity. According to the RBV, competitive advantage is achieved through valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney, 1991). In this regard, this study extends the previous research framework by identifying key internal resources, such as TQM factors (top management support, continuous improvement, training, customer focus, performance assessment), that drive operational efficiency in forensic institutions (Prashar, 2023). Furthermore, employee resistance is considered as moderating variable for this study. It exhibits the role of the employees' attitudes and adaptability for quality management to be effective in organizations. Although previous research explained the direct relationship between TQM and productivity, the current study gives novelty by examining the role of resistance to change as a potential catalyst or barrier of the link between TQM and changing productivity (Nguyen et al., 2021). Moreover, through the integration of employee resistance into the RBV framework, this study also reconciles the evolving theories of quality management and organizational behavior by putting the resistance effect into the kaleidoscope of LIMS adoption and productivity implications.

Practically, the study results offer recommendations for forensic institutions to improve productivity through TQM-driven strategies and manage employee resistance. The study highlights the role of support from top management in the successful implementation of TQM practices and LIMS. The commitment of leadership is important to delineate the resources, as well as, to sensitize the quality-commenting culture, which ultimately encourages the workforce in the change strategies (Ahmed & Sajid, 2023). All forensic laboratory managers would benefit from taking proactive steps to improve communications, encourage leadership training, and set clear goals for quality improvement to facilitate the

successful implementation of LIMS. Employee resistance to change, a common barrier to TQM implementation, was the most significant challenge identified in this study. Such resistance is often driven by fear of job displacement, lack of familiarity with digital forensic systems or a reluctance to move away from traditional forensic methodologies (Akanmu et al., 2023). This study aims to provide the necessary information and recommendations, it includes that forensic institutions undertake specific training programs, technical support, and a culture of continuous improvement at forensic institutions to reduce resistance to change. Finally, involving employees in the LIMS implementation process can help foster acceptance to change and lessen resistance, resulting in improved productivity and forensic service delivery.

Another important contribution from this study is that performance evaluation mechanisms should also be integrated for continuous improvement. Forensic laboratories should adopt systematic evaluation frameworks, such as Lean Six Sigma, to assess their workflow efficiency, error rates, and service quality. Organizational performance can be assessed through periodic quality audit reviews, employee feedback systems and tracking of key performance indicators (KPIs) which can indicate the areas that need to be improved and monitor the effects of quality management efforts (Verma et al., 2022). In turn, this could enable forensic institutions to tailor their performance assessment with their productivity goal and attain enhanced operational performance, underpinned by quality improvement endeavours. Additionally, the study stresses a quality management approach based on a customer focus for a forensic laboratory. Providing services of high quality to customers such as law enforcement agencies, legal professionals, and judicial institutions is a technique that will ensure forensic processes to meet the needs and expectations of customers (Alzoubi, Alshurideh, & Kurdi, 2019). For instance, forensic laboratories should involve stakeholders by developing collaborative partnerships to ensure their services align with the criminal justice system's broader requirements. By soliciting feedback from key stakeholders, forensic institutions may improve their processes to generate forensic analyses most likely to assist the judiciary (Nguyen, Pham, & Tran, 2021).

At a policy level, there is a need for standardization, where regulators of forensic laboratories should be developing TQM implementation and LIMS adoption guidebooks. In this context, the article can recommend relevant approaches of the government agencies for forensic institution to be sponsored in terms of providing funding to develop advanced training programs, funding for forensic technology infrastructure, and developing best practices in quality management (Alzoubi et al., 2019). Clinical quality is also important, and having one or more national quality management frameworks in place would ensure that such systems and quality processes measure the quality of input and output and better forensic service delivery, compliance with international forensic standards and implementation, increasing performance and productivity. Nevertheless, this study is not without limitations, as it focuses on specific factors contributing to TQM but does not examine potentially influential ones. Longitudinal research could be carried out in future studies for investigating the dynamics of the relationship between TQM, employee resistance, and productivity over time. Another consideration for future research is in considering the role of organizational culture in the development of an organization’s employee attitudes towards TQM adoption and investigating industry-specific TQM challenges by comparing forensic laboratories to other high-stakes environments like healthcare and pharmaceuticals. Also, qualitative research

methods such as interviews and case studies would help in gaining deeper insights into employee perceptions regarding LIMS" adoption and quality improvement initiatives.

Conclusion

This research understands the impact of Total Quality Management (TQM) factors towards forensic laboratory productivity, by intervening with employee resistance as moderating variable. Forensic institutions operate in highly regulated environments, where accuracy, efficiency, and compliance with legal standards are paramount. The application of total quality management (TQM) strategies such as leadership commitment, customer focus, continuous improvement, employee training, performance assessment, and recognition could improve forensic productivity. The success of these quality management initiatives, however, relies on employee buy-in and adaptability to change. An important aspect of TQM is that existing literature has already reported that TQM can aid productivity towards various industries but specific studies for analyzing TQM impact on the forensic science institutions direct impact, especially in post-LIMS phase, are limited. There is a gap in knowledge of the influence of employee resistance on the success of TQM led quality gains in forensic laboratories, a gap that is addressed by the findings in this study. Most of the studies viewed resistance as an impediment, whereas a few have highlighted its moderating influence in TQM-productivity relationship. The comprehensive conceptual framework outlined in this study combines TQM Theory, Resource-Based View (RBV) and Change Management Theory to clarify the conditions under which forensic institutions can maximize operational efficiency whilst establishing a more complex balance of opposing interests among employees and stakeholders in response to changes of intention.

These results confirm that when employee resistance is efficiently administered with regard to TQM, forensic institutions will be able to take full advantage of TQM to optimize workflow efficiency, minimize forensic errors, and accelerate case processing. On the other hand, high resistance to change means TQM initiatives are less likely to succeed and productivity increases could be sacrificed. Implementing structured change management strategies, engaging leadership support, and providing targeted training programs can help mitigate resistance and support the successful adoption of quality management practices in forensic settings. Moreover, this study indicates the requirement of context-specific investigation of TQM in forensic laboratories, since forensic institutions have distinct regulatory, technological, and operational conundrums. Empirical validation of the conceptual framework(s) proposed in this research could include case studies and/or longitudinal analyses that can ascertain the long-term implications of TQM on forensic productivity. Also, studies comparing forensic laboratories in different regions and legal jurisdictions can give better insight into how TQM implementation reflects in diverse forensic environments.

We hope that by bridging these research gaps, forensic entities can design better quality management plans, provide better service, and provide better adherence to the forensic practices of proficiency testing. The combination of TQM and LIMS can lead to process improvement, but only if the productivity of the work force is enhanced. These findings highlight the importance of changing management to prepare forensic practitioners to adapt to technological developments and quality improvement initiatives. Finally, forensic laboratories need to understand that quality management is not only a technical or procedural issue but also a human-centric process. Forensic institutions can manage better

productivity growth and operational excellence through embracing continuous improvement, engaging in people-focused change-management and minimizing the resistance to change. In this manner, addressing employee concerns and aligning organizational goals with the development of the workforce will help TQM be a tool used strategically to help forensic laboratories succeed in the long term.

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