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Mapping Priority Improvements in Quality Improvement Projects: An Integrated Study of Quality and Risk Management

Wiwik Sulistiyowati[1], Mokhammad Suef[2], Moses Laksono Singgih[3]

Abstract

This study develops a model to identify critical success factors that determine the success of quality improvement projects by analyzing the relationships between quality management principles, project implementation, and risk management and determining priority factors that require improvement. This study uses an approach that combines three main methods. The first method analyzes the relationship between various factors that affect project success. The second method identifies low-performing aspects that require prioritization for improvement. The third method aims to identify the root cause of problems in quality improvement projects. The study results indicate that quality management principles, risk management, and project implementation have a direct impact on the success of quality improvement projects. However, the role of project implementation as a mediator between risk management and project success is not very strong, although it significantly affects quality management principles. Key factors needing improvement include employee involvement, leadership, and quality planning. This study offers insight into how quality and risk management can support one another, helping to identify key factors for improvement and providing a more comprehensive approach to enhancing quality.

Keywords: *Critical Success Factor, Quality Improvement Project, Quality Management Principles, Risk Management.*

Introduction

Quality improvement projects (QIPs) are crucial for an organization to enhance its efficiency, product quality, and consumer satisfaction. QIP aims for continuous improvement in an industry/company (Ang et al. 2023; Jevgeni, Eduard, and Roman 2015; Singh and Singh 2012, 2015; Sraun and Singh 2017). QIP is very effective if it is aligned with the targeted results, for example, to increase consumer satisfaction; this directly impacts the company's reputation and plays a vital role in consumer retention (Samuel et al. 2021; Zailani et al. 2023). To achieve optimal results, organizations integrate several quality concepts when implementing QIP by combining the principles of quality management (QMP) with the implementation of risk management (RMI). QMP includes top management commitment, process-oriented, and consumer-focused (Bulto 2023; Hussain et al. 2023; Koval, Nabareseh, and Marciniak 2018; Majumdar 2016). Meanwhile, RMI aims to ensure that projects can be anticipated to resolve uncertainties and risks during quality improvement projects (Hopkinson 2024; Motorin 2021). Integrating QMP and RMI in QIP can increase the success of quality improvement projects.

Quality improvement projects are strategic tools an organization uses systematically to address in-efficiency and product standards. (Elliott, McKinley, and Fox 2008; Phillips et al. 2010). The primary objective of a quality improvement project is to identify the causes of process variability and implement corrective actions that enhance the production process's efficiency and ensure the production of high-quality products. An essential element in implementing a quality improvement project is setting clear goals, studying the system, designing improvement efforts by targets, and measuring the impact (Mortimer et al. 2018; Mukwakungu and Mbohwa 2018). However, despite the efforts made, the success of QIP has varied because not all projects achieve the desired results.

Several previous studies have stated that factors that affect the success of quality improvement projects are management commitment, customer satisfaction, employee involvement (Dückers, Wagner, and Groenewegen 2008) supplier relationships and the existence of training and education for employees (Brennan et al. 2013; Xiong et al. 2016), quality culture, Teamwork, communication (Bullington et al. 2002) scope (Jaca et al. 2011)), time, cost, product quality and profit (Chandra 2015). In addition, some of the factors that cause project failure are lack of top management commitment, poor communication, incompetent teams, systematization to change, wrong selection of strategies and methods of implementing quality improvement projects (Antony et al. 2019; Antony and Gupta 2019; McLean, Antony, and Dahlgaard 2015; Stellman and Greene 2007) This inconsistency highlights the need for a robust framework that integrates quality management principles to effectively implement risk management in quality improvement projects, thereby increasing the likelihood of success.

The successful implementation of quality improvement projects (QIPI) depends on the application of quality management principles (QMP) (PMBOK 2021; Pribadi, Fauzi, and Ekawijana 2023) and the implementation of effective risk management (RMI) (Fathurohman, Ekhsan, and Laela 2023; Luko 2013; Purdy 2010). QMP ensures that every process in the project upholds the set quality standards, which ensures variability (Date 2017; Saparina, Wahab, and Mirfani 2020). RMI aims to strengthen project implementation by identifying potential risks and sources of risk and mitigating these risks to reduce obstacles and disruptions that can cause project failure. This is achieved by integrating a comprehensive approach between QMP, RMI, and QIPI to improve the RMQIP success rate.

Quality improvement projects (QIP) have been widely implemented in manufacturing and service companies. The standard used is a quality management standard (ISO 9001), but not all apply risk management and quality management principles contained in TQM in their implementation. In its implementation, there is still the possibility of success and failure. Therefore, it is essential to investigate the key factors that contribute to the success of quality improvement projects. Some previous researchers have found that the key indicators of project success are time, cost, and quality (A. Kassem, Khoiry, and Hamzah, 2019). Meanwhile, Chandra (2015) stated that the key indicators of project success include cost, time, quality, consumer satisfaction, and profit (Chandra,22015). Research on project success factors continues to discuss the project's scope in general, rather than in the realm of QIP and considers risks as well as the application of TQM principles. This study aims to develop and validate a conceptual model that explores the relationship between quality management principles (QMP), risk management implementation (RMI), and quality improvement project implementation (QIPI) and its impact on the success of quality improvement projects (RMQIP) using Structural Equation Modelling – Partial Least Square (SEM-PLS); and to find out the factors that are prioritized for improvement using the Importance-Performance Map Analysis (IPMA) method. SEM-PLS is a data analysis technique that enables the handling of small sample sizes and accommodates complex model structures (Barclay, Higgins, and Thompson 2015; Dijkstra

2016; Hair, Joseph et al. 2014). The IPMA method provides a strategic framework for prioritizing improvement efforts by assessing the significance and performance of various project components (Haverila, Haverila, and Twyford 2020). Priority remediation is achieved by identifying critical and underperforming areas. This short-term approach is particularly useful in quality improvement projects, where a systematic focus on the impact area can significantly enhance the results of implementing quality improvement projects through effective resource allocation and a focus on critical issues. To identify the root cause of QIP implementation inefficiency, this study employs the root cause analysis (RCA) concept approach. RCA is an investigative method that identifies the root cause of the problem (Lanida, Yustiawan, and Dzykryanka, 2019; Latino, Latino, and Latino, 2016; Pal, Franciosa, and Ceglarek, 2014; Sulistiyowati and Sari, 2018; Zulbainarni and Khumaera, 2020). By integrating SEM-PLS, IPMA, and RCA, the study presents a comprehensive model that prioritizes and addresses critical issues hindering the success of quality improvement projects.

The study is organized into four sections; the first section examines the conceptual relationship between QMP, RMI, and QIPI, emphasizing their influence on the success of quality improvement projects (RMQIP). The second section describes the research methodology, detailing the data collection and processing techniques used for data analysis to validate the proposed conceptual framework. The third section is the results and discussion, providing practical management recommendations. The fourth section summarizes the main findings, management implications, and suggestions for further research. This comprehensive structure aims to understand the critical factors of success in quality improvement projects (RMQIP), offering practitioners theoretical insights and actionable guidance.

Literature Review and Hypotheses Development

Quality Improvement Project (QIP)

Quality improvement projects (QIP) aim to improve organizational processes, efficiency, and outcomes (Vos et al. 2010). The aspects of the quality improvement project consist of 1) Implementation strategy. The implementation strategy is based on a methodical approach aimed at quality improvement. Some methods include Six Sigma, Lean Thinking, and Statistical Process Control, as well as previous research utilizing the Lean Six Sigma method. Implementing Lean Six Sigma in various sectors has shown that quality improvement activities can improve operational efficiency and minimize product defects (Kaswan and Rathi 2020). Leadership and quality culture are the determining factors for the success of quality improvement projects (O'Donovan et al. 2019). In its implementation, monitoring and optimizing the continuous process of quality improvement projects require technology. With the development of Industry 4.0, marked by the development of the Internet of Things (IoT) and Artificial Intelligence (AI) can be used by organizations to track performance, identify process inefficiencies in real-time, and improve precise, accountable, and transparent decision-making (Chow-Chua and Goh 2000; Eleftheriadis and Myklebust 2016).

Structural Equation Modelling – Partial Least Square (SEM-PLS)

SEM-PLS is a commonly employed statistical method for analyzing complex relationships between variables in research models (Calvo-Mora, Domínguez-CC, and Criado 2018). It is beneficial when dealing with small samples, non-normal data distributions, and formative constructs (Joseph F. Hair and Sarstedt 2019). The critical aspects of SEM-PLS are: 1) Formative and reflective models: SEM-PLS can model both formative and reflective constructs.

Formative indicators define constructs, while reflective indicators are effects of latent constructs, making SEM-PLS suitable for measuring multidimensional constructs (Hair, Joseph et al. 2014); 2) Handling complex models with undersized samples: Studies show that SEM-PLS can produce reliable results even with smaller sample sizes compared to those required for covariance-based SEM (Joseph F. Hair et al. 2017); 3) Prediction-oriented approach: SEM-PLS emphasizes maximizing the variance explained through endogenous variables, making it valuable for predictive accuracy (Shmueli et al. 2016). Recent advancements in SEM-PLS include analyzing model fit through the standardized root mean square residual (SRMR) to measure the difference between observed and predicted values (Henseler, Hubona, and Ray 2016). Using bootstrap and prediction techniques allows researchers to test hypotheses with small samples and assess the model's predictive relevance (Q^2) (Barclay, Higgins, and Thompson 2015; Joe F. Hair 2021; Shmueli et al. 2016).

Importance Performance Map Analysis (IPMA)

IPMA is a strategic management tool that helps organizations prioritize areas for improvement by identifying important underperforming attributes (Joseph F. Hair et al. 2017). The critical aspects of IPMA are as follows: 1) Framework and objectives: IPMA integrates two dimensions: importance and performance. The analysis visualizes factors with high importance but low performance as priorities for improvement, while low-importance, low-performance factors receive less attention (Bartoška, Svobodová, and Jarkovská 2011; Kim 2022; Teeluckdharry, Teeroovengadum, and Seebaluck 2024); 2) Methodological integration: In recent years, integrating IPMA with SEM-PLS has improved the predictive accuracy of IPMA by considering interactions between multiple factors and their contributions to overall performance (Ringle and Sarstedt 2016; Sternad Zabukovšek et al. 2022).

Root Cause Analysis (RCA)

RCA is a systematic process used to identify the root cause of a problem (Charles et al. 2016; Latino, Latino, and Latino 2016; Shaqdan et al. 2014; Sulistiyowati and Sari 2018). The critical aspects of RCA are: 1) Methodology and process: RCA involves identifying the problem, collecting data, analyzing it, and implementing corrective actions. Using statistical methods, RCA helps organizations systematically trace causal relationships to identify the root cause (Alifia and Dhamanti 2022; Sulistiyowati, Handoko, and Catur Wahyuni 2020); 2) Differentiating between root cause and symptoms: RCA focuses on addressing the root cause rather than merely treating the symptoms, ensuring long-term solutions (Charles et al. 2016).

Hypothesis Development

Relationship between Quality Management Principles (QMP) and Quality Improvement Project Implementation (QIPI)

Quality management principles (QMP) focus on improving quality, efficiency, and consumer satisfaction (Hellingsworth, Hall, and Anderson 2020). These principles include leadership commitment, customer focus, quality improvement, and process orientation (Shabrina Ayu Hananta and Jeni Susyanti 2024). Implementing a structured QMP directly impacts the success of quality improvement projects (QIPI) because QMP provides a systematic approach to managing and improving processes (Lobo, Samaranayake, and Laosirihongthong 2018; Mohsen Alawag et al. 2023). When applied effervescently, QMP, by prioritizing quality, assists organizations to reduce waste in processes and achieve consistent output (Bulto 2023; Kuzaiman et al. 2018). Meanwhile, implementing quality improvement projects (QIPI) refers to implementing structured projects to improve an organization's quality (Chartier et al. 2019). The relationship between QMP and QIPI is significant because QMP is a foundation that supports consistent implementation, reduces variability, and improves the implementation of quality improvement projects to achieve the set results (Salah, Carretero, and Rahim 2010).

Previous research on the relationship between QMP and QIPI, based on the direct impact of this study, shows that the implementation of QMP has a positive effect on QIPI by creating a structured and disciplined approach to quality (Netland and Sanchez, 2014). With the commitment of the leadership and continuous improvement directly related to the quality improvement project, it will better achieve the target, and this is because it provides a clear direction and fosters a culture of accountability with the involvement of the leadership in QIPI will have a direct influence on the implementation of the project (Shan, Ahmad, and Nor 2016; Sulistiyowati, Suef, and Singgih 2023; Suriadi et al. 2019). Several previous studies have shown that QMP has a positive effect on QIPI. Thus, this study proposes the following hypotheses:

H1: Quality Management Principles (X1) affect the Implementation of Quality Improvement Projects (X3).

The Relationship between the Implementation of Risk Management (RMI) and the Implementation of Quality Improvement Projects (QIPI)

Risk management implementation (RMO) is a systematic approach used to identify, assess, mitigate, and monitor risks that have an impact on the goals or targets of the implementation of quality improvement projects (QIPI) (Hopkinson 2024). In the context of QIPI, RMI has an essential role in helping organizations anticipate potential disruptions and develop strategies to ensure the implementation and effectiveness of QIPI (Hudin and Hamid 2014a; Jiang and Zhao 2012). (Hudin and Hamid 2014b; Jiang and Zhao 2012). Several previous studies have shown the direct impact of RMI on implementing QIPI. A survey conducted by Al-Ansi., et al. (2019) indicates that RMI has an essential role in achieving QIPI by reducing the impact of uncertainty and potential disruptions (Al-Ansi, Olya, and Han 2019). (Al-Ansi, Olya, and Han 2019). Organizations that integrate RMI into QIPI tend to experience a success rate of QIPI because it effectively addresses and reduces project risks (Almarzooqi et al. 2023a; El Khatib, Al Zeyoudi, and Shaqar 2020). Other research indicates that RMI serves as a preventive mechanism for QIPI. Empirical studies using SEM-PLS quantitatively show the positive impact of RMI on QIPI results. The study found that RMI was positively and significantly related to the performance of QIPI. Empirical evidence reinforces the idea that RMI is not just on protective measures but is an integral component of quality-focused project management (Barclay, Higgins, and Thompson 2015; Mustapha et al. 2023). This new insight underscores the importance of continuous risk assessment and its impact on maintaining quality standards throughout project execution (Harpster 2016; Malikova 2017; M. A. Samani et al. 2017; Mahmoud Asad Samani et al. 2014; Zhemchugova and Levshina 2020). Based on previous research, it can be concluded that RMI has a substantially positive impact on QIPI, particularly when employed with a structured approach to identify, assess, and mitigate risks that may hinder QIP's efforts. Thus, this study proposes the following hypotheses:

H2: Risk Measurement (X2) affects Quality Improvement Project Implementation (X3)

Relationship between Quality Management Principles (QMP) and Quality Improvement Project Success Factors (RMQIP)

Quality management (QMP) principles include several vital elements, e.g., focus on consumers, leadership commitment, employee engagement, process approach, and continuous improvement, all of which support high-quality outcomes (Nápoles-rojas, Isaac-godínez, and Moreno-pino 2015). When applied to QIP, these principles can directly affect the success factors of quality improvement projects (RMQIPs). These success factors include stakeholder satisfaction, timeliness, adherence to quality standards, and project sustainability (Kim-Soon 2012; Pallari et al. 2019a). The relationship between QMP and RMQIP is crucial, as it provides the structured foundation necessary to achieve consistent quality in project outputs. When QMP becomes a part of the quality improvement project framework, with a systematic approach that encourages effective decision-making, problem-solving, and alignment between the achievement of consumer expectations, all of which are some of the critical factors for the success of quality improvement projects (Mohsen Alawag et al. 2023; Tambare et al. 2022).

Some previous studies have explored the relationship between QMP and RMQIP, highlighting the positive impact of QMP on the success of RMQIP. Studies show that the elements of QMP, namely the focus on consumers and employee engagement, contribute significantly to the success of RMQIP (Aghimien et al. 2019; Bulto 2023; Inoue and Yamada 2013). Other research shows that continuous improvement, the core of QMP, has been proven to directly affect RMQIP by creating a culture that values quality improvement as feedback (Glowalla and Sunyaev 2015; Sunder M and Antony 2018). Research on integrating QMP with QIP performance metrics reveals that aligning project success factors with measurable quality standards enables organizations to assess project effectiveness effectively. Thus, this study proposes the following hypotheses:

H3: Quality Management Principles (X1) affect Quality Improvement Project Success Factors (Y).

The Relationship between the Implementation of Risk Management (RMI) and the Success Factor of Quality Improvement Projects (RMQIP)

The success factors of the Quality Improvement Project (RMQIP) include the timeliness of project implementation, compliance with quality standards, and the effectiveness of stakeholder satisfaction costs, all of which are influenced by the effective implementation of risk management (RMI) (PMBOK 2021; Radujković and Sjekavica 2017). By proactively addressing uncertainty, RMI can enhance RMQIP by reducing the likelihood of repeated errors, improving project predictability, and enabling project teams to be prepared to tackle unexpected challenges without compromising quality. It is supported by research that shows that organizations are more effective in allocating resources, making informed decisions in dealing with risks, and maintaining continuous improvement efforts (Almarzooqi et al. 2023b; Hersyah and Derisma 2019). Previous research on the relationship between RMI and RMQIP has expanded significantly, with studies examining how risk management contributes to various project success factors across multiple fields. Some findings from previous studies indicate that RMI has a direct impact on the RMQIP factor, specifically that implementing risk management strategies in quality improvement projects can enhance the achievement of desired outcomes by mitigating risks that hinder project progress. This study highlights how RMI contributes to project schedule stability, budget compliance, and stakeholder satisfaction (Chandra 2015; Eldaia, Hanefah, and Marzuki 2022). The research focused on the role of RMI in enhancing quality standards. This study illustrates the role of RMI as a preventive measure, allowing project teams to anticipate and mitigate risks that negatively impact quality standards. By implementing proactive risk management, quality improvement projects can maintain quality standards and achieve the quality objectives of the project (Barafort, Mesquida, and Mas 2017; Harpster 2016). Based on previous research, it can be concluded that a comprehensive approach to the relationship between RMI and RMQIP is essential for RMI to achieve the success of RMQIP. Therefore, this study proposes the hypothesis:

H4: Risk Measurement (X2) Affects Quality Improvement Project Success Factors (Y)

Relationship between Quality Improvement Project Implementation (QIPI) and Quality Improvement Project Success Factors (RMQIP)

Quality Improvement Project Implementation (QIPI) is a systematic approach to implementing projects that aim to improve quality. Effective implementation of QIPI requires organizations to align their resources, processes, and personnel to improve quality. Some RMQIP factors include key performance metrics such as project timelines, compliance with quality standards, budget compliance, and stakeholder satisfaction. QIPI plays an essential role in achieving this factor. The relationship between QIPI and RMQIP is fundamental, as the effectiveness of QIPI directly impacts the project's success. QIPI serves as a medium between the objectives of the strategic quality improvement project and its results, which are the key determinants of the success of RMQIP (Woolhandler, Ariely, and Himmelstein 2012). Previous research related to the relationship between QIPI and RMQIP, namely the results of research on continuous improvement practices in QIPI, have proven to impact RMQIP directly; this is supported by research showing that QIPI can maintain alignment with quality standards, improving RMQIP (Bani-Hani, Al-Ahmad, and Alnajjar 2009; Randhawa and Ahuja 2017). Another study shows the impact of QIPI on project performance metrics. By using SEM-PLS to investigate the relationship between QIPI and RMQIP, we found a significant correlation between QIPI and RMQIP in terms of quality, timeliness, and cost efficiency (Carnerud 2018). Several previous studies have demonstrated that the structured approach of QIPI can significantly enhance RMQIP by effectively aligning resources and promoting cost efficiency. Thus, this study proposes the following hypotheses:

H5: Quality Improvement Project Implementation (X3) affects Quality Improvement Project Success Factors (Y).

The relationship between Quality Improvement Project Implementation (QIPI) mediating Quality Management Principles (QMP) to the success of quality improvement projects (RMQIP)

On the other hand, implementing the Quality Improvement Project (QIPI) refers to applying the principles outlined in the QMP to improve quality. QIPI involves planning, resource allocation, quality control, and continuous monitoring to achieve quality objectives (Jones, Kwong, and Warburton 2021). In this context, QIPI serves as a mediator variable between QMP and RMQIP. The success of RMQIP is measured by quality standards, punctuality, consumer satisfaction, and overall performance (Chandra 2015; Inoue and Yamada 2013; Kishk and Ukaga 2010; Tambare et al. 2022). QIPI mediation implies that QMP may not be enough to encourage RMQIP. Instead, implementing QMP through QIPI translates QMP into a real success factor (Kulenović, Folta, and Veselinović 2021; Matsoso and Benedict 2015; Sobhi, Salah, and Magdy 2016). Several previous studies that examined the relationship between QIPI as a mediator of QMP and RMQIP, namely indirect impact, show that QMP indirectly affects RMQIP when mediated by QIPI, supported by research that states that QMP elements such as leadership commitment indirectly contribute to RMQIP by developing policies and standard operating procedures (SOPs) in QIPI. Research shows that QMP establishes the basis for improving quality through practical QIPI quality management principles translated into tangible project success factors (Bozdogan 2010; Okwu et al. 2021). Another study shows that QIPI is an operational mechanism of QMP. Research indicates that QMP sets the strategic quality direction, while QIPI applies QMP principles to workflows, schedules, and project objectives. This study emphasizes that QIPI allows QMP to directly influence RMQIP by integrating quality objectives into each stage of the project, thus bridging the gap between its principles and practices (Abdullah, Uli, and Tarí 2008; Ahmed and Idris 2021; Guspianto, Asyary, and Ibnu 2021; Miller et al. 2018). The research resulted in empirical validation of the mediation role of QIPI. Empirical studies using SEM0PLS have validated QIPI as a mediator in the QPM-RMQIP relationship. The continuous improvement of QIPI is a driver of project success. Based on several previous studies, this analysis can provide a comprehensive understanding of the mediating role of QIPI in the relationship between QMP and RMQIP. Therefore, this study proposes the following hypotheses:

H6: The implementation of the Quality Improvement Project (X3) mediates the Quality Management Principles (X1) on the Success Factors of the Quality Improvement Project (Y).

The relationship between Quality Improvement Project Implementation (QIPI) mediating the Implementation of Risk Management (RMI) to the success of quality improvement projects (RMQIP)

Risk Management Implementation (RMI) is a structured approach that identifies, assesses, analyses and mitigates risks that have the potential to interfere with the achievement of project objectives. In the context of QIPI, RMI is critical in minimizing uncertainty and facilitating the implementation of quality improvement projects (Ágoston, van Mourik, and Strengers 2011; Pallari et al. 2019b). Nonetheless, RMI indirectly translates into successful quality results. By implementing effective QIPI, RMI is operationalized to improve project quality, achieve goals, and meet success criteria (Tricco et al. 2012). QIPI acts as a mediator by transforming risk mitigation strategies into actionable project steps that directly contribute to the success factors of RMQIP. QIPI ensures that risk management strategies are well integrated into the QIPI implementation process, scheduling, and project quality targets, thus enabling risk mitigation efforts to have a direct impact on project success metrics such as cost efficiency, timeliness, compliance with quality standards and customer satisfaction (PMBOK 2021). The mediation function implies that while the RMI establishes the foundation for risk mitigation, the QIPI functions to execute the strategy by adjusting to the quality improvement objectives, thus influencing the RMQIP (Almarzooqi et al. 2023a; Perkins et al. 2014; Tan 2020). Previous research on the integration between RMI and the QIPI framework enables the integration of names as an RMI strategy to respond to changes in the project environment. Integrating the QIPI framework with RMI ensures that risk mitigation practices are flexible and responsive, enabling projects to tailor risk strategies to their needs and achieve quality improvement project objectives. This adaptive approach further enhances the mediation effect between RMI and RMQIP. Research that integrates the ISO 31000 framework for risk management and quality management cycles (e.g., PDCA) affects the achievement of quality management project outputs (Fathurohman, Ekhsan, and Laela 2023; Malikova 2017; M. A. Samani et al. 2017). Based on previous research, this study provides a comprehensive analysis of the mediating role of QIPI in the relationship between RMI and RMQIP. So, this study proposes the following hypotheses:

H7: Quality Improvement Project Implementation (X3) mediates Risk Measurement (X2) and affects Quality Improvement Project Success Factors (Y).

The Conceptual Model

The conceptual model outlines the relationship between latent factors and their manifest variables. Figure 1 illustrates the relationship between exogenous and endogenous latent constructions. Several studies have examined the behavioural factors that influence the success or failure of quality improvement projects in the manufacturing industry, concluding that various factors contribute to success and failure. Therefore, in this study, critical factors affecting the success of quality improvement project implementation are measured using Structural Equation Modeling with Partial Least Squares (SEM-PLS), Importance-Performance Analysis (IPA), and Root Cause Analysis (RCA).

The **Y** variable represents the **Critical Success Factors** of Quality Improvement Projects, which include five indicators: cost, time, quality, scope, and customer focus.

Variable X consists of three components:

- **X1**, which represents **quality management principles** (QMP) with three indicators,
- **X2**, which refers to the **implementation of risk management** (RMI) with eight indicators,
- **X3** signifies the **implementation of quality improvement projects** (QIPI).

There are a total of 21 indicators across the four variables. **Figure 1** displays the relationships between the exogenous and endogenous latent variables as depicted in the conceptual model. The study encompasses five direct effect hypotheses and two mediation effect hypotheses, all of which influence the success of quality improvement projects.

Direct Effect Hypothesis

H1: Quality Management Principles (X1) affect the Implementation of Quality Improvement Projects (X3).

H2: Risk Measurement (X2) affects Quality Improvement Project Implementation (X3)

H3: Quality Management Principles (X1) Affect the Success Factors on Quality Improvement Project (Y)

H4: Risk Measurement (X2) Affects Success Factors on Quality Improvement Project (Y)

H5: Quality Improvement Project Implementation (X3) Affects the Success Factors on Quality Improvement Project (Y)

b. Mediation Effect Hypothesis

H6: The implementation of the Quality Improvement Project (X3) mediates the Quality Management Principles (X1) on the Success Factors of the Quality Improvement Project (Y).

H7: Quality Improvement Project Implementation (X3) mediates Risk Measurement (X2) and affects the Success Factors of the Quality Improvement Project (Y).

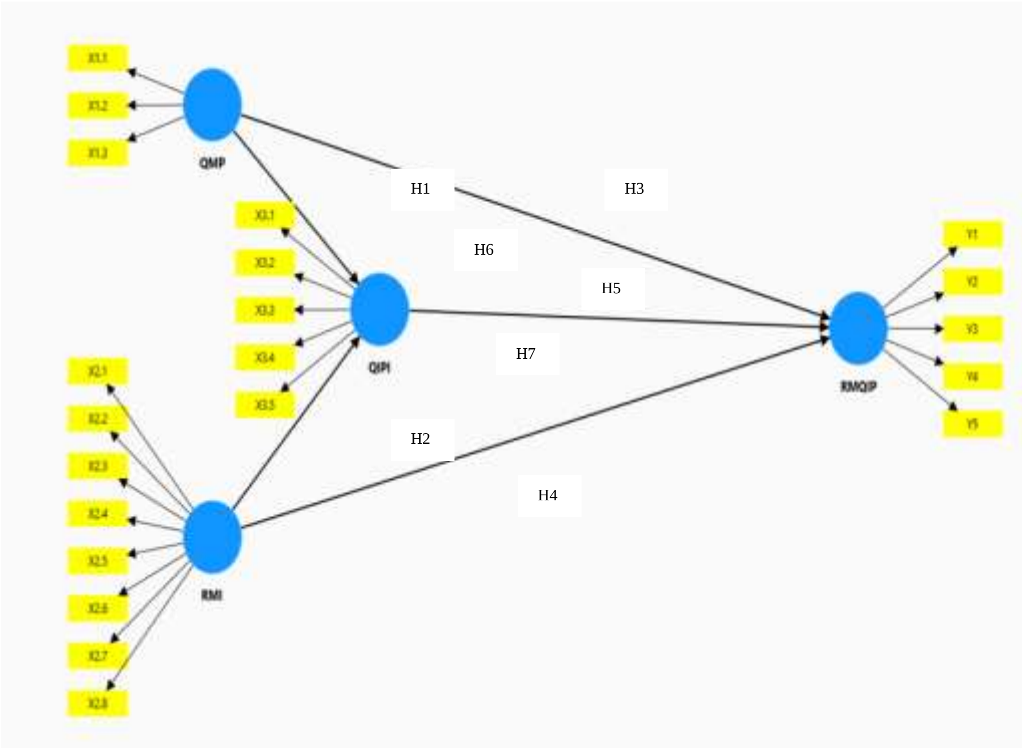

Figure. 1 Conceptual Model Based on Hypothesis

Research Method

This study employs a multi-method approach that integrates Structural Equation Modeling—Partial Least Squares (SEM-PLS), Importance-Performance Map Analysis (IPMA), and Root Cause Analysis (RCA). SEM-PLS assesses the strength and significance of relationships between variables, while IPMA identifies improvement priorities by highlighting factors of high importance but low performance. RCA is used to investigate the cause of faults and provide recommendations for improvement.

This study uses a survey that focuses on gathering information about expert opinions that are not sensitive. Data collection is used to determine the influence of quality management principles on the application of risk management in implementing quality improvement projects and to assess how it affects the success of these projects. According to the ethical principles and guidelines of the American Psychological Association (APA), this survey requires ethical approval from the relevant committee. This research was conducted by ethical standards by providing complete information about the study's purpose, adhering to guidelines, determining the role of the respondents, and obtaining consent from each respondent. Ensure that the quality and reliability of the data from the survey results are carried out consistently and accurately according to standards related to the questionnaire's items; this helps maintain the integrity of survey items (Bergkvist 2021; Bergkvist and Rossiter 2007).

The ethics committee of Universitas Muhammadiyah Sidoarjo approved this work in June 2024. Approval was received after the committee reviewed the research proposal and the questionnaire items. All respondents were human subjects who provided informed consent before participating in this study. This agreement is outlined in the introduction, which explains the research's purpose, rights, obligations, and nature. After that, respondents will be given the option to participate in this research. Respondents will be guaranteed privacy and confidentiality for their answers. Additionally, respondents were informed that they could withdraw from the study at any time and that there would be no consequences.

Sample Size

The minimum sample size in SEM-PLS analysis is determined by either 1) ten times the number of the most prominent formative indicators used to measure a construct or 2) ten times the number of the most extensive structural paths leading to a particular construct (Hair, Joseph et al. 2014; J. Hair et al. 2010; Haryono 2016; Purwanto and Sudargini 2021). Based on these criteria and 20 indicators, the required sample size is 5 x 20 = 100 respondents. In this study, 120 respondents were included, which exceeds the minimum requirements. The sampling technique is purposive sampling, where respondents are selected based on specific criteria. In this study, eligible respondents are those with experience in implementing quality improvement projects and knowledge of risk management

Variable Measurement Scale

The questionnaire uses a Likert scale ranging from 1 to 5 points. The first, second, and fourth questionnaires use a 5-point Likert scale where 1 indicates "very poor"; 2 indicates "poor"; 3 indicates "good"; 4 indicates "very good"; and 5 indicates "excellent"

The first questionnaire measures the Y variable (success of quality improvement projects). In contrast, the second questionnaire measures the X1 variable (quality management principles), the third questionnaire measures X2 (risk management implementation), and the fourth questionnaire measures X3 (quality improvement projects implementation). The Likert scale produces data that can be treated as continuous or interval data. Since the order of responses is maintained, the Likert scale meets the assumptions for Structural Equation Modelling (SEM) analysis.

Instrument Design

In this study, the exogenous latent variable (Y) is crucial to the success of quality improvement projects. The endogenous variables are as follows: X1 represents the factor of quality management principles, X2 represents risk factors for quality improvement projects, and X3 represents the factor related to the implementation of quality improvement projects.

The instrument (questionnaire) design includes both Y and X variables. There are five indicators for the Y variable: cost, time, quality, scope, and focus on the consumer. The X variables consist of three categories:

- X1 (quality management principles) has three indicators: people engagement, leadership, and relationship management.
- X2 (risk management) has eight indicators: strategic risk, operational risk, technical risk, financial risk, human resources risk, stakeholder risk, project management risk, and environmental risk.
- X3 (quality improvement project implementation) includes six indicators: quality planning (QP), education and training (ET), quality control (QC), quality assurance (QA), and quality performance measurement (QPM).

Tables 1, 2, 3, and 4 present the variables and indicators influencing the successful implementation of quality improvement projects.

Variable	Code	Indicators	Reference
Success Factors of the Quality Improvement Project (RMQIP*)* / (Y))	Y1	Cost	(Chandra 2015)
	Y2	Quality	
	Y3	Scope	
	Y4	Time	
	Y5	Customer Focus	

Table 1 Identification of Factors on the Success of Quality Improvement Projects

Variable	Code	Indicators	Reference
Quality management Principle (QMP/ (X1))	X1.1	Engagement People	(Antunes et al. 2021; Kumar and Sharma 2015; Neyestani and Juanzon 2017)
	X1.2	Leadership	(Dückers, Wagner, and Groenewegen 2008)(Chandra 2015; Dückers, Wagner, and Groenewegen 2008; Kassem, Khoiry, and Hamzah 2020)
	X1.3	Relationship Management	(Antunes et al. 2021; Kumar and Sharma 2015; Neyestani and Juanzon 2017)

Table 2 Identification of Quality Management Principal Factors (X1)

Respondent Demographic Data

The manufacturing companies selected for this research have been in operation for at least three years, have implemented a quality improvement project, and are legally established businesses. The respondents were required to have experience in implementing quality improvement projects and an understanding of risks. Data for the respondents were collected through a questionnaire from the Department of Industry and Trade, East Java Province, in 2023. The sample areas are companies located in Sidoarjo, Pasuruan, Mojokerto, Gresik, and Surabaya. The data provided by these agencies included information on large, medium, and micro industries, with this research focusing on large and medium-sized enterprises.

The respondents were employees involved in implementing quality improvement projects and had a sound understanding of risk management. One hundred and twenty respondents participated in the study, representing 30 companies, with 4 to 5 respondents from each company. The respondents included members of improvement and innovation teams, leaders, supervisors, and directors. The questionnaire results indicated that all data was valid and reliable. The next step was to process the data using SEM-PLS. Based on the demographic analysis, 70 respondents (58.33%) were male, and 50 (41.67%) were female. Regarding age distribution, 25 respondents (20.83%) were aged 20-30 years, 50 respondents (41.67%) were aged 31-40 years, 31 respondents (25%) were aged 41-50 years, and 15 respondents (12.5%) were over 50 years old. **Table 5** presents the demographic data of the respondents.

Variable	Code	Indicators	Reference
Risk Management Implementation (RMI/(X2))	X 2.1	Strategic risk	(Kasap and Kaymak 2007), (Schieg 2006), (Popescu and Dascalu 2011), (Shah et al. 2017), (Befrouei 2016), (Mishra et al. 2019)
	X 2.2	Operational Risk	(Schieg 2006)
	X 2.3	Technical risk	(Schieg 2006)
	X 2.4	Financial Risk	(Schieg 2006), (Shah et al. 2017), (Befrouei 2016), (Stosic et al. 2017)
	X 2.5	Human Resources Risk	(Schieg 2006)
	X 2.6	Stakeholder Risk	(Schieg 2006)
	X 2.7	Project Management Risk	(Schieg 2006)
	X 2.8	Environmental Risk	(Schieg 2006)

Table 3 Identification of Risk Factors in Quality Improvement Projects (X2)

Variable	Code	Indicators	Reference
Quality Improvement Project Implementation (QIPI/(X3))	X3.1	QP *(Quality Planning)*	(Gibson and Gebken 2003; Peña and Parshall 2001)
	X3.2	ET (Education & Training)	(Bullington et al. 2002; Jaca et al. 2011)
	X3.3	QC *(Quality Control)*	(Gibson and Gebken 2003; Prathapchandran and Palson 2019; Salvi 2020)
	X3.4	QA *(Quality Assurance)*	(Gibson and Gebken 2003; Prathapchandran and Palson 2019; Salvi 2020)
	X3.5	QPM *(Quality Performance Measurement)*	(Jaca et al. 2012)

Table 4 Identification of Factors in the Implementation of Quality Improvement Projects (X3)

Data Analysis

Data is collected through online Google Forms surveys. The survey includes a structured questionnaire designed to get respondent responses. A statement of consent from the respondents is obtained in writing via the Google form. In the respondents' section, there is a statement indicating whether they agree or disagree with continuing to fill out the questionnaire. Before the respondents answered further, they were informed about the purpose of the research and asked to agree to participate in this research. In addition, it ensures compliance with ethical research standards. Respondents were also informed about the privacy and confidentiality of the information and responses provided. The questionnaire was distributed to 150 respondents, of which 135 returned (in response). After checking, 120 respondents completed the questionnaire according to the instructions, and further data testing was carried out. When the data from Excel is imported into the SEM-PLS software, the following process cannot be carried out if there is incomplete data. Incomplete data will be discarded and cannot be used for processing and analyzing research data. Data analysis was conducted using PLS-SEM, a multivariate statistical technique that compares the values of dependent and independent variables. PLS-SEM is particularly useful for designing SEM models based on variance values, especially when there are data specification and distribution challenges, such as small sample sizes, missing data, and multicollinearity. The results were evaluated for validity and reliability using Cronbach's alpha score. Validity and reliability tests ensure that the methods and tools used for research are consistent and reliable. The instrument is considered valid based on the results of PLS-SEM processing if the ideal loading factor values are 0.7. To assess the reliability, the composite reliability value must be > 0.6, and Cronbach's alpha must be ≥ 0.7, indicating that the instrument is reliable (Haryono 2016). Another measure of convergent validity is the Average Variance Extracted (AVE) value, which indicates the extent to which a latent construct accounts for the variance or diversity of the manifest variables. The higher the variant captured by the latent construct, the better the manifest variables represent the latent construct. (Haryono 2016). An AVE value of at least 0.5 is considered a good measure of convergent validity, indicating that latent variables can explain more than half of the variance in their indicators. The results of the PLS-SEM analysis are then used to determine priority indicators for improvement using the IPA method. The data was used to prioritise improvement factors based on the loading factors from the original sample and the average questionnaire responses related to implementing quality improvement projects. The latent variable building, which consists of the relevant items and has a minimum loading value of 0.50 and a t-statistic value of more than 2.00, is represented by the measurement model outside the image. In Figure 4, A yellow box with a loading value larger than 0.50 is connected by an arrow to the blue circle representing the latent variable measurement (Figure 2 and a t-statistic greater than 2.00) (Joseph F. Hair et al. 2017).

Respondent Profile		Frequency	Percentage
Gender	Men	70	58.33%
	Woman	50	41,67%
Age	20-30	25	20.83%
	31-40	50	41.67%
	41-50	30	25%
	> 50	15	12,5%
Positions	Owner	30	25%
	Production Manager	7	5.83%
	Quality Control Manager	5	4.167%
	Production Supervisor	8	6.67%
	Supervisor Quality Control	7	5.83%
	Production Leader	30	25%
	Quality Control Leader	30	25%
	Improvement and Innovation team	3	2.5%
Topic of Quality Improvement Project	Decrease of reject product	60	50 %
	Decrease of lead time	15	12.5 %
	yield improvement	25	20.83 %
	Quality Product Improvement	20	16.67 %

Table 5 Data demography Respondent

Result

Evaluation of Reflective Measurement Models

The model is evaluated based on the validity and reliability of the latent variable formulation. The reflective measurement model evaluation uses the results of the loading factor (LF) or outer loading, which measures construct validity and reliability, as well as the correlation between each measurement item and the variable. An acceptable loading factor value is ≥ 0.7 (Hair, Joe 2021; Hair, Joseph et al. 2022). Composite reliability (CR) is used to assess internal consistency, with a minimum acceptable value of 0.70. Additionally, Cronbach's alpha and Rho A can be used to evaluate reliability (Hair, Joe 2021; Hair, Joseph et al. 2022). Convergent validity is determined using the Average Variance Extracted (AVE), which measures how well each variable explains the variance of its indicators. (Joe F. Hair 2021; Haryono 2016).

Based on **Table 6**, all indicators' LF values (original sample, or O) are ≥ 0.7, indicating that all measurement items are valid and reflect their corresponding variables. For example, the LF value for X1.1 is 0.861, and its square (communality indicator) is 0.861 x 0.861 = 0.7413 (74.13%); this means that changes in the Quality Management Principle (QMP) variable will be reflected by 74.13% in the X1.1 indicator (Engagement People). The highest indicator for reflecting QMP is X1.1, showing that an increase in the application of quality management principles will be strongly reflected in the Engagement People indicator. For the Risk Management Implementation (RMI) variable, the highest indicator is X2.3 (Technical Risk) with an LF value of 0.910, and the square LF (communality indicator) is 0.910 x 0.910 = 0.8281 (82.81%); this indicates that changes in the RMI variable will be reflected by 82.81% in the Technical Risk indicator (X2.3). Similarly, for the Quality Improvement Project Implementation (QIPI) variable, the highest indicator is X3.5 (Quality Performance Measurement), with an LF value of 0.844, and its commonality indicator is 0.844 x 0.844 = 0.7123 (71.23%). For the Quality Improvement Project Success (RMQIP) variable, the highest indicator is Y1 (Cost) with an LF value of 0.846. Its commonality indicator is 0.846 × 0.846 = 0.7157 (71.57%). This means that changes in RMQIP will be reflected in the Cost indicator of 71.57%.

Based on **Table 7,** all latent factors are accepted and appropriate. The level of convergent validity is based on an AVE value of greater than 0.5, with AVE values ranging from a maximum of 0.763 to a minimum of 0.592, meeting the requirements for good convergent validity. The reliability levels were also acceptable, as all Cronbach's alpha and CR values were greater than 0.7. Therefore, the measurement indicators are consistent and reliable in measuring all variables (QMP, RMI, QIPI, and RMQIP).

Variable	Original sample (O)	Sample means (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
X1.1 <- QMP	0.861	0.860	0.029	29.700	0.000
X1.2 <- QMP	0.816	0.814	0.042	19.312	0.000
X1.3 <- QMP	0.840	0.840	0.031	27.305	0.000

X2.1 <- RMI	0.873	0.874	0.027	32.804	0.000
X2.2 <- RMI	0.865	0.863	0.042	20.684	0.000
X2.3 <- RMI	0.910	0.909	0.020	44.394	0.000
X2.4 <- RMI	0.844	0.846	0.044	19.150	0.000
X2.5 <- RMI	0.863	0.860	0.028	30.501	0.000
X2.7 <- RMI	0.894	0.892	0.022	40.561	0.000
X2.8 <- RMI	0.865	0.864	0.028	31.303	0.000
X3.1 <- QIPI	0.764	0.763	0.046	16.752	0.000
X3.3 <- QIPI	0.710	0.706	0.064	11.032	0.000
X3.4 <- QIPI	0.754	0.752	0.061	12.371	0.000
X3.5 <- QIPI	0.844	0.843	0.028	30.151	0.000
Y1 <- RMQIP	0.846	0.844	0.042	19.971	0.000
Y2 <- RMQIP	0.798	0.796	0.054	14.769	0.000
Y3 <- RMQIP	0.767	0.768	0.050	15.370	0.000
Y4 <- RMQIP	0.764	0.765	0.047	16.296	0.000

Table 6 Loading Factor and T-Statistics

Evaluation of Discriminant Validity

Discriminant validity assesses how well a construct or variable is differentiated from other constructs/variables and is statistically tested. Discriminant validity at the construct level is evaluated using the Fornell-Larcker Criterion and HTMT (Heterotrait-Monotrait Ratio) measurements, while at the indicator level, cross-loading is used cross-loading.

Variable	Code	Mean	Standard Deviation	Outer Loading	Cronbach's Alpha	Rho_A	Composite Reliability (CR)	AVE
Quality management	X1.1	4.083	0,945	0.861	0.790	0.792	0.877	0.704

Table 7 Validation and Reliability Test

Principle (QMP/ (X1))	X1.2	4.167	0,922	0.816				
	X1.3	3.950	0,909	0.840				
Risk Management Implementation (RMI)	X2.1	3.625	0,966	0.873	0.948	0.950	0.958	0.763
	X2.2	3.575	0,843	0.865				
	X2.3	3.658	0,885	0.910				
	X2.4	3.617	0,998	0.844				
	X2.5	3.483	1,007	0.863				
	X2.7	3.583	0,966	0.894				
	X2.8	3.650	1,007	0.865				
Quality Improvement Project Implementation (QIPI/X3))	X3.1	3.800	0,934	0.764	0.769	0.777	0.853	0.592
	X3.3	3.925	0,915	0.710				
	X3.4	3.950	0,980	0.754				
	X3.5	3.892	0,963	0.844				
Success Factors of the Quality Improvement Project (RMQIP) / (Y))	Y1	3.825	0,945	0.846	0.805	0.810	0.872	0.631
	Y2	3.908	0,922	0.798				
	Y3	4.033	0,909	0.767				
	Y4	3.750	0,986	0.764				

Structural Model Evaluation

Evaluating the structural model involves testing the hypothesized relationships between the variables. This evaluation is done in three steps: 1) Multicollinearity Check: The Inner VIF (Variance Inflation Factor) checks for multicollinearity between variables. A VIF value below 5 indicates that multicollinearity is absent; 2) Hypothesis Testing: Hypotheses are tested by examining the t-values or p-values of statistical tests. If the t-value is more significant than 1.96 (as indicated in the t-table) or the p-value is less than 0.05, there is a significant influence between the variables. 3) F-Square Value Analysis: This value helps assess the strength of direct relationships at the structural level. An f-square value of 0.02 indicates a low effect, 0.15 indicates a moderate effect, and 0.35 indicates a high effect. (Joe F. Hair 2021; Haryono 2016). The f-square value is also used to assess the mediation effect, with the following interpretations:

0.02 for a low mediation effect, 0.075 for a medium mediation effect, and 0.175 for a high mediation effect. (Ogbeibu and Gaskin 2023).

Hypothesis Test

The results of the path analysis can be used to explain the factors influencing the success of the quality improvement project. Test results for direct effects are based on path coefficient measurements and indirect impact (mediation) using the specific indirect effect test results. Mediation variables explain the presence of an intermediate or intervening variable that affects the relationship between two other variables. The hypothesis test results for the direct effects are shown in **Table 8** as follows:

H1: **Quality Management Principles (QMP) (X1) influence Quality Improvement Project Implementation (QIPI) (X3).**

There is a significant effect of QMP on QIPI, with a path coefficient value of 0.471 and a significant t-statistic (7.078 > 1.96) or a P-value (0.000 < 0.05). Thus, Hypothesis 1 is accepted, indicating that any change in the QMP variable will significantly increase QIPI.

H2: **Risk Management Implementation (RMI) (X2) influences Quality Improvement Project Implementation (QIPI) (X3).**

There is a significant effect of RMI on QIPI, with a path coefficient value of 0.155 and a significant t-statistic (2.141 > 1.96) or a P-value (0.000 < 0.05). Thus, Hypothesis 2 is accepted, indicating that any change in the RMI variable will result in a significant increase in QIPI.

H3: **Quality Management Principles (QMP) (X1) influence Quality Improvement Project Success Factors (RMQIP) (Y).**

There is a significant effect of QMP on RMQIP, with a path coefficient value of 0.204 and a significant t-statistic (2.373 > 1.96) or a P-value (0.000 < 0.05). Thus, Hypothesis 3 is accepted, indicating that any change in the QMP variable will significantly increase RMQIP.

H4: **Risk Management Implementation (RMI) (X2) influences Quality Improvement Project Success Factors (RMQIP) (Y).**

There is a significant effect of RMI on RMQIP, with a path coefficient value of 0.332 and a significant t-statistic (4.210 > 1.96) or a P-value (0.000 < 0.05). Thus, Hypothesis 4 is accepted, indicating that any change in the RMI variable will result in a significant increase in RMQIP.

H5: **Quality Improvement Project Implementation (QIPI) (X3) influences Quality Improvement Project Success Factors (RMQIP) (Y).**

There is a significant effect of QIPI on RMQIP, with a path coefficient value of 0.366 and a significant t-statistic (4.807 > 1.96) or a P-value (0.000 < 0.05). Thus, Hypothesis 5 is accepted, indicating that any change in the QIPI variable will significantly increase RMQIP.

Meanwhile, the mediation effect hypothesis is found in Table 9.

H6: **Quality Improvement Project Implementation (QIPI) (X3) mediates the effect of Quality Management Principles (QMP) (X1) on Quality Improvement Project Success Factors (RMQIP) (Y).**

QIPI significantly mediates the influence of QMP on RMQIP, with a mediation path coefficient of 0.173, a significant t-statistic (p = 0.000 < 0.05), and a P-value of 0.000. Thus, Hypothesis 6 is accepted.

H7: **Quality Improvement Project Implementation (QIPI) (X3) mediates the effect of Risk Management Implementation (RMI) (X2) on Quality Improvement Project Success Factors (RMQIP) (Y).**

QIPI does not significantly mediate the effect of RMI on RMQIP, with a mediation path coefficient of 0.057, a t-statistic (1.871 < 1.96), and a P-value of 0.061 > 0.05. Thus, Hypothesis 7 **was rejected.**

The confidence interval used in the direct and indirect hypothesis tests (mediation tests) is 95% with an alpha value of 5%, so the z-table is 1.96.

Variable	Original sample (O)	Sample means (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision
QIPI -> RMQIP	0.366	0.371	0.076	4.807	0.000	Supported
QMP -> QIPI	0.471	0.476	0.067	7.078	0.000	Supported
QMP -> RMQIP	0.204	0.201	0.086	2.373	0.018	Supported
RMI -> QIPI	0.155	0.158	0.072	2.141	0.032	Supported
RMI -> RMQIP	0.332	0.339	0.079	4.210	0.000	Supported

Table 8 Statistical Indicators of the Relationship Path Between Variables

Variable	Original sample (O)	Sample means (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	
QMP -> RMQIP	0.173	0.176	0.043	4.053	0.000	Supported
RMI -> RMQIP	0.057	0.059	0.030	1.871	0.061	**Rejected**

Table 9 Statistical Indicators of Mediation Tests

Model Quality and Fit Evaluation

To the evaluate of quality and fit of the model, the following measurements are used: 1) R-square value; 2) F-square value; 3) Upsilon statistical test results; 4) Q-Square results; 5) GoF Index; and 6) SRMR value.

R-Square Value

The R-squared value indicates the proportion of variation in the endogenous variables that the exogenous variables can explain. **Table 10** presents the R-squared values. Based on **Table 10,** the variation in the QIPI variable explained by the QMP and RMI variables is 29.5%, indicating a minor influence. Similarly, the RMQIP variable explained by the QIPI, QMP, and RMI variables shows a moderate impact of 48.5%.

Variable	R-square	R-square adjusted
QIPI	0.295	0.283
RMQIP	0.485	0.472

Table 10 R-Square Value

F-Square Value

The F-Square value is used to measure the effect size of a variable at the structural level. Based on **Table 11**, the F-Square values are as follows:

1) The QIPI variable on RMQIP is 0.183, indicating a moderate effect.

2) The QMP variable on QIPI has a value of 0.280, indicating a moderate effect.

3) The QMP variable on RMQIP has a value of 0.056, indicating a low effect.

4) The RMI variable on QIPI has a value of 0.030, indicating a low effect.

5) The RMI variable on RMQIP has a value of 0.184, indicating a moderate effect.

Variable	f-square
QIPI -> RMQIP	0.183
QMP -> QIPI	0.280
QMP -> RMQIP	0.056
RMI -> QIPI	0.030
RMI -> RMQIP	0.184

Table 11 F-Square Value

Upsilon Stats

The Upsilon statistical value measures the mediation effect and shows the influence of the mediation variable at the structural level. Based on Table 12:

1. For Hypothesis 6 (H6), QIPI mediates the indirect effect of QMP on RMQIP with a moderate Upsilon (v) value of 0.173. With a 95% confidence interval, increasing QIPI improvements will raise this mediation role to 0.173.

2. For Hypothesis 7 (H7), QIPI mediates the indirect effect of RMI on RMQIP with a low Upsilon (v) value of 0.057. With a 95% confidence interval, increasing QIPI improvements will raise this mediation role to 0.057.

Hypothesis	Path Coefficient	p-Value	95 % confidence interval Path Coefficient	

			Batas Bawah	Batas Atas	Upsilon V Statistic
QMP ➔ QIPI ➔ RMQIP	0.173	0.000	0.098	0.266	0.173
RMI ➔ QIPI ➔ RMQIP	0.057	0.031	0.006	0.124	0.057

Table 12 Upsilon V Statistical Values

PLS *Predict*

Since PLS is an SEM analysis aimed at prediction, the PLS Predict method is used to validate the model's predictive power. This method compares the PLS and linear regression (LM) models. If the PLS model has lower RMSE (Root Mean Squared Error) or MAE (Mean Absolute Error) values than the LM model, it is considered to have high predictive power. If most indicators have lower values in PLS, the model has medium predictive power (Hair, Joseph et al. 2022). Based on **Table 13,** the proposed PLS Regression (PLS) model demonstrates high predictive power, as evidenced by lower RMSE and MAE values for the QIPI and RMQIP variables compared to the LM model.

Variable	Q^2predict	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE
X3.1	0.189	**0.698**	**0.582**	0.721	0.607
X3.3	0.111	**0.640**	**0.494**	0.689	0.525
X3.4	0.128	**0.795**	**0.641**	0.815	0.660
X3.5	0.197	**0.697**	**0.568**	0.733	0.593
Y1	0.319	**0.573**	**0.461**	0.609	0.489
Y2	0.244	**0.607**	**0.482**	0.632	0.507
Y3	0.190	**0.630**	**0.492**	0.631	0.508
Y4	0.131	**0.823**	**0.621**	0.864	0.640

Table 13 PLS Predict Value

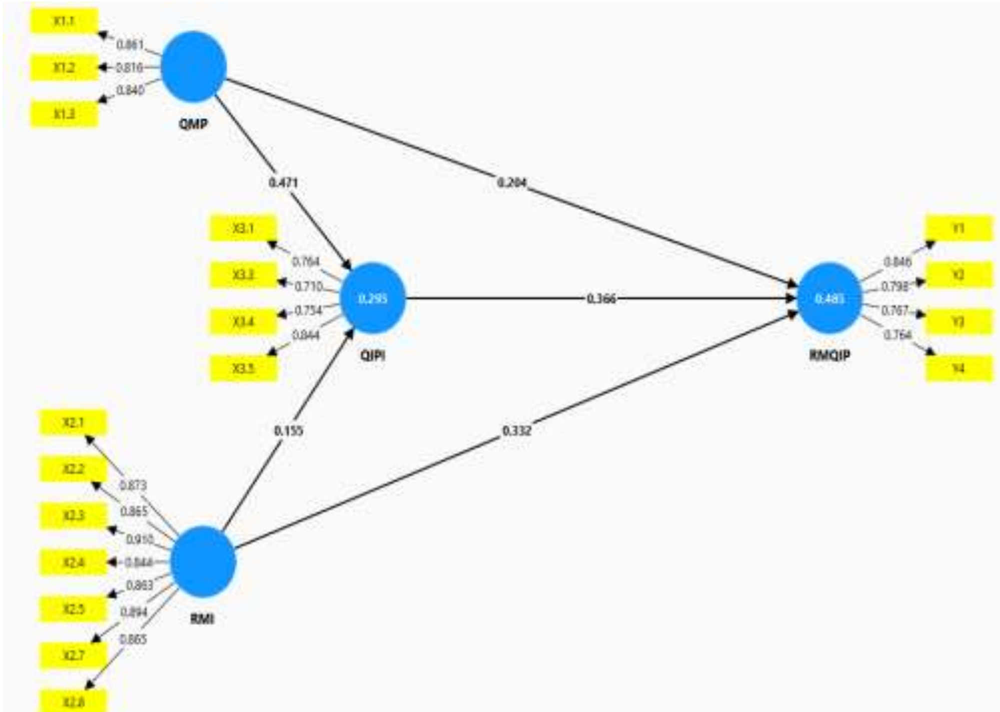

Figure. 2. SEM-PLS Model Critical Factors for the Success of Quality Improvement Projects.

Importance Performance Map Analysis (IPMA)

After data processing and evaluating the PLS-SEM model, it was found that all variables had a significant and positive direct influence. Additionally, one hypothesis with a mediation effect showed a crucial indirect influence. Based on the SEM-PLS measurement results, several improvement activities can still be implemented to enhance project success.

The importance-performance map analysis (IPMA) is applied as a factor for improvement. The importance value is derived from the total effect indicator of RMQIP, while the performance value is based on the performance of the indicators for RMQIP. The data used for IPMA processing is shown in **Table 14.** Based on **Figure 3,** the priority indicators for improvement are those with low performance but of high importance. Three indicators stand out:

1. Quality Management Principles (X1) with the People Engagement indicator (X1.1) have an important value of 0.152 and a performance value of 54.167.

2. Quality Management Principles (X1) with the Leadership indicator (X1.2) have an important value of 0.140 and a performance value of 58.333.

3. Quality Improvement Project Implementation (X3) with the Quality Planning indicator (X3.1) has an important value of 0.125 and a performance value of 60.000.

The values of importance and performance are then plotted on an IPMA function map in SEM-PLS to identify areas and indicators that are priorities for improvement, which can enhance the success of quality improvement projects; this also indirectly affects the SEM-PLS results after implementing activities to improve these priority indicators. **Figure 4** shows the Root Cause Analysis for prioritize improvement

Variable	Indicators		Importance (total effect from RMQIP)	Performance (performance for RMQIP)
Quality management Principle (QMP/X1)	X1.1	Engagement People	0.152	54.167
	X1.2	Leadership	0.140	58.333
	X1.3	Relationship Management	0.156	65.000
Risk Management Implementation (RMI/X2)	X2.1	Strategic risk	0.064	65.625
	X2.2	Operational Risk	0.059	64.375
	X2.3	Technical risk	0.063	66.458
	X2.4	Financial Risk	0.074	65.417
	X2.5	Human Resources Risk	0.062	62.083
	X2.7	Project Management Risk	0.062	64.583
	X2.8	Environmental Risk	0.061	66.250
Quality Improvement Project Implementation (QIPI/ (X3)	X3.1	QP *(Quality Planning)*	0.125	60.000
	X3.3	QC *(Quality Control)*	0.111	64.167
	X3.4	QA *(Quality Assurance)*	0.107	65.000
	X3.5	QPM *(Quality Performance Measurement)*	0.132	63.056

Table 14 The Importance-Performance Map Analysis

Figure 3. Importance of Performance Map Analysis

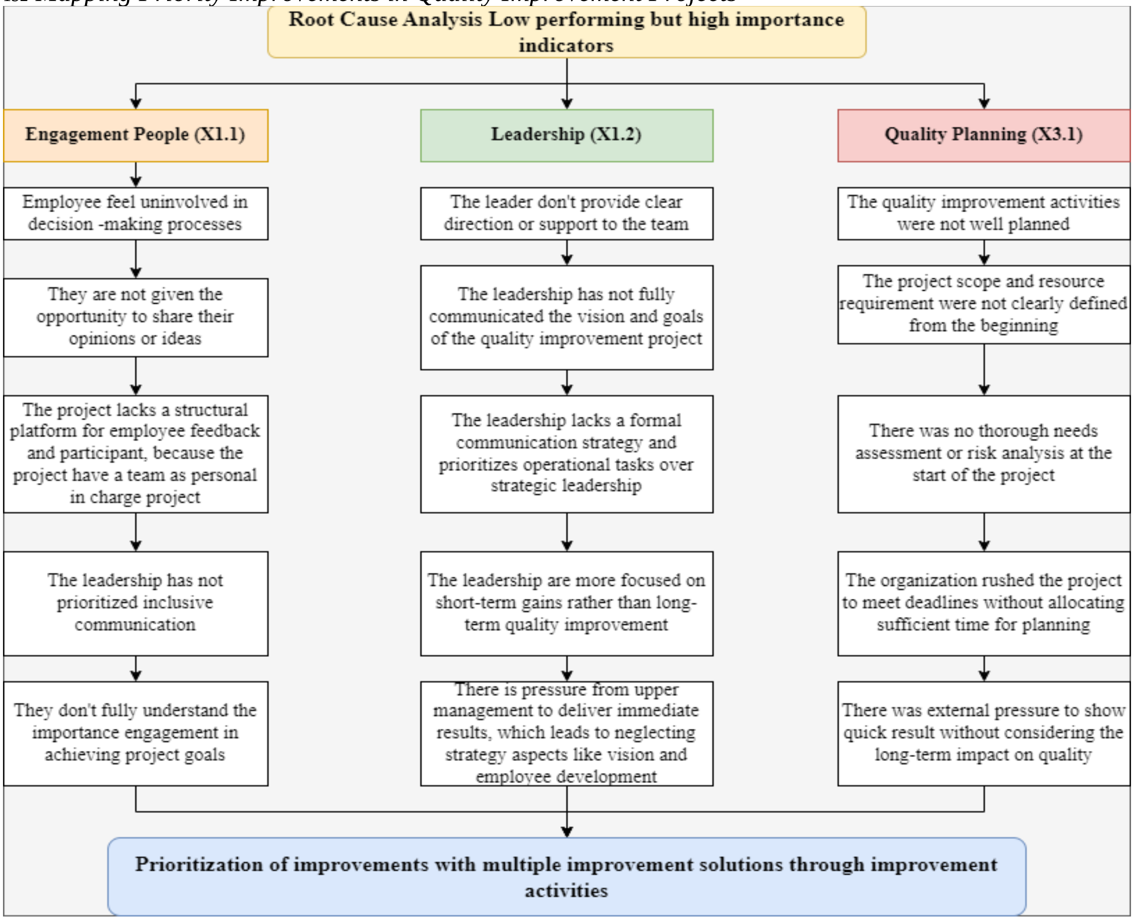

Figure 4. Root Cause Analysis on Indicators with High Importance and Low Performance

Discussion

Research results from data processing using SEM-PLS demonstrate that Quality Management Principles (QMP), Risk Management Implementation (RMI), and Quality Improvement Project Implementation (QIPI) have a positive impact on the success of quality improvement projects through direct effects. Regarding the indirect effects through mediation, QMP exhibits a significant and positive impact on the success of quality improvement projects via QIPI.

The IPMA Analysis reveals that the priority indicators for improvement have high importance but low performance, specifically in the QMP variables for People Engagement (X1.1) and Leadership (X1.2). Additionally, low performance is found in the QIPI variable for the Quality Planning (X3.1) indicator. People Engagement is crucial and should be prioritized for improvement through employee training to motivate and encourage proactive contributions to the success of quality improvement projects; this is consistent with research showing the significant influence and positive impact of Total Quality Management implementation. (Antunes et al. 2021).

Employee engagement is highlighted in ISO 9001:2015, emphasizing employee involvement as a critical principle in producing high-quality outcomes. Ensuring that employee engagement aligns with organizational goals and fosters a culture of continuous improvement is essential. Previous research supports the notion that employee involvement is crucial in enhancing performance and achieving project targets (Gadolin and Andersson 2017; Kompaso and Sridevi 2010). However, ineffective communication and exclusion from decision-making processes often lead to reduced employee involvement. (Sunder M and Antony 2018).

Leadership is pivotal in quality improvement projects, ensuring that projects are directed, appropriately managed and have explicit goals. Challenges must be addressed promptly. Previous research has shown that leadership plays a significant role, particularly during the early stages of projects (Alefari, Salonitis, and Xu 2017; Chaithanapat et al. 2022; Javed 2015; Sawaean and Ali 2020; Zaman et al. 2019). Research on leadership styles shows that transformational leadership enhances employee engagement, innovation, and commitment to quality goals, especially in manufacturing (Zaman et al. 2019). On the other hand, transactional leadership, which focuses on structure, rewards, and punishment, can be more effective in industries with strict compliance requirements (Osei-Kyei and Chan 2018). Leadership challenges in quality improvement are further supported by Radnor and Osborne (2016), who concluded that leaders fostering a culture of trust and openness are more successful in overcoming resistance and ensuring the successful implementation of quality improvements (Radnor, Holweg, and Waring 2012).

Quality planning is crucial for laying the foundation for successful project implementation, as it ensures that all aspects of the project are well-structured and that risks are effectively anticipated. Previous research supports the notion that quality planning is crucial for defining goals, allocating resources, and establishing success criteria. (Keshk, Maarouf, and Annany 2018; Senaratne and Thushangi 2012). Therefore, it can be concluded that employee involvement, leadership, and quality planning are integral to the success of quality improvement projects, as they ensure employees' participation and commitment to continuous improvement. Effective leadership supports this by providing the necessary direction and motivation to encourage employee ideas and creativity, and quality planning is the basis for achieving quality goals.

Recommended Improvement of Activities

The recommended improvement activities for the indicators that are a priority for improvement are 1) People Engagement (X1.1), 2) Leadership, and 3) Quality Planning.

1) People Engagement

The importance value is 0.152, and the performance value is 54.167. The recommended activity is an employee involvement investment program through participation in Quality Improvement Projects (QIP); this includes training and workshops, as well as developing a feedback system where employees can contribute suggestions and ideas during quality improvement projects.

2) Leadership (X1.2)

The importance value is 0.140, and the performance value is 58.333. Improvement activities should focus on leadership in developing strategies for quality improvement projects. Leadership training related to quality.

3) Quality Planning (X3.1)

Importance value: 0.125, performance value: 60.000. Improvement activities should focus on setting clear goals, scope, and resource allocation, as well as preparing a measurable QIP implementation schedule; this includes defining risk management and quality planning processes.

Conclusion: Theoretical and practical implications, Contribution

Conclusion

This study developed and validated a conceptual model examining the relationships between Quality Management Practices (QMP), Risk Management Index (RMI), and Internal Process Improvement (IPI) and their impact on the success of Quality Improvement Projects (QIP). Using SEM-PLS, this study assessed the significance of relationships between variables. IPMA was used to prioritize areas or indicators that need improvement. The results confirm the positive impact of QMP, RMI, and QIPI on the success of RMQIP, but the mediation effect of QIPI between RMI and RMQIP was weak and insignificant. The direct effects of QMP and RMI positively impact the success of quality improvement projects, with strong leadership and good employee involvement being essential drivers of this effect. The mediation effect indicates that QIPI effectively mediates the relationship between QMP and RMQIP, demonstrating that QIPI is a crucial mechanism in quality management that affects project success. Engagement People, Leadership, and Quality Planning are identified as top priorities for improvement due to their high importance but low performance.

Managerial Implication

Managers should focus on several activities based on priority improvement: 1) Increasing Employee Engagement: Conduct training programs and encourage employee participation in decision-making to increase motivation and proactive contributions. Employees should be involved in workshops and feedback systems to foster helpful ideas for project implementation.; 2) Strengthening Leadership: Provide training focused on managing quality improvement projects, ensuring leaders understand how to motivate and guide teams through challenges. Emphasize transformational leadership to enhance employee engagement and commitment.; 3) Improving Quality Planning: Ensure that detailed and structured quality planning is in place to implement quality improvement projects successfully. Managers must set clear goals, allocate resources, and define risk mitigation strategies to support quality improvement efforts.

Contribution

The contributions of this research are: 1) increasing understanding of combining quality and risk management. This study demonstrates how quality management principles (QMP) and risk management implementation (RMI) collectively contribute to the success of quality projects, providing a more integrated perspective on quality improvement; 2) Prioritization of repair areas. Using IPMA, the study identifies specific priorities (people/employee engagement, leadership, quality planning) that can guide the organization towards positive, impactful change; 3) Methodological contribution, which is by combining SEM-PLS, IPMA, and RCA to provide a structured path to assess quality project factors and data on the level of quality and performance, so that it can be applied to various quality assessment contexts.

Limitation and Future Research Direction.

The limitations of this research include a) Generalizability: This research is conducted in a specific context, and the findings may not be fully generalizable across all industries or project types. Future research should investigate similar models in other sectors to validate these findings.; b) Mediation Effect: The mediation effect of QIPI between RMI and RMQIP was not statistically significant, suggesting that other mediators or moderators could influence the relationship between risk management and project success. To address these limitations, future research should consider the following approaches: 1) Using Other Mediators: Future research should examine other potential mediators; 2) Industry-Specific Studies: Extending the research to specific industries, such as healthcare and the service sector, could provide valuable insights into how quality and risk management impact quality improvement projects in different contexts.

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