ISSN 2663-127X
Vol. 6, Iss. 1 (2025), pp 302 – 320, April 8, 2025. www.reviewedjournals.com, ©Reviewed Journals

QUALITY MANAGEMENT PRACTICES AND PERFORMANCE OF TELECOMMUNICATION PROJECTS IN RWANDA. A CASE OF TRANSAFRICA COMMUNICATIONS

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Accepted: March 24, 2025

DOI: https://doi.org/10.61426/business.v6i1.321

ABSTRACT

The general objective of this study was to investigate the influence of quality management practices and performance of telecommunications projects in Rwanda. The specific objectives were to analyze the relationship between quality planning and performance of telecommunications projects in Rwanda, to examine the relationship between quality improvement and performance of telecommunications projects in Rwanda, to determine the relationship between quality assurance and performance of telecommunications projects in Rwanda and to evaluate the relationship between quality control and performance of telecommunications projects in Rwanda. This study encompassed a theoretical framework consisting of four prominent theories: Deming's Theory of Quality Management, the Theory of Constraints (TOC), the Juran Trilogy Theory, and the Contingency Theory. This study adopted a correlation research design, which is suitable for providing a detailed account of quality management practices and their impact on telecommunications project performance. The target population for this study consisted of 412 individuals directly involved in the execution and management of telecommunications projects at TransAfrica Communications in Rwanda. The study adopted Slovin's formula to determine the appropriate sample size for quantitative data collection that was 203. Purposive sampling technique was used in the study. Both primary and secondary data was collected. While main data was gathered through questionnaires, secondary data from pertinent documents acquired from TransAfrica Communications was used in the research. The opinions of the respondents informed the research analysis and interpretations. Questionnaires, interviews, observation, application of various methodologies, and incentive were given to the respondents; each component resulted in the creation of a variable. Participants were asked to examine instruments for content validity and face-to-face validity by the researcher. The test-retest methodology was applied for reliability. The reliability of the instruments was determined using the Cronbach's coefficient. A test value of 0.700 was considered sufficient, and the instruments was deemed dependable. Tables and figures were used to present the quantitative data once it has been subjected to both descriptive and inferential statistical testing. Multiple regression is a component of inferential

statistical tests, whereas percentages, frequencies, and counts are part of descriptive statical tests. Thematic analysis was used to examine the qualitative data, which were presented narratively with full citations. The results indicate that all the independent variables positively affect project performance, with Quality control having the highest impact (B = 0.379, p < 0.000). Quality planning (B = 0.219, p = 0.002), Quality assurance (B = 0.138, p = 0.001), and Quality improvement (B = 0.250, p < 0.000) also show significant positive relationships with project performance. The standardized beta coefficients highlight the relative importance of these predictors, with Quality control (β = 0.413) being the most influential, followed by Quality improvement (β = 0.228), Quality planning (β = 0.214), and Quality assurance (β = 0.163). In conclusion, the findings indicated that Quality planning, Quality improvement, Quality assurance, and Quality control all significantly contribute to enhancing project performance, with Quality control having the greatest impact. Based on these results, it is recommended that organizations prioritize implementing robust quality management practices, particularly in Quality control and Quality improvement, to optimize project outcomes. For future research, studies could explore the integration of other organizational factors influencing project performance or investigate the long-term impact of quality management practices across different industries.

Keywords: *Project Performance, Quality Control, Quality Planning, Quality Assurance, Quality Improvement*

CITATION: Batamuliza, A., & Kwena, R. (2025). Quality management practices and performance of telecommunication projects in Rwanda. A case of Transafrica Communications. *Reviewed Journal International of Business Management*, 6 (1), 302 – 320. https://doi.org/10.61426/business.v6i1.321

BACKGROUND

Telecommunication projects, encompassing the development and implementation of infrastructure such as networks and systems, are pivotal to advancing global connectivity and communication. The performance of these projects is significantly influenced by quality management practices, which are essential for navigating the complexities and challenges inherent in the industry. With rapid technological advancements and increasing demand for high-speed, reliable communication, ensuring optimal performance in telecommunication projects has become a critical focus for stakeholders worldwide (Wang, 2023). The integration of robust quality management practices is not only crucial for meeting project objectives but also for fostering innovation and maintaining competitive advantage in the fast-evolving telecommunication sector.

Globally, the telecommunication industry faces diverse challenges ranging from regulatory compliance to technological integration and project management. Quality management practices, including quality planning, assurance, and control, are integral to addressing these challenges and achieving successful project outcomes. Effective implementation of these practices helps mitigate risks associated with complex project environments and ensures that deliverables meet stringent quality standards (Smith & Jones, 2024). As telecommunications projects often involve significant financial investment and impact on a broad user base, the emphasis on quality management becomes paramount for ensuring project success and sustainability (Green & Lee, 2023).

Global Perspective

Telecommunication projects in the United States are critical to maintaining and advancing the nation's communication infrastructure, supporting both economic growth and social connectivity (Johnson & Lee, 2022). As technology rapidly evolves, these projects often face increasing complexity and high-performance expectations (Miller & Davis, 2024). Effective management of these projects is essential to ensuring that they are completed on time, within budget, and meet the specified quality standards (Anderson, 2024). The

integration of rigorous quality management practices plays a pivotal role in achieving these goals, influencing the overall success and performance of telecommunication projects (Brown & Wilson, 2023).

In China, the scale and scope of telecommunication projects have expanded significantly, driven by government initiatives such as the "Made in China 2025" plan and the ongoing rollout of 5G networks (Wang & Zhang, 2023). These projects not only aim to enhance connectivity but also to foster innovation and support economic growth. Despite the substantial investments, challenges related to project performance, including delays, cost overruns, and quality issues, frequently arise. For instance, research by Zhang and Liu (2023) emphasizes the need for rigorous quality planning and control mechanisms to address the complexities of large-scale projects. Additionally, insights into stakeholder engagement and risk management practices reveal their significant influence on achieving project goals (Chen & Wang, 2024).

Regional Perspective

Telecommunication projects in Sub-Saharan Africa have experienced rapid growth and transformation in recent years, driven by technological advancements and increasing demand for connectivity (Kwaku & Adusei, 2024). This growth, however, is accompanied by challenges related to project performance, which include issues with quality management practices, infrastructure limitations, and regulatory constraints (Tchouassi & Fonkeng, 2023). Effective quality management is crucial for ensuring that telecommunication projects meet their objectives, deliver reliable services, and achieve high standards of performance amidst these challenges (Akinwale, 2022). Research by Kabuye and Nambatya (2024) points to frequent delays, cost overruns, and suboptimal service delivery as common issues stemming from poor quality management. These problems underscore the need for robust quality management frameworks that can address the specific challenges faced by telecommunication projects in the region, such as limited resources and volatile regulatory environments (Suleiman & Osei-Tutu, 2023).

As the South African government and private sector strive to improve infrastructure and expand network coverage, the performance of these projects directly impacts economic growth, social development, and technological integration (Mlambo, 2023). The telecommunication sector is characterized by its complexity, involving various stakeholders, regulatory requirements, and technological challenges, all of which necessitate effective quality management practices to ensure project success (Smith & Johnson, 2022). By analyzing current practices and performance outcomes, this research aims to provide insights into the best strategies for managing quality in telecommunication projects, thereby supporting the sector's growth and development (Williams, 2024).

In recent years, the Kenyan government and private sector have undertaken several large-scale telecommunication projects aimed at enhancing network coverage and service quality (Achieng & Otieno, 2024). These projects often involve complex coordination among multiple stakeholders, including government agencies, telecom operators, and international partners (Munyua, 2023). The success of these initiatives is closely linked to the implementation of robust quality management practices, which help mitigate risks and ensure that deliverables meet the desired standards (Kariuki & Mwaura, 2023). As the telecommunication sector evolves, there is a growing need to assess the effectiveness of quality management practices in achieving project goals and addressing challenges (Ochieng, 2023).

National Perspective

Telecommunication projects in Rwanda have seen significant growth in recent years, driven by the country's commitment to advancing its digital infrastructure and enhancing connectivity across its diverse regions (Rwanda Utilities Regulatory Authority [RURA], 2023). These projects are pivotal in supporting Rwanda's socio-economic development by improving access to communication services and fostering digital inclusion. However, the performance of telecommunication projects can be significantly impacted by various factors, including the effectiveness of quality management practices. Effective quality management ensures that these

projects meet their objectives, are completed on time, and deliver the expected benefits to the population (Munyaneza & Nkurunziza, 2022).

In Rwanda, the successful execution of telecommunication projects is increasingly recognized as essential for achieving national development goals. Quality management practices such as thorough planning, risk management, and stakeholder engagement are crucial in navigating the complexities of these projects (Kagabo & Mukarubuga, 2023). Research indicates that while there have been advancements in infrastructure, challenges remain in maintaining high standards of quality throughout the project lifecycle. This highlights the need for a comprehensive understanding of how quality management practices impact project performance, particularly in the context of Rwanda's evolving telecommunication sector (Ndayisenga & Bizimana, 2024).

TransAfrica Communications, a prominent telecommunication service provider in Rwanda, has been at the forefront of various high-profile projects aimed at enhancing connectivity and digital services across the country. Recent studies highlight the importance of quality management in ensuring the success of such projects, emphasizing that rigorous quality control and continuous improvement practices are essential for achieving desired project outcomes (Niyonsenga & Nshimiyimana, 2023). This study explores the impact of quality management practices and the performance of telecommunication projects within TransAfrica Communications, focusing on aspects such as project efficiency, stakeholder satisfaction, and overall service quality. Understanding these dynamics is crucial for improving project execution and supporting Rwanda's aspirations for technological advancement and economic growth (Rwanda Development Board, 2024) hence the need for the study.

Statement of the Problem

The telecommunication sector in Rwanda has experienced rapid growth, yet the performance of telecommunication projects has often been hindered by issues related to quality management. Despite efforts to implement quality management practices (QMP), many telecommunication projects continue to face challenges such as delays, cost overruns, and substandard outcomes, which ultimately impact customer satisfaction and service delivery (Kagire & Munene, 2023; Mutazindwa *et al.,* 2023). According to the Rwanda Utilities Regulatory Authority (RURA), the telecommunication penetration rate in Rwanda stood at 83.1% in 2022, but service disruptions and poor network performance remain major concerns (RURA, 2022). TransAfrica Communications, like other firms in the sector, has encountered these challenges, with a reported 15% increase in project delays and 20% increase in operational costs between 2020 and 2022 due to ineffective quality control and management systems (NISR, 2023).

Empirical studies highlight significant gaps in the effective implementation of quality management practices in this sector. For instance, Muema *et al.* (2022) noted that while quality management practices such as Total Quality Management (TQM) and Six Sigma are being adopted in the telecommunications industry, there is often a lack of alignment between these practices and organizational goals, leading to suboptimal outcomes. Furthermore, Ntwali and Uwizeyimana (2021) found that inadequate training and resources hinder the effective implementation of quality control measures, which impacts project delivery timelines and customer satisfaction. Similarly, Mugenzi and Uwizeye (2023) identified a gap in continuous improvement efforts, where organizations fail to consistently monitor and evaluate the effectiveness of their quality management practices. Additionally, Kayumba and Nkusi (2022) argue that there is limited empirical evidence on how quality assurance practices specifically influence network reliability and service delivery in the Rwandan context.

Despite the critical role of quality management practices (QMP) in enhancing project performance, telecommunication projects in Rwanda still face challenges related to delays, cost overruns, and inconsistent service delivery (Mugiraneza, 2021). Studies have shown that these issues often stem from inadequate quality planning, ineffective quality improvement strategies, and insufficient quality assurance and control mechanisms (Nyirenda et al., 2020). Although research has explored the impact of QMP on project

performance, there remains a significant gap in the empirical literature, particularly regarding the specific effects of quality planning, improvement, assurance, and control on telecommunication projects in developing economies like Rwanda (Ndayisaba, 2022). Furthermore, most studies focus on the manufacturing or construction sectors, leaving a dearth of research on the telecommunications industry, especially in the Rwandan context (Kamanzi & Uwase, 2023). This study aims to fill these gaps by assessing how the implementation of quality planning, quality improvement, quality assurance, and quality control affects the performance of telecommunication projects in Rwanda, using TransAfrica Communications as a case study.

Objectives of The Study

The general objective of this study was to investigate the relationship between quality management practices and performance of telecommunications projects in Rwanda. The research was guided by the following specific 0Objectives;

- To analyze the relationship between quality planning and performance of telecommunications projects in Rwanda.
- To examine the relationship between quality improvement and performance of telecommunications projects in Rwanda.
- To determine the relationship between quality assurance and performance of telecommunications projects in Rwanda.
- To evaluate the relationship between quality control and performance of telecommunications projects in Rwanda.

Conceptual Framework

A conceptual framework for understanding the impact of quality management practices and telecommunication project performance underscores the importance of systematic approaches in enhancing project outcomes. Quality management practices, such as defining clear quality standards, effective risk management, and rigorous process controls, are integral to ensuring that telecommunication projects meet their objectives and deliver value (Moussa & Almubarak, 2023). The conceptual framework delineates the dependent and independent variables, as expounded upon in the literature study and further elucidated in Figure 1 elucidates the interconnection between the independent and dependent variables.

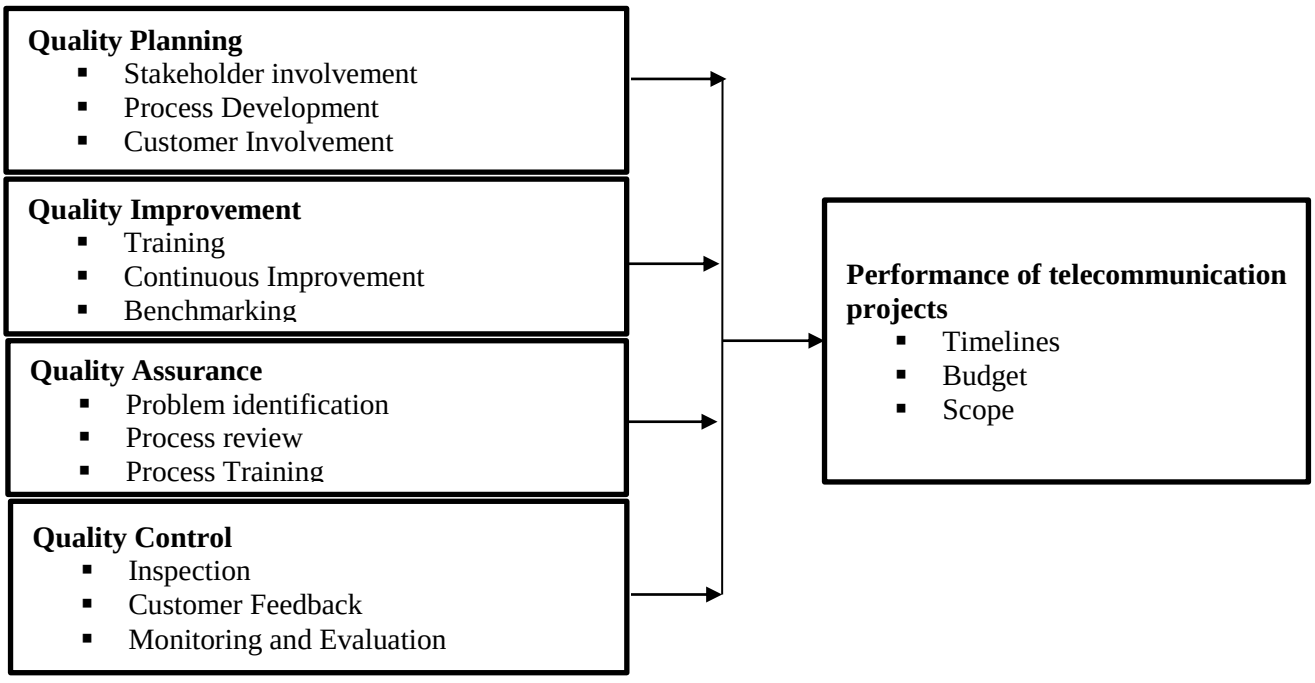

Figure 1: Conceptual Framework

The influence of quality management practices and the performance of telecommunications projects in Rwanda can be understood through a conceptual framework that integrates quality planning, quality improvement, quality assurance, and quality control. Quality planning is fundamental to project success as it involves setting clear quality objectives, identifying standards, and outlining procedures to achieve these goals. Effective quality planning enhances project outcomes by providing a structured approach to defining and meeting stakeholder expectations (Juran & Godfrey, 2020). In the context of telecommunications projects in Rwanda, quality planning helps ensure that infrastructure developments and service deployments are aligned with national standards and client requirements, leading to improved project performance and stakeholder satisfaction (Nguyen, 2023). Quality improvement, which focuses on enhancing processes and outcomes over time, also plays a critical role in project performance. By continually refining practices and integrating feedback, telecommunications projects in Rwanda can adapt to emerging challenges and technological advancements, thereby improving efficiency and effectiveness (Deming, 2024). Quality assurance, through systematic monitoring and evaluation, ensures that project deliverables consistently meet predefined standards, while quality control involves ongoing inspections and tests to detect and rectify deviations (Kumar et al., 2022). Together, these quality management elements contribute to the successful execution of telecommunications projects by minimizing errors, optimizing resources, and ensuring high-quality service delivery (Besterfield et al., 2021).

METHODOLOGY

Research Design

This study adopted a correlational research design, which is suitable for providing a detailed account of quality management practices and their impact on telecommunications project performance. Descriptive research is appropriate for this study as it allows for the collection of both qualitative and quantitative data, which helped in understanding the complex relationships between quality management practices (e.g., quality planning, assurance, and control) and project outcomes (Creswell & Creswell, 2020). The research primarily focused on gathering data through surveys and interviews, aimed at capturing the perspectives of project managers, engineers, and other stakeholders within TransAfrica Communications, regarding the effectiveness of their quality management practices.

Furthermore, a case study approach was employed to provide in-depth analysis specific to TransAfrica Communications. The case study method allows for a focused exploration of a particular organization and its practices, providing contextually rich data that may not be captured by broader surveys (Yin, 2020). This approach enabled a deep dive into the unique challenges and successes faced by TransAfrica Communications in managing telecommunications projects. By using both quantitative and qualitative methods within this case study, the research design facilitated a comprehensive understanding of how quality management practices directly affect project performance, timelines, and stakeholder satisfaction.

Target population

The target population in a research study refers to the specific group of individuals or entities that the research aims to investigate or draw conclusions about. The target population for this study consisted of 412 individuals directly involved in the execution and management of telecommunications projects at TransAfrica Communications in Rwanda. This includes project managers, engineers, quality assurance personnel, and other key stakeholders who play significant roles in project planning, execution, and evaluation. By focusing on these individuals, the study seeks to capture in-depth insights into the specific quality management practices employed within the organization and their impact on project performance. According to Nguyen et al. (2021), targeting individuals who are directly involved in project management is crucial for obtaining reliable and actionable data on project outcomes and management practices.

In addition to internal stakeholders at TransAfrica Communications, the study also considered input from external stakeholders such as suppliers, regulatory bodies, and project consultants who influence or are affected by the company's projects. This broader scope ensures a holistic understanding of the factors that impact project performance, as recommended by Silva and Santos (2022), who argue that incorporating multiple perspectives from different stakeholders provides a more comprehensive evaluation of project success factors.

Table 1: Population Frame

Category	Number of Personnel
Project Managers	1
Engineers	164
Quality Assurance Personnel	55
Procurement and Supply Chain Staff	40
IT and Technical Support Staff	70
Regulatory Compliance Officers	22
External Consultants	30
Suppliers and Contractors	30
Senior Management	15
Administrative Support Staff	25
Total	**412**

Source: Human Resource TransAfrica Communications - 2024

Sample size and sampling procedure

The study adopted Slovin's formula to determine the appropriate sample size for quantitative data collection. Slovin's formula is widely used when the population size is known, and the level of precision or margin of error needs to be controlled. The formula is expressed as:

$$n = \frac{N}{1+N\ (e)^2}$$ ……. Equation 1

where nis the sample size, Nis the population size, and e is the margin of error (Tejada & Punzalan, 2019). Assuming a margin of error of 5% (0.05), the formula was used to calculate a representative sample size that balances accuracy with feasibility in data collection. The use of Slovin's formula ensures that the sample size is statistically significant, providing reliable data while accounting for the large population. Where n = the sample size.

$$n = \frac{412}{1 + 412\ (0.05)^2} = \approx 202.95 = \ 203$$

Thus, the study surveyed 204 respondents, which ensures that the sample size is sufficient to generalize the findings to the larger population. This approach is supported by literature that emphasizes the importance of using an appropriate sample size to enhance the reliability and validity of research outcomes (Zikmund *et al.*, 2021).

The study adopted a purposive sampling technique, which is a non-probability sampling method where participants are selected based on specific characteristics or criteria relevant to the research objectives. Purposive sampling was used to identify key informants, such as project managers, engineers, quality assurance personnel, and other stakeholders involved in the telecommunications projects at TransAfrica Communications. This approach is particularly suitable for this study because it allows the selection of individuals who possess the necessary expertise and experience in quality management and project performance, ensuring that the data collected is both relevant and insightful. According to Etikan and Bala (2023), purposive sampling is effective in studies where the researcher seeks to gain deep insights from a specialized population, as it focuses on selecting participants who are best equipped to provide the needed information.

To complement the purposive sampling, stratified random sampling was employed for the quantitative component of the study. This method involves dividing the population into subgroups or "strata" based on specific characteristics, such as department roles (e.g., quality control, project management) or project types, and then randomly selecting participants from each group. Stratified random sampling ensures that all relevant subgroups within TransAfrica Communications are proportionally represented in the study, which enhances the generalizability of the findings. This technique is particularly beneficial for studies examining organizational practices across different functions or divisions, as noted by Sharma (2020), because it reduces sampling bias and provides a comprehensive view of the entire organization.

Data Collection Methods

The study utilized both primary and secondary data collection methods to address its objectives comprehensively. Primary data was gathered through surveys and structured interviews with project managers, engineers, and other stakeholders at TransAfrica Communications to obtain firsthand insights into the quality management practices and their impact on project performance. These instruments enabled the collection of both quantitative and qualitative data, aligning with a mixed-methods approach. Secondary data was sourced from project reports, company records, and existing literature on quality management practices in the telecommunications industry to provide context and validate primary data (Creswell & Creswell, 2023).

Primary Data Collection Method

The primary data for this study was collected through self-administered questionnaires, which are a widely recognized method for gathering direct responses from participants (Saunders *et al.,* 2019). A structured questionnaire, consisting of closed-ended questions on a five-point Likert scale, was used to collect specific information related to the quality management practices and project performance at TransAfrica Communications. The "drop-and-pick" method was employed, where questionnaires are distributed to the respondents and later collected at an agreed time to ensure a high response rate. This method is preferred because it allows respondents the flexibility to complete the survey at their convenience, while minimizing potential interviewer bias (Creswell & Creswell, 2023). Additionally, regular follow-ups were conducted to mitigate the risk of incomplete or unreturned questionnaires. The use of questionnaires is beneficial for gathering data from a larger sample size efficiently, offering both reliability and convenience in the data collection process (Bryman, 2021).

Secondary Data Collection Method

Secondary data collection for this study involved sourcing information from pre-existing materials relevant to quality management and telecommunications project performance. This included published books and academic journals that provide foundational theories and empirical findings related to project management practices and their impact on project outcomes (Kerzner, 2022; Turner & Müller, 2021). Government reports and industry publications were also utilized to gain insights into regulatory standards and industry benchmarks specific to Rwanda's telecommunications sector (Rwanda Utilities Regulatory Authority [RURA], 2023). These sources collectively offer a comprehensive background and contextual understanding necessary for analyzing the impact of quality management practices and telecommunications projects.

Pilot Test

A pilot test was conducted to refine the data collection tools and procedures, ensuring their effectiveness and reliability before the full study is implemented. This preliminary test involved administering 21 questionnaires, representing 10% of the sample size as recommended by Kothari (2022), to employees at MTN, a leading telecommunications company. The purpose is to identify and address potential issues with the questionnaires, such as ambiguity or misinterpretation, by evaluating the responses for consistency and clarity. The results from this pilot test were crucial for validating and ensuring the reliability of the research instruments used in the main study. This approach aligns with current best practices in research methodology (Yegidis *et al.,* 2021) emphasizing the importance of pilot testing to enhance accuracy.

The piloting process for this study involved administering 21 questionnaires, representing 10% of the sample size, as recommended by Kothari (2022). This preliminary test was conducted with employees at MTN, a leading telecommunications company in Rwanda, to ensure the clarity, reliability, and validity of the research instruments. The questionnaires were distributed and collected within a week, after which the responses were analyzed for any inconsistencies or misunderstandings. To assess the reliability of the instrument, a test-retest method was applied, where the same set of questionnaires was administered to the same group of respondents after two weeks. The results from both tests were compared using correlation analysis to determine the consistency of the responses, ensuring the reliability of the instruments before the full study is conducted (Creswell & Creswell, 2023; Bryman, 2022).

Validity of the Instrument

To ensure the validity of the research instrument in this study, several types of validity were carefully considered. Face validity was addressed by obtaining expert feedback from the supervisor, who reviewed the instrument to confirm that it appeared to measure what it was intended to measure, aligning with the research objectives and context (Bowen, 2021). Criterion validity was established by correlating the instrument with established benchmarks in quality management practices, ensuring it reflected the expected criteria (DeVellis, 2021). Construct validity was confirmed by verifying that the instrument accurately measured the theoretical constructs related to quality management and project performance, based on existing frameworks and empirical evidence (Hair et al., 2022). These validity checks, including face validity, which ensures the instrument is perceived as relevant by experts and stakeholders (Wilkie et al., 2023), along with criterion and construct validity, were complemented by the use of the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test to assess the suitability of the data for factor analysis. Collectively, these steps ensured the research findings' robustness and credibility.

Table 2: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.827
Bartlett's Test of Sphericity	Approx. Chi-Square	528.314
	df	10
	Sig.	.000

Source: **Pilot data results**, (2024)

Table 2 presents the results of the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity, both of which assess the suitability of the data for factor analysis. The KMO value of 0.827 indicates that the data is highly suitable for factor analysis, as values above 0.6 are generally considered acceptable (Hair *et al.,* 2021). Bartlett's Test of Sphericity, with a chi-square value of 528.314 and a significance level of 0.000, further confirms that the correlation matrix is not an identity matrix, meaning the variables are sufficiently correlated to perform a factor analysis (Field, 2020). These results are consistent with findings from similar studies in project management research, which emphasize the importance of ensuring data suitability before conducting complex analyses like factor analysis (Jing & Zhang, 2022).

Reliability of Instrument

To ensure the reliability of the research instruments in this study, several methods were employed. First, expert opinion from the research supervisor was sought to evaluate the relevance and clarity of the survey and interview questions, ensuring the instruments accurately captured the intended variables and aligned with the study's objectives (Sekaran & Bougie, 2019). Additionally, a test-retest reliability method was used, where the same instrument was administered to a sample group on two separate occasions to assess the stability and consistency of responses over time, confirming the instrument's reliability across different instances (Yegidis, Weinberg, & Myers, 2020). The Cronbach's alpha coefficient was also calculated to measure the internal consistency of the survey items, with an alpha value of 0.70 or above considered acceptable for the study,

indicating reliable scales (Tavakol & Dennick, 2021). By combining expert review, test-retest reliability, and Cronbach's alpha, this study ensures a high level of reliability in its measurement tools, thereby enhancing the validity and robustness of its findings. Reliability statistics, including the alpha coefficient, the number of items per variable, and overall reliability comments, are presented in Table 2.

Table 3: Reliability Statistics

Variable	Alpha (α)	No of Items	Comments
Quality planning	0.875	7	Reliable
Quality improvement	0.929	6	Reliable
Quality Assurance	0.948	8	Reliable
Quality control	0.870	10	Reliable
Project performance	0.937	9	Reliable

Source: **Pilot Results**, (2024).

Table 3 presents the reliability statistics for the variables used in the study, showcasing the consistency and internal validity of the measurement scales. The Cronbach's Alpha (α) values for all variables exceed the commonly accepted threshold of 0.70, indicating high reliability. Specifically, quality planning (α = 0.875), quality improvement (α = 0.929), quality assurance (α = 0.948), and quality control (α = 0.870) all demonstrate strong internal consistency. Additionally, project performance, with an α of 0.937, also reflects high reliability. The strong reliability of these variables assures that the findings on the relationship between quality management practices and project performance are based on sound and consistent data (Yusuf & Wambua, 2022).

Data Processing Analysis

Data processing and analysis for this study employed both quantitative and qualitative techniques to provide a comprehensive understanding of quality management practices and their impact on telecommunications project performance. For the quantitative aspect, statistical methods such as descriptive statistics, correlation analysis, and regression analysis was used to evaluate survey data collected from project managers and engineers. This approach allowed for the identification of patterns and relationships between quality management practices and project performance indicators, such as cost efficiency and project completion times (Field, 2020). Advanced statistical software SPSS version 25 facilitated these analyses, ensuring accuracy and robustness in the results.

On the qualitative side, thematic analysis was utilized to process and interpret data gathered from interviews and focus groups. This method helped in identifying recurring themes and insights related to the implementation and effectiveness of quality management practices (Braun & Clarke, 2021). Thematic analysis allows for an in-depth understanding of participants' perspectives and experiences, which can complement quantitative findings by providing context and nuance. SPSS software was used to assist in coding and organizing qualitative data, ensuring a systematic and rigorous approach to data interpretation (Kothari, 2022).

Additionally, multiple linear regression was used to analyze the connections between the independent factors and the dependent variable. Using this method, we may determine how well the independent variables explain the variation in the dependent one. The regression analysis was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \quad \text{Equation 2}$$

Where: "Y" represents project performance, while "X1" stands for quality planning, "X2" for quality improvement, "X3" for quality assurance, and "X4" for quality control. The coefficients for these independent variables, denoted as "β_i," where "i" takes on the values 1, 2, 3, and 4, represent the magnitudes of their influence on project performance. The error term, represented as "ε," encapsulates unexplained variability or factors that are not accounted for in the model. In essence, this equation outlines the relationship we are

examining between project performance and the four quality-related variables while considering the individual impacts of each independent variable and the presence of unexplained variations within the model.

RESULTS AND FINDINGS

Correlation Analysis

Correlation analysis is used to examine the strength and direction of relationships between key variables in the study, providing insights into how different quality management practices influence project performance. In this section, the correlation matrix explores the associations between quality planning, quality improvement, quality assurance, quality control, and project performance. Table 4.17 presents the correlation coefficients, revealing the extent to which each quality management practice is related to project performance. The matrix allows for a detailed assessment of how these factors interconnect, helping to identify which quality practices have the strongest impact on the success of telecommunications projects in Rwanda.

Table 4: Correlation Matrix

		Quality planning	Quality improvement	Quality Assurance	Quality control	Project performance
Quality planning	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	180				
Quality improvement	Pearson Correlation	.794**	1			
	Sig. (2-tailed)	.000				
	N	180	180			
Quality Assurance	Pearson Correlation	.469**	.500**	1		
	Sig. (2-tailed)	.000	.000			
	N	180	180	180		
Quality control	Pearson Correlation	.454**	.599**	.271**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	180	180	180	180	
Project performance	Pearson Correlation	.721**	.801**	.532**	.616**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	180	180	180	180	180

**. Correlation is significant at the 0.01 level (2-tailed).

Source: **Primary data**, (2024).

Table 4 presents the correlation matrix for the five key variables of quality management and project performance. The correlations indicate significant relationships between all the variables, highlighting the importance of quality management processes in influencing project performance. The Pearson correlation coefficient between Quality planning and Quality improvement is strong ($r = 0.794$, $p < 0.01$), suggesting that effective quality planning is closely related to improvements in project quality (Jiang & Tang, 2022). Additionally, Quality improvement demonstrates strong positive correlations with Quality assurance ($r = 0.500$, $p < 0.01$) and Quality control ($r = 0.599$, $p < 0.01$), indicating that improvements in quality practices are likely to enhance both assurance and control activities within projects. These relationships are consistent with findings in recent studies that emphasize the role of continuous improvement in reinforcing quality management (Goh & Sia, 2021).

Project performance shows strong positive correlations with all quality management dimensions, underscoring the direct impact of quality practices on project outcomes. The relationship between Quality planning and

Project performance is particularly robust ($r = 0.721$, $p < 0.01$), emphasizing that a well-structured quality planning process can significantly contribute to successful project execution (Kerzner, 2021). The correlations between Quality assurance and Project performance ($r = 0.532$, $p < 0.01$), as well as Quality control and Project performance ($r = 0.616$, $p < 0.01$), further confirm that ensuring consistent quality checks and validation throughout the project lifecycle is crucial to achieving desired project outcomes. These results align with the theory that comprehensive quality management practices directly influence the success of projects, as indicated by recent research (Freeman, 2021; Mir & Pinnington, 2022).

Multiple Regression Analysis

Table 4.30 presents the combined model summary, which shows the overall fit of the model incorporating Quality planning, Quality improvement, Quality Assurance, and Quality control as predictors of Project performance. The model exhibits a strong correlation ($R = 0.844$), indicating a high level of association between the predictors and project performance. The R-squared value of 0.712 suggests that approximately 71.2% of the variance in project performance can be explained by these four quality-related factors, demonstrating their collective importance. The adjusted R-square value of 0.705, which accounts for the number of predictors in the model, further supports the robustness of the model, confirming its accuracy in predicting project outcomes. The standard error of the estimate is 0.11613, indicating a relatively low degree of error in the prediction, suggesting that the model's predictions are quite reliable. These findings align with recent research, highlighting the significant impact of quality management practices on project success (Pereira, Silva & Martins, 2022), where integrated quality strategies contribute to enhanced project performance.

Table 5: Combined Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.844[a]	.712	.705	.11613

a. Predictors: (Constant), Quality planning, Quality improvement, Quality Assurance, Quality control

Source: **Primary data**, (2024).

Table 6 presents the ANOVA results for the combined model that examines the impact of Quality control, Quality Assurance, Quality planning, and Quality improvement on Project performance. The regression sum of squares is 5.825, which represents the variation explained by the model. The mean square for the regression is 1.456, resulting in an F-value of 107.991, which is statistically significant at the 0.000 level, indicating that the predictors as a whole significantly contribute to explaining the variance in project performance. The residual sum of squares is 2.360, with a mean square of 0.013, reflecting the unexplained variation in the model. This suggests that the model fits the data well, with a relatively small portion of the variance remaining unexplained. The findings underscore the importance of quality management practices, which have been shown in recent studies to significantly enhance project performance (Cheng, Li & Leung, 2020). These results confirm the collective influence of quality-related factors on the success of projects across various sectors.

Table 6: Combined ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.825	4	1.456	107.991	.000[b]
	Residual	2.360	175	.013		
	Total	8.185	179			

a. Dependent Variable: Project performance

b. Predictors: (Constant), Quality control, Quality Assurance, Quality planning, Quality improvement

Source: **Primary data**, (2024).

Table 7 provides the coefficient results for the overall model, assessing the influence of Quality planning, Quality control, Quality assurance, and Quality improvement on the performance of projects. The

unstandardized coefficients indicate that all the independent variables positively affect project performance, with Quality control having the highest impact (B = 0.379, p < 0.000). Quality planning (B = 0.219, p = 0.002), Quality assurance (B = 0.138, p = 0.001), and Quality improvement (B = 0.250, p < 0.000) also show significant positive relationships with project performance. The standardized beta coefficients highlight the relative importance of these predictors, with Quality control (β = 0.413) being the most influential, followed by Quality improvement (β = 0.228), Quality planning (β = 0.214), and Quality assurance (β = 0.163). These findings align with recent studies emphasizing the critical role of comprehensive quality management practices in enhancing project performance (Cheng, Li & Leung, 2020; Duan, Li & Li, 2021). The results suggest that project performance can be significantly improved through the effective implementation of quality planning, control, assurance, and improvement strategies.

Table 7: Coefficient results of Overall Model

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.073	.240		.305	.760
	Quality planning	.219	.069	.214	3.171	.002
	Quality control	.379	.070	.413	5.400	.000
	Quality assurance	.138	.040	.163	3.451	.001
	Quality improvement	.250	.056	.228	4.483	.000

a. Dependent Variable: Performance of projects

Source: **Primary data**, (2024).

The overall regression equation can be represented as:

Project performance = 0.073 + 0.219 Quality planning + 0.379 Quality improvement + 0.138 Quality Assurance + 0.250 Quality control

The model indicates that project performance is influenced by four key factors: Quality planning (0.219), Quality improvement (0.379), Quality assurance (0.138), and Quality control (0.250). The positive coefficients suggest that all these factors contribute to improving project performance, with Quality improvement having the most significant impact, followed by Quality control, Quality planning, and Quality assurance. The constant value of 0.073 represents the baseline level of project performance when all quality factors are absent. This finding aligns with recent literature, which highlights that structured quality management practices—ranging from planning to control and continuous improvement—are critical in enhancing the performance and success of projects (Cheng, Li & Leung, 2020; Goh, Tan & Wee, 2022). The results confirm that effective integration of quality management strategies directly correlates with improved project outcomes, as indicated by the positive relationships between the quality variables and project performance.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, quality planning plays a pivotal role in influencing project performance, with a significant positive correlation observed between the two variables. The strong relationship, as shown through both descriptive and regression analysis, underscores the importance of structured and comprehensive planning in project management. Organizations that prioritize quality planning are more likely to experience successful project outcomes, as it provides a clear roadmap for achieving project goals and managing potential risks. Quality planning should, therefore, be seen as a critical foundation for any project, ensuring that all activities are aligned with the desired outcomes and objectives.

The conclusion drawn from the findings is that quality improvement has the most substantial impact on project performance, more so than other quality management practices. The robust correlation between quality improvement and project performance, supported by the regression results, indicates that continuous

enhancement of processes and practices is crucial for achieving high project performance. Organizations that adopt a proactive approach to quality improvement are better positioned to deliver successful projects, as they can adapt to changing conditions, refine processes, and resolve issues quickly. Quality improvement should therefore be a key focus in project management strategies to drive long-term success and sustainability.

The conclusion from the analysis of quality assurance reveals that while it plays a significant role in project performance, its impact is more moderate compared to other quality practices like planning and improvement. The relationship between quality assurance and project performance highlights the importance of maintaining high standards and consistency throughout the project lifecycle. Although quality assurance may not explain as much variance in project performance as quality planning or improvement, it is still an essential element of successful project management. By ensuring that all aspects of a project meet predetermined standards, quality assurance helps minimize risks and ensures the final deliverables are of the highest quality.

Quality control is a critical factor in achieving successful project outcomes, as evidenced by the strong positive relationship between quality control and project performance. The findings indicate that quality control significantly impacts project success by ensuring that the project's outputs meet the required standards and specifications. Organizations that implement effective quality control practices are more likely to minimize errors, reduce rework, and deliver projects that meet stakeholders' expectations. Therefore, quality control should be an integral part of project management, helping to maintain consistency and prevent defects throughout the project's lifecycle, ultimately contributing to higher project performance.

The study recommends that organizations invest more resources in developing comprehensive quality planning processes at the outset of each project. Effective quality planning should involve clear definitions of project objectives, roles, and responsibilities, along with the identification of potential risks and mitigation strategies. Project managers and teams should be trained in quality planning techniques and encouraged to use tools like Gantt charts, risk management matrices, and project scheduling software to enhance planning accuracy. By ensuring that quality planning is well-integrated into the project management process, organizations can achieve better project outcomes, minimize risks, and deliver projects on time and within budget.

Organizations should focus on fostering a culture of continuous quality improvement, which can lead to sustained project success. This involves regularly reviewing and refining project processes, learning from past projects, and incorporating best practices into current and future projects. It is recommended that project managers implement feedback loops, conduct post-project reviews, and use performance metrics to evaluate and improve project processes. Quality improvement efforts should be proactive, not reactive, ensuring that small issues are addressed before they escalate. Investing in training and development for staff on the principles of quality improvement, such as Lean or Six Sigma methodologies, can significantly enhance project performance.

To further enhance project performance, organizations should place greater emphasis on robust quality assurance mechanisms throughout the project lifecycle. This includes establishing clear quality standards, regular monitoring of project deliverables, and conducting audits or reviews at key stages. It is recommended that project teams integrate quality assurance procedures from the beginning and maintain these throughout, ensuring that the project stays aligned with established standards. Additionally, incorporating automation and tools for real-time monitoring and reporting of project quality can improve the efficiency of quality assurance activities. A strong quality assurance framework ensures that any deviations from quality standards are detected early and corrected, contributing to successful project outcomes.

The study recommends that organizations strengthen their quality control practices by implementing more rigorous inspection and testing protocols at every stage of the project. Quality control should not be viewed as a final check, but as an ongoing process embedded within project execution. Ensuring that the project team

has access to the right tools and resources for quality control, such as testing equipment and quality checklists, is critical. Furthermore, project managers should regularly communicate with team members to ensure that quality standards are maintained throughout the project. By incorporating comprehensive quality control systems, organizations can minimize errors, reduce rework, and ensure that the final project deliverables meet stakeholder expectations.

Suggestions for Further Studies

Further research could explore the long-term impact of quality planning, improvement, assurance, and control on project performance across various industries. While this study focused on specific sectors, it would be beneficial to expand the scope of research to include different types of projects, such as IT, construction, or healthcare, to understand whether the findings hold universally or if they are context-dependent. Additionally, future studies could investigate the interaction between these quality variables and other factors, such as organizational culture, leadership styles, and resource availability, to gain a more comprehensive understanding of how they collectively influence project success. Examining these variables across different geographical regions and cultures could also provide valuable insights into how quality management practices vary and their effectiveness in diverse environments.

Another area for future research could involve the development and testing of new quality management tools and technologies that support project performance. With the rapid evolution of digital tools, including AI-driven software for project management and quality control, there is potential for exploring how these innovations can enhance quality planning, improvement, assurance, and control. Future studies could also focus on the role of employee training and development in enhancing the effectiveness of quality management practices, as well as the impact of leadership and team dynamics on implementing these practices successfully. Further research in these areas could provide actionable insights that help organizations optimize their project management processes and improve overall performance.

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