The Relation between Supply Chain Performance and Quality Management Practices to Assure Sustainability in Medical Pharmacies

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Abstract

The research examines the role of the total quality management (TQM) practices in relation to sustainability performance and the mediating effect of supply chain performance in Egyptian medical pharmacies. Data was processed utilizing structural equation modeling (SEM) with AMOS. Data was gathered from 407 medical pharmacies respondents located across Egypt. Five total quality management (TQM) dimensions (leadership, strategic planning, customer focus, human resource management, information, and analysis) were used to measure total quality management (TQM) practices and sustainability performance was assessed by the three dimensions (economic, environmental and social performance). The findings showed that all total quality management (TQM) dimensions have a significant effect on both sustainability performance and supply chain performance. Supply chain performance was significant and positive in relation to sustaining performance ($\beta = 0.180$, $p < 0.001$) and functioned as a partial mediator in the total quality management (TQM)-sustainability linkage. The structural model accounted for the variance of 54% of supply chain performance ($R^2 = 0.540$) and 71.6% of sustainability performance ($R^2 = 0.716$). The study adds to the body of the literature by providing an empirical analysis on the pharmaceutical sector in Egypt examining the mediation role of supply chain performance in the total quality management (TQM) and sustainability relationship, which is of great significance to healthcare managers and policymakers

***Keywords**: Total Quality Management, Sustainability Performance, Supply Chain Performance, Medical Pharmacies, Structural Equation Modeling, Egypt.*

Introduction

The pharmaceutical industry has increasing organizational efficiency and sustainability goals (Ofori et al., 2025). Total Quality Management (TQM) as a strategy promoting the integration of quality and sustainability in operational processes has become a critical approach in the health care industry. Maintenance of operational and environmental sustainability is equally important (Masoudi & Shahin, 2025). In Egypt, research on medical pharmacy sector of the supply chain healthcare has been largely inconclusive on the relationship between total quality management (TQM) practices and sustainability performance through supply chain mechanisms.

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The environmental impact of the pharmaceutical industry is energy-intensive processes, and the production of hazardous waste and high carbon emissions (Vineeth. et al., 2025) While the industry is crucial to public health, Total quality management practices (TQMPs), in this regard, can enhance operational and sustainability efficiencies (Aichouni et al., 2023). Economic, environmental and social sustainability performance are defined as from a broader perspective sustainability, the interrelated levels of impact are derived from the performance of the supply chain, and the total quality management (TQM) practices.

While separate studies on total quality management (TQM) and supply chain management are numerous, very few have explored the mediation processes by which various components of total quality management (TQM) affect sustainability performance in the pharmaceutical industry, especially in developing countries like Egypt (Abdulameer & Ibrahim, 2025). This study aims to fill this gap by examining total quality management practices (TQMPs) (leadership, strategic planning, customer focus, human resource management, and information and analysis) and their impact on sustainability performance (economic, environmental, and social) through the mediation of supply chain performance in Egyptian medical pharmacies.

Literature Review and Theoretical Framework

Total Quality Management Practices

Total Quality Management (TQM) brings together continuous improvement, customer focus, and employee participation to drive organizational excellence (Sarmad et al., 2024). The Malcolm Baldrige National Quality Award Framework identifies five key pillars (leadership, strategic planning, customer focus, human resource management, and information systems) that work together to foster a quality-focused culture (Adulapuram et al., 2024). When aligned effectively, these dimensions create lasting performance improvements throughout the organization (Zawawi et al., 2025; Bharath et al., 2025).

Leadership emerges as the cornerstone of total quality management (TQM), establishing the vision and commitment necessary for organization-wide quality focus (Abozraiq et al., 2025; Djuric et al., 2024). Transformational leaders inspire employees and strategically allocate resources to create environments where quality naturally thrives (Djuric et al., 2024). This proves especially vital in pharmaceuticals, where strict regulations and patient safety demands make quality leadership indispensable (Vassos et al., 2024). Strategic planning translates this vision into concrete action by aligning long-term quality objectives with business strategy (Abozraiq et al., 2025). By balancing quality initiatives with organizational goals and directing resources strategically, organizations achieve measurable performance gains (Bharath et al., 2025).

Customer focus hinges on systematically gathering feedback and responsively addressing client needs (Zawawi et al., 2025). In healthcare settings, this extends beyond patients to include providers, regulators, and other stakeholders (Vassos et al., 2024). Customer-centered organizations consistently deliver superior service quality and improved patient outcomes (Adulapuram et al., 2024). Human resource management forms total quality management (TQM)'s practical foundation through comprehensive training, employee empowerment, and active quality improvement participation (Zawawi et al., 2025). Evidence confirms that engaged, well-trained employees generate substantial quality improvements (Adulapuram et al., 2024), particularly in pharmaceuticals where trained personnel ensure compliance and product quality (Adulapuram et al., 2024). Finally, information systems enable data-driven decision-making and performance tracking (Krajcsák, 2019). In pharmaceuticals, robust systems prove essential for traceability, quality control, and regulatory compliance (Vassos et al., 2024).

Total Quality Management and Sustainability Performance

Organizations increasingly recognize that their triple bottom line -encompassing economic, environmental, and social dimensions- depends fundamentally on how effectively they implement total quality management practices (TQMPs) (Hong et al., 2018). Research spanning decades demonstrates that

total quality management (TQM) positively influences corporate sustainability across multiple dimensions (Tessema et al., 2025). By embedding a culture of continuous improvement, total quality management (TQM) naturally fosters sustainable innovation and uncovers opportunities for growth that benefit both business and environmental outcomes (Restuputri et al., 2025).

Economically, total quality management (TQM) delivers substantial returns through improved operational efficiency, waste reduction, and heightened customer satisfaction (Restuputri et al., 2025; Sarmad et al., 2024). When organizations prevent process defects, streamline resources, and minimize control inefficiencies, they substantially reduce quality management costs (Restuputri et al., 2025). In pharmaceuticals particularly, enhanced process control and reduced variability directly strengthen operational performance (Sharma & Modgil, 2020).

Environmentally, total quality management (TQM) drives meaningful improvements by emphasizing waste minimization, resource conservation, and process optimization (Rashid et al., 2025). Lean manufacturing principles embedded within total quality management (TQM) frameworks enable organizations to achieve quality goals while simultaneously lowering environmental footprints (Rashid et al., 2025; Restuputri et al., 2025). This integration highlights the critical need for environmental management systems and green innovations that advance organizational sustainability (Restuputri et al., 2025).

Socially, total quality management (TQM) cultivates positive change by ensuring employee wellbeing, strengthening community relationships, and upholding ethical standards (Mariappanadar et al., 2025). Organizations practicing total quality management (TQM) foster inclusive, psychologically safe work environments that encourage collaborative decision-making (Mariappanadar et al., 2025; Restuputri et al., 2025). This commitment to quality culture satisfies employees' psychological needs while strengthening organizational social responsibility (Zawawi et al., 2025).

Recent empirical research confirms these connections convincingly. Restuputri et al. (2025) demonstrate how operational efficiency and emission reduction enhance sustainability performance, while Tessema et al. (2025) establish links between total quality management (TQM), knowledge sharing, and business integration. In healthcare, studies by Zehir & Zehir (2023) and Tonjang & Thawesaengskulthai (2022) confirm total quality management (TQM)'s positive impact on organizational performance and sustainability across all three dimensions. Based on this theoretical foundation and empirical evidence, we propose: **H1: It is expected that total quality management Practices have a positive impact on the sustainability performance in Egyptian medical pharmacies**

Total Quality Management (TQM) and Supply Chain Performance

Supply chain performance fundamentally depends on efficiency, effectiveness, and responsiveness in managing goods, data, and money flows across networks (Karmaker et al., 2021). In pharmaceutical contexts specifically, performance requires product availability, consistent quality maintenance, and cost control (Sharma & Modgil, 2020; Alsmairat et al., 2024).

Total quality management (TQM) practices significantly enhance supply chain operations by strengthening coordination, information sharing, and supplier relationships (Sharma & Modgil, 2020; Alsmairat et al., 2024). Research from Indian pharma demonstrates that total quality management (TQM) influences supply chain components and operational performance through improved strategic partnerships and procurement quality (Sharma & Modgil, 2020). Similarly, Egyptian pharmaceutical studies confirm that management commitment, customer focus, supplier management, training, and continuous improvement directly boost supply chain efficiency (Alsmairat et al., 2024) - particularly important given strict pharmaceutical regulations (Vassos et al., 2024; Alsmairat et al., 2024).

Conversely, lacking total quality management (TQM) undermines performance significantly. Jordanian pharmaceutical research reveals that supplier, distributor, and intermediary relationships directly impact sustainability, with total quality management (TQM) serving as the critical mediating mechanism

(Alsmairat et al., 2024). Essentially, Total quality management (TQM) creates an operational framework enabling effective supply chain management. Therefore, we hypothesize: **H2: It is expected that total quality management practices have a positive impact on the supply chain performance in Egyptian medical pharmacies.**

Supply Chain Performance and Sustainability Performance

Organizations increasingly recognize that operational effectiveness directly drives sustainable development, particularly through enhanced supply chain performance (Agbenyegah and Kumadey, 2024). Sustainable supply chain management extends beyond economics to embrace social inclusion across entire supply networks (Agbenyegah and Kumadey, 2024; Sabat et al., 2020).

Strong supply chain performance correlates directly with sustainability outcomes across multiple dimensions (Awan et al., 2022). Manufacturing research reveals that green supply chain management mediates relationships between lean practices and sustainability with impressive explanatory power—R^2 values of 64% and 71.9% respectively (Awan et al., 2022). In pharmaceuticals, supply chain viability becomes essential for achieving sustainable performance (Agbenyegah & Kumadey, 2024). Ghana's pharmaceutical sector demonstrates strong relationships between sustainable supply chain management and performance, where management commitment functions as a critical moderating factor (Agbenyegah & Kumadey, 2024). Pharmaceutical companies must be embed sustainability throughout their supply chains via deliberate strategies and policies (Agbenyegah & Kumadey, 2024).

Effective supply chain management reduces waste and maximizes resource efficiency, positively impacting the triple bottom line (Hong et al., 2018; Sabat et al., 2020). Sustained adoption generates economic benefits through cost savings, environmental gains via reduced emissions, and social improvements through better working conditions and community engagement (Hong et al., 2018). Innovative technologies enhance these outcomes- blockchain-enabled traceability systems strengthen quality management and governance (Sahoo, 2024), while strong supply chain partnerships and digital capabilities drive sustainable performance through integration and information sharing (Alsmairat et al., 2024). Based on this evidence, we propose: **H3: It is expected that the supply chain performance has a positive impact on the sustainability performance in Egyptian medical pharmacies.**

Mediation Role of Supply Chain Performance

Supply chain performance fundamentally shapes how quality management drives sustainability outcomes (Sagher et al., 2025; Alsmairat et al., 2024). Research shows operational capabilities mediate this relationship. In Yemeni telecommunications, total quality management (TQM) mediated between process reengineering and sustainable performance (Sagher et al., 2025), while pharmaceutical firms demonstrate total quality management (TQM)'s mediating role between supply chain relationships and sustainability (Alsmairat et al., 2024). The dynamic capabilities framework explains why: strengthening total quality management (TQM) enhances quality management, streamlines processes, and improves coordination (Tessema et al., 2025; Sharma & Modgil, 2020). This enables organizations to achieve sustainability through efficient resource use and responsible practices (Agbenyegah & Kumadey, 2024). Manufacturing confirms this pattern: green supply chain management mediates lean manufacturing's sustainability effects (Awan et al., 2022), while Industry 4.0 moderates with total quality management (TQM) (Yadav et al., 2020). In pharmaceuticals, supply chain performance drives sustainable outcomes (Vassos et al., 2024). We hypothesize: **H4: It is expected that supply chain performance mediates the relationship between total quality management practices and sustainability performance in Egyptian medical pharmacies.**

Conceptual Framework

The conceptual framework was established after analyzing existing theories and models and was applied to data collection and data analysis. The aim of this research was to gain a deeper insight into the

field of interest by examining the relationship between the independent variables (Total Quality Management Practices), mediator variable (Supply Chain Performance) and dependent (Sustainability Performance) variable.

The variable "Total Quality Management Practices" is measured by five dimensions (Leadership, Strategic planning, Customer focus, Human resource management, Information and analysis) (Abbas & Kumari, 2023), The variable "Sustainability Performance" is measured by three dimensions (Economic performance, Environmental performance, Social performance) (Mukhtar et al., (2025); Habidin, et al., (2015), and the variable "Supply Chain Performance" is measured by 8 items (Ozkanlisoy & Bulutlar, 2023).

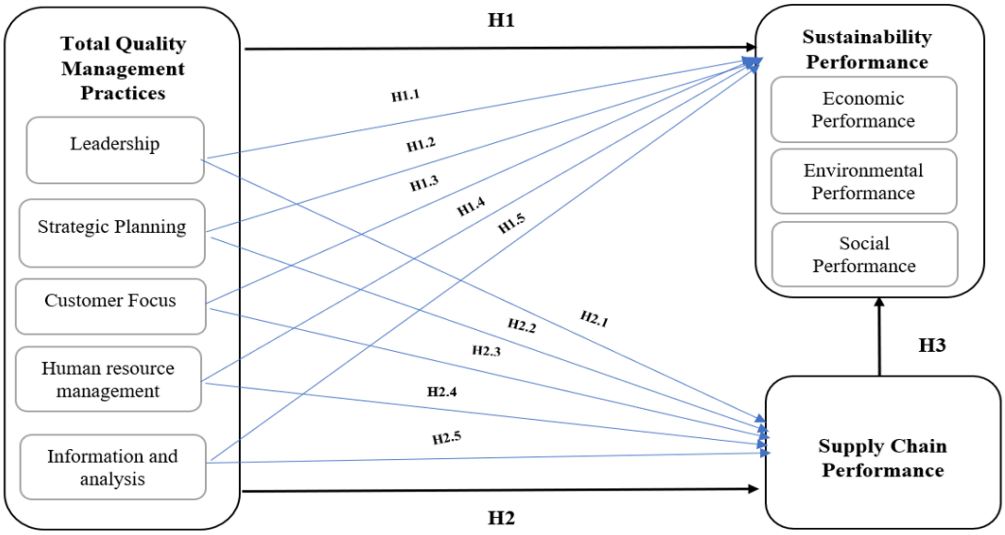

Figure 1 Conceptual Framework

Research Problem and Questions

Pharmacies in the Egyptian medical market are beginning to realize the importance of the business imperative for adopting total quality management and total supply chain management to meet the challenges of global competition, limitations imposed by the regulatory environment, and stakeholder concerns for sustainability in response to Mohamed and Salman (2025). However, Ofori et al (2025) describe the substantial knowledge gaps on the mechanisms of total quality management (TQM) and the sustainability outcomes, while Masoudi and Shahin (2025) focus on the central role of supply chain management in this equation. Other authors, such as Singh and Regasa (2026) address the importance of total quality management (TQM) components and the associated trade-offs in relation to sustainability.

Pharmaceutical businesses in Egypt are faced with unique challenges as a result of their specific market structure (Mohamed & Salman, 2025), regulatory environment, as well as competitive and organizational (Mohammed et al., 2024) which necessitates research that is specific to the Egyptian context (Magued, 2023) as opposed to relying on analyses based on disparate contexts (Chen, 2026).

Based on the pervious discussion the research questions can be summarized in the following:

RQ1: What is the impact of the total quality management practices on the sustainability performance in Egyptian medical pharmacies?

RQ2: What is the impact of the total quality management practices on the supply chain performance in Egyptian medical pharmacies?

RQ3: What is the impact of the supply chain performance on the sustainability performance in Egyptian medical pharmacies?

RQ4: Does supply chain performance mediate the relationship between the total quality management practices and sustainability performance in Egyptian medical pharmacies?

Research aim and objectives

The overarching aim of this research is to investigate the impact of the total quality management practices on the sustainability performance in Egyptian medical pharmacies, with particular emphasis on examining how supply chain performance mediates this relationship. The research pursues the following specific objectives: To examine the relationship between the total quality management practices and the sustainability performance in the Egyptian medical pharmacies, To investigate the relationship between the total quality management practices and supply chain performance in the Egyptian medical pharmacies, To investigate the relationship between supply chain performance and sustainability performance in the Egyptian medical pharmacies, To investigate the mediation role of supply chain performance between the total quality management practices and sustainability performance in the Egyptian medical pharmacies and To develop a framework for the relationship between the total quality management practices, supply chain performance and sustainability performance in the Egyptian medical pharmacies using structural equation modelling.

Research Methodology

Research Design and Sample

This research study employed a quantitative design utilizing a cross-sectional survey for the purpose of exploring the relationship between total quality management (TQM) practices and the performance of the supply chain and the sustainability performance of medical pharmacies in Egypt. The study population comprised employees of different categories of medical pharmacies in Egypt. This included: hospital pharmacies, community pharmacies, clinical pharmacies, industrial pharmacies, online Pharmacies and other

Convenience sampling resulted in questionnaires being distributed to 700 respondents. 469 of the questionnaires were returned, producing a return rate of 67%. In the data screening, 62 questionnaires (9%) were set aside, owing to ambiguous answers, non-participation, or ineligibility. 231 questionnaires (33%) were not distributed to the target respondents. 407 valid responses were recorded, resulting in an effective response rate of 58%. This rate exceeds the criterion established for studies involving structural equation modelling.

Measurement Instruments

This study measured total quality management (TQM) through five interconnected dimensions grounded in the Malcolm Baldrige National Quality Award and validated total quality management (TQM) frameworks (Abbas & Kumari, 2023; Zawawi et al., 2025; Bharath et al., 2025). Leadership (4 items) captured senior management commitment to quality vision and resource allocation. Strategic planning (4 items) examined alignment between quality goals and organizational objectives. Customer focus (4 items) assessed needs assessment and service responsiveness mechanisms. Human resource management (4 items) evaluated training, empowerment, participation, and recognition practices. Information and analysis (4 items) measured data collection and decision-support processes. Supply chain performance incorporated eight items (Ozkanlisoy & Bulutlar, 2023; Sharma & Modgil, 2020; Alsmairat et al., 2024) spanning procurement, inventory, distribution, supplier management, and overall efficiency. Sustainability performance employed the triple bottom line framework (Mukhtar et al., 2025; Habidin et al., 2015; Hong et al., 2018; Restuputri et al., 2025) with four items each for economic performance (profitability, cost savings, productivity, financial growth), environmental performance (waste reduction, energy savings, compliance, green initiatives), and social performance (employee wellbeing, social responsibility, community involvement, ethical conduct, stakeholder satisfaction). All constructs used a five-point Likert scale from strongly disagree to strongly agree (Zawawi et al., 2025; Bharath et al., 2025).

Data Analysis Procedures

The validity and reliability of the measurement model were assessed using confirmatory factor analysis (CFA) and the AMOS software package. Structural equation modeling (SEM) was used to analyze the accepted theoretical models and hypothesized relationships. For the mediation analysis, the performance of the supply chain was evaluated to determine if it mediates the impact of total quality management practices (TQMPs) on sustainability performance, assessing this through direct, indirect, and total effects analysis. (Hair et al., 2019)

Discussion of Study Results

Demographic Profile

The demographic study provided a sample representative of the Egyptian pharmacy and medical workforce. With regard to the gender analysis, there are 282 male respondents (69.3%) and 125 respondents (30.7%) females. Age analysis shows that the majority were aged between 26 and 35, with 151 respondents making up (37.1%). This was followed by 36 to 45 year-olds who had 146 respondents (35.9%), and 46 years and older with 90 respondents (22.1 %). The survey respondents' educational achievements show substantial professional readiness with 181 respondents (44.5%) having master's degrees, 171 (42%) having bachelor's, and 55 (13.5%) having PhD or DBA degrees. The level of experience indicated that 189 respondents (46.4%) had 10 years or more of experience, 78 (19.2%) had between 1 to less than 5 years, and 62 (15.2%) had between 5 and less than 10 years. The position distribution also shows a range of variety with 123 (30.2 %) holding administrative positions, 122 (30%) are pharmacists, and 80 (19.7%) are pharmacy managers. The largest category of pharmacy types is hospital pharmacies with 165 (40.5%), followed by community pharmacies with 126 (31%), and clinical pharmacies with 50 (12.3%).

Results of Measurement Model

The analysis of factors confirmed a cohesive and strong psychological characteristic of all the constructs. All the constructs have demonstrated composite reliability (CR) values above the 0.70 benchmarks. These include leadership (0.842), strategic planning (0.839), customer focus (0.925), human resource management (0.836), information and analysis (0.848), supply chain performance (0.952), economic performance (0.907), environmental performance (0.867), and social performance (0.856) (Hair et al., 2019). This result indicates a solid internal consistency reliability.

All of the measured constructs had average variance extracted (AVE) values above the 0.50 threshold. These include leadership (0.574), strategic planning (0.566), customer focus (0.755), human resource management (0.576), information and analysis (0.587), supply chain performance (0.714), economic performance (0.710), environmental performance (0.619), and social performance (0.604). This indicates there is adequate convergent validity; the constructs explain more than half of the indicator's variance (Hair et al., 2019). Model fit indices showed a good fit between the measurement model and the data. The chi square over the degrees of freedom (χ^2/df) is 1.995 (df = 702), which is well below the 3.0 threshold. The RMSEA was 0.050, which indicates a close fit (less than 0.08). The TLI is at 0.935, while the CFI is at 0.942; both above the 0.90 threshold for acceptable fit per Zawawi et al. (2025) and Sagher et al. (2025). This means the measurement model fits, has good psychometric properties, and allows us to proceed to evaluate the structural model.

Results of the Structural Model

The structural model exhibited a good fit: χ^2/df = 2.309 ($p < 0.05$); within threshold, RMSEA = 0.057, TLI = 0.915, CFI = 0.922. This confirms that the theoretical model is suitable for the empirical data.

Table 1: Structural Model Fit Indices

Fit Index	Value	Acceptable Threshold	Interpretation
Degrees of Freedom (DF)	717	> 0	Valid
χ2/DF	2.309	≤ 3.0	Good Fit
RMSEA	0.057	< 0.08	Good Fit
TLI	0.915	≥ 0.90	Acceptable/Good Fit
CFI	0.922	≥ 0.90	Acceptable/Good Fit

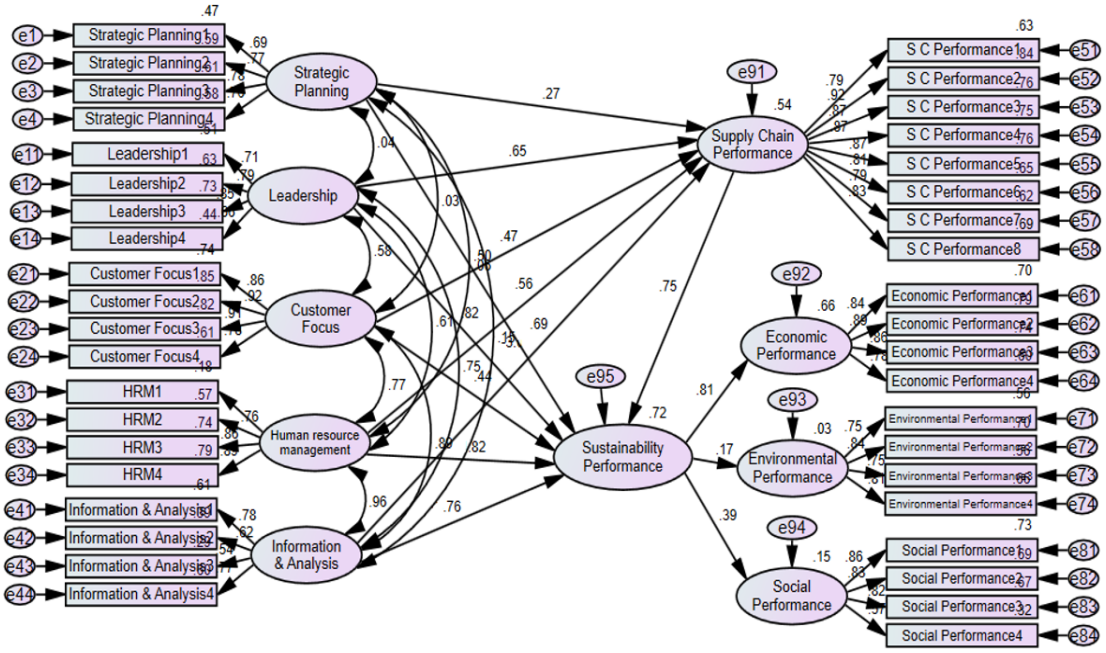

Figure (2) The Structural Model (Final Result)

1- **Direct Effects on Sustainability Performance (Supporting H1):**

Leadership ⟶ Sustainability Performance: β = 0.817, CR = 12.317, p = 0.000 (highly significant) - Strategic Planning ⟶ Sustainability Performance: β = 0.503, CR = 3.378, p = 0.025 (significant) - Customer Focus ⟶ Sustainability Performance: β = 0.436, CR = 6.501, p = 0.000 (highly significant) - Human Resource Management ⟶ Sustainability Performance: β = 0.821, CR = 3.054, p = 0.002 (highly significant) - Information and Analysis ⟶ Sustainability Performance: β = 0.764, CR = 5.387, p = 0.000 (highly significant).

All findings show that total quality management (TQM) dimensions can be validated against the sustainability performance construct which supports H1. Leadership and human resource management stand out as having the most prominent direct effects. This indicates that organizational commitment and employee engagement are fundamental for achieving sustainability.

2- **Direct Effects on Supply Chain Performance (Supporting H2):**

Leadership ⟶ Supply Chain Performance: β = 0.646, CR = 12.317, p = 0.000 (highly significant) - Strategic Planning ⟶ Supply Chain Performance: β = 0.274, CR = 2.248, p = 0.025 (significant) - Customer Focus ⟶ Supply Chain Performance: β = 0.473, CR = 13.755, p = 0.000 (highly significant) - Human Resource Management ⟶ Supply Chain Performance: β = 0.562, CR = 4.726, p = 0.000 (highly significant) - Information and Analysis ⟶ Supply Chain Performance: β = 0.692, CR = 6.336, p = 0.000 (highly significant)

H2 is confirmed, all total quality management (TQM) dimensions have influenced supply chain performance significantly (Watto et al., 2025). Customer focus and Information & Analysis have even more significant impact on the supply chain Performance. This reveals that for the supply chain performance, customer integration and data analytics as decision-making tools, operationally, are imperative.

3- **Direct Effect on Supply Chain Performance to Sustainability Performance (Supporting H3):**

Supply Chain Performance ⟶ Sustainability Performance: β = 0.180, CR = 7.395, p = 0.000 (highly significant)

H3 is supported as, to a certain degree, improved supply chain performance leads to improved sustainability (Zhu & Wu, 2022).

4- **Indirect Effects and Mediation (Supporting H4):**

Leadership ⟶ Supply Chain Performance ⟶ Sustainability Performance: Indirect effect p = 0.004 (significant)

Strategic Planning ⟶ Supply Chain Performance ⟶ Sustainability Performance: Indirect effect p = 0.004 (significant)

Customer Focus ⟶ Supply Chain Performance ⟶ Sustainability Performance: Indirect effect p = 0.003 (significant)

Human Resource Management ⟶ Supply Chain Performance ⟶ Sustainability Performance: Indirect effect p = 0.003 (significant)

Information and Analysis ⟶ Supply Chain Performance ⟶Sustainability Performance: Indirect effect p = 0.004 (significant)

Considering all mediation routes, all impacts were validated at the 5% significance threshold, thus supporting H4. From this, it can be deduced that supply chain performance is equally critical in explaining the effect of total quality management (TQM) practices on sustainability performance in addition to the direct effects.

5- **Variance Explained**

The construct of the total quality management practices (leadership, strategic planning, customer focus, human resource management, information and analysis) explained 54% of the variance in supply chain performance (R^2 = 0.540), which indicates strong explanatory power. The integrated model with direct and indirect supply chain performance pathways explained 71.6% of the variance in sustainability performance (R^2 = 0.716). This indicates strong performance of the overall model and the validation of both direct and indirect pathways as important contributors to the sustainability outcome.

Table 2: Direct Effects

Hypothesized path			Standardized Beta (β)	P-Value	Hypothesis Supported
Supply Chain Performance	←	Leadership	.646	.000	Yes
Supply Chain Performance	←	Strategic Planning	.274	.000	Yes
Supply Chain Performance	←	Customer Focus	.473	.000	Yes
Supply Chain Performance	←	Human resource management	.562	.000	Yes
Supply Chain Performance	←	Information and analysis	.692	.000	Yes
Sustainability Performance	←	Leadership	.817	.000	Yes
Sustainability Performance	←	Strategic Planning	.503	.000	Yes
Sustainability Performance	←	Customer Focus	.436	.000	Yes
Sustainability Performance	←	Human resource management	.821	.000	Yes
Sustainability Performance	←	Information and analysis	.764	.000	Yes
Sustainability Performance	←	Supply Chain Performance	.180	.000	Yes

Interpretation Relative to Literature

The results are consistent with the existing body of knowledge on total quality management (TQM) and sustainability and the mediation mechanisms of the supply chain that expands existing knowledge (Wang et al., 2020). The dominating effect of leadership on sustainability (β = 0.817) is in line with the literature that positions top management commitment as a requisite for the integration of quality and sustainability (Sin et al., 2021). The quantified effect of human resource management (β = 0.821) copes with the literature that recognizes the importance of employee-driven organizational engagement to attain sustainability in healthcare.

Effects of customer focus (β = 0.436 direct; β = 0.473 on supply chain) align with research indicating customer integration strategies improve both quality and sustainability (Kamra et al., 2024). The information

and analysis effect on supply chain performance (β = 0.692) aligns with current focus on information systems to optimize supply chain and measure sustainability performance.

The mediation results acknowledge existing literature by showing supply chain mechanisms, in part, describe the total quality management (TQM) impact on sustainability. This indicates that organizations are unlikely to achieve sustainability with the direct application of total quality management (TQM); a more effective, integrated supply chain, is the necessary complementary mechanism that converts quality practices into sustainability (Zouari et al., 2025).

Table 3: Indirect (Mediating) Effects

Indirect Path	P-Value	Mediation Type	Hypothesis Supported
Leadership → Supply Chain Performance → Sustainability Performance	.004	Partial Mediation	Yes (H4.1)
Strategic Planning → Supply Chain Performance → Sustainability Performance	.004	Partial Mediation	Yes (H4.2)
Customer Focus → Supply Chain Performance → Sustainability Performance	.003	Partial Mediation	Yes (H4.3)
Human Resource Management (HRM) → Supply Chain Performance → Sustainability Performance	.003	Partial Mediation	Yes (H4.4)
Information & Analysis → Supply Chain Performance → Sustainability Performance	.004	Partial Mediation	Yes (H4.5)

The 71.6% of variance in sustainability performance is a substantial amount of the variance and indicates the model in question captures the key factors that clarify sustainability performance in the pharmaceutical industry (Thi & Vu, 2025). This also means the total quality management (TQM) and supply chain practices identified are the most significant of the many practices and mechanisms available to medical pharmacies in the attainment of sustainability.

Research Recommendations

Pharmacies should establish sustainability governance through dedicated committees reporting to leadership, appointing sustainability coordinators, embedding sustainability metrics in strategic planning, and conducting regular audits. Implement comprehensive total quality management (TQM) using ISO 9001 frameworks, quality circles, statistical process control, and real-time performance dashboards. Invest in staff through quality and sustainability training, career development pathways, knowledge-sharing communities, and recognition programs for sustainability champions. Enhance supply chain sustainability by establishing supplier evaluation criteria, adopting green procurement policies, implementing reverse logistics for medication disposal, and collaborating with healthcare providers on demand planning. Finally, leverage digital technologies through integrated pharmacy management systems, computerized prescribing and inventory controls, data analytics for sustainability monitoring, and participation in national health information networks.

Limitations and Future Research

This study's Egyptian pharmacy context may limit generalizability to other healthcare systems and economies. Its cross-sectional design restricts cause-effect conclusions; longitudinal research is needed to establish total quality management (TQM)'s sustainability impact over time. The study examined three sustainability dimensions -economic, environmental, and social- though comprehensive assessments consider additional dimensions like governance, innovation, and resilience. Supply chain performance was measured through eight internal supplier items. Future research should explore other supply chain elements including resilience, risk management, and stakeholder engagement, which may uniquely mediate total quality management(TQM)-sustainability relationships.

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