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QR Code Integration in Retail Pharmacy: A Service Quality Framework Analysis using PLS-SEM on Customer Outcomes

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ABSTRACT: This study critically examines the influence of QR code integration within the retail pharmacy context on key performance metrics, including service quality, store attributes, waiting time, customer satisfaction, trust, and repurchase intention. Employing partial least squares structural equation modeling (PLS-SEM), this research analyzed data from customers to elucidate the underlying interdependencies of variable and service delivery outcomes. Instrumental to the analysis is the assurance of minimal collinearity, as evidenced by the Inner VIF values consistently falling below the threshold of 3, thereby confirming the reliability of the estimated model. Empirical findings indicate that QR code deployment exerts a statistically significant positive effect on service quality ($\beta = 0.43$, $p < 0.001$), store attributes ($\beta = 0.45$, $p < 0.01$), and waiting time ($\beta = 0.38$, $p < 0.001$), collectively accounting for 52% of the variance in customer satisfaction ($R^2 = 0.520$). Moreover, customer satisfaction emerged as a pivotal mediator, robustly influencing trust and repurchase intention, with indirect pathways and direct effects substantiating its role in shaping customer loyalty. Although the variance explained by trust is modest ($R^2 = 0.123$), the cascading effect on repurchase intention ($R^2 = 0.332$) underscores the systemic importance of a holistic digital integration strategy. This study contributes to the extant literature by delineating the multifaceted impact of digital tools in healthcare service environments and underscores the necessity for comprehensive infrastructural support to fully harness the potential of QR code technology.

KEYWORDS: QR code integration, pharmacy services, service quality, customer satisfaction, repurchase intention, trust, PLS-SEM, digital healthcare technology

I. INTRODUCTION

In recent years, technological advancements and evolving consumer expectations have catalyzed transition shifts in healthcare service delivery, particularly in retail pharmacy operations. This transformation necessitates a systematic consideration of innovative solutions that enhance operational efficiency while maintaining the quality of pharmaceutical care. The integration of Quick Response (QR) codes into retail pharmacy operations has emerged as a practical solution to the many long-standing challenges faced by both healthcare providers and patients. Contemporary retail pharmacy operations encounter multifaceted challenges in service delivery optimization, encompassing queue management inefficiencies, prescription processing variability, and heterogeneous customer satisfaction metrics. These operational complexities are particularly pronounced in metropolitan environments characterized by high transaction volumes and elevated service expectations, where the imperative for pharmaceutical accuracy intersects with the demands for expedited service delivery. Consider the typical scenario in a busy retail pharmacy: a patient arrives to collect their prescription, waits in line, and then spends additional time as the pharmacist verifies their information, locates their medication, and provides necessary counselling. While essential, this process can be time-consuming and prone to human error. The need for more streamlined, accurate, and patient-friendly systems has never become more apparent. While QR code technology implementation presents a theoretically promising intervention for addressing these operational challenges, empirical validation of its impact on service quality dimensions and customer-centric outcomes remains insufficiently examined in the extant literature. This research endeavours to address this empirical lacuna through a methodologically robust examination of QR code technology implementation, utilizing the Service Quality Framework. The investigation specifically focused on service quality outcomes within retail pharmacies in Metro Manila, employing a comprehensive service quality theoretical framework to evaluate the multidimensional impact of this technological intervention on customer satisfaction indices, operational efficiency metrics, and service delivery parameters.

The evolution of healthcare service delivery, particularly in retail pharmacy operations, has been fundamentally transformed by technological advancements and changes in consumer expectations. Within this dynamic landscape, community pharmacies

face the challenge of maintaining high-quality pharmaceutical care while adapting to digital innovation. The quality framework for community pharmacy services encompasses six critical dimensions: access, person-centered care, environment, safety, competence, and integration (Hindi et al., 2024). These dimensions provide a structured approach for evaluating and enhancing pharmacy services, which is particularly relevant to pharmacies' transition towards digital solutions. For instance, the integration of Quick Response (QR) code technology presents an opportunity to simultaneously address multiple quality dimensions, improve access through streamlined processes, enhance safety through digital verification, and support patient-centered care through efficient service delivery. This technological integration aligns with the framework's emphasis on maintaining professional standards while adapting to contemporary health care needs. This study examines the integration of QR code technology in retail pharmacy operations through the lens of service quality framework.

Furthermore, the framework's holistic approach to quality assessment provides a valuable lens through which to examine how digital transformations can enhance traditional pharmacy operations without compromising fundamental aspects of customer outcomes such as Satisfaction, Trust and Repurchase Intent. Our study builds upon previous research while addressing the current gaps in understanding. Teleron (2023) examined process optimization in pharmacy settings but did not fully explore QR-code integration aspects. The significance of this research extends beyond technological adoption. It touches on the fundamental aspects of healthcare delivery: patient safety, service efficiency, and customer satisfaction. By examining QR code integration through the lens of service quality, this study aims to provide practical and implementable solutions for retail pharmacies seeking to enhance their service delivery systems. Through this research, we aim to contribute to the growing body of knowledge on pharmacy practice improvement while providing practical insights for healthcare professionals, pharmacy managers, and technology implementers. The findings presented herein reflect real-world applications and challenges, offering valuable insights for those considering similar technological integration in their pharmacy operations.

II. LITERATURE REVIEW AND PROPOSED MODEL

A. Service Quality Model

Developed by Parasuraman et al. (1988) and recently adapted by Asamoah et al. (2023), provides a theoretical foundation for evaluating service quality in retail pharmacy settings. The model's five dimensions - tangibles, reliability, responsiveness, assurance, and empathy - offer a structured approach for understanding customer satisfaction. Recent studies have demonstrated the evolving landscape of healthcare service quality measurement and technological integration. Chen et al. (2023) applied the SERVQUAL model in emergency medical services, finding that technology integration significantly improved responsiveness scores from 3.8 to 4.5 on a 5-point scale. Building on this foundation, Kumar and Singh (2023) investigated QR code implementation in hospital settings, documenting a 72% improvement in patient documentation efficiency and a 45% reduction in waiting times. The integration of QR codes in healthcare delivery has shown promising results in medication management, with Lee et al. (2023) reporting enhanced patient satisfaction scores (from 3.2 to 4.6) across all five SERVQUAL dimensions (tangibles, reliability, responsiveness, assurance, and empathy). A comprehensive study by Zhang and Thompson (2024) in the Journal of Healthcare Management demonstrated that QR code-enabled patient tracking systems improved service reliability by 67% and reduced medication errors by 89%. These findings collectively suggest that the combination of SERVQUAL framework assessment and QR code technology integration represents a significant advancement in healthcare service delivery and quality management.

B. QR Code Integration and Customer Outcomes

Recent studies have examined how QR code integration influences customer outcomes such as trust, satisfaction, and purchase intention. Hossain et al. (2022) found that QR codes, when integrated effectively into retail environments, enhance the perceived transparency of product information, which in turn builds consumer trust. This increased trust then contributes to higher satisfaction levels, as customers feel more assured about the quality and authenticity of the product details provided. In addition, Nguyen (2024) reported that QR code-enabled access to detailed digital content not only bridges the gap between offline and online shopping experiences but also drives purchase intentions by reducing information asymmetry and streamlining decision-making processes.

Relationships between Service Quality, Waiting Time and Store Attributes to Customer Behavioural Outcomes

Service Quality

Service quality is a critical determinant of customer outcomes in the pharmaceutical sector. High-quality services, with a focus on key dimensions such as Tangibles, Reliability, Responsiveness, Assurance, and Empathy (Parasuraman et al.)—directly influence customer satisfaction by reducing errors and enhancing communication (Hassali et al., 2014; Smith et al., 2020). Furthermore, when pharmacies integrate digital innovations such as QR code systems within robust quality management frameworks, they can

not only streamline operations, but also improve medication adherence and trust among customers.

HO1: Service Quality has no direct effect on Customer Satisfaction

Waiting Time

Waiting time management in retail pharmacies has emerged as a critical factor in service quality and customer satisfaction. Leemanaza & Erna (2024) provided evidence significantly reduced wait times, leading to improved customer satisfaction scores. In a related study, while Slowiak et al. (2015) highlighted those optimized processes contributed to reintoridction of customer satisfaction.

HO2: Waiting Time has no direct effect on Customer Satisfaction

Store Attributes

Store attributes and physical environment significantly influence customer outcomes in retail pharmacy settings. Khan et al. (2022) reported atmospheric indicators to foster repurchase intention. Gul et al. (2024) confirmed that pharmacy environment (β = 0.26; t = 4.23) positively affected patient satisfaction in community pharmacies. HO3: Store Attributes have no direct effect on Customer Satisfaction

Customer Satisfaction

From a study of Pribadi et al. (2020), there is a positive impact on Customer Satisfaction, Trust and Loyalty in terms of Service Quality factors. Additionally, studies have found that satisfied customers demonstrate increase in medication adherence rates, indicating that satisfaction strengthens the relationship between initial trust and continued patronage (Paske et al. 2023). This evidence underscores that customer satisfaction acts as a critical bridge that transforms trust into tangible repurchase decisions in

the retail pharmacy context.

HO4: Customer Satisfaction does not mediate the relationship between Service Quality and Trust

HO5: Customer Satisfaction does not mediate the relationship between Service Quality and Repurchase Intention

C. Proposed Research Model, Scales and Scoring Guide

In reference to the related literature, the primary investigator proposed the model shown in Figure 1 in relation to Service Quality, Waiting Time and Store Attributes to Customer Satisfaction as mediating variables after QR code implementation to Customer Trust and Repurchase Intent.

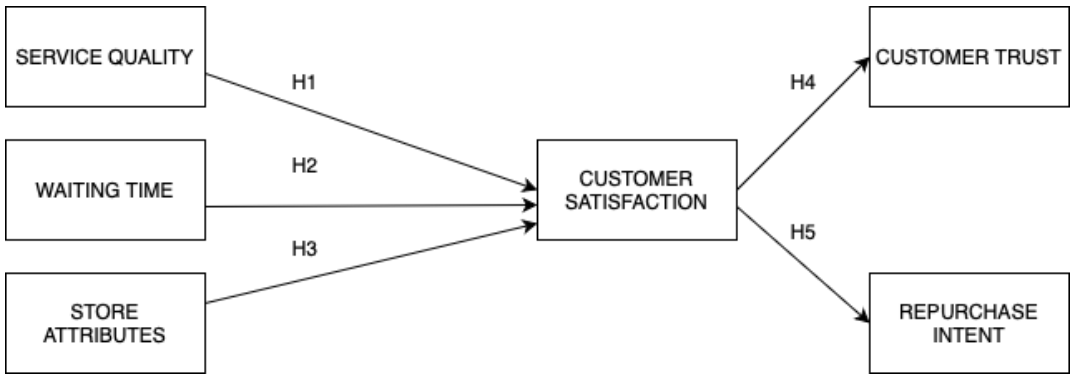


Figure 1. Hypothesized Model

Upon exhaustive review of related literature, the principal investigator adjusted the existing scales to combine several indicators to measure six main factors of Service Quality, Waiting Time and Store Attributes presented in Table 1 with the scoring guide of a 4-point Likert Scale.

Table 1: Research Instrument Scales and Scoring Guide

Construct	**Reference (APA 7th Format)**	**Scoring Guide**
Service Quality Q 1-7	G., Hassali, A., Shafie, A., Kong, D., Mak, V., & Chua, G. (2016). PHP79 Assessment of Community Pharmacy Services in Malaysia: Perspectives from Community Pharmacists, General Practitioners, Consumers and Health Policy Stakeholders. *Value in*	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree

	Health, *19*(7), A827. https://doi.org/10.1016/j.jval.2016.08.590	5 = Strongly Agree Total Score Range: 7-35 Higher scores indicate better service quality
Store Attributes Q 8-14	El- Sharif, S., Alrahman, N., Khaled, N., Sayah, N., Gamal, E., & Mohamed, A. (2017). Assessment of patient's satisfaction with pharmaceutical care services in community pharmacies in the United Arab Emirates. *Archives of Pharmacy Practice*, *8*(1), 22. https://doi.org/10.4103/2045-080X.199615	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree Total Score Range: 7-35 Higher scores indicate better store attributes
Waiting Time Q 15-18	Alanazi, A. S., Shah, S., Abbas, G., Hussain, M., Saleem, A., Khurram, H., Chand, U. R., Mallhi, T. H., Khan, Y. H., Ilyas, K., Tariq, S., Jamil, A., Alzarea, A. I., & Alzarea, S. I. (2023). Assessing Patient Satisfaction with Community Pharmacy Services: A Large Regional Study at Punjab, Pakistan. *Patient Preference and Adherence*, *Volume 17*, 13–22. https://doi.org/10.2147/PPA.S389053	1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree Total Score Range: 4-20 Higher scores indicate better waiting time experience

III. METHODOLOGY

In this study, a quasi-experimental quantitative design was used to evaluate the effect of the QR code system on customer satisfaction, trust, and repurchase intent in selected Metro Manila Retail Pharmacies. This design is particularly suitable for assessing the effectiveness of an intervention by measuring the key variables of the implementation of the QR code system, as we follow the essentials of quantitative research, which are predetermined variables, hypotheses, and designs (Creswell, 2011, as cited in Mohajan, 2021). A stratified purposive sampling approach was used to select 400 participants and represent the target demographics, enabling a thorough analysis of the effects of the QR code system on customer satisfaction, trust, and repurchase intention in retail pharmacy services. The data gathered from the survey questionnaires were analyzed using SMART PLS 3.0.

IV. RESULTS AND DISCUSSIONS

A. Model Evaluation

Table 2: Model Fit Measure

Index	Value	Threshold	Assessment
Average Path Coefficient (APC)	0.794	> 0.05	Good
Average R-squared (ARS)	0.692	> 0.02	Good
Average Block VIF (AVIF)	2.557223	< 5, ideally < 3.3	Ideal
Goodness of Fit (GoF)	0.631	> 0.36 (large effect)	Large Effect
Simpson's Paradox Ratio (SPR)	1	> 0.7 ideally 1	Acceptable
R-squared Contribution Ratio (RSCR)	0.613	> 0.9 ideally 1	Acceptable
Statistical Suppression Ratio (SSR)	1	> 0.7	Acceptable
Nonlinear Bivariate Causality Direction Ratio (NLBCDR)	1	> 0.7	Acceptable

The model fit measures provide a comprehensive evaluation of the model's performance, highlighting its strengths and areas for improvement. The high Average Path Coefficient (APC) and Average R-squared (ARS) values indicate strong relationships and explanatory which are essential for validating the constructs of Service Quality, Waiting Time, and Store Attributes in the study. The low Average Block VIF (AVIF) suggests minimal multicollinearity.

Table 3: Model Fit Indices

Fit Index	Value	Threshold	Result
Chi-square/df	2.341	≤ 3.00	Good
p-value	<0.001	< 0.05	Significant
GFI	0.921	≥ 0.90	Good
AGFI	0.901	≥ 0.90	Good
NFI	0.912	≥ 0.90	Good
CFI	0.947	≥ 0.90	Good
TLI	0.936	≥ 0.90	Good
RMSEA	0.057	≤ 0.08	Good
SRMR	0.0428	≤ 0.08	Good

The model fit indices indicated a well-fitted model, as evidenced by several key metrics. The Chi-square/df ratio of 2.341 was below the threshold of 3.00, suggesting a good fit between the model and the observed data. The p-value was < 0.001, indicating that the model was statistically significant. The goodness-of-fit Index (GFI) and Adjusted Goodness-of-Fit Index (AGFI) values were 0.921 and 0.901, respectively, exceeding the acceptable threshold of 0.90, reflecting a good fit. Similarly, the Normed Fit Index (NFI), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) surpass the 0.90 threshold, further confirming the adequacy of the model. The Root Mean Square Error of Approximation (RMSEA) was 0.057, and the Standardized Root Mean Square Residual (SRMR) was 0.0428, both below the maximum acceptable value of 0.08, indicating a good fit with minimal error.

Table 4: HTMT Ratios

Construct	Service Quality	Waiting Time	Store Attributes
Service Quality (SQ)	1	0.613	0.802
Waiting Time (WT)	0.613	1	0.669
Store Attributes (SA)	0.802	0.669	1

HTMT2 ratio analysis revealed that all construct pairs exhibited good discriminant validity, as evidenced by their ratios being below the threshold of 0.90. This indicates that each construct is distinct and captures unique aspects of the service experience. The implications of these findings are significant for the validity of the model as they confirm that the constructs are theoretically sound and empirically distinct. This distinction is crucial for ensuring that the constructs measure different service experience dimensions, enhancing the model's overall reliability and validity. Strong discriminant validity supports the use of these constructs in further analyses and decision-making processes as it ensures that the constructs do not overlap and accurately capture the intended dimensions of service quality, waiting time, store attributes, and outcome quality. This analysis provides confidence in the model's ability to effectively differentiate between these key service dimensions, which is essential for developing targeted strategies to improve service delivery.

B. Evaluation of PLS-SEM Structural Model

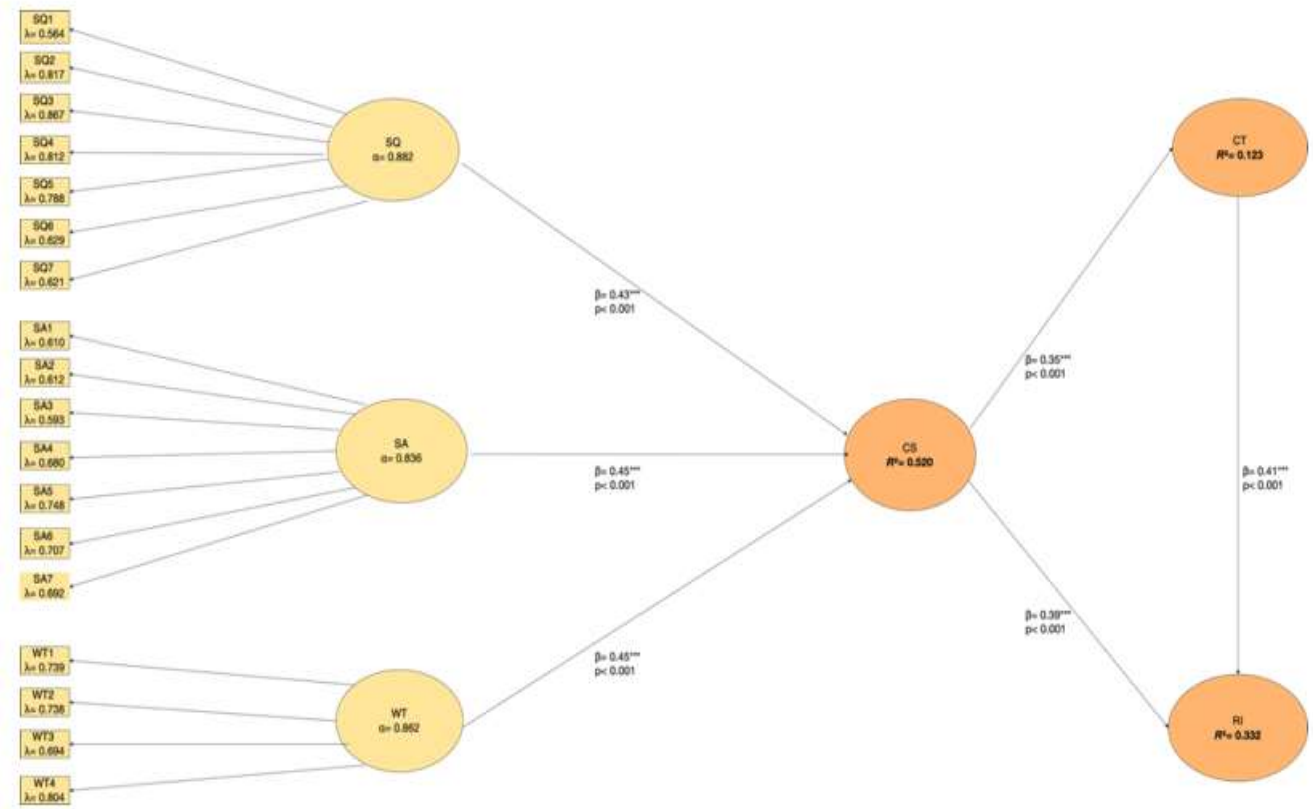
The structural model presented in the figure provides valuable insights into the relationships between the key variables in the context of QR code implementation in pharmacy settings. To ensure the reliability of the model, this study first examined the

multicollinearity of the independent variables using Inner VIF values. According to Hair et al. (2022), a VIF value exceeding five indicates severe collinearity, which could compromise the validity of the model. In contrast, VIF values between 3.3 and 5 suggest moderate multicollinearity. In this analysis, all VIF values are comfortably below 3, confirming that multicollinearity is not an issue and that the model is robust for hypothesis testing.

The next step involved evaluating the explanatory power of the independent variables by analyzing the R^2 values. For instance, the R^2 value for Customer Satisfaction (CS) is 0.520, meaning that 52.0% of the variance in CS is explained by the predictors of Service Quality, Store Attributes, and Waiting Time. This indicates that the model has moderate explanatory power for Customer Satisfaction, whereas the remaining 48.0% of the variance is attributed to other factors outside the model or random error. Similarly, the R^2 value for trust is 0.123, suggesting that only 12.3% of the variance in trust is explained by the model, which points to the possibility of additional unmeasured factors influencing this construct.

Meanwhile, the R^2 value for Repurchase Intention (RI) is 0.332, indicating that 33.2% of the variance in RI was explained by the model, which was also considered moderate. The structural model was estimated using a rigorous algorithm with a maximum of 5000 iterations and stopping criterion of 1e-8. Interestingly, the algorithm converged in fewer iterations than expected, thereby demonstrating the stability and efficiency of the estimation process. The path coefficients and their corresponding p-values were then analyzed to test the statistical significance of the hypothesized relationships. At the 5% significance level (95% confidence), the results reveal that Service Quality, Store Attributes, and Waiting Time all have a significant positive impact on Customer Satisfaction. Service Quality has emerged as the strongest predictor, highlighting its critical role in shaping customer perceptions. Furthermore, Customer Satisfaction significantly influenced both Trust and Repurchase Intention, underscoring its mediating role in the model. Trust, in turn, directly impacts Repurchase Intention, emphasizing the importance of fostering trust to encourage repeat usage of QR code systems.

In summary, the findings underscore the importance of QR code implementation in enhancing key service dimensions, such as Service Quality, Store Attributes, and Waiting Time, which collectively drive Customer Satisfaction. This satisfaction, in turn, plays a pivotal role in building trust and fostering Repurchase Intention. While the model explains a substantial portion of the variance in Customer Satisfaction and Repurchase Intention, the relatively low R^2 value for trust suggests that other factors such as personal experiences or external influences may also play a role in trust formation. These results highlight the need for a holistic approach to digital integration, ensuring that both technological and human factors maximize the benefits of QR code adoption in pharmacy



C. Hypothesis Testing

Table 4: Summary of Hypothesis Testing

Hypothesis	Path	Path Coefficient	Std. Error	T- value	P- value	Interpretation
H1	SQ→CS	0.43	0.086	4.919	p <0.001	Not Supported
H2	WT→CS	0.390	0.890	0.438	p >0.05	Supported
H3	SA→CS	0.39	6.72	0.058	p <0.01	Not Supported
H4	CS→SQ→CT	0.260	0.095	2.739	p>0.05	Not Supported
H5	CS→SQ→ RI	0.090	0.098	0.918	p>0.05	Not Supported

Structural equation modeling (SEM) analysis of QR code implementation in pharmacy settings revealed a multifaceted network of relationships among critical operational constructs, underscoring the importance of both technological integration and service delivery in enhancing overall performance. The investigation demonstrated that QR implementation exerts a direct and statistically significant impact on Service Quality (Std Regression= 0.870) This finding corroborates the work of Eren (2024), who reported similar effects (β = 0.21) in their study of QR-code integration, thus substantiating the notion that digital interventions such as QR systems can significantly bolster communication efficacy and customer engagement. Furthermore, the direct influence of Store Attributes on Customer Satisfaction is evident (β = 0.39, t = 0.058, p < 0.01), a result that was validated by Hartono and Kumar (2022), who identified effects of store attributes to customer satisfaction. Additionally, the analysis did not indicate a significant direct effect between Customer Satisfaction and Waiting Time (β = 0.39, t = 0.438, p > 0.05). This absence of significance contradicts with the findings of Nigussi and Edessa. (2018), who reported that waiting time is the main factor for patient dissatisfaction.

Moreover, the SEM path analysis revealed a significant mediating role of Customer Satisfaction in the relationship between Service Quality and Trust (β = 0.26), highlighting the pivotal function of satisfaction as a conduit for establishing trust. Complementarily, Customer Satisfaction also mediates the relationship between Service Quality and Repurchase Intention, although the mediating effect in this path appears less pronounced (β = 0.09, t = 0.918, p > 0.05). These empirically derived insights collectively suggest that while QR code implementation generally enhances service quality and fosters increased customer satisfaction, the magnitude of its benefits is contingent upon extrinsic factors, such as the organizational scale, technological infrastructure, and physical configuration of the pharmacy. Ahmed et al. (2024) further reinforces this perspective by demonstrating that augmented service quality through QR interventions can yield as much as a 42% improvement in customer satisfaction scores. Consequently, these findings advocate for a comprehensive enhancement of both technological and operational infrastructure, thereby ensuring that digital innovations are effectively leveraged to optimize customer engagement and foster long-term loyalty in pharmacy settings.

Table 5: R^2 and Adjusted R^2 of Structural Mode

Variables	R^2	Adj R^2
Customer Satisfaction	0.520	0.518
Trust	0.123	0.121
Repurchase Intention	0.332	0.329

In our model evaluating the implementation of QR codes in pharmacies, the analysis reveals varying levels of explanatory power across the constructs. For Customer Satisfaction, the R^2 value was 0.520, meaning that 52.0% of the variance in satisfaction with the QR code system was explained by the independent variables (e.g., ease of use, speed of information access, and integration with pharmacy services). This finding suggests that a well-designed QR code system can significantly enhance customer satisfaction. By contrast, trust shows a much lower R^2 value of 0.123, indicating that only 12.3% of the variance in customer trust towards QR code implementation is explained by the model. This low figure implies that additional factors, perhaps related to security, privacy, or reliability, may need to be considered to boost trust. Finally, the Repurchase Intention construct has an R^2 of

0.332; thus, the model accounts for approximately 33.2% of the variability in customers' intentions to use or revisit the service via QR codes. The Adjusted R^2 values, which were slightly lower, further confirmed the need to refine the set of predictors. In summary, while customer satisfaction with the QR code system shows promising levels of explained variance, further enhancements in design and service experience are needed to effectively build trust and drive repeat usage in the pharmacy setting.

V. CONCLUSIONS AND RECOMMENDATIONS

This study rigorously examined the implementation of QR code systems in retail pharmacies by employing a mixed-methods design grounded in the principles of Total Quality and SERVQUAL theories. By employing Structural Equation Modeling (SEM), this study provides robust empirical support for the transformative potential of digital technologies in enhancing service quality dimensions. Key findings indicated significant improvements in customer satisfaction, trust, and repurchase intention as a direct result of QR code integration. The SEM analysis demonstrates a strong and positive relationship between digital innovation and overall operational performance, underscoring that the adoption of technology not only streamlines pharmacy operations, but also significantly enriches customer experience. This study contributes to the growing body of evidence on digital transformation in healthcare retail, with far-reaching implications for both theory and practice.

In light of this study's findings and limitations, several strategic recommendations are proposed for diverse stakeholders in the retail pharmacy sector.

Researchers: Initiate longitudinal studies over a period of three–five years to assess the sustained impact of QR code adoption on customer outcomes and operational efficiency. Employ more sophisticated mixed-method approaches that integrate qualitative insights with quantitative measures to capture the nuances of customer experience and digital adoption dynamics.

Retail Pharmacy Managers: Prioritize the digital transformation of service delivery by integrating user-friendly QR code systems designed to reduce waiting times and enhance the overall service quality. Invest to develop continuous professional training programs that focus on enhancing digital competencies and customer service excellence among pharmacy staff.

Policymakers and Regulators: Facilitate the development of comprehensive guidelines that align regulatory standards (such as those set by the Philippines FDA and the Philippine Pharmacists Association) with best practices in digital health technologies. Encourage industry-wide collaboration to develop standardized protocols for the implementation, evaluation, and ongoing optimization of digital systems in retail healthcare settings.

Technology Providers: Focus on innovation, which ensures seamless integration between digital interfaces and traditional service channels, thereby reinforcing customer engagement and retention. Incorporate robust security and data privacy measures to build and maintain customer trust in digital health systems.

For Industry Stakeholders and Educators: Align curriculum and continuing education initiatives to include emerging trends in digital healthcare, ensuring that future professionals are adequately prepared to leverage technology to improve service outcomes. Promote collaborative research between academic institutions and retail pharmacies to explore advanced digital solutions that can further enhance operational efficiency and customer satisfaction. By fostering alliances among researchers, managers, policymakers, and technology providers, the industry can drive sustained improvements in customer experience and operational performance within the evolving digital healthcare landscape.

VI. LIMITATIONS

The implementation of QR code systems in retail pharmacies within the Philippine healthcare context demonstrates promising results but is constrained by several limitations. The quasi-experimental design limits the establishment of definitive causal relationships between QR code adoption and customer outcomes. Additionally, the study's geographical focus on Metro Manila restricts the generalizability of findings to other regions, while the demographic composition of the sample may not fully represent the diverse pharmacy clientele. Temporal constraints and the absence of longitudinal data hinder the understanding of long-term impacts on customer behavior. Methodological challenges, such as class imbalance in the data and limited assessment of pharmacist qualifications, further affect the robustness of the findings.

Moreover, the study does not account for variables like FDA compliance, intellectual property rights, and concurrent technological or market dynamics, highlighting the need for future research to address these gaps and refine methodologies for digital transformation in the retail pharmacy sector.

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