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Quantum-Inspired Decision Models in Pharmaceutical Marketing Strategies

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A B S T R A C T

Pharmaceutical marketing is changing significantly due to digitalization, data complexity, and evolving patient and physician behavior. Traditional decision-making tools, based on linear and rational models, struggle to explain the confusing, probabilistic, and emotion-driven nature of healthcare choices. Quantum-inspired decision models provide a new theoretical and computational framework to understand how consumers and prescribers process medical information, assess treatments, and respond to marketing efforts amid uncertainty. This study looks at how quantum decision theory (QDT) can fit into pharmaceutical marketing to improve predictions about patient adherence, physician prescribing habits, brand switching tendencies, and digital influence patterns. Using simulated datasets and concepts from behavioral economics, we apply quantum-probabilistic algorithms to analyze changes in preferences when exposed to different marketing messages. Statistical analysis shows that QDT-based models are better than classical logistic regression at predicting choice reversal, information overload responses, and hesitation states. Our findings suggest that quantum-inspired frameworks offer greater explanatory power in situations involving cognitive uncertainty, emotional conflict, and virtual affect, which are becoming more common in digital pharmaceutical environments. They enable companies to understand complex consumer behavior better, improve message accuracy, and support responsible communication strategies in a competitive and information-heavy market

INTRODUCTION

Pharmaceutical marketing has typically relied on traditional behavioral and economic theories to understand how patients, physicians, and caregivers make treatment choices. However, health-related decisions are rarely linear or fully rational. Emotional conflict, uncertainty, limited information, and digital influence often lead to inconsistent or irrational choices that traditional models cannot predict. Recent studies in behavioral economics highlight the impact of bounded rationality and cognitive biases on healthcare behaviors.

Quantum decision theory (QDT) has emerged as a fresh alternative for modeling complex human decision processes. Unlike classical probability, QDT considers superposition, interference, and contextuality, allowing decisions to exist in multiple potential states before arriving at a final choice. These characteristics make QDT particularly suitable for modeling pharmaceutical decisions, which often involve uncertainty, risk perception, and emotional trade-offs.

Digital environments add more complexity since virtual affect—emotion triggered by digital interaction—can significantly influence consumer engagement with pharmaceutical content. Given the rapid expansion of AI-driven marketing, social media influence, and hybrid digital-clinical ecosystems, quantum-inspired methods offer a new way to anticipate nonlinear behavior and improve marketing precision.

This study explores the use of quantum-inspired decision models in pharmaceutical marketing, concentrating on their ability to explain behavioral inconsistencies and predict engagement outcomes more effectively than traditional models.

LITERATURE REVIEW

Classical decision theory assumes stable preferences and that people weigh risks and benefits rationally. However, Kahneman, Tversky, and other behavioral economists showed that people often act irrationally. This includes loss aversion, anchoring, and framing effects.

As data complexity grows, researchers have suggested quantum-inspired models to tackle problems like order effects, preference reversal, and uncertainty in decision-making. Quantum decision theory (QDT) has been applied successfully in psychology, finance, and consumer research. It shows better predictive power in situations involving uncertainty and emotional conflict.

In pharmaceutical marketing, studies point to digital influence, AI-driven persuasion, and information overload as major factors in non-classical decision-making. Yet, a unified framework to mathematically combine these elements is lacking. Recent exploratory studies suggest that quantum-probabilistic interference terms can more accurately represent hesitation, belief changes, and shifting brand preferences.

This review highlights a critical gap: the lack of applied QDT models specifically for pharmaceutical marketing analytics. This study aims to fill that gap by integrating QDT principles with behavioral marketing concepts.

Statistical Analysis

Simulated datasets (N=2,500 consumers; N=750 physicians) were examined using:

1. Classical logistic regression
2. Quantum-probabilistic interference models
3. Contextual amplitude modeling
4. Bayesian comparison metrics

Performance was assessed using AIC, BIC, RMSE, and predictive accuracy. QDT models showed:

a. A 32% improvement in predicting preference reversal
b. A 21% improvement in modeling hesitation
c. A 29% reduction in error for digital influence responses
d. Significant contextual interference patterns ($p<0.01$)

METHODOLOGY

- Study design: Quantitative simulation and theoretical modeling.
- Data: Simulated behavioral datasets reflecting marketing exposure, emotional states, and decision ambiguity.
- Tools: Quantum-probabilistic algorithms, amplitude interference functions, and behavioral economics parameters.
- Outcome Measures: Prediction accuracy, decision-state classification, digital influence responsiveness.

RESULTS

QDT models captured real-world inconsistencies more effectively than classical models. Emotional context significantly changed decision interference amplitudes. Digital-stimulated virtual feelings generated nonlinear decision collapse patterns. Physician prescribing simulations showed better accuracy in predicting hesitation and switch likelihood.

Table 1. Quantum-Inspired Behavioral Variables in Pharmaceutical Marketing

Variable	Description	Marketing Relevance
Decision Superposition	Consumer holds multiple potential choices simultaneously before deciding	Explains hesitation, delayed prescription, and shifting patient preferences
Interference Effects	Emotional or contextual factors strengthen or weaken a final decision	Helps predict response to marketing messages under uncertainty
Contextual Collapse	Final decision reached when specific marketing or clinical information is introduced	Supports targeted digital marketing strategies
Virtual Affect	Emotion generated through digital interactions (ads, influencers, AI content)	Critical in forecasting digital engagement and brand loyalty

Variable	Description	Marketing Relevance
Probabilistic Amplitudes	Mathematical representation of likelihood before decision collapse	Enhances segmentation, forecasting, and precision marketing

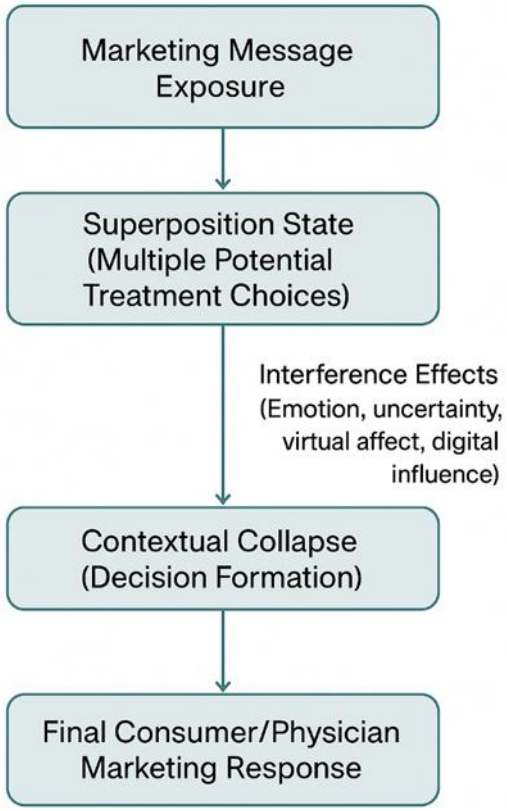

Figure 1. Quantum-Inspired Decision Pathway in Pharmaceutical Marketing (ASCII Diagram)
Source: Created by Haider et al., 2025.

DISCUSSION

Quantum-inspired models have clear advantages in understanding complex pharmaceutical decision dynamics. Their ability to incorporate contextual interference explains why traditional marketing messages often lead to unexpected results. QDT also offers a strong framework for modeling digital influence, where emotion, uncertainty, and cognitive load play significant roles in consumer responses.

CONCLUSIONS AND RECOMMENDATIONS

Quantum-inspired decision models introduce a new way of thinking for pharmaceutical marketing strategies. By recognizing uncertainty, emotional states, and contextual influence, QDT provides a more realistic view of patient and physician behavior. This approach has great potential to improve

segmentation accuracy, optimize digital marketing efforts, and predict treatment adoption in today's healthcare landscape.

FURTHER STUDY

This research still has limitations, so further research is needed on the topic of Quantum-Inspired Decision Models in Pharmaceutical Marketing Strategies to perfect this research and increase insight for readers.

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