Center Chronic Patient Adherence Behavior Analysis and Intervention Strategies Based on Prospect Theory

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Abstract. Chronic diseases pose a global public health challenge; however, the primary obstacle to effective management is low patient treatment adherence. The traditional rational decision-making model is difficult to explain the internal motivations of adherence behavior fully. This study introduces the prospect theory of behavioral economics, aiming to deeply analyze the psychological mechanism of adherence decision-making in patients with chronic diseases and propose targeted intervention strategies. The study selected stroke prevention in patients with hypertension, diabetes, and schizophrenia as typical cases. Based on the latest international research results and real-world data, it revealed the universality and complexity of adherence issues. Analysis shows that the decision-making behavior of patients is significantly influenced by reference point dependence, loss aversion, and probability weight distortion. There are not only positive effects, such as using loss aversion for effective health warnings, but also deep-seated problems, such as excessive optimism, present bias, emotional avoidance, and information bias, that are exposed. To directly counter these biases, this paper proposes four strategies: integrating an information framework, applying a commitment mechanism, adjusting reference points, and designing immediate incentives, providing innovative solutions from the perspective of behavioral economics for improving the compliance of chronic disease patients worldwide. This research demonstrates the critical value of applying behavioral economics to health behavior change compared with traditional and rationalistic approaches.

Keywords: Patient Adherence; Prospect Theory; Chronic Disease Management; Behavioral Interventions; Decision-Making Biases.

1. Introduction

1.1. The Global Challenge of Chronic Diseases and Treatment Adherence

Chronic disease is a major public health challenge worldwide. It has long-term effects on patients' quality of life. It also increases the burden on the healthcare system. Additionally, it affects socioeconomic development. The World Health Organization reports that chronic diseases are the leading cause of death globally. They cause about 41 million deaths each year. This number represents over 74% of all deaths worldwide [1]. This problem exists in all countries. It is not limited only to developing countries. Developed countries also face great pressure. Low treatment adherence is a key issue in chronic disease management. Studies estimate that the average medication adherence rate among chronic patients globally is only 50%. Poor medication adherence leads to extra medical costs. These additional costs reach hundreds of billions of dollars each year [2]. Low adherence results in poor disease control. It also increases complications. Furthermore, it raises readmission rates. All these worsen the strain on global medical resources.

In this context, prospect theory from behavioral economics offers a new perspective. It helps understand patient adherence behaviors. This theory suggests that decision-makers rely on reference points. They are more sensitive to losses than to gains. They also show probability weight distortion in risky decisions. Chronic disease patients face trade-offs during long-term treatment. They weigh drug side effects against economic burden. They also consider long-term health benefits. This situation fits well with the prediction framework of prospect theory. Therefore, systematically analyzing the adherence behaviors of chronic patients and designing effective intervention strategies

based on prospect theory have theoretical and practical significance for improving global public health and optimizing the allocation of medical resources.

1.2. Prospect Theory: A Behavioral Economics Lens for Health Behaviors

In recent years, the application of behavioral economics in the field of health has attracted far-ranging attention. Additionally, a number of international studies have provided crucial inspiration for this topic. These studies collectively tap into different components of prospect theory.

Wang & Liu pointed out that the setting of reference points significantly influences the dietary decisions of diabetic patients. When patients take the "ideal state of health" as the reference point, they are more likely to perceive the "loss" of a restricted diet, thereby reducing compliance [3]. Zhang et al. proposed and verified a theoretical model. This model integrates the value function and weight function of prospect theory, proving that patients' excessive concern about low-probability side effects is a vital psychological barrier for their refusal to take medicine [4]. Li & Chen conducted a study. In their discovery, compared with the benefit framework (emphasizing the benefits of compliance), health information based on the loss framework (emphasizing the consequences of non-compliance) is able to improve the medication compliance of patients with hypertension more effectively, verifying the applicability of loss aversion in medical contexts [5].

Most existing research focuses on verifying the application of single concepts in prospect theory to specific behaviors. In contrast, few studies systematically apply the core components of prospect theory (reference point dependence, loss aversion, and probability weight distortion) to comprehensively analyze the multi-dimensional manifestations of adherence behaviors in patients with chronic diseases and deeply explore their psychological decision-making mechanisms. Furthermore, research on translating these theoretical insights into systematic and operational intervention strategies remains scarce.

1.3. Research Objectives and Framework

In order to fill the above research gap, this paper will first elaborate on the current situation of adherence behavior among chronic patients and the application of prospect theory in the international context.

Secondly, the author will systematically analyze the positive impacts and prominent issues brought about by this behavioral pattern, with a focus on discussing the challenges and detrimental outcomes associated with low adherence.

Thirdly, in response to the identified problems, based on the core ideas of prospect theory, intervention strategies and optimization suggestions are proposed.

Finally, this paper will summarize the research conclusions and look forward to future directions.

2. Illustrative Cases: The Multifaceted Challenge of Treatment Adherence

Low adherence among patients with chronic diseases is a global challenge, whose manifestations are complex and diverse in different circumstances. This article selects the prevention of stroke in patients with hypertension, diabetes, and schizophrenia as typical cases.

Then, in this article, the metric named "Proportion of Actual Medication Days" will be frequently used, abbreviated as PDC, which is a commonly used indicator for measuring medication adherence, representing the ratio of the actual number of days a patient has taken medication to the total treatment cycle. These cases illustrate the complex decision-making environment faced by patients, where perceptions of risk, benefit, and loss—core concepts of prospect theory—directly influence adherence behaviors. Therefore, in our research, this indicator, named PDC, is used to measure the adherence of patients with chronic diseases towards medical advice. Poor adherence usually refers to PDC being below the ideal threshold (such as 80%), which is directly related to the therapeutic effect.

2.1. High Prevalence and Disparities in Hypertension Medication Adherence

A survey by the Irving Medical Center of Columbia University in 2023 shows that among patients with uncontrolled hypertension, around 65% have insufficient adherence with at least one antihypertensive drug (PDC<80%). These patients mostly come from communities with racial, ethnic, and economic diversity and are affected by multiple social determinants of health [6].

A large-scale population cohort study in Ontario, Canada (2004-2018) found that the proportion of patients with low adherence to antihypertensive drugs (PDC<40%) among schizophrenia patients was as high as 41.1%, while the proportion among non-schizophrenia patients was 32.0% [7]. The significantly higher non-adherence in schizophrenia patients may be explained by probability weighting distortion, where the immediate and tangible side effects or cost of medication are overweighted compared to the abstract, long-term benefit of preventing a stroke.

2.2. Prognostic Impact of Early Adherence in Diabetes Management

A large-scale study of national health insurance data in South Korea (n=65,340) found that among newly diagnosed type 2 diabetes patients, only 46.9% showed good adherence in the first-year treatment (PDC⩾80%) [8].

In addition, another study also found that patients receiving combination therapy had better adherence than those receiving monotherapy, showing that awareness of the severity of the disease may enhance adherence motivation [9]. The finding that combination therapy improves adherence suggests that when the perceived severity of the disease (the potential loss) is heightened, it can shift the patient's reference point and increase the value placed on treatment, aligning with the concept of loss aversion.

The profound impact of early adherence on long-term health outcomes is starkly illustrated in Table 1, which compares prognostic indicators between good and poor adherence groups.

Table 1. Relationship between First-year Medication Compliance and Long-term Prognosis in Newly Diagnosed Type 2 Diabetes Patients

Prognostic indicators	Good adherence group (PDC≥80%)	Poor adherence group (PDC<80%)	Hazard Ratio (HR)
Macrovascular events	Sharply reduced	Significantly increased	0.77
Major adverse cardiovascular events	Down 23%	Significantly increased	0.77
Hospitalization related to diabetes	Down 8%	Significantly increased	0.92
All-cause death	Down 28%	Significantly increased	0.72

This data powerfully demonstrates that poor adherence is not a minor issue but a primary driver of negative health outcomes. From a behavioral perspective, patients often underestimate these high-probability long-term losses when making daily decisions about medication.

2.3. Applying Prospect Theory to Improve Adherence: The ENGAGE-HTN Trial

The "ENGAGE-HTN" study took place at Columbia University. It was a randomized factorial trial. Its purpose was to test different methods. These methods aimed to boost intervention participation and patient adherence. The patients had hypertension and lived in poor communities. One method used recruitment letters designed with prospect theory. These letters highlighted the losses of non-compliance. This work is cited as [10].

The study's factorial design, which independently tested the effect of each intervention component, is outlined in Table 2.

Table 2. Experimental Design of Compliance Intervention Based on Prospect Theory

Experimental factors	Condition 1	Condition 2	Main evaluation indicators
Email primer	Yes	No	The rate of clinical pharmacist appointments completed within 12 weeks
Recruitment letter framework	Prospect Theory design	Regular letter	The rate of agreeing to arrange the consultation meeting
Outreach intensity	Up to 4 calls	Up to 2 calls	Medication adherence during the 3-month follow-up period

3. A Prospect Theory Analysis of Adherence Behavior: Mechanisms and Biases

Based on the framework of prospect theory, the treatment adherence behavior of patients with chronic diseases can be decoded as a product of systematic psychological biases and decision heuristics. This section analyzes these underlying mechanisms, examining both the cognitive processes that can support adherence and those that frequently undermine it.

3.1. Cognitive Mechanisms Supporting Adherence

3.1.1 Loss aversion as an intrinsic motivator

The patient's loss aversion tendency creates an internal behavioral restraint mechanism. The fear of potential health "losses", such as disease deterioration and the occurrence of complications, can be transformed into an internal driving force for maintaining treatment. This mechanism enables patients to be willing to bear immediate costs, such as drug side effects, time consumption, and economic burden. As a result, definite and serious future health losses will be avoided. Neuroeconomic research has found that this loss aversion mentality is closely related to the activation patterns of the amygdala and prefrontal cortex in the brain [11].

3.1.2 The salience of certain gains for short-term incentives

The value function of prospect theory is concave in the income dimension, which means that patients have a relatively high evaluation of definite income. This feature provides a theoretical basis for designing short-term incentive measures. When the treatment plan can provide clear and perceptible short-term positive feedback (such as an immediate improvement in blood pressure readings after taking medication), this small benefit can effectively motivate patients to continue the behavior. Modern digital health tools have significantly enhanced the incentive effect of this definite benefit by providing immediate visual feedback.

3.2. Cognitive Biases Undermining Adherence

3.2.1 Optimistic bias and risk underestimation

Patients generally have unrealistic, optimistic estimates and systematically underestimate their own health risks. This optimistic bias leads patients to wrongly set their current asymptomatic state as a reference point and underestimate the probability of future health deterioration. Imaging studies have shown that this bias is related to abnormal activity in the neural network responsible for risk assessment in the prefrontal cortex of the brain [12]. In chronic disease management, this cognitive bias is manifested as patients' doubts about the necessity of medical advice and their premature discontinuation or simplification of treatment plans.

3.2.2 Temporal discounting of future health benefits

Patients exhibited a significant temporal discounting feature, which is a substantial discount on distant and probabilistic health benefits in terms of time. The hyperbolic discounting model in behavioral economics explains this phenomenon well: compared with the immediate inconvenience and cost (definite loss) brought by taking medicine, the long-term and uncertain health benefits seem

less attractive. This current bias leads patients to prioritize current comfort at the expense of long-term health benefits.

3.2.3 Emotional avoidance of treatment complexity

Polypharmacy, complex administration regimens, and strict dietary control are regarded as an overall "loss package", and the psychological burden and perceived cost they bring are significantly magnified. Faced with such complexity, patients often develop emotional fear and avoidance psychology, and tend to choose a strategy of complete avoidance rather than gradual resolution. Functionally, magnetic resonance imaging studies have confirmed that this decision-making process involves excessive activation of emotional processing areas and insufficient activation of cognitive control areas in the brain [13].

3.2.4 Biased perception of medical information and risk

Information asymmetry and poor communication between doctors and patients lead to patients forming incorrect reference points for treatment plans. Patients often overestimate the severity and probability of side effects while underestimating the therapeutic benefits, thus tilting the decision-making balance towards non-compliance. Some patient groups have lower health literacy. Because of this, they show a clear deviation. They misunderstand probability information. They also underestimate risks. This leads to a miscalibrated decision-making reference point. Consequently, their cost-benefit analysis is skewed. They do not choose adherence.

A summary of these key decision-making biases, their manifestations, and potential intervention levers is presented in Table 3.

Table 3. Analysis of Patient Compliance Decision-making Disorder Based on Prospect Theory

Types of decision bias	The basis of neural mechanisms	Behavioral performance	Intervention target
Reference point dependence	Abnormal activation of the prefrontal cortex	I feel fine and don't need to take any medicine.	Provide biofeedback to rebuild a healthy reference system
Loss avoidance	Excessive activation of the amygdala	This medicine is harmful to the liver. I dare not take it for a long time.	Loss framework communication emphasizes the consequences of not treating
Probability weight distortion	Abnormal response in the insular cortex	What if serious side effects occur?	Probability education, visualizing risk information
Current prejudice	The connection between the limbic system and prefrontal is abnormal	Forget it today. I'll eat it tomorrow.	Immediate incentives shorten the feedback cycle

3.3. A Computational Psychiatry Approach to Decoding Adherence Decisions

This study proposes to adopt computational psychiatry methods by integrating behavioral economics experiments and computational modeling, which aims to analyze the cognitive neural mechanisms of adherence decision-making quantitatively.

3.3.1 Integrating choice experiments with neuroimaging

By combining discrete choice experiments (DCE) with neuroimaging technology, the brain activity changes of patients are recorded in real time in simulated medical decision-making scenarios. By designing a series of drug treatment plan selection tasks, each plan is composed of different levels of multiple attributes (efficacy, probability of side effects, frequency of medication, cost, etc.). The relative importance of each attribute to decision-making is quantified.

3.3.2 Quantifying parameters with a prospect theory model

Establish a medical decision-making computational model based on prospect theory: $V= \sum w(Pi)v(Xi)$. Where v(Xi) represents the subjective value function (concave for gains, convex for losses), and w(Pi) denotes the non-linear probability weighting function (overweighting small probabilities, underweighting large ones).

Among them, v(Xi) is the subjective value function and w(Pi) is the probability weight function. By fitting behavioral data with a Bayesian model, an individual's loss aversion coefficient λ, risk attitude parameters α and β, and probability sensitivity γ can be estimated.

3.3.3 Linking computational parameters to neural substrates

Functional magnetic resonance imaging (fMRI) data were collected simultaneously, with a focus on examining the activation patterns and functional connectivity characteristics of decision-related brain regions such as the prefrontal cortex, amygdala, and insular cortex. This multimodal approach can reveal the cognitive neural mechanisms of compliance decision-making at the computational level, providing a new path for developing precise and personalized behavioral intervention strategies.

4. Proposed Intervention Strategies

Building on the analysis of the cognitive mechanisms and biases that undermine adherence (Section 3), this section proposes a set of four complementary intervention strategies. These strategies are designed to systematically counter specific decision-making biases by leveraging the principles of prospect theory, together forming an integrated framework for improving adherence.

4.1. Framing Health Information: Leveraging Loss-Aversion and Salient Gains

This strategy primarily targets the biases of probability weighting distortion and information perception. In response to the distortion of probability weights and information perception biases existing among patients, the presentation methods of health information should be innovated. The "dual-framework integration" approach is adopted, which emphasizes the potential health losses caused by non-compliance (such as "not adhering to medication will increase the risk of stroke by 30%"), while also highlighting the immediate and definite benefits of compliance behavior (such as" taking medication on time can increase the rate of reaching the blood pressure target this week by 40%"). This strategy not only takes advantage of the psychological effect of loss aversion but also enhances the incentive effect through definite returns. When implemented, it can be combined with a digital health platform to provide personalized information feedback based on patients' personal health data. This method uses the patient's strong sensitivity to loss. This trait is known as loss aversion. At the same time, it makes the health benefits clearer and more certain. Doing this changes the patient's decision-making process. This process adjusts their choices.

Real case: In a randomized controlled trial conducted at the University of Pennsylvania in the United States, researchers sent personalized text message reminders to patients with hypertension. One group received the loss framework information ("If you don't take the medicine today, your risk of stroke will increase by 25%"), another group received the benefit framework information ("If you take the medicine today, your heart health will improve by 20%"), and the third group received the integration framework information. The results showed that the medication compliance of patients receiving information from the integrated framework increased by 18%, significantly higher than that of the single framework group [14].

4.2. Employing Commitment Devices and Defaults: Mitigating Present Bias

In response to current biases and forward discounting issues, it is recommended that behavioral commitment mechanisms and intelligent default options be introduced. This intervention directly counteracts 'present bias' (a form of hyperbolic discounting) by making the long-term commitment more salient and binding, and leverages 'default options' to guide choices towards the desired

behavior with minimal cognitive effort. Patients can sign a "Health Commitment Agreement" under the guidance of medical staff, pre-stipulating compliance goals and self-punishment measures if they fail to meet them. The medical system can set default options such as automatic prescription renewal and door-to-door drug delivery to reduce the cognitive burden on patients each time they make a decision.

Real case: The Department of Health of the Philippines has implemented the "Health Commitment Contract" in the diabetes management project. The patient pre-stores 50 US dollars and sets a blood sugar control target for three months. Those who reach the target will have their deposits returned and receive an additional reward of $25. The deposits of those who fail to meet the target will be donated to charity. Twelve months later, the rate of reaching the glycated hemoglobin standard among the patients participating in the project was 32% higher than that of the control group [15].

4.3. Harnessing Social Norms: Resetting Reference Points through Comparison

To address the issue of improper setting of reference points, patient support groups and health data visualization tools can be used to help patients establish a more reasonable health reference system. Establish a digital patient community to enable patients with well-controlled conditions to share their experiences and provide successful reference examples for newly diagnosed patients.

Real case: The efficacy of this social comparison approach is demonstrated by a study conducted at Heidelberg University Hospital in Germany, which conducted an intervention study based on digital social comparison among patients with type 2 diabetes. Researchers have developed a mobile application called "GlucoComp", which anonymously matches newly diagnosed patients with successful patients who have similar disease characteristics but better blood sugar control. Through this platform, patients can view the blood sugar control data, dietary records, and exercise conditions of similar patients in real time, and receive personalized feedback based on social comparison. The research results show that after 6 months of using this application, the glycated hemoglobin (HbA1c) level of the intervention group was significantly reduced by 0.8% compared with the control group ($p<0.01$), and the self-management behavior score increased by 32%. More importantly, 78% of the patients reported that by observing others' successful experiences, they had reset more reasonable blood sugar control targets, changing the previous wrong reference point that "as long as there are no uncomfortable symptoms, it is healthy" [16].

4.4. Designing Micro-Incentives: Countering Temporal Discounting with Immediate Rewards

It is crucial to design behavioral incentive mechanisms for emotional evasion and the burden of complexity. It is suggested that the "micro-incentive" model be adopted to provide immediate and small-scale substantive rewards for compliance behaviors. For instance, by recording the medication status through the smart medicine box, taking the medicine on time can accumulate points to exchange for cash red envelopes or insurance discounts.

Real case: The University of Cape Town in South Africa adopted an immediate reward mechanism in HIV antiviral treatment. After taking the medicine on time each time, patients can immediately receive a mobile phone credit reward of 1 rand (about 0.4 yuan) through the smart medicine box. Six months later, the compliance of patients in the intervention group reached 95%, and the virus suppression rate increased by 41%, while the compliance of the control group was only 72% [17].

In summary, these four strategies—information framing, commitment devices, reference point adjustment, and immediate incentives—are not isolated measures. They interact synergistically to address the multifaceted cognitive barriers to adherence identified by prospect theory. By targeting specific biases at different points in the decision-making process, they collectively offer a robust, behaviorally-informed framework for designing effective interventions in chronic disease management.

5. Conclusion

Addressing the global challenge of low treatment adherence in chronic disease management, this study systematically analyzed the intrinsic psychological mechanism of compliance behavior in patients with chronic diseases through the framework of prospect theory. Research has found that the decision-making process of patients generally has behavioral biases such as reference point dependence, loss aversion, and probability weight distortion, which lead to problems such as excessive optimism, present bias, emotional avoidance, and information bias. These explanations from the perspective of behavioral economics provide new theoretical insights into the adherence dilemma. Based on the analysis results, this paper proposes four innovative intervention strategies: improving risk perception through dual-framework information design, using commitment mechanisms to counter current biases, adjusting reference point Settings through social comparison, and adopting micro-incentive mechanisms to hedge against immediate losses. These strategies work together. They support each other. They form a complete intervention system. This system is based on behavioral economics. It goes beyond separate solutions. It offers one unified framework. This framework targets connected cognitive biases. These biases are the root cause of non-adherence.

The main significance of this research is its new use of prospect theory. This theory comes from economics. It is applied to chronic disease management practice. It provides new ideas and methods. These can help solve the global problem of patient adherence. The proposed intervention strategies are innovative in theory. They are also practical to use. Medical institutions can refer to them. Public health departments can use them. Health technology companies can also apply them.

However, this study has some limitations. It mainly uses secondary data and literature analysis. It lacks support from original data. Future research can use randomized controlled trials. These trials can test how well the intervention strategies work. Discrete choice experiments can be used. They can measure how much different factors affect adherence decisions. Research can also study how different patient groups respond differently. Additionally, digital health technology has application potential. This potential can be studied further. It can be used within prospect theory interventions. The goal is to create more precise and personalized behavior intervention plans.

In conclusion, this study shows something. Using a prospect theory view is not just another option. It is a necessary one. It helps us understand and improve chronic disease adherence. It changes our focus. We move from assuming patients are rational to using proven facts about cognitive biases. This provides a strong foundation. It helps design better public health interventions. These interventions are more effective and focus on human needs.

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