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Transactions on Economics, Business and Management Research
ISSN: 2960-1789, eISSN: 2960-2254 | Volume 10
MEEA 2024

Behavioral Economics Strategies to Improve Medication Adherence in Diabetes

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Abstract. Nowadays, diabetes has become an international challenge. In spite of the great technological advances in human society compared to a few decades ago, a cure for this disease has never been discovered. Hundreds of millions of patients are suffering from it, and in order to enable diabetics to keep their condition as stable as possible, this paper examines how to enhance patients' medication adherence from the perspective of behavioral economics. After reclassification of the influencing factors through tables such as pivot tables, among the data of 1127 patients selected who required long-term medication, 559 were affected by Convergence and Avoidance of Harm and were reluctant to take medication. Another 231 participants suffered from cognitive bias. A further 165 patients made irrational calculations about whether or not to take their medication. The remaining patients were influenced by some objective factors. Based on the analysis of the distinct causes of medication non-adherence in diabetic patients, it was found that this could be tackled by allowing patients to be more informed about their condition, improving access to education in order to break down information barriers, increasing the presence of family and friends, and illustrating the cost of treatment with the help of visualization tools. Beyond financial and dietary approaches, these facilitation methods could nudge as much to stabilize patients' medication-taking behaviors.

Keywords: Diabetes; Behavioral Economics; Medication Non-adherence; Health Management.

1. Introduction

Diabetes is an ongoing medical condition that develops when the body either cannot use the insulin that the pancreas generates adequately or fails to create enough of it [1]. When this happens, a hypoglycemic crisis would be triggered, which enhances the probability of cognitive impairment of the patient [2]. In addition, it will also aggravate the financial burden of patients. The prices of some common medicines and medical equipment, such as insulin and blood glucose meters, remain high, and these perishable items will lead to a long-term increase in the expenditure of patients on medications, which will ultimately affect the family's financial situation and even jeopardizes the harmony of the family in the absence of a complete cure for the disease. It has long been a heated topic of discussion in the field of public health management. It is believed that by 2030, nearly 439 million people worldwide will suffer from the disease [3]. Once plagued with this disease, it is very difficult to completely cure it as of current technology. Therefore, scientists have made joint efforts to efficiently prevent and minimize the suffering of patients.

Currently, the main research focus of scholars is on the complication mechanism and preventive control of diabetes mellitus, which in turn leads to the derivation of several models and methods to be used to support their research results. Firstly, a few quantitative methods have emerged to examine how to prevent diabetes and how to control behaviors of people with diabetes utilizing monetary and dieting theories to reduce the risk of exacerbating the disease. For example, Participants can use the existing evaluation criteria to obtain their own risk scores to determine their chances of developing diabetes and to prevent the disease from occurring [3]. Certain characteristics of specific groups (e.g. the elderly population) can also be investigated by means of modelling, which in turn leads to a comprehensive conclusion that will help patients to self-monitor health conditions and overcome cognitive biases as much as possible [4].

However, the problem is that people are not always rational and are plagued by personal barriers like overconfidence, decision fatigue and self-exhaustion and cognitive biases which prevent them from quantifying all tasks according to a precise plan [5]. Moreover, over-intervention in factors like blood glucose in potential patients could even increase the risk of disease in such individuals to some extent [6]. In this case, applying the behavioral economics approach is of great necessity. Recent research findings support this, with a primary focus on food and financial paths under behavioral economics that support diabetes patients' coherent physical circumstances and sensible management. To address the current gap in diabetes management research, this paper seeks to explore additional tools beyond financial and dietary interventions. The aim is to identify and evaluate alternative methods that can contribute to stabilizing the physical conditions of diabetic patients. By expanding on existing literature, this research will provide new insights and potential strategies for improving health outcomes for those living with diabetes, ultimately aiming to foster more comprehensive and effective management approaches.

2. Major Elements of Behavioral Economics

Behavioral economics, the discipline that integrates ideas from marketing, psychology and economics to examine people's process of behaving and decision-making [7]. The academic area encompasses numerous principles such as Present Bias, Default Bias, Loss Aversion and Utility Curvature, playing an indispensable role in public health qualitative research [4]. In terms of the available research results, by using behavioral economics principles it is possible to enhance the adherence of diabetic patients to a healthy lifestyle. Respondents have been able to make more rational judgements with the assistance of electronic health control systems. Preliminary goals of lowering blood glucose and reducing medication have been achieved [8]. Furthermore, some researchers have investigated and found that a more refined and customised exercise programme for diabetic patients, complemented by a suitable dietary plan, is more likely to nudge patients towards an outcome which they desire to achieve [9]. Supported by a range of research techniques, a number of financial indicators can lead to favourable scenarios in diabetes prevention and patient self-management [10].

2.1. Nudge

Early in 2008, behavioral economist Richard Thaler and researcher Cass Sunstein proposed a novel approach to research in the field of public policy in a book for the first time - nudge. Since its introduction, the idea has been widely discussed and reflected upon. Nudge is a specific intervention in the field of decision-making based on people's cognitive biases, thus guiding the decision-maker's final choice. The requirement for using nudges, as both writers underline, is that no alternative be eliminated and that the option being supported offers no additional value in the financial or other domains. This research methodology is still being developed and applied today in many different fields, such as marketing, public health management, economics and others [11].

2.2. Prospect Theory

Within the topic of behavioral economics, psychologists Kahneman and Tversky produced a fresh study on the decision-making process in 1979. They used it to describe decision-making behavior under risk and uncertainty and dubbed it Prospect Theory later [12]. It has also been referred to as Loss Aversion in some instances. This theory's most popular explanation is that, despite having the equal chance of winning and losing, most people tend to be more sensitive to their own losses. This effect is embedded in every aspect of our daily lives, sometimes generating solid investment returns, while at other times it can result in over-conservatism and missed opportunities.

2.3. Mental Accounting

Thaler first described mental accounting as the collection of cognitive processes that people and families use to arrange, assess, and monitor their financial dealings [13]. Three functions of mental accounting processes are thought to exist: choice simplification, maintaining self-control in the face

of enticing consumption opportunities, and optimizing hedonic enjoyment from decision results [13]. But the truth is that people are very poor at mental accounting. In some cases, even if they know the optimal decision path given probabilistic statistics, they are likely to choose a final solution that runs counter to it. Everybody has dealt with this conundrum at some point. In the world of business, people divide their money into several mental categories, and the identical commodities placed in various accounts will have varying costs and profit margins. People are therefore perpetually caught in a variety of cognitive biases. In some cases, the Mental Accounting theory is usually associated with academic categories like overconfidence, sharing the behavioral characteristics of people who tend to avoid harm, which leads to various irrational consequences.

3. Methodology

3.1. Dataset and Study Design

This paper draws on a dataset from a national sample survey of the health status of the population in Singapore conducted by Lixia Ge et al. in 2018-2019, which focused specifically on examining the corresponding relationship between old and young people who are long-term consumers of prescription medication and their non-adherence medication-taking behaviors [14]. This dataset was drawn from residents in the central and northern regions of Singapore, and the experimenter adopted a systematic sampling approach that considered the vast majority of residential neighborhoods in the sample area. Respondents who were not permanent residents of the area for more than six months and who did not have a long history of taking medication had their data cleaned, leaving 1,127 pieces of data in the end, which is enormous enough to conclude relevant evidence to contribute to public health management sector.

For this paper, the purpose of the study was not to compare the differences in medication taking behaviors between the two groups, but to identify common characteristics to explore the reasons and countermeasures for not taking medication, and thus the two columns of data were combined.

As diabetes is one of the most representative chronic diseases, this dataset can be used to focus on patients' overall perceptions of their non-medication behaviors for this disease, thus assisting in the identification of the reasons for the stabilization and deterioration of diabetic patients' conditions, and in the further exploration of the corresponding measures to address them.

3.2. Statistical Features

According to the statistical data from the initial survey, depression symptoms were reported by over 90% of patients who did not take their medication as prescribed [14]. The p-value was 0.069, indicating that there was a greater than 90% chance that the occurrence of negative symptoms and signs was linked to long-term medication non-adherence, which reinforces the plausibility of this dataset for the diagnosis of diabetes mellitus as a cause of the development of the chronic disease [14].

This experiment builds a pivot table with the Total column as the value and the domain column as the index based on the various domains listed in Table 1. It then uses the sum function to output the corresponding count values of each of the five categories in descending order. All of this is done within a structure created in Excel. The pivot table output is shown in Table 2.

Table 1. The Prevalence of Reasons for Medication Non-Adherence among Patients with Health Conditions [14].

Domain	Reason for medication non-adherence	Total(N=1127)	p-value
Patient	I was afraid of developing drug dependence or I worry about long-term effects of my medications	345	0.825
Therapy	I had problems with taking medication at specific time (e.g., with meal, on an empty stomach, not at home)	110	0.498
Patient	I just forgot	103	0.418
Therapy	I took several medications several times a day	90	0.052
Therapy	I wanted to avoid side effects	85	0.136
Patient	I did not see any benefit in taking the medication	80	1.000
Socioeconomic	The medication was too expensive	62	0.673
Therapy	My doctor frequently changed my therapy	39	0.604
Condition	I felt sad, down, or blue	38	1.000
Healthcare System	I had run out of medication (e.g., did not get refills on time, medication was not available)	37	0.286
Patient	I did not understand why I need to take this medication or why it is important to stick to the instructions	30	0.122
Therapy	My medication regimen was too complex (e.g., odd dosing timings, irregular number of daily doses, cut tablets, use inhalers, injections)	28	0.545
Patient	I did not know how to read or do not understand what is written on the medication labels	26	0.034
Healthcare System	My doctor did not involve me in my treatment choices	18	0.318
Condition	It was hard for me to swallow the pills I had to take	13	0.079
Condition	I had physical difficulty in opening / administering medications	12	0.370
Socioeconomic	I did not want other people to see me taking medication	11	0.222

Table 2. Pivot Table to Demonstrate the Medication Non-Adherence among Patients with Health Conditions in Various Categories

Pivot table of various categories	
Domain	**Total**
Patient	584
Therapy	382
Socioeconomic	73
Condition	63
Healthcare system	55

4. Reasons Why Individuals with Diseases may not Comply with Their Medication Regimen

According to Table 2, we can see that within each group, 584 patients attributed the lack of adherence to their medication to various reasons of their own, 352 patients claimed that the treatment regimen influenced the taking of the medication on time, 73 patients considered the possibility of the situation from a socio-economic point of view, and the remaining 63 and 55 patients considered the prerequisites and the imperfections of the healthcare system as the root causes of the problem, respectively.

These data provide great support for our research perspective in behavioral economics. The reasons in this dataset are next categorized from another perspective, in broad terms we can see them as subjective and objective reasons, but as behavioral economics is heavily involved with subjective human factors and thoughts, which also fits with the findings of this dataset, these categories can be subdivided into Cognitive Bias(CB), Convergence and Avoidance of Harm(CAH), Irrational Calculations(IC) and Other Reasons(OR). The number of sample fits for the complete dataset is counted in a table (Table 3) that was divided using these four categories:

Table 3. Reclassifying the Reasons for Medication Non-Adherenceamong Patients from a Behavioral Economics Perspective.

Number	Category	Total(N=1127)
1	CB	231
2	CAH	559
3	IC	165
4	OR	172

5. From Public Diseases to Diabetes

Diabetes, being the most common and the most affected of the many diseases, Table 3 can be used to infer the causes of patients' inability to stabilise their conditions. 559 out of the 1127 patients had CAH. When individuals who suffer diabetes take medication to lower blood sugar or to stimulate insulin secretion to control blood sugar, they frequently worry about how the drug will affect their own bodies—that is, about not taking it properly enough or about adverse consequences. This demonstrates their concern and caution for their own health, but it also fosters mistrust towards the physician and leads to prescription refusal. Besides, 231 data points to CB, a scenario that diabetics experience from time to time. This phenomenon frequently manifests in patients of advanced age with chronic medical conditions. These patients, having varying degrees of knowledge about their illness and having accumulated considerable experience in their prolonged battle with the disease, may overlook the significance of medication due to carelessness or overconfidence.

However, it is important to note that they are not qualified medical professionals. The absence of continuous monitoring of their comprehensive physiological data using specialized instruments can easily lead to oversight, a situation that necessitates prompt medical consultation. Ultimately, allowing one's own judgment to interfere with one's medical condition is highly undesirable and may have adverse consequences. 165 patients cited IC as a major factor influencing treatment, for some individuals with diabetes, the long-term financial and other burdens associated with medication adherence can be significant, leading them to perceive taking medication as a non-essential aspect of their daily routine. Consequently, they may neglect or forget to take their medication. This phenomenon often occurs without rational self-reflection, as these individuals primarily focus on the immediate financial burden and the perceived value of money over their physical health, failing to adopt a long-term perspective. The remaining 172 patients cited a range of objective factors as barriers to medication adherence. These included difficulties in swallowing tablets, inability to take medication at a specified time of day, and other such challenges. Parallel challenges were observed in diabetic patients, encompassing fears of pain associated with insulin injections, inconvenience of

administering insulin in public settings, the inconvenience of self-testing blood glucose levels, and the requirement for multiple daily injections. However, not all these factors are objective, and there may also be some cognitive errors due to the patients' own cognitive biases, so that these can also be explained by behavioral economics.

6. Measures to Promote Compliance and Adherence to Medical Advice for People with Diabetes Mellitus

After gaining insight into the cognitive biases exhibited by individuals with diabetes, it is imperative to seek appropriate solutions from diverse perspectives. As a bystander, some solutions to nudge diabetic patients could be proposed. Primarily, fostering a deeper understanding of their own condition and prescribed medication is crucial. This can be achieved by promoting the accessibility and clarity of condition-related information. Additionally, physicians should endeavor to communicate with patients using simple yet effective language, thereby minimizing confusion and ignorance. On this foundation, patients will be more inclined to cooperate with their treatment plans, alleviating concerns such as the perceived complexity of prescription information or the belief that they have already ingested sufficient medication. Such an approach lays a fundamental and feasible foundation for the stabilization of their condition.

In addressing patients' tendency to avoid harm, society should prioritize awakening their awareness that physical health is invaluable and should always be a primary concern. Education and guidance, delivered through institutions such as geriatric universities and other educational modalities, involving healthcare professionals, media networks, and the public, are imperative. Various psychological phenomena, including fear and anxiety, can be mitigated to a significant extent through social norms and group pressure. For instance, establishing a community or social media network for individuals with diabetes fosters the exchange of encouragement, experiences, and support, thus providing emotional value. Furthermore, group conventions can be implemented in this context, such as establishing mutual commitments to adhere to medication schedules, medical appointments, insulin administrations, and timely blood glucose monitoring. As many people with diabetes are in the elderly group, for their family members, it can also be effective to ease their depressive mood, mobilise the enthusiasm to cooperate with the treatment, increase the length of time of companionship, reduce loneliness and other negative impacts.

Addressing irrational calculations in patients, particularly among diabetics who refuse medication due to perceived high costs, requires a multifaceted approach to mitigate their preconceived notions and impulsive behaviors that persist despite understanding the potential consequences. To this end, we propose utilizing visualization tools and granular statistical data to illustrate the quantitative relationship between the risks associated with medication adherence versus non-adherence, and the significant financial implications of untreated diabetes. On an economic analysis, adhering to medication regimes poses a low-risk and low-reward scenario compared to the high-risk and potentially high-cost outcome of untreated diabetes. However, the level of risk associated with non-adherence far outweighs any economic savings achieved through medication avoidance. Therefore, it is imperative to encourage timely medication adherence to stabilize diabetic conditions and mitigate the associated risks. By employing these techniques, we aim to provide patients with a clear understanding of the long-term economic and health implications of their decision-making, ultimately facilitating more rational choices regarding their healthcare.

For some objective factors that prevent people with diabetes from taking or injecting medication due to their own physical condition, we can likewise mitigate or address them as much as possible through means of nudge. Whether at home or in the office, insulin and glucose control devices can be placed as prominently as possible to always reinforce the impression that the patient is taking his or her medication. On this basis, they will have a higher probability of noticing and picking up the medicine bottles.

7. Conclusion

Out of all the 1,127 data entries, CAH is the primary concern for patients with chronic medication-intensive diseases, including diabetes, which shows their avoidance, apprehension, and resistance to the side effects of their medications. This accounts for nearly half of the cases. CB comes next. Although patients may have trouble detecting it on their own, the researchers could determine reasons when they examine them from a more detached perspective. 165 patients are influenced by IC and mismeasure the value of taking medication in relation to their physical health. The rest of the data is sorted into OR classes. To address these issues, we can expand their tunnels and prevent some of the black swan events of their illnesses by making them aware of their conditions at an educational level and educating and guiding their behaviors with the assistance of visual diagrams or instruments.

The article is unique in enhancing self-management of diabetic patients, especially in improving medication compliance. It opens up a novel perspective in terms of research angle, and after analysing the numerous factors that have been derived to be highly influential, it explores the solutions from the educational, psychological and technological aspects. The objective causes can also be partially transformed to the classical method of behavioral economics to achieve augmentation. Therefore, these findings act as a catalyst for research in the field of diabetes on initiatives relevant to the promotion of patient stabilisation.

Datasets on large diabetic populations are often more complex to collect since medical information is necessarily private to some extent. Hence, researchers mainly use secondary data rather than primary data when conducting research. In the future, primary data by methods such as survey and interview can be obtained, thus enriching the source of data and the reliability of the research outcomes. In addition, when assessing the reasons for the interviewees' medication non-adherence, there may be instances where individual pieces of information satisfy both categories, and there may not be a fully defined qualitative categorisation criterion for behavioral economics. This also provides a new pathway forward for behavioral economics, which is how to develop computational approaches to research that enable the relevant methodologies to be more distinctive.

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