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The Application of Interpretive Structural Modeling in Diabetes Health Management App Interface Design

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Abstract. This article aims to optimize the interface design of a diabetes health management app, guided by the Interpretative Structural Modeling (ISM) and Matrice d'Impacts Croisés Multiplication Appliquée à un Classement (MICMAC) models. Through a literature review, 10 key factors influencing app interfaces were identified, and their importance, hierarchical structure, and MICMAC results were extensively studied. Targeted interface recommendations are proposed to meet the specific needs of diabetes patients, ultimately enhancing their quality of life and health.

Keywords. Diabetes, Health Management App, ISM, MICMAC, Interface Design

1. Introduction

Diabetes mellitus is a common chronic metabolic disease that is mainly categorized as type 1, type 2, atopic and gestational diabetes mellitus. A recent report shows that diabetes is one of the leading causes of death worldwide.[1] The report states that the prevalence of diabetes is increasing and the number of patients is expected to exceed 366 million by 2030. This trend has enormous social and economic implications. However, the risk of complications and economic burden can be reduced through self-management of chronic diseases. Advances in smartphones and related technologies offer innovative solutions for diabetes treatment. With this in mind, this paper focuses on meeting the specific needs of people with diabetes and aims to provide a series of recommendations on the design of health management application interfaces to better serve users.

2. Background

In recent years, driven by the widespread adoption of mobile internet and smart devices, diabetes health management applications (Apps) have gained significant attention as a pivotal domain for research and practical use. Studies have demonstrated the impactful role of mobile interventions in supporting self-care and blood glucose monitoring, with

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C. Eberle et al.'s investigation underscoring the effectiveness of diabetes health management Apps in patient care.[2] Likewise, Basilico et al.'s research underscored the convenience of these Apps for tracking variables such as blood glucose, diet, and exercise.[3]While most existing literature has focused on the functionalities of health management Apps, the significance of interface design has received equal attention. Moore et al.'s study revealed user preferences for easily accessible graphical information, simple design, and features providing dietary and insulin use information, as well as social networking support.[4] Linda T. Muijs et al.'s research demonstrated the overall positive impact of diabetes management Apps on patients' well-being, emphasizing the importance of personalized settings.[5] Ossai, C's findings highlighted the significance of kinetic effects and detailing in interface design, contributing to user engagement and prolonged usage.[6] Similarly, Nadadur, Set al. identified stability as a critical principle in interface design, ensuring a harmonious experience for users.[7] Conversely, Gao, C et al.'s study highlighted the importance of high information content and quality of service in management Apps.[8] Collectively, these studies underline the necessity for an in-depth exploration of interface design for diabetes health management Apps, emphasizing its pivotal role in enhancing usability, ease of use, and user satisfaction.

3. Materials and method

3.1. ISM Modeling and MICMAC Modeling

The Interpretive Structural Modeling (ISM) technique, put forth by Prof. Wahlfeldt in the U.S. in 1973, deconstructs intricate systems into subsystems and merges them through a fusion of human expertise, experience, and computational support, yielding a multi-tiered, recursive explanatory structural model.[9] ISM models find prevalent usage in sectors like organizational management and market analysis, and have seen emerging employment in design realms in recent times.

The MICMAC model, introduced by Dupperin and Godet in 1973, is a method for analyzing interrelationships and interactions among system elements.[10] MICMAC analysis outcomes are displayed in a quadrant diagram, classified into four zones: I independent, II dependent, III linked, and IV spontaneous. Horizontal coordinates denote dependencies, while vertical coordinates signify driving forces, resulting in the term "driving force-dependency matrix." The MICMAC model elucidates variable interdependencies, supporting decision-makers in comprehending system intricacies.

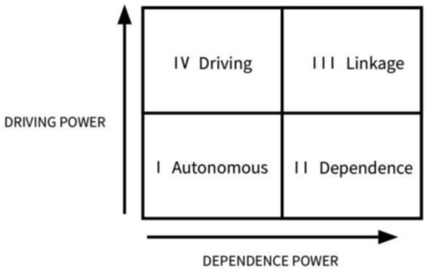

Figure 1. Principle of MICMAC analysis

ISM and MICMAC are often used together because their respective characteristics complement each other, providing a more comprehensive and in-depth problem analysis. The ISM model can reveal the hierarchical structure of the problem and the dependencies among factors, aiding in understanding the reasons behind the problem. On the other hand, the MICMAC model can quantitatively analyze the degree of influence and correlation between factors, offering specific data support. Through the collaborative application of these two models, a better understanding of the influencing factors of the problem can be achieved, leading to the development of more effective solutions.

3.2. ISM model construction and analysis

In this research, we conducted a search for journal articles on ScienceDirect using the keywords "diabetes," "health management application," and "design." We then compiled and summarized diverse factors related to user interface design to pinpoint potential factors. Once these potential factors were identified, the ISM method was employed to establish the interrelationships among them. This procedure initiated with the development of a form distributed to user interface designers for evaluation. Experts were tasked within the form to choose additional factors impacting a given factor, thus constructing an interlinked network of factors. These factors are outlined in Table 1.

Table 1. Factors influencing the interface design of diabetes apps .

SN	Factors	Definition Description
1	Color	Color of the interface.
2	simplicity	The interface is characterized by clarity, simplicity, lack of redundancy, and complexity.
3	user-friendly design	Create an interface that meets user expectations and is easy to use by placing the user's needs at the center.
4	recognizability	Users are able to quickly and accurately recognize the characteristics of the elements, functions and interactions on the interface.
5	comprehensibility	The design and layout of the interface enables the user to easily understand the features of the application's functionality, information and interaction.
6	privacy protection	Design and implement application interface policies designed to protect users' personal information from unauthorized access and use.
7	ease of use	The design and interaction side of the application interface

		should enable users to use the application efficiently and have a pleasant experience.
8	dynamics and details	An animation effect that interface elements present when the user interacts with the application.
9	stability	Ability to maintain consistent performance and functionality in a variety of situations.
10	personalization	The ability to customize and optimize the interface and content for each user based on individual differences in preferences, interests, and habits.

The adjacency matrix was constructed through spss (see Table 2). In the adjacency matrix, "1" indicates that there is an influence relationship between two factors and "0" indicates that there is no relationship. The reachability matrix was calculated using spss (see Table 3). The reachable matrix was generated by adding the adjacency matrix A to the unit matrix I and applying a power operation to the matrix A + I. These calculations yielded values for the drivers and dependencies that will be used in subsequent MICMAC analyses to help classify all variables.

Table 2. Adjacency matrix.

SN	Factors	1	2	3	4	5	6	7	8	9	10	Driving Power
	Color	1	1	1	1	1	1	1	1	1	1	11
	simplicity	1	1	1	1	1	1	1	1	1	1	11
	user-friendly design	1	1	1	1	1	1	1	1	1	1	11
	recognizability	0	0	0	1	1	0	1	1	1	0	5
	comprehensibility	0	0	0	1	1	0	1	1	1	0	5
	privacy protection	1	1	1	1	1	1	1	1	1	1	11

	ease of use	0	0	0	1	1	0	1	1	1	0	5
	dynamics and details	0	0	0	0	0	0	0	1	1	0	2
	stability	0	0	0	0	0	0	0	0	1	0	1
0	personalization	1	1	1	1	1	1	1	1	1	1	11
	Dependence Power	5	5	5	8	8	5	8	9	10	5	

Table 3. Reachability matrix.

SN	Factors	1	2	3	4	5	6	7	8	9	10
1	Color	1	1	1	1	1	1	1	1	1	1
2	simplicity	1	1	1	1	1	1	1	1	1	1
3	user-friendly design	1	1	1	1	1	1	1	1	1	1
4	recognizability	0	0	0	1	1	0	1	1	1	0
5	comprehensibility	0	0	0	1	1	0	1	1	1	0
6	privacy protection	1	1	1	1	1	1	1	1	1	1
7	ease of use	0	0	0	1	1	0	1	1	1	0
8	dynamics and details	0	0	0	0	0	0	0	1	1	0
9	stabilit	0	0	0	0	0	0	0	0	1	0

	y										
10	personalization	1	1	1	1	1	1	1	1	1	1

Table 4 shows the reachability matrix after removing the transmissibility, which has an important role in the analysis. By removing the transmissibility, more accurate and clear information can be obtained to help identify and understand the relationship between the variables in the system and help the decision maker to make better judgments about the relationship of the system.

Table 4. Reachability Matrix after removing transitivity.

SN	**Factors**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Color	1	1	1	1	1	1	1	1	1	1
2	simplicity	0	0	0	0	0	0	0	0	0	0
3	user-friendly design	0	0	0	0	0	0	0	0	0	0
4	recognizability	0	0		1	1	0	1	1	1	0
5	comprehensibility	0	0	0	1	1	0	1	1	1	0
6	privacy protection	1	1	1	1	1	1	1	1	1	1
7	ease of use	0	0	0	0	0	0	0	0	0	0
8	dynamics and details	0	0	0	0	0	0	0	1	1	0
9	stability	0	0	0	0	0	0	0	0	1	0
10	personalization	1	1	1	1	1	1	1	1	1	1

Table 5. Iteration results

SN	Factors	Reachability Set	Antecedent set	Intersection set	Level
1	Color	1、2、3、4、5、6、7、8、9、10	2, 3, 4, 5, 6, 7, 8, 9, 10	2, 3, 4, 5, 6, 7, 8, 9, 10	VI
2	simplicity	2、1、3、4、5、6、7、8、9、10	1, 3, 4, 5, 6, 7, 8, 9, 10	1, 3, 4, 5, 6, 7, 8, 9, 10	VI
3	user-friendly design	3、1、2、4、5、6、7、8、9、10	1, 2, 4, 5, 6, 7, 8, 9, 10	1, 2, 4, 5, 6, 7, 8, 9, 10	VI
4	recognizabili ty	4、5、6、1、2、7、8、9、10、3	4, 5, 7, 8, 9	4, 5, 7, 8, 9	III
5	comprehensi bility	5、6、7、1、2、8、9、10、4、3	4, 5, 7, 8, 9	4, 5, 7, 8, 9	III
6	privacy protection	6、1、2、3、4、5、7、8、9、10	1, 2, 3, 4, 5, 7, 8, 9, 10	1, 2, 3, 4, 5, 7, 8, 9, 10	VI
7	ease of use	7、4、5、1、2、8、9、10、3、6	4, 5, 7, 8, 9	4, 5, 7, 8, 9	III
8	dynamics and details	8、1、10、2、3、4、5、6、9、7	9, 10	9, 10	II
9	stability	9、1、10、2、3、4、5、6、7、8	10	10	I
10	personalizati on	10、1、2、3、4、5、6、7、8、9	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 3, 4, 5, 6, 7, 8, 9	VI

Based on the hierarchical structure shown in Table 5, we developed a model of user interface design influencing factors. The results are shown in Table 6. It can be seen here that all the factors are categorized into four levels. Stability is the highest level of the ISM model and it depends on other critical success factors for effective application interface design.(Rows 1-9 in the first row of the table below represent simplicity, user-friendly design, recognizability, comprehensibility, privacy protection, ease of use,dynamics and details, stability, personalization.)

Table 6. Hierarchical results

Level	Factors	1	2	3	4	5	6	7	8	9
evel 1	stability	1	1	1	1	0	1	1	0	1
evel 2	dynamics and details	0	1	1	1	0	1	0	0	1
evel 3	recognizability，comprehensibility，ease of use	0	0	0	0	0	0	0	0	0
evel 4	Color，simplicity，personalization，privacy protection，user-friendly design	0	0	0	0	1	0	0	0	0

Figure 2 shows the explanatory structural model of the factors influencing user satisfaction of the application interface design obtained in this study. The arrows indicate the direction of each influencing factor. The results show that these factors are categorized into five levels in the hierarchical model. 'Stability', which is the goal of the whole system, is located at the highest level and is directly influenced by the second level, 'Dynamics'. The third tier contains the most factors, with recognizability, comprehensibility and ease of use driving the higher tier factors. Tier 4 factors include color, simplicity, user-friendly design, privacy protection, and personalization.

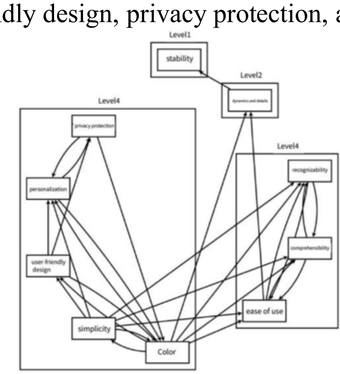

Figure 2. Hierarchy diagram

3.3. MICMAC model construction and analysis

From the results of the reachability matrix, it can be seen that the mean value of the driving force is 7.3, and the mean value of the dependence is 6.8, and this mean value is used as the quadrant demarcation line, so as to divide all the factors into the four quadrants of the driving force-dependence space (e.g., Fig. 2).The MICMAC method has been used to further categorize the factors influencing the diabetic health management APP interface user satisfaction, and to explore the hidden indirect influence relationship between factors.

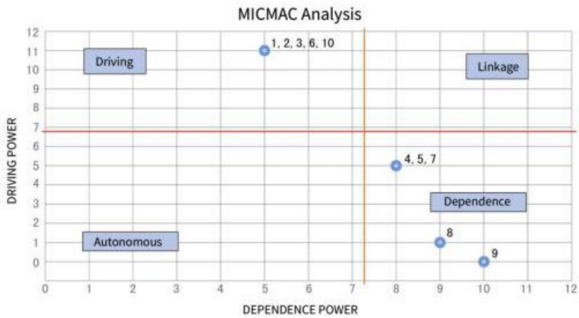

Figure 3. MICMAC Analysis

From the provided MICMAC analysis quadrant diagram, we deduce that variables within the independent (I) quadrant possess minimal influence on the entire system and demonstrate moderate independence. Variables in the Dependent (II) quadrant exhibit partial reliance on the system; they could be affected by other variables and exert a substantial system impact. Variables in the spontaneous (IV) quadrant, like stability, emerge autonomously within the system, resisting direct influence from other variables. Stability might stand as a relatively autonomous factor, experiencing limited interference from external factors.

4. Conclusion

Based on the above analysis, it is emphasized that in the interface design of diabetes health management apps, the stability of the system is the most crucial factor as it directly impacts user experience and the long-term usability of the application. The use of dynamic effects should be moderate to attract users but not excessive to avoid disrupting users' need for system stability. In the third layer, particular attention should be given to recognizability, comprehensibility, and usability, ensuring a simple and intuitive design for user understanding and use. While other factors are considered, they should not take precedence over the core user experience and system reliability. The goal of these recommendations is to ensure that the app offers comprehensive functionality while providing users with an outstanding and user-friendly experience.
By enhancing the stability of the interface design, there is a significant improvement in user experience. Taking Airbnb as an example, the mobile interface incorporates

images with golden ratios such as 1:1, 3:2, and 13:21. This enhances the layout of the interface, making it more rational and comfortable, thereby reinforcing a sense of stability. (e.g., Fig. 4)

Figure 4. Screenshot of Airbnb interface

The subtlety of motion design often manifests in the details. For instance, consider the Apple App Store, where the page transition effect unfolds from the center to the periphery. This method effectively reduces the time required for page transitions, creating a more cohesive visual experience, as illustrated in Figure 5.

Figure 5. Screenshot of Apple App Store interface

Therefore, based on the content of the article, it can be concluded that in the interface design of diabetes health management apps, more attention should be paid to the stability and motion design of the interface. Stability enhances user experience, while motion design, through clever details, enhances the interactivity of the user interface. Both factors collectively contribute to sustained user engagement and a better interactive experience. Careful consideration of these aspects in interface design holds the potential to provide diabetic patients with a more humane, user-friendly, and satisfying health management tool.

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