The Feasibility of Applying Artificial Intelligence Detection Technology in Predicting the Risk of Hypertension

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Abstract

According to statistics from the World Health Organization (WHO) in 2022, cardiovascular diseases account for the largest proportion among noncommunicable diseases, causing approximately 17.9 million deaths annually. The next leading causes are cancer (9.3 million people), chronic respiratory diseases (4.1 million people), and diabetes (2 million people, including deaths from kidney diseases caused by diabetes). These four categories of diseases contribute to over 80% of premature deaths from noncommunicable diseases. Therefore, preventing the occurrence of diseases and understanding the functional status of various organ systems in the body has become crucially important. This study utilized techniques developed in the field of preventive medicine in Europe and the United States, combined with artificial intelligence detection technology, to analyze and compare the big data obtained from extracted organ cell functional response data. This analysis helps infer the functional status, developmental trends, and probabilities of diseases that may occur in the organs. These results can serve as a basis for individuals to make adjustments and reduce health risks. The study adopted a case study approach, collecting artificial intelligence detection data from 12 cases, while conducting cross-analysis with biochemical test data and body mass index to confirm the feasibility of artificial intelligence detection in predicting the risk of hypertension. Through the analysis and comparison, we found a high degree of correlation among the three test results. Therefore, the results of this study can be a reference for relevant professionals in academia, government, and industry.

Keywords: Artificial intelligence, Preventive medicine, Hypertension, Health risk assessment, Disease probability prediction

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1. INTRODUCTION

According to the statistical data from the Taiwan Ministry of Health and Welfare between 2015 and 2020, the number of hypertension patients per 100,000 population increased from 5,881 to 6,706, showing a steady growth trend of 12.3% [1]. Modern individuals are affected by factors such as unhealthy diets, hectic lifestyles, social environments, and climate pollution, resulting in an annual increase in health risk indices. According to the statistics from the Taiwan Ministry of Health and Welfare, the total healthcare expenditure increased from approximately 434.8 billion New Taiwan Dollars (NTD) in 2010 to 656.4 billion NTD in 2019, with a growth rate of 51% over the course of 10 years [1]. The increase in healthcare costs represents an increase in the demand for medical services, which can also be seen as an elevation of the health risk index for individuals. This has significant implications for the government's management burden and severely affects people's quality of life. Therefore, in order to effectively reduce the incidence of diseases and the burden of treatment costs, healthcare policies should focus on preventive care rather than solely pursuing the diversity and efficacy of treatment methods [2]. This aligns with the concept of ancient Eastern preventive medicine, as described in the Huangdi Neijing: "The superior physician treats the disease before it occurs, and prevents disorder before it arises" [4].

The government should enhance the willingness and initiative of the people to actively manage their health. Therefore, it is crucial to enable individuals to easily understand their health risks and obtain suitable methods for optimizing their well-being. Currently, hypertension is one of the most common and prevalent chronic diseases. If it can be detected and adjusted early on effectively, it will significantly reduce the burden of medical costs associated with the disease and minimize harm to the body. This study aims to establish a feasible service system through artificial intelligence detection and big data analysis. It enables individuals to quickly and effortlessly understand their physical condition and make prompt adjustments to reduce the damage caused by diseases.

2. LITERATURE REVIEW

Artificial Intelligence (AI) is typically used in computational technology to simulate mechanisms assisted by human intelligence, such as thinking, deep learning, adaptation, engagement, and sensory understanding [5, 6]. Some devices can perform roles that typically involve human interpretation and decision-making [7]. These technologies employ interdisciplinary approaches that can be applied to various fields, including medicine and health. The phenomena of population aging and declining birth rates have led to increased energy consumption and worsening environmental pollution, posing greater challenges to human survival. The incidence of chronic diseases continues to rise, with significant diseases showing an increasing trend in patient numbers and mortality rates year by year [8]. Although modern medical technology continues to advance, many new diseases are being discovered, along with corresponding medications. The medical process often involves identifying the primary causes of diseases through more extensive and detailed diagnostic tests, which also significantly increase medical risks and costs [9].

Currently, medical technology research primarily focuses on gaining a more accurate understanding of the development process of diseases and developing more drugs and treatment methods. However, an increasing number of cases demonstrate that people may experience various discomforts even when biochemical and medical test data fall within normal ranges. This means that individuals may not be ill but also not in a healthy state [10]. Finding technological means to prevent disease initiation and control diseases has become a significant challenge for healthcare professionals and the healthcare industry [11]. Hypertension is a chronic disease and falls under lifestyle diseases. If we follow the modern medical approach of diagnosing and using medication for long-term control, aiming to delay continuous organ damage caused by the disease and extend the duration of disease affliction (unhealthy lifespan), it will result in a sustained increase in the burden of medical costs. Therefore, designing health management programs based solely on treating diseases does not provide practical help in improving people's quality of life or reducing the burden of healthcare costs.

Modern artificial intelligence technology is rapidly developing and finding extensive applications in the field of healthcare. Among them, wearable technologies are particularly diverse, capable of collecting physiological and health behavior data and establishing big data databases for analysis, aiming to promote the development of preventive medicine through technological instruments [12]. Big data is a typical buzzword in the business and research communities, referring to a large amount of numerical data collected from various sources. In the healthcare field, we can obtain massive data, known as healthcare big data. Data mining and machine learning techniques can help process this information and provide valuable insights for doctors and patients [13]. Artificial intelligence utilizes complex algorithms and specialized software to analyze vast and complex diagnostic data. It can provide accurate and viable results without the need for direct human input. This technology is capable of interpreting and advancing information through intelligent machines. The primary goal of artificial intelligence is to analyze the correlations between treatment and prevention methods and patient outcomes [14].

Artificial intelligence has been widely applied in the healthcare field, including healthcare service management, predictive medicine, clinical decision-making, patient data, and diagnostics [15]. In the current medical symptom interpretation, big data computation has reached a mature stage. Through AI computations and cross-analysis, a large amount of biochemical and instrumental test data can be combined with database information to assist healthcare professionals in quickly identifying the development of disease symptoms and providing the most appropriate treatment plans. This has become a major trend in the healthcare industry [17]. The global outbreak of COVID-19 has posed significant challenges to public health policies and clinical healthcare professionals worldwide. Treatment-based healthcare management policies and health education methods are facing severe tests. Therefore, it has become extremely important to establish preventive and health promotion measures before the occurrence of diseases [18].

The application of preventive medicine primarily targets the "sub-healthy" population, who are in a state between health and illness. They may experience persistent discomfort, but their diagnostic data still falls within the normal range for medical disease diagnosis. Prolonged feelings of discomfort can lead to physical and mental stress, resulting in organ dysfunction and premature aging. Therefore, early detection and adjustment are key factors in preventive medicine and health promotion. Developed countries are facing the challenge of an aging population, leading to a demand-supply gap in healthcare services. Therefore, the healthcare industry must focus on providing fast services to patients while ensuring accurate diagnosis, reliable resource control, and efficient healthcare system management [19]. The development of artificial intelligence can help organize a large amount of medical records into systematic knowledge. This technology possesses the ability to learn and analyze rapidly and can continuously self-correct to establish more accurate predictive models. Computer systems are used to compute and simulate human thoughts and behavioral characteristics. These technologies find wide applications in areas such as health examinations, disease diagnosis, and surgical procedures [14]. Developing the healthcare and health industry and promoting innovative research and development capabilities have become common goals for governments worldwide [20]. One of the most challenging and prominent objectives today is the development and application of biosensors and trackers to improve healthcare systems and infrastructure. Biosensors can efficiently and sensitively detect and record characteristics [21]. Big data and artificial intelligence technologies have already transformed the way healthcare is delivered globally [22].

This study utilizes artificial intelligence to conduct health risk analysis and detection on individuals. Additionally, we incorporate biochemical testing and body mass index for cross-analysis. Our goal is to utilize technological means of detection to identify early disease development trends, thereby reducing the incidence of diseases, improving people's quality of life, and relieving the government's healthcare burden.

3. RESEARCH METHODOLOGY

This study adopts a case study approach within the scope of empirical research, utilizing both qualitative and quantitative methods while integrating theory and practical application. Currently, the medical field primarily relies on biochemical testing and body constitution data as the main indicators for identifying the risk of hypertension. This research invited 30 participants to undergo testing and data collection, taking into accounts the participants' locations and available time. Considering factors such as the use of detection instruments, data analysis, and the time required for biochemical testing data provision, the entire process spanned approximately six months. After reviewing the relevant data, only data from 12 participants were complete enough to undergo analysis. In this study, 12 participants were subjected to artificial intelligence detection, biochemical testing, and collection of body constitution data. The collected data was then cross-referenced to assess and validate the risk of hypertension. The research aims to confirm the correlation among these three detection methods and explore the feasibility of utilizing artificial intelligence detection and data analysis techniques in predicting hypertension risk.

3.1 Research Subjects

For this study, 12 participants from the white-collar class were selected as research subjects, with an equal distribution of 6 males and 6 females. The participants were required to be aged 20 years or above, with no restriction on whether they had a history of hypertension. However, participants who were taking medication for hypertension control were asked to provide information regarding their medication usage. If the participants had a family history of hypertension among their immediate relatives, it suggested a potential genetic predisposition to the condition and increased disease risk. This information was considered as a reference for the conclusion analysis. The details of the research subjects are provided in TABLE 1 for further reference.

Table 1: Research Subject Data

Number	Age/Gender/ Family Medical History/ Medication Control	Number	Age/Gender/ Family Medical History/ Medication Control
1	63/Female/Hypertension, Diabetes/None	7	49/Male/Hypertension/None
2	63/Male/Hypertension/None	8	40/Male/None/None
3	52/Male/Hypertension, Diabetes /None	9	44/Male/Hypertension/None
4	26/Female/None/None	10	55/Male/None/None
5	58/Female/Hypertension/None	11	70/Female/Hypertension, Diabetes/Yes
6	54/Female/None/None	12	54/Female/None/None

3.2 Research Tools

A. Artificial intelligence detection device

The application of artificial intelligence technology in collecting physiological data and health behavior information has made significant progress. Artificial intelligence detection techniques are constantly advancing and widely applied in various fields, creating endless possibilities [12]. With the development of technology, numerous technological applications have emerged. Big data analytics has several fundamental characteristics. Firstly, there is the volume of data, which is rapidly increasing from megabytes (MB) to petabytes (PB). Secondly, there is the velocity of data generation, requiring fast processing to meet real-time analysis and decision-making needs. Thirdly, there is the variety of data, which exists in various forms such as numerical, images, text, sound, video, and different signals. Lastly, there is the veracity of data, as data generation and acquisition become more freely accessible with the widespread use of the internet and mobile devices [23]. The artificial intelligence detection device used in this study was developed by the Institute of Psychophysics of the Russian Republic's National Academy of Sciences. The design concept of this device originated from space projects, aiming to address the challenges of maintaining astronauts' physical health during space missions under harsh conditions.

The design principle of this instrument is to collect signals by detecting the intensity and time difference of cellular energy reactions. These signals are then linked and calibrated with abnormal body functions and disease states determined through empirical medical examinations. The different stages of disease development are confirmed by analyzing the signal patterns, and a large-scale database is accumulated through case accumulation. Currently, the database contains millions of records for comparison. This device is a non-invasive body detection instrument that uses a signal emitter to sequentially emit normal frequency signals of different organs to the reflex zones of the brain. By utilizing frequency resonance effects, it receives the reflected frequency response signals, which are then cross-compared with the database to assess similarity. The results are provided to analysts for reference and explanation in assessing the health risks of the body. The detection process does not require fasting, injection of contrast agents, or the use of high-energy light, thus causing no harm to the body. The instrument can perform daily detection and track the body's condition. It can serve as a frontline tool for healthcare policy implementation and is suitable for health management and consultation. When combined with modern medical biochemical tests or imaging examinations, it can complement the judgment of organ dysfunction and structural damage. The analysis and conclusion information can be used as a reference for initial diagnosis by medical institutions and healthcare professionals. It can also provide a basis for developing personalized health management plans for health managers.

B. Biochemical testing data

Biochemical testing is the most important reference data for medical decision-making in modern healthcare. The variability of biochemical test data is not high, and it is generally conducted on a three-month cycle. In this study, research participants need to undergo blood tests at a medical laboratory. The reference table for basic test items is provided in TABLE 2.

Table 2: Basic Test Items

Item	**Content**
Blood Pressure-related	Vascular Stiffness Index, Arterial Stiffness Index

C. Body Composition Data

Physique data is essential equipment commonly used in weight management. Its working principle is based on the application of the bioelectrical impedance analysis (BIA) method. Bioelectrical impedance refers to the resistance to the flow of electric current. For muscles and blood, the conductivity between body fat and the skin is poor, resulting in an increase in impedance. Bioelectrical impedance analysis (BIA) is a relatively inexpensive method for estimating body fat [24]. Therefore, when body weight is the same, the higher the body fat, the larger the impedance data. Body fat percentage (BFP) is estimated based on the scale of bioelectrical impedance analysis (BIA). Visceral fat and body fat percentage are also reference factors for body mass index (BMI). BMI is widely used as an indicator for assessing weight status in epidemiology, clinical nursing, and clinical nutrition. Refer to TABLE 3 for physique data items.

Table 3: Physique Data Items

Item	**Content**
Blood Pressure	Visceral Fat, Body Fat

3.3 Research Procedure

Schedule a time for twelve research subjects to undergo artificial intelligence instrument and physiological data testing. Additionally, please provide biochemical test data within ten days from medical institutions or testing facilities, please refer to FIGURE 1 for the research process.

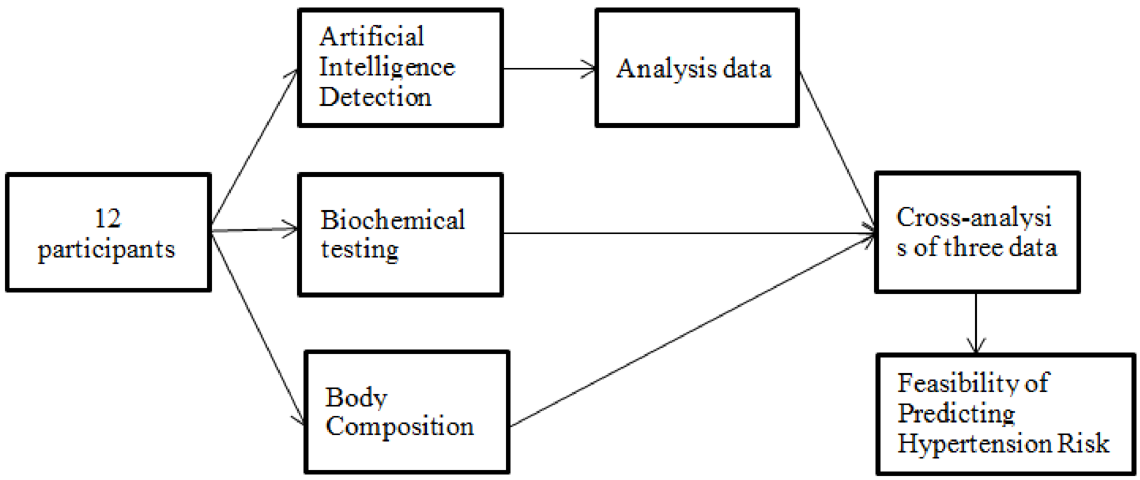

Figure 1: Research Process

3.4 Explanation of Data Interpretation Criteria

The three designated assessment items in this study have specific indicators that relate to the risk of developing hypertension or the functional status of bodily organs after disease onset. The criteria for determining these indicators are as follows:

A. Artificial intelligence detection instrument

Hypertension is a significant risk factor for the development of atherosclerosis and cardiovascular diseases [25]. Similarly, atherosclerosis can also lead to hypertension. In the classification categories of the database, such as "disease classification," "growth factors," and "pathological patterns," if the detected matching data contains factors related to hypertension and the data is below 0.425, a risk warning will be issued. For example, "hypertensive syndrome" and "vascular dysfunction" indicate potential hypertension-inducing diseases. Please refer to TABLE 4 for the evaluation criteria.

Table 4: Explanation of Detection Data

Number	**< 0.225**	**0.225~0.425**	**0.425~1.000**	**> 1.000**
Meaning	High-risk	Moderate-risk	Low-risk	No risk at present

B. Biochemical testing

Biochemical testing is one of the primary reference data for assessing the body's condition in modern medicine. Hypertension is a modern disease that is highly correlated with dietary content, environmental stress, and lifestyle habits. A diet high in oil, fats, and sugars, along with a sedentary lifestyle and reduced exercise, can lead to metabolic abnormalities and an increasing population with hypertension. There is a causal relationship between hypertension and the interpretation of blood biochemical test values. Each test data is interconnected. In this study, blood test items are divided into two categories, and the data interpretation criteria are as follows: Hypertension primarily refers to indicators such as "arterial stiffness index" and "vascular stiffness index." If the values exceed the standard range, it indicates a warning for hypertension. Please refer to TABLE 5 for the testing criteria.

Table 5: Standard for Basic Testing Items

Item	Standard	Item	Standard
Vascular Stiffness Index	0.0~5.0	Arterial Stiffness Index	0.0~3.0

C. Physiological data

1. Physiological data is a commonly used reference in modern medical practice to determine the likelihood of developing hypertension. Excessive body fat and visceral fat are among the major factors contributing to the risk of hypertension. As the measurement values gradually increase, they can provide references for the occurrence of the disease and after the onset. By inputting the gender, age, and height of the research subjects, relevant values can be calculated using measurement instruments. According to data from the Taiwan Ministry of Health and Welfare, the ideal body fat percentage for males less than 30 years old should fall within the range of 14% to 20%, while for males over 30 years old, the ideal range is between 17% and 23%. A percentage exceeding 25% is considered obesity. For females under 30 years old, the ideal body fat percentage should be in the range of 17% to 24%, and for females over 30 years old, the ideal range is between 20% and 27%. An exceeding percentage of 30% is categorized as obesity. Therefore, the scope of individuals in this study falls within the specified ranges [26]. Therefore, if the test data falls outside the standard range, a warning can be issued. Please refer to TABLE 6 for the criteria for interpretation.

Table 6: Interpretation Criteria for Physiological Data

Reference Values for Males		Reference Values for Females	
Testing Item	Reference Value	Testing Item	Reference Value
Visceral Fat	< 9	Visceral Fat	< 5
Body Fat	< 20% for individuals below 30 years old < 23% for individuals aged 30 and above	Body Fat	< 24% for individuals below 30 years old < 27% for individuals aged 30 and above

4. RESEARCH RESULTS

Based on the design principles and academic theoretical foundations of the three testing methods used in this study, and the analysis of the testing and examination data interpretations, the correlation between the predictive risk of developing hypertension using artificial intelligence detection instruments and the conclusions drawn from modern medical biochemical tests and commonly used physiological data judgments was examined. The feasibility of their application was confirmed. The results of the cross-referencing can be found in the Comprehensive Analysis Table (TABLE 7).

Table 7: Comprehensive Assessment Table

Number	Age	Gender	Hypertension Risk Warning					
			AI Detection		Biochemical Test		Physiological Data	
			Hypertension Vascular	Dysfunction Arterial	Stiffness Index	Vascular Stiffness Index	Visceral Fat	Body Fat
1	63	Female	0.34*	0.06*	1.41	2.61	8.00*	37.5*
2	63	Male	0.34*	0.34*	3.96*	5.33*	20.0*	27.6*
3	35	Male	0.45	0.43	1.45	2.65	12.0*	28.5*
4	26	Female	0.28*	0.28*	2.39*	3.59*	2.50	27.5
5	58	Female	0.34*	0.33*	2.76*	4.20*	8.50*	36.1*
6	70	Female	0.38*	0.33*	2.61*	3.83*	10.0*	41.9*
7	49	Male	0.39*	0.34*	2.04*	3.17*	11.5*	21.6
8	54	Male	0.33*	0.36*	2.20*	3.80*	10.5*	34.5*
9	44	Male	0.34*	0.34*	5.43*	4.25*	16.5*	30.3*
10	55	Male	0.34*	0.27*	2.85*	4.17*	11.0*	20.0
11	54	Female	0.38*	0.31*	2.61*	4.10*	6.50*	30.7*
12	54	Female	0.34*	0.34*	2.22*	3.49*	12.0*	48.4*

Note: * Indicates a risk warning

In the biochemical test, the standard range for the arterial stiffness index is 0 to 3. Except for Cases 1 and 3, all other test data are above 2, indicating a risk of disease. The standard range for the vascular stiffness index is 0 to 5. Except for Cases 1 and 3, all other test data are above 3, indicating a risk of disease. In the physiological data measurement, the standard values for visceral fat are below 9 for males and below 5 for females. The standard values for body fat are below 20% for males under 30 years old and below 23% for males over 30 years old, as well as below 24% for females under 30 years old and below 27% for females over 30 years old. According to the test results, Case 4 falls within the standard range for both visceral fat and body fat indicators, while Cases 7 and 10 still fall within the standard range for the body fat indicator. However, the data for other research cases are above the standard values, indicating an increased risk of disease.

After cross-referencing three sets of testing data from 12 research cases, this study identified a total of seven cases (numbers 2, 5, 6, 8, 9, 11, and 12) that consistently presented warning signals for the risk of developing hypertension. When comparing the results of artificial intelligence (AI) detection with biochemical test data, except for case number 1, the risk warning conclusions for the other 11 cases were consistent. The AI detection, when compared with the physical constitution data test, also yielded consistent risk warning signals, except for four cases (numbers 3, 4, 7, and 10) where differences were observed. The risk warning conclusions for the remaining eight cases were consistent. Similarly, when comparing the results of biochemical test data with the physical constitution data, consistent risk warning signals were identified. Except for five cases (numbers 1, 3, 4, 7, and 10) where differences were observed, the risk warning conclusions for the other seven cases were consistent.

5. CONCLUSION

The feasibility of utilizing artificial intelligence (AI) detection technology in predicting the risk of hypertension was assessed through cross-referencing three sets of testing data. The study found that the AI detection system yielded consistent risk warning conclusions for 7 cases, accounting for approximately 58% of the total. When comparing the AI detection data with the biochemical test data, 11 cases (approximately 92%) presented consistent risk warning conclusions. Similarly, when comparing the AI detection data with the physical constitution data, 8 cases (approximately 67%) showed consistent risk warning conclusions. The purpose of this study was to explore the feasibility of using AI detection for predicting the risk of hypertension. By utilizing modern medical reference testing methods such as biochemical tests and physical constitution data, a definition for preventive warning signals regarding hypertension risk was proposed. The various sets of testing data were cross-referenced to determine the consistency of the risk warning conclusions. The analysis revealed a high consistency of 92% between the AI detection data and the biochemical test values for hypertension risk warning. Since biochemical tests serve as an essential basis for diagnosing diseases in modern medicine, this result indicates the feasibility of using AI detection to provide risk warning signals for hypertension.

AI detection devices utilize novel detection technologies and large-scale databases to assess and collect data on the body's cellular energy response state. These devices acquire non-invasive testing data that does not harm the human body. By cross-referencing the data with computational modules and databases, they can infer the risk values associated with one's physical health. With the assistance of healthcare professionals, imbalances in the body can be adjusted in advance and with efficiency, leading to a significant reduction in disease risks. The advancement of AI detection technology enables systematic interpretation of diseases and the provision of medical advice by healthcare personnel, making precision medicine a hallmark of modern healthcare. Through AI-assisted detection, preventive medicine can also achieve precision health, which is an outcome of technological progress. Medical treatment and health prevention are two distinct fields. Medical treatment focuses on curing diseases and reducing their impact on the body, while health prevention aims to keep the body from falling ill. It involves maintaining a good physical condition despite life stress, dietary factors, and environmental influences. Therefore, harnessing AI technology to assist individuals in health prevention is the optimal way to enhance the quality of life.

Research limitations and future research directions

This study employed a case study approach to validate the feasibility of using AI technology to predict the risk of hypertension. It provides a simple and practical method for implementing preventive medicine while reducing the burden on healthcare resources. However, there are several limitations to consider. Each research case required simultaneous implementation of three testing methods and data collection, which could be affected by factors such as geographical location, instrument availability, and time constraints. Due to these limitations, this study focused on a feasibility assessment using a sample size of 12 research cases. For future research, it is recommended to expand the number of research cases and incorporate multiple verification methods for data collection and analysis. Additionally, exploring the application of AI technology in subcategory testing and analysis for the top ten diseases would be beneficial. This would aim to improve the frontline of the healthcare system by leveraging AI technology, making preventive medicine more comprehensive. By addressing these research directions, the integration of AI technology can further enhance the implementation of preventive medicine and contribute to a more robust healthcare system.

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