Background Investigating the factors affecting the number of hospitalization days of people with diabetes and with covid_19, a cross sectional study

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Research Article

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Abstract

Background

All over the world, the availability of hospital beds is one of the fundamental challenges of modern healthcare. On the other hand, the COVID-19 pandemic and underlying illnesses exacerbate this problem by increasing the number of hospitalization days. Therefore, this study aims to determine the factors that affect the number of days of hospitalization of people with diabetes and with COVID-19.

Method

The Artificial neural network models used information from 183 of 200 patients to train the multilayer feed-forward back-propagation algorithms in 70% of the data. Then, model performance was assessed by the remaining 30%. In model selection, we evaluated different combinations of connection, the number of hidden layers, and the number of neurons in each hidden layer.

Results

Based on results, biorhythm cycles (physical biorhythm and emotional biorhythm) and duration of symptoms had second and third importance after demographic factors (age, hypertension, addiction, and Q2 therapy) in predicting the duration of hospitalization. And the two variables of age (22.3%) and addiction (16.6%) contribute the most to importance in the demographic section.

Conclusion

So the number of hospitalization days decreased when the disease was controlled by providing adequate training for affected individuals, conducting regular and periodic screenings for early diagnosis of mental illnesses, consuming a high-fiber, low-carb, low-fat diet, receiving proper sleep training, utilizing cognitive behavioral therapies, participating in resistance sports. Additionally, replacing long-term care centers such as nursing homes where educated nurses provide services to patients, will impose less cost on the government as compared to hospitals.

Contribution of the paper

What is already known?

Currently studies have demonstrated that demographic variables such as age, o2 therapy, hypertension and addiction are correlated with the length of hospitalization and also previous studies have demonstrated that these factors predict the duration of hospitalization and increase the cost of the healthcare system.

What this study adds?
This study demonstrated that biorhythm cycles (physical biorhythm and emotional biorhythm) and duration of symptoms had second and third importance after demographic factors (age, hypertension, addiction, and Q2 therapy) in predicting the duration of hospitalization. And the two variables of age (22.3%) and addiction (16.6%) contribute the most to importance in the demographic section.

Introduction

All around the world, healthcare delivery systems need to control costs while maintaining high-quality services and improving access to them. Improving the health system's performance can enhance the level of well-being, the standard of living, and economic growth in any country)1). On the other hand, increasing healthcare costs, while being an important issue for employers and patients due to the payment of medical insurance and care, is also the main financial challenge for governments (2). The cost of hospital services is highest in modern healthcare delivery systems (3). The significant point to note is that providing hospital beds in developing countries has always been a challenge and is likely the most significant factor influencing the functioning of hospitals within a country (4). Otherwise, hospitals would not be able to operate with the necessary efficiency (5, 6).

The global spread of the Covid-19 disease has caused an increase in the demand for hospital beds (7, 8). Since the onset of the Covid-19 pandemic in Iran in March 2020, it has become apparent that the country has only 4.6 ICU beds available per 100,000 people. This, compared to 10.6 beds in South Korea and 22.8 beds in Saudi Arabia, indicates severe pressure on the healthcare system in the country (9). Meanwhile, in an epidemic like Covid-19, the prevalence of only 0.6% of the disease will exceed the capacity of ICUs in Iran (10, 11). The shortage and occupancy rate of hospital beds can be attributed to various factors, one of which is chronic diseases such as diabetes mellitus. This condition not only increases health costs but also leads to higher bed occupancy rates, longer hospital stays, and higher rates of readmission (12). Studies have shown that diabetic patients with uncontrolled levels of pro-inflammatory cytokines, especially interleukins 1 and 6 and tumor necrosis factor-alpha (TNF-α), and diabetes weaken the immune system by preventing neutrophil chemotaxis, phagocytosis, and intracellular killing of microbes (13, 14). So, the impaired immune response and irregular pro-inflammatory cytokine production in afflicted patients can significantly accentuate the severity of COVID-19 infection (15).

Additionally, the weakened immune system that people with diabetes experience as a result of chronic high blood sugar and severe fluctuations in glucose levels may impact patients’ ability to recover and respond to treatment. Previous studies have shown that several markers, such as C-reactive protein, fibrinogen, and D-dimer, were elevated in diabetic patients with COVID-19, leading to increased cytokine storms and worsening disease severity (16).

Diabetes triples the risk of negative consequences of covid-19 such as hospitalization, admission to the intensive care unit, intubation, and death. To address the issue of insufficient hospital beds and mitigate the occupancy of such beds due to diabetic patients afflicted with the coronavirus, an empirical
investigation was conducted to identify determinants that affect the length of hospital stay for said patients (17).

**Method**

In South Khorasan Province, the PCR test results of all patients were registered in the medical care monitoring center. After obtaining the code of ethics (IR.BUMS.REC.1400.251) from Birjand University of Medical Sciences Ethics Committee, we extracted data from positive test responses who have diabetes. Information was recorded for each patient including age, duration of symptoms, birthday, referral date for a PCR test, addiction (0 = no, 1 = yes), saturation by pulse oximetry (SPO2) in admission time, having high blood pressure (0 = no, 1 = yes), and duration of hospitalization. The emotional and physical biorhythms on admission day were computed by following formulas according to the number of days between birthday and admission time (t).

Physical rhythms = sin (2πt/23)

Emotional rhythms = sin (2πt/28)

These sine-wave structures include four following points in each cycle.

- **Active point:** the above of that cycle
- **Passive point:** the bottom of that cycle
- **Critical point:** where the cycle crosses the zero line from plus to minus
- **Zero point:** where the cycle crosses the zero line from minus to plus

Finally, the duration of hospitalization was estimated by age, SPO2, duration of symptoms, addiction, hypertension, and emotional and physical rhythms point

**Data analysis**

Topology, learning algorithm, and transfer function determine ANN model structures that simulate the function of the human brain (18). The ANN models can determine the algorithm between the inputs and output variables without limited underlying assumptions like normality, variance equality, etc (18). The online supervised learning method used information from 183 of 200 patients in the training and 17 remaining in validation data sets. In the present study, we used the topology of the multilayer perceptron (MLP), functions such as the hyperbolic tangent or sigmoid to connect input and hidden layers, and linear, hyperbolic tangent or sigmoid as the transfer function of the hidden and output layer with 2 neurons in the hidden layer. Then the effect of increasing hidden neurons to 40 was assessed in the selected model. We repeated each training epoch three times to avoid the effect of random assignment of weights and random correlations. The Statistical 100 Package for Social Sciences version 26 (SPSS Inc.,
Chicago, Illinois, USA) determined the input variables' importance in predicting hospitalization duration. The mean of three sums of square errors in both training and validation sets was used to model selection.

**Results**

The information of 200 people with diabetes was assessed. The participants had a mean age of 63.25 ± 16.08 years old. And almost patients were female (55%). Table 1 shows the sum of square errors in training and validation sets. The ANN models with hyperbolic tangent and sigmoid as the transfer function of the hidden and output layers (T-S) respectively had the highest precision overly. Table 2 reveals increasing hidden nodes to 10 improves this model's performance slightly. So, the best ANN model is T-S with 10 nodes in the hidden layer.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>sum of square error for different transfer function combinations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T-L</td>
</tr>
<tr>
<td>Training</td>
<td>89.87</td>
</tr>
<tr>
<td>Validation</td>
<td>10.28</td>
</tr>
</tbody>
</table>

T-L: hyperbolic tangent as the transfer function of the hidden layer and linear as the transfer function of the output layer

T-T: hyperbolic tangent as the transfer function of both the hidden and the output layers

T-S: hyperbolic tangent as the transfer function of the hidden layer and sigmoid as the transfer function of the output layer

S-L: sigmoid as the transfer function of the hidden layer and linear as the transfer function of the output layer

S-T: sigmoid as the transfer function of the hidden layer and hyperbolic tangent as the transfer function of the output layer

S-S: sigmoid as the transfer function of the hidden layer and sigmoid as the transfer function of the output layer

<table>
<thead>
<tr>
<th>Table 2</th>
<th>sum of square error for different numbers of neurons in the hidden layer</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Training</td>
<td>1.85</td>
</tr>
<tr>
<td>Validation</td>
<td>0.21</td>
</tr>
</tbody>
</table>

The demographic section (age, hypertension, addiction, and Q2 therapy) had the highest importance in predicting the duration of hospitalization (Fig. 1). The two variables of age (22.3%) and addiction (16.6%)
contribute the most to importance in this section (Fig. 1). And, the sections of the biorhythm cycles (physical biorhythm and emotional biorhythm) and clinical (duration of symptoms) had second and third importance after demographic factors. Physical and emotional biorhythms had the same importance in the biorhythm cycles.

**Discussion**

During the post-modern era, providing financial coverage for health expenses, ensuring adequate insurance policies, providing adequate hospital beds, and maintaining quality health care services, in general, have been among the foremost challenges faced by modern governments. In recent years, with the advent of the COVID-19 pandemic and the escalating prevalence of chronic ailments, such as diabetes, these challenges have assumed greater dimensions(1–4). International studies indicate that 4% of the population who are admitted to hospitals annually consumes half of the health resources. Additionally, inpatient services account for 37% of total indirect treatment costs, while more than 70% of direct treatment resources are allocated toward patient care. For instance, in Iran, over 4.6% of the GDP is allocated to healthcare expenditures, with approximately 40% of the government's healthcare spending going towards hospital care (19). In India, the cost of ICU beds accounts for 20–40% of the total cost of hospital beds (20). Therefore, over the past two decades, high-income and developed countries have also reduced the capacity of hospital beds, because in addition to being costly, the overcrowding of the hospital environment, due to high medical errors (21) and In this study, in addition to the factors studied in previous studies, the effect of biorhythm (physical and emotional) on predicting the number of days in diabetic patients who impose a high therapeutic burden on the treatment system due to the type of disease was investigated. It was noticed that this factor had a significant impact on the number of days of hospitalization of patients. The impact of biorhythms on various indicators such as the occurrence of occupational accidents, the physical strength of female volleyball players, and the muscle strength of athletes have been found to be significant in past research (22–24). On the other hand, sleep quality, nutrition, psychological variables, and exercise affected biorhythm (25). Studies have shown that the glycemic index affects psychological variables such as depression, diabetes distress, etc (26).

Therefore, it seems that firstly controlling glycemic index not only directly affects the control of short-term and long-term complications of diabetes but also by influencing psychological variables and eventually biorhythm, it will be able to have a significant impact on disease control, thus by reducing the hospitalization period of patients, it will reduce the burden of the disease on the healthcare system. In the second instance, it is possible to increase the awareness of patients by providing appropriate training, thereby helping to reduce the stress patients (27). According to the recommendation of the American Diabetes Association, implementing regular and routine screenings to diagnose early mental health conditions, such as anxiety, depression, diabetes distress, and others, can effectively reduce their impact on biorhythm and decrease the number of days spent hospitalized (26). Moreover, weight loss, proper sleep training, utilization of cognitive behavioral therapies that are effective in improving the quality of sleep in patients, and adoption of a high-fiber, low-carbohydrate, low-fat, or vegetarian or Mediterranean diet, represent other efficacious methodologies for regulating the biorhythm and minimizing the duration
of hospital stays(27, 28). Since exercise and physical activity are effective in regulating the biological biorhythm, it is recommended that aerobic and resistance exercises be considered for people with diabetes(28).

The present study showed that age, after the biorhythm, is the most important factor in predicting the number of hospitalized days for diabetic patients with COVID-19. Other studies have also confirmed the effect of the age factor on the length of hospitalization for diabetic, cardiac, COVID-19 patients, and the elderly(29–33) This is happening while aging populations represent one of the most important features of the 21st century. In the near future, almost all developed and developing countries will experience a rapid expansion of their aging and elderly populations. Consequently, as the duration of hospitalization increases, there will be a corresponding need to expand hospital bed capacity (34). Therefore, to decrease expenses and mitigate other issues, it is recommended to leverage the United States' experience in this domain and institute long-standing care facilities encompassing nursing homes, assisted living and retirement centers, rehabilitation centers, daycare establishments, and palliative care services. Furthermore, it is suggested to substitute hospitals with nursing homes that are staffed with knowledgeable and skilled nurses, which will effectively reduce overall government costs (21).

According to the results of this study, the length of illness and addiction were ranked third and fourth, respectively, as the most significant factors contributing to the occupancy of hospital beds. In other words, it is advisable for sick individuals to on time seek medical care to lessen the strain on the healthcare system. On the other hand, to prevent addiction, it's necessary to raise awareness among individuals, families, and society in general (35, 36) Measures should be taken to prevent easy access to drugs for individuals (37) not only to reduce the adverse societal consequences of addiction but also to decrease the financial burden imposed on the healthcare system by reducing hospital bed occupancy.

**Limitations**

First limitation was covid-19 pandemic which made it difficult to collect data which was solved with the cooperation of Birjand University of Medical Sciences. The second limitation of the study was that since it was a cross-sectional study, no causal conclusions could be drawn from it. The third limitation of the study was that since the data of the study is related to a province in Iran, one should be careful in generalizing the results.

**Declarations**

Ethical Approval: The study received approval from Birjand University of Medical Sciences Ethics Committee. (IR.BUMS.REC.1400.251)

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Availability of data and materials:

We declare that all of authors have accessed to data.

References


Figures
Figure 1

The factor importance from the selected Artificial Neural Network.