Research on the adverse reactions of medicines based on deep learning models

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Abstract. The frequent occurrence of adverse drug reactions in medical events has become the focus of increasing attention in various countries. The quality of adverse reaction reports is the basis for medical risk assessment and analysis. Only by obtaining high-quality and valuable information can scientific treatment be carried out. Analysis, however, at present, there is no quantitative analysis on the relationship between the factors affecting adverse drug reactions and the degree of adverse reactions. There are few reasonable mathematical models. This article adopts the method of deep learning to establish a "human-machine material law ring". "The mathematical model between the five factors and the degree of adverse drug reactions in China analyzes adverse drug reactions in China, and provides effective guidance for reducing drug accidents and improving China's adverse drug reaction monitoring system.

1. Introduction

Adverse drug reaction (ADR) is an important part of drug safety monitoring. According to the first paragraph of Article 63 of the "Administrative Measures for Adverse Drug Reaction Reporting and Monitoring", an adverse drug reaction refers to "the occurrence of qualified drugs under normal usage and dosage. Of adverse reactions that have nothing to do with the purpose of medication." In recent years, with the development of ADR monitoring, the number of reports has been increasing, the proportion of new and serious ADR and reported events has also been increasing. The overall quality and availability of ADR reports in China has been continuously improving [1]. According to the "Current situation and Prospect of ADR monitoring in China" published by Liu Yulong et al., it is pointed out that ADR monitoring implemented in China in recent years is mostly passive monitoring, that is, relying on medical staff to find ADR cases. There are many problems in this model, such as easy underreporting and incomplete reporting information, which aggravates the workload of medical staff. Therefore, the limitations are relatively large, and reported cases only account for a part of the actual adverse drug events (ADE). Therefore, it is proposed to explore the active monitoring development model of ADR in China to report and monitor ADR [2]. In 2018, Bao Huiling analyzed the factors influencing the quality of adverse drug reaction reports in China using the total quality management
theory, the five-factor theory of "human-machine material law" and the analytic hierarchy process, and screened and ranked the importance. The results showed that the order of importance of factors affecting the quality of adverse drug reaction reports is personnel factors, method and regulatory factors, software and hardware factors, material factors, and environmental factors. In addition, based on this, the methods and Suggestions for improving China's adverse reaction reporting system and improving the quality of adverse reaction reporting are proposed [3]. In March 2020, Chen Liye and others explored an easy-to-use long-term method for evaluating the quality of adverse drug reaction case reports, and carried out a more scientific evaluation method for case reports, using literature analysis methods and drawing on existing evaluation methods at home and abroad. Use the expert consultation method to establish the index weight, and use the analytic hierarchy process to construct the quality evaluation system of the adverse drug reaction case report. It also shows that the adverse drug reaction case evaluation system established by the multiplicative calculation feature is scientific and reasonable, which can facilitate the dynamic management of the content of the adverse reaction report, and can further establish an efficient scientific evaluation [4]. However, the current analysis of the exact relationship between adverse drug reactions and their factors does not have a good physical model, and it is impossible to judge the relationship between adverse drug reactions. Therefore, this article aims to establish a reliable and reasonable model to analyze adverse drug reactions and their factors. The relationship between the influencing factors will help us more effectively and timely control the risks of medication and ensure the safety of the public's medication.

2. Principles and Algorithms
The basic flow chart is as follows (see figure 1).
Figure 1. Prediction method and flow chart of adverse drug reactions in China based on deep learning model.
The deep learning method adopted in this paper was first proposed by scholar Hinton in 2006 and explained two basic ideas: First, increasing the number of hidden layers can improve the learning ability of deep learning network. Secondly, the training time of the multi-layer system is longer and more difficult, but the training difficulty and time are reduced if the training is done separately. Deep learning can automatically extract features from data samples, reduce the process of artificial feature construction and has more advantages in the processing of large data sets. In recent years, good research has been achieved in the fields of image classification, speech recognition, and natural language processing. As a result, there are common structures such as recurrent neural network, convolutional neural network, and recurrent neural network. As far as its application in natural text and other sequence problems is concerned, the recurrent neural network structure has certain advantages.

The three common algorithms for deep learning include: convolutional neural network, recurrent neural network, and recurrent neural network.

The cost function is:

$$L_2 = \frac{1}{2n} \sum_x \| y(x) - a(x) \|^2$$

Where, \(n\) represents the number of samples, \(x\) is the input sample point, \(y(x)\) is the actual output value, \(a(x)\) is the output value of the neural network, and \(L\) represents the number of layers of the neural network.

The error equation of the output layer is:

$$\frac{\partial C}{\partial a_j} \sigma'(z_j)$$

3. Experimental results and discussion

3.1. Experimental design

This article collects the symptoms of some common drug adverse reactions in the domestic market, and classifies the severity of adverse drug reactions according to the manifestations of these symptoms. 1 to 4 are mild, and the symptoms are mild and undeveloped, and 5 to 7 is moderate, which is manifested in the symptoms of adverse reactions that have damage to vital organs or system functions, and 8 to 10 is severe, which is manifested in severe damage to the adverse reactions, resulting in disability or shortening or life-threatening. Taking the 10-point scale as the evaluation criterion of severity and as the output vector of deep learning is conducive to the establishment of deep learning model and intuitive judgment of subsequent prediction results. At the same time, the five-factor theory of "man-machine material method loop" is applied, and personnel factor, hardware and software factor, material factor, method regulation factor and environment factor are taken as the input vectors of deep learning. See Table 1 for specific data.

Table 1. Samples of deep learning training for judging the degree of adverse drug reactions.

| Five factor drug name | Personnel factor | Hardware and software factors | Material factor | Method regulatory factors | Environmental factor | Degree of adverse reactions (Ten point system) |
|-----------------------|-----------------|-------------------------------|----------------|--------------------------|----------------------|---------------------------------------------|
| Rosiglitazone         | 91              | 1                             | 1              | 12                       | 1                    | 5                                           |
| Yinzhihuang Injection | 78              | 1                             | 1              | 10                       | 0                    | 10                                          |
| Compound amino acid injection | 100 | 1 | 1 | 0.92 | 8 | 1 | 4 |
|-------------------------------|-----|---|---|------|---|---|---|
| Levofloxacin                  | 67  | 1 | 1 | 1.31 | 12| 1 | 8 |
| Azithromycin                  | 89  | 1 | 1 | 0.76 | 15| 1 | 7 |
| Cefatriaxone                  | 72  | 1 | 1 | 0.79 | 12| 1 | 5 |

In Table 1, each factor in the five-factor theory of "man-machine material method loop" is subdivided into multiple criteria layers. It can be divided into the number of full-time staff, whether there is ADR database, whether there is prescription drug, contents of the report form, implementation rules and whether there is monitoring leading group. The detailed official reports provide strong support for the data sources in figure 2.

![Figure 2](image-url)

**Figure 2.** The relationship between each criterion layer and the degree of adverse reactions.

The test process of ADR based on deep learning was carried out on the above data, and the numerical values of the training model were obtained. The results showed that there was a clear inverse relationship between the degree of ADR and the method criteria among the five factors. When the implementation rules of the drug are clear, the adverse reaction degree of the drug is weak, and when the implementation rules are vague, the adverse reaction degree of the drug is strong. On the contrary, the degree of adverse reactions was consistent with the content of the report form. While other influencing factors have less influence on the degree of adverse reactions, and the former is more caused by the latter. For example, the relationship between prescription drugs and the degree of adverse reactions is reflected in the reality. It is precisely because of the serious adverse reactions of drugs that the audience of drugs must carefully choose to take them, which is the reason why they are included in the prescription drugs.

### 3.2. Results and discussion

Table 2 shows the training results of the above data on the basis of deep learning. It can be found that the relative error of the prediction results of Yinzhihuang injection and azithromycin is the largest, reaching 9%. The reasons may be the following: 1. The content of the report form is based on the number of words in the rosiglitazone report form. The level of detail varies, but the specific effective content has not been analyzed. The fewer words, the less effective content, and the greater the error. The content of the report form of Yinzhihuang injection is 0.89, and its relative error is -0.09; 2. The severity of adverse reactions is not detailed or rigorous; especially for the severe and moderate boundaries. Therefore, the following suggestions are made for the improvement of the model: use the category as the content of the report form, and do a good job of classification calculation; the degree of adverse reaction is then refined, and the severity of each symptom is judged as a standard. The results of this model show that the relative error between the calculated value and the actual value is small, and the design model is good.
Table 2. Comparison of adverse drug reaction degree and deep learning predictive value

| Name of drug                  | Degree of adverse reactions | Calculated value | Relative error |
|-------------------------------|----------------------------|------------------|----------------|
| Rosiglitazone                 | 5                          | 4.90             | 0.02           |
| Yinzhihuang Injection         | 10                         | 10.95            | -0.09          |
| Compound amino acid injection | 4                          | 4.33             | -0.07          |
| Levofloxacin                  | 8                          | 8.52             | -0.06          |
| Azithromycin                  | 7                          | 7.71             | -0.09          |
| Cefatriaxone                  | 5                          | 4.66             | 0.07           |

4. Conclusions

In this paper, a deep learning model was established based on the data of adverse drug reaction degree and its influencing factors. The basic process is as follows: define relevant concepts and establish prediction model, carry out data processing, set up node number, network layer number loss function, threshold value and network super parameters. Conduct the training of the whole model to verify the generalization ability of the model and test and evaluate the performance of the model, and finally use it to process the data.

According to the results of the model, the training results of the model are good, and it plays an important role in judging the degree of adverse drug reactions. Based on these five factors, some Suggestions are put forward to improve the ADR monitoring system and improve the quality of ADR reports in China. First, investment in scientific research should be strengthened to improve the professional knowledge and skill proficiency of researchers and improve their professional ability. Second, it is necessary to improve relevant regulations and implementation rules, improve management measures, improve content of measures, establish a reward and punishment system, require all kinds of units to make the most detailed reports, and set up electronic files; Third, improve the publicity, change the public's perception of adverse drug reactions, and establish a complete and convenient public feedback channel for adverse drug reactions.

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