Appendix 3

The multi-layer perceptron clinical prediction models

To integrate various clinical information and improve prediction accuracy while preventing the impact of scale differences between different types of data on model precision, this study first normalized all data according to their types, as shown in the formula below.

$$Z=(X-\mu)/\sigma$$

Z-score normalization: This method transforms the data into a standard normal distribution, where the mean is 0 and the standard deviation is 1. The formula is as follows: where X is the original data point, μ is the mean of the data, and σ is the standard deviation.

The core of the model includes two innovative MLP modules: the Attribute-Mixing MLP and the Case-Mixing MLP. The Attribute-Mixing MLP operates across all attributes, capturing complex interactions and associations between different attributes, while the Case-Mixing MLP strengthens the integration of features across different cases, thereby enhancing the model's ability to learn from variations between cases. Additionally, by employing layer normalization and residual connections, we enhanced the network's training stability. Each MLP module consists of several fully connected layers and nonlinear activation functions, specifically designed to reveal the deep nonlinear structures within the input data. During the training phase, we also introduced dropout and data augmentation strategies to effectively suppress overfitting. The construction of this framework fully leverages the complexity of medical data, significantly improving the accuracy and efficiency of the diagnostic process.