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T1 _____	**1924935**	F1 _____
T2 _____		F2 _____
T3 _____	Problem Chosen	F3 _____
T4 _____	**C**	F4 _____

2019
MCM/ICM
Summary Sheet

Multi-algorithm Combined Model for Dealing with Abuse of Opioids

Summary

The abuse of addictive opioids has brought unprecedented challenges. We conducted an analysis to solve this problem better.

For part 1, we first refer to **the SIR model** and propose a propagation characteristic analysis model. **The result is that** synthetic opioids and heroin both tend to grow in high-volume areas and spread to low-volume areas. Then, we combined **the entropy method** and **the ARIMA model** to propose a predictive model for drug abuse in the state. To analyze the county more easily, we use **principal component analysis** to analyze it. **The result is:** in 2018,HAMILTON(39061) is the most prone to abuse of synthetic opioids, CUYAHOGA(39035) is second, MONTGOMERY(39113) is third; MONTGOMERY(39113) is the most prone to heroin abuse, followed by LAKE(39085), and the third is LUCAS(39095).When this situation continues, after 2022, when the total number of drug abuses in Ohio (39) reached **the threshold** of 275,040, both synthetic opioids and heroin suddenly exploded.

For part 2,through **the BP neural algorithm**,we find several items with larger weights in each indicator. **The result is:**divorced men, low-educated people, and separated men likely that they are likely to abuse opioids.

For Part 3,we have proposed some solutions to the opioids crisis and verified the feasibility of these solutions through the model.

In addition, we also verified the model. When using 2017-2016 data to predict 2017, **the average relative error is 7.757%**, and the accuracy of the model is high.

We also analyzed the advantages and disadvantages of the model and gave the improvement aspects.

Keywords: Synthetic Opioids and Herion;ARIMA;BP neural algorithm;Opioids Crisis

Contents

1 Introduction

1.1 Background

The abuse of opioids is increasingly becoming a cause of hindering the health of the American people.Even economically, opioid may become a lack of talent in certain important neighborhoods of the United States by making people with high academic qualifications addicted, thereby affecting the economy.At the same time, a large number of opioid addicts will also put a heavy pressure on the medical system.

Therefore, it is necessary to find out the causes and objects of abuse of opioids and stop such abuse in time.

1.2 Restatement of the Problem

In the face of the increasingly serious opioids abuse situation, combined with the existing information, considering the five states of Ohio, Kentucky, West Virginia, Virginia, and Pennsylvania,we need to complete the following:

1. Use the data provided by the NFLIS to create a mathematical model that describes the propagation characteristics of synthetic opioids and heroin over time between the five states and their counties.At the same time, identify the locations in the five states that may have begun to use specific opioids.
   After that,given a threshold, elaborate what will happen when this threshold is reached ,which the US government should be concerned , and use the model to predict when and where the threshold will be reached.
2. Use the data provided by the U.S. Census socio-economic to improve the previous model and use reasonable assumptions to explain which factors are related to the abuse of opioids.
3. Combine the results of previous models to determine a viable solution to the opioid crisis. Also check the feasibility of the program and identify factors that may lead to success or failure.

2 Assumptions and Justifications

We make the following assumptions to approximate and simplify the problem.

1. **The change of data with time is regular, and this law does not change in a short time.** This is the most fundamental condition for making predictions.

2. **The reported data is the total occurrence value, that is to say, there is no case that drug abuse has occurred and is not reported.**Because the reported drug abuse should be positively related to what actually happened, so to some extent, the reported drug abuse can be used instead of the actual value.

3. **Ignore the differences in the spread of different drugs between different regions.**This condition will make the calculation of the model simpler and easier to understand.

4. **Drugs produced in the region are allocated to local and other regions according to a fixed ratio.**This condition simplifies the calculation of the model.

5. **If the United States makes adjustments, it will only affect the production of drugs.**This condition makes the model more reasonable, because it is also the main regulation of the state in the actual operation process.

Besides these general assumptions, there are also hypotheses we make for the specific models.We will present and discuss them inspecific model.

3 Symbol Description

Table 1: Notations

Symbol	Meaning
$S(t)$	the Amount of drug
$P(t)$	the Amount of drug Produced
$I(t)$	the Number of drugs Shipped from other Regions
ε	the Adjustment Factor
θ	the Acceptance Rate of drugs
η	The Rate of Adjustment
C	Contribution Rate
W	Weight or Weight Matrix

4 Model 1:Propagation Analysis and Prediction Model

4.1 Propagation Analysis Model based on SIR model

In this model, we add a new hypothesis:**This year's local production value is only adjusted by the local occurrence value of the previous year, ignoring the influence of other years and other regions.**This condition makes us not have to consider the complicated calculations brought by multi-regional effects.

4.1.1 Preparation of Analysis Model

According to the Wikipedia[1], we classify opioids, the results are shown in Table 11 (in the appendix).

According to the classification method of Table 1, the number of synthetic opioids and heroin in each state and county can be obtained separately. Here, we present the synthetic opioids in Ohio (Table 2) and the heroin situation in Kentucky (Table 3). In each table, we consider the number of abused opioids

Table 2: The situation of Synthetic Opioids in 39(Ohio)

Year	Synthetic Opioids	Total	Proportion
2010	757	70999	0.01
2011	636	71282	0.01
2012	525	85415	0.01
2013	587	93747	0.01
2014	1942	101423	0.02
2015	5250	109150	0.05
2016	12867	115276	0.11
2017	23437	119349	0.20

Table 3: The situation of heroin in 21(Kentucky)

Year	Herion	Total	Proportion
2010	629	29588	0.02
2011	899	28285	0.03
2012	2320	27502	0.08
2013	4175	26820	0.16
2014	4362	27077	0.16
2015	4045	25811	0.16
2016	3716	26530	0.14
2017	3231	28870	0.11

(synthetic synthetic opioids or heroin), the total amount of drug use in the year, and the proportion between the two as a function of time.

Next, we discuss the propagation characteristics of synthetic opioids and heroin.

4.1.2 Establishment of Analysis Model

Suppose S(t) is the amount of drug in a particular region, P(t) is the amount of drug produced in the region, and the ratio of local to other regions is assumed to be m: (1-m).

I(t) is the number of drugs shipped from other regions.

ε is the adjustment factor of national macro policy to production. θ is the acceptance rate of drugs produced in other regions. The rate of adjustment of the number of local drugs in the previous year to this year's production is η.

Through the principle of the SIR model[2], the relationship between the production amount P and the local drug amount S is obtained as Equation (1)

$$\begin{cases} P(t) = S(t-1) \cdot \frac{1+\eta}{1+\varepsilon} \\ S(t) = mP(t) + \theta I(t) \end{cases} \tag{1}$$

By Equation (1) , there is:

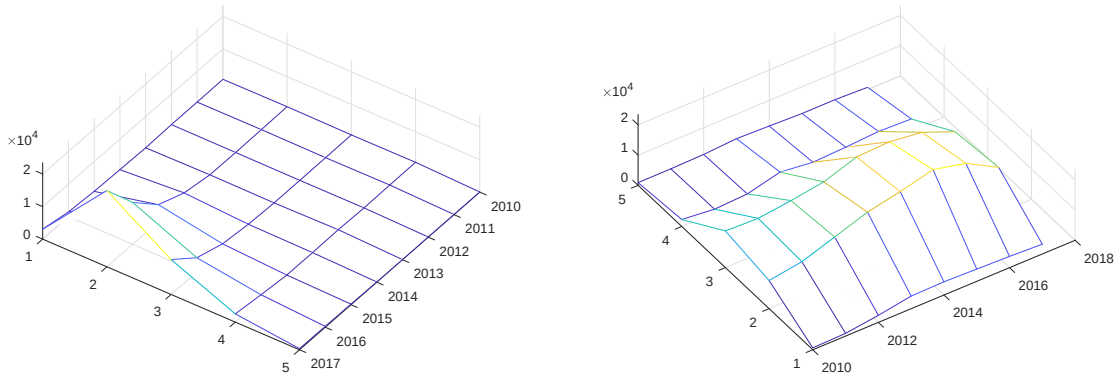
$$S(t) = S(t-1) \cdot m\frac{1+\eta}{1+\varepsilon} + \theta I(t) \tag{2}$$

Differential for Equation (2), there is:

$$\frac{dS(t)}{dt} = m\frac{1+\eta}{1+\varepsilon}dS(t-1) + \theta \cdot \frac{dI(t)}{dt} \tag{3}$$

4.1.3 Results of Analysis Model

With Equation (3), the data is brought into MATLAB to draw a 3D surface map. Among them, the propagation of synthetic opioids and heroin between states is shown in Figure 1.In the figure, 1-5 represents the corresponding State (21, 39, 42, 51, 54).



Synthetic Opioids Heroin

Figure 1: Propagation Characteristics of Opioids

It can be seen from the figure that the synthetic opioid and heroin have similar propagation characteristics, which are transmitted from a high concentration area to a low concentration area, while the concentration of high concentration area tends to be higher.

4.2 Prediction Model Combined with Entropy Method and ARIMA

With the propagation model, we get the propagation properties of opioids. From this, we can predict where the abuse of opioids is most likely to occur and calculate the threshold.

4.2.1 Establishment of Prediction Model

Entropy Method In information theory, entropy is a measure of uncertainty[3]. The larger the amount of information, the smaller the uncertainty and the smaller the entropy. According to the characteristics of entropy, we can calculate the degree of dispersion of a project by calculating the entropy value. The greater the degree of dispersion of the project, the greater the impact on the comprehensive evaluation.

Select n states, m years, then x_{ij} is the value of the i-th state of the j-th year.

Standardize each year:

$$x'_{ij} = \left[\frac{|x_{ij}| - \min\left(|x_{1j}|, |x_{2j}|, \cdots, |x_{nj}|\right)}{\max\left(|x_{1j}|, |x_{2j}|, \cdots, |x_{nj}|\right) - \min\left(|x_{1j}|, |x_{2j}|, \cdots, |x_{nj}|\right)}\right] \times 100 \quad (4)$$

Calculate the proportion of the i-th state in the year j:

$$p_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \quad (5)$$

Calculate the entropy of the j-th year:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln\left(p_{ij}\right) \quad (6)$$

where $k = \frac{1}{\ln(n)}$.
Calculate the coefficient of variation for the j-th year. For the j-th year, the larger the variation, the smaller the entropy value. Define the coefficient of variation:

$$g_j = \frac{1 - e_j}{m - E_e} \quad (7)$$

where $E_e = \sum_{j=1}^{m} e_j$.
Calculate the weight:

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j} \quad (8)$$

Calculate the score for each state:

$$s_i = \sum_{j=1}^{m} w_j \cdot p_{ij} \quad (9)$$

ARIMA ARIMA is a common prediction method for analyzing time sequence[4]. The model structure of ARIMA(p,d,q) is:

$$\begin{cases} \Phi(B)\nabla^d y_t = \Theta(B)\varepsilon_t \\ E(\varepsilon_t) = 0, Var(\varepsilon_t) = \sigma_\varepsilon^2, E(\varepsilon_t\varepsilon_s), \quad s \neq t \\ E(y_t\varepsilon_t) = 0, \qquad\qquad \forall s < t \end{cases} \tag{10}$$

where $\nabla^d = (1-B)^d$.
$\Phi(B) = 1 - \theta_1 B - \ldots - \theta_q B_q$ is the autoregressive coefficient polynomial in a stationary reversible ARMA(p,q) model;
$\Theta(B) = 1 - \theta_1 B - \ldots - \theta_q B_q$ is the moving smoothing coefficient polynomial in the stationary reversible ARMA(p,q) model.
And $\{\varepsilon_t\}$ is a zero mean white noise sequence.

Prediction Model In order to reduce the error, we use the entropy method to predict the weight of each state (county) and use ARIMA to predict the weight. Finally, a comprehensive analysis identifies the areas with the highest probability.

In the analysis of the proportion of the county, since there are many counties in each state, we use principal component analysis to analyze[5]:

If the sample data X is an n×p matrix:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix}$$

Standardize the raw data:

$$x_{ij}^* = \frac{x_{ij} - \bar{x}_j}{\sqrt{Var(x_j)}} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, p) \tag{11}$$

where $\bar{x_j} = \frac{1}{n}\sum_{i=1}^n x_{ij}; Var(x_j) = \frac{1}{n-1}\sum_{i=1}^n (x_{ij} - \bar{x})^2 (j = 1, 2, \ldots, p)$

Calculating the sample correlation coefficient matrix: $R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \vdots & \vdots & & \vdots \\ r_{p1} & r_{p2} & \cdots & r_{pp} \end{bmatrix}$

$$r_{ij} = Cov(x_i^*, x_j^*) = \frac{\sum_{k=1}^n (x_i^* - \bar{x}_i)(x_j^* - \bar{x}_j)}{n-1}, n > 1 \tag{12}$$

Calculating the eigenvalue $\lambda_1, \lambda_2, \ldots, \lambda_p$ of the correlation coefficient matrix R and the corresponding eigenvector $a_i = (a_{i1}, a_{i2}, \ldots, a_{ip}), i = 1, 2, \ldots, p)$ Calculate the contribution rate of each principal component

$$C_i = \frac{\lambda_i}{\sum_{i=1}^p \lambda_i} \tag{13}$$

Calculate the principal component score in the following form

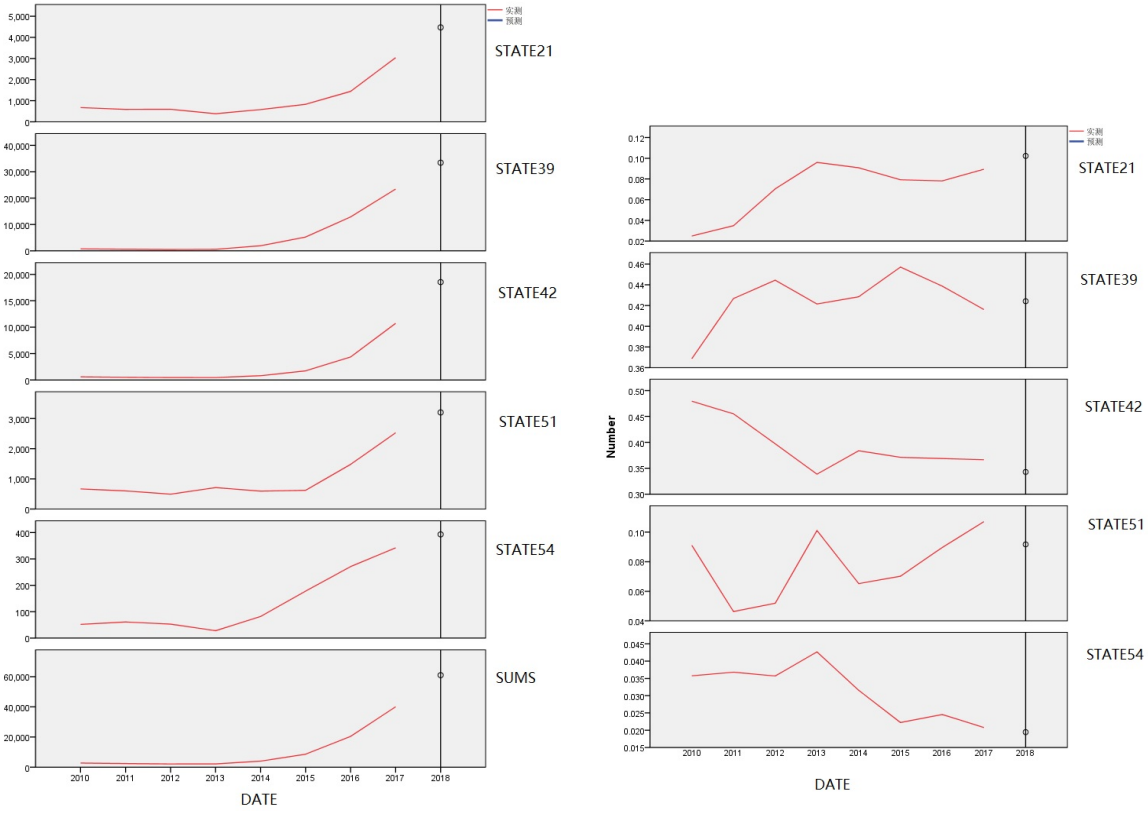
$$F = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1k} \\ f_{21} & f_{22} & \cdots & f_{2k} \\ \vdots & \vdots & & \vdots \\ f_{n1} & f_{n2} & \cdots & f_{nk} \end{bmatrix}$$

$$f_{ij} = a_{j1}x_{i1}^* + a_{j2}x_{i2}^* + \cdots + a_{jp}x_{ip}^*, i = 1, 2, \ldots, n; j = 1, 2, \ldots, k \tag{14}$$

4.2.2 Results of Prediction Model

The entropy is calculated by EXCEL, and the Proportion is predicted by SPSS. The results of States are shown in Figure 2 and Table 4,5, respectively. Where $W = Proportion \times Entropy$.(When predicting the proportion of synthetic opioids, we predict the number of each states and total number at the same time, and finally obtain the ratio. When predicting the proportion of heroin, it is directly predicted. These two methods are essentially identical.)

As can be seen from the table, 39(Ohio) is the most likely state of drug abuse in the future, both in synthetic opioids and in heroin. Thus, principal component



Synthetic Opioids Herion

Figure 2: Prediction Results of ARIMA Model

Table 4: Prediction Model Results for each State,Synthetic Opioids

State	21	39	42	51	54
Proportion	0.0733	0.5478	0.3039	0.0525	0.0064
Entropy	2158.0111	16629.7353	7160.8756	1876.2172	278.5188
W	158.1863	9110.2279	2176.2715	98.4750	1.7940

Table 5: Prediction Model Results for each State,Herion

State	21	39	42	51	54
Proportion	0.0753	0.4290	0.3864	0.0788	0.0305
Entropy	3717.9331	19318.2933	16490.7247	3570.1504	1321.3134
W	280.0756	8288.3012	6371.9830	281.1815	40.2644

analysis was applied to Ohio.
The results are shown in the Table 6,7.

Table 6: Prediction Model Results for each County in 39,Sythetic Opioids

W	604	1899	2455	5746	361	667	1437	560	14139	174
County	39001	39003	39005	39007	39009	39011	39013	39015	39017	39019
W	2018	7791	5944	2179	3565	68	567	88722	1614	1259
County	39021	39023	39025	39027	39029	39031	39033	39035	39037	39039
W	1139	4110	998	2441	18799	263	1685	1063	5880	721
County	39041	39043	39045	39047	39049	39051	39053	39055	39057	39059
W	117271	3064	244	42	-11	1287	287	76	2191	629
County	39061	39063	39065	39067	39069	39071	39073	39075	39077	39079
W	254	346	25098	1119	1448	1606	12825	4654	263	6857
County	39081	39083	39085	39087	39089	39091	39093	39095	39097	39099
W	1747	4009	35	644	4526	189	53030	66	309	1037
County	39101	39103	39105	39107	39109	39111	39113	39115	39117	39119
W	221	531	103	113	245	126	3676	1421	12	2454
County	39121	39123	39125	39127	39129	39131	39133	39135	39137	39139
W	1380	1126	2517	748	2714	13817	14366	9577	827	379
County	39141	39143	39145	39147	39149	39151	39153	39155	39157	39159
W	763	14	4846	1114	3158	-2	1355	163		
County	39161	39163	39165	39167	39169	39171	39173	39175		

Similarly, it can be seen from the table that HAMILTON(39061) is the most prone to abuse of synthetic opioids, CUYAHOGA(39035) is second, MONTGOMERY(39113) is third; MONTGOMERY(39113) is the most prone to heroin abuse, followed by LAKE(39085), and the third is LUCAS(39095).

At the same time, when we continue to use this model to predict, we found that after 2022, when the total number of drug abuses in Ohio (39) reached 275,040, both synthetic opioids and heroin suddenly exploded. So, we think 275040 is the threshold.

Table 7: Prediction Model Results for each County in 39,Herion

W	224.8	73.9	204.6	134.0	-131.7	181.6	-109.7	91.2	91.4	15.6
County	39001	39003	39005	39007	39009	39011	39013	39015	39017	39019
W	148.3	218.8	-237.2	-32.2	65.7	-112.7	68.5	-1577.2	-157.2	-180.7
County	39021	39023	39025	39027	39029	39031	39033	39035	39037	39039
W	63.2	-418.3	723.3	-206.2	-973.5	-75.4	-309.8	-8.1	105.7	36.6
County	39041	39043	39045	39047	39049	39051	39053	39055	39057	39059
W	531.4	-52.2	211.4	-18.6	-2.6	132.5	59.6	-10.2	55.3	266.4
County	39061	39063	39065	39067	39069	39071	39073	39075	39077	39079
W	27.7	123.1	1185.9	57.6	635.4	86.3	319.1	956.4	-75.4	338.7
County	39081	39083	39085	39087	39089	39091	39093	39095	39097	39099
W	138.4	-101.3	121.5	147.2	30.2	-93.2	3567.9	12.9	-60.9	-276.1
County	39101	39103	39105	39107	39109	39111	39113	39115	39117	39119
W	-45.2	35.8	17.3	53.3	-80.9	74.1	-10.2	89.0	22.2	-129.2
County	39121	39123	39125	39127	39129	39131	39133	39135	39137	39139
W	-16.7	106.1	632.7	-53.2	248.7	-952.8	-315.6	33.0	32.7	162.8
County	39141	39143	39145	39147	39149	39151	39153	39155	39157	39159
W	30.8	48.1	439.9	106.6	-170.0	22.1	-56.4	-122.8		
County	39161	39163	39165	39167	39169	39171	39173	39175		

5 Model 2:Weight Analysis Model

5.1 Preparation of Model 2

On the basis of the first part, we need to consider the U.S. Census socio-economic data. Taking into account the impact of economy, education, marriage and other factors,we selected 19 indicators, including Total households, Nonfamily households, MARITAL STATUS, EDUCATIONAL ATTAINMENT, etc.

5.2 Establishment of Model 2

With Model 1, we predict that the data for 2018 is shown in Figure 3.

The data matrix is processed by interpolation and compared with the data of previous years to obtain the target matrix of BP neural network.

With the NNtool toolbox of MATLAB, a weight matrix W of 1×19 is obtained.

As shown in Figure 4,the hidden layer has 10 neurons and the output layer has 1 output neuron. We subdivide the data given by Part 2 and get the training matrix of the neural network we built.

For the neurons of the hidden layer, we get the weight matrix $W1(10 \times 19)$:

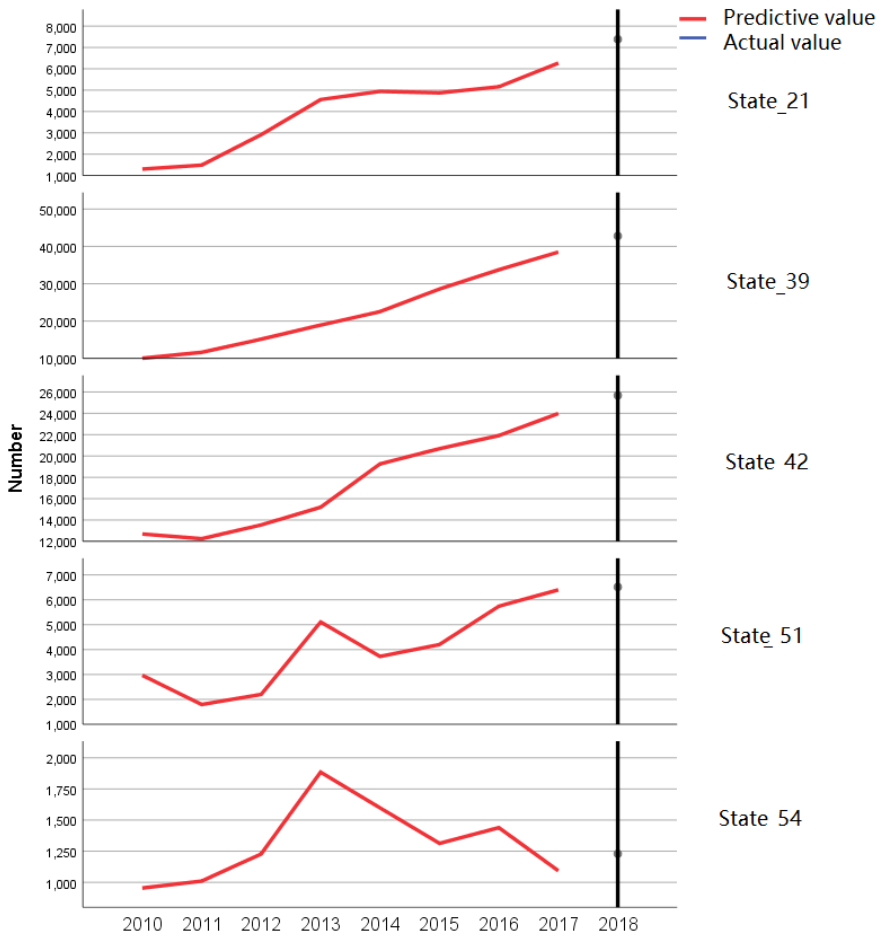


Figure 3: Predicted Value in 2018

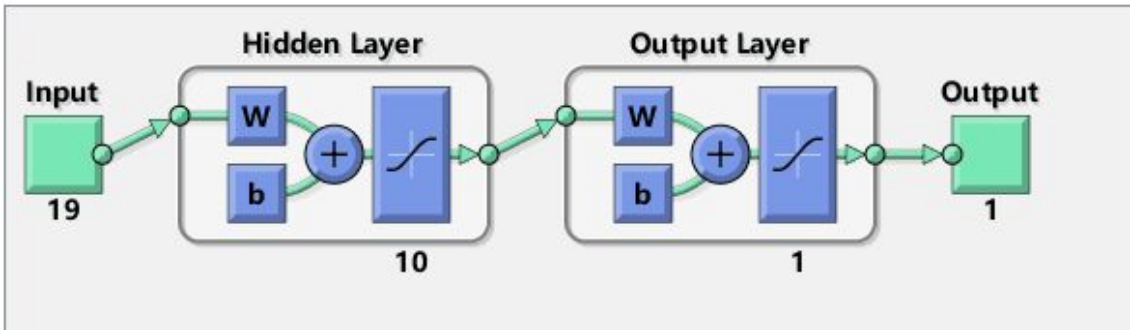


Figure 4: BP Neural Network Diagram

corresponding to it by the function of the matlab nntool toolbox:

$$W1 = \begin{bmatrix} w1_{11} & w1_{12} & \cdots & w1_{1q_1} \\ w1_{21} & w1_{22} & \cdots & w1_{2q_1} \\ \vdots & \vdots & & \vdots \\ w1_{p_1 1} & w1_{p_1 2} & \cdots & w1_{p_1 q_1} \end{bmatrix} (p_1 = 10, q_1 = 19)$$

Use a similar method to get the weight matrix of the output layer $W2(1 \times 19)$:

$$W2 = \begin{bmatrix} w1_{11} & w1_{12} & \cdots & w1_{1q_2} \end{bmatrix} (q_2 = 19)$$

For each indicator x_i, a weight matrix W is obtained:

$$W = W2^T(X * W1) \tag{15}$$

where,* means Hadamard product.

5.3 Results of Model 2

Using matlab for calculation, we get the weight matrix as shown in Table 8.

It can be seen from the table that divorced men, low-educated people, and separated men have a high weight, that is, it is likely that they are abusing opioids.

In addition, the weight of total households is also very high, indicating that family factors also have a great impact on opioids.

6 Solution to the Opioids Crisis

6.1 Some Solutions to the Opioids Crisis

Combining the results of the Part 1 and the Part 2, we give several solutions as follows:

1. Promulgation of laws restricting the production of opioids (fundamental measures)
2. Restrict the circulation of opioids between different regions (direct measures)
3. Appropriately reduce the growth rate of the population
4. Provide better education services
5. Establish a community rehabilitation center

Table 8: Weight Matrix

indicator	W
Males Divorced	0.8796
Total households	0.5295
Less than 9th grade	0.5122
Males Separated	0.4098
Males 15 years and over	0.3024
Females Never married	0.199
Some college, no degree	0.118
Females 15 years and over	0.098
Graduate or professional degree	0.0032
Females Widowed	-0.1114
Females Divorced	-0.2253
High school graduate (includes equivalency)	-0.2475
Females Separated	-0.2545
Associate's degree	-0.3631
Males Never married	-0.378
Males Widowed	-0.3813
Bachelor's degree	-0.4421
Nonfamily households	-0.5906
9th to 12th grade, no diploma	-0.7002

6.2 Program Feasibility Demonstration

After the implementation of the above scheme, the model is used for prediction. The results obtained are shown in Table 9. (In actual operation, the policy is implemented by adjusting the value of the corresponding indicator."Before" in the table, data for 21 states in 2011.)

It can be seen from the table that when the corresponding indicators change according to the expectations of the policy, the predicted number of abused Opioids is significantly reduced. It is proved that the policy is effective.

7 Validating the Model

In order to verify the correctness of the model, we use the 2010-2016 data to predict 2017 and compare it with the actual situation, and get the Table 10.

As can be seen from the table, the prediction results are close to the actual values. For this set of data, the average relative error is 7.757%

Table 9: Before and after policy implementation

Indicator	Before	After
1	1681085	1581085
2	549670	559670
3	1687162	1587162
4	509862	519862
5	32002	22002
6	46532	56532
7	197189	187189
8	1783365	1683365
9	422346	412346
10	43653	53653
11	192110	202110
12	237722	247722
13	227766	217766
14	300804	310804
15	987495	1087495
16	577977	567977
17	192610	202610
18	353907	363907
19	240824	230824
Reports of drug abuse	28285	20792

Table 10: Model Verification

State	21	39	42	51	54
2017 Predictive value	6702	34698	25668	7112	1135
2017 Actual value	6269	38482	23979	6398	1093
Relative Error	0.069	0.098	0.070	0.112	0.038

8 Conclusions

Through the above discussion, we have the following conclusions

1. The synthetic opioid and heroin have similar propagation characteristics.They are transmitted from a high concentration area to a low concentration area, while the concentration of high concentration area tends to be higher.
2. When the number of opioids abuse reaches a threshold, the number of opioids will suddenly increase rapidly.
3. Divorced men, low-educated people, and separated men are likely to abuse opioids. The abuse of opioids is also likely to occur in areas with large households.
4. Taking corrective measures in a timely manner can reduce the harm caused by the abuse of opioids.

9 Evaluate of the Mode

9.1 Strengths

- This model **has a good point of innovation**, combining economic knowledge to link the dissemination of opioids with the production and sale of products.
- After verification, **the accuracy of the model is high.**
- The established models are connected and independent of each other, and **can work separately to improve efficiency.**

9.2 Weaknesses

- The model does not take into account the local drug retention and **may make the predictions slightly larger.**
- The model does not take into account the geographical situation of each region.
- In fact, there is a volatility in the ratio and the total quantity, and the model does not consider the difference between the two trends.

10 Memo

To the Chief Administrator:

Our team analyze the abuse of Opioids in an attempt to understand the seriousness of abuse of Opioids and how to address the abuse of Opioids.

By analyzing the 2010-2017 opioids abuse data and the 2010-2016 Census socio-economic data, we have obtained the following conclusions

1. **The propagation of opioids has certain characteristics.**

   Both the synthetic opioid and heroin have similar propagation characteristics, which are transmitted from a high concentration area to a low concentration area, while the concentration of high concentration area tends to be higher.

   At the same time, after our prediction, we believe that in 2018,Ohio is the most likely state of drug abuse in the future, both in synthetic opioids and in heroin.And,HAMILTON is the most prone to abuse of synthetic opioids, CUYAHOGA is second, MONTGOMERY is third;While MONTGOMERY is the most prone to heroin abuse, followed by LAKE, and the third is LUCAS.

2. **Indulging in opioids abuse is very dangerous.**

   When we continue to use our model to predict, we found that after 2022, when the total number of drug abuses in Ohio reached 275,040, both synthetic opioids and heroin suddenly exploded.

3. **People who are abused by opioids can be foreseeable**

   Divorced men, low-educated people, and separated men are likely to abuse opioids. The abuse of opioids is also likely to occur in areas with large households.

4. **The crisis caused by the abuse of opioids can be circumvented**

   Taking corrective measures in a timely manner can reduce the harm caused by the abuse of opioids.

So, we made the following suggestions and hope that you can adopt them.

1. **Promulgation of laws restricting the production of opioids.**

   This is the fundamental way to solve the abuse of opioids, and it is the most effective method.

2. **Restrict the circulation of opioids between different regions.**

3. **Provide better education services**

   Reduce low-education, and educate people not to abuse opioids.

4. **Establish a community rehabilitation center**

   Encourage people to treat diseases without the abuse of opioids

Although the crisis brought by the abuse of opioids is severe, we believe that through joint efforts and reasonable measures, we can tide over the difficulties.

Thank you!

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Appendices

Appendix A The Tables

Table 11: Classification of Opioid

synthetic opioid	non-synthetic opioid	others
3,4-Methylenedioxy U-47700	Acetyldihydrocodeine	Heroin
3-Fluorofentanyl	Burenorphine	
3-Methylfentanyl	Codeine	
4-Fluoroisobutyryl fentanyl	Dihydrocodeine	
4-Methylfentanyl	Hydrocodone	
Acetyl fentanyl	Hydromorphone	
Acetylcodeine	Morphine	
Acryl fentanyl	Oxycodone	
Alphaprodine	Oxymorphone	
ANPP	Thebaine	
Benzylfentanyl		
Butorphanol		
Butyryl fentanyl		
Carfentanil		
cis-3-methylfentanyl		
Crotonyl fentanyl		
Cyclopentyl fentanyl		
Cyclopropyl fentanyl		
Cyclopropyl/Crotonyl Fentanyl		
Desmethylprodine		
Dextropropoxyphene		
Dihydromorphone		
Fentanyl		
Fluorobutyryl fentanyl		
Fluorofentanyl		
Fluoroisobutyryl fentanyl		
Furanyl fentanyl		
Furanyl/3-Furanyl fentanyl		
Hydrocodeinone		
Isobutyryl fentanyl		
Levorphanol		
Meperidine		
Metazocine		
Methadone		
Methorphan		
Methoxyacetyl fentanyl		

synthetic opioid	non-synthetic opioid	others
Mitragynine		
Morphine		
MT-45		
Nalbuphine		
o-Fluorofentanyl		
Opiates		
Opium		
Pentazocine		
Pethidine		
p-Fluorobutyryl fentanyl		
p-Fluorofentanyl		
Phenyl fentanyl		
p-methoxybutyryl fentanyl		
Propoxyphene		
Remifentanil		
Tetrahydrofuran fentanyl		
Tramadol		
trans-3-Methylfentanyl		
U-47700		
U-48800		
U-49900		
U-51754		
Valeryl fentanyl		

Appendix B The Programmes

Here are simulation programmes we used in our model as follow.

Input matlab source:

```
function [s,w]=shang(x)
[row,col]=size(x);
[X,ps]=mapminmax(x');
ps.ymin=0.002;
ps.ymax=0.996;
ps.yrange=ps.ymax-ps.ymin;
X=mapminmax(x',ps);
X=X';
for i=1:row
    for j=1:col
        p(i,j)=X(i,j)/sum(X(:,j));
    end
end
k=1/log(row);
for j=1:col
    e(j)=-k*sum(p(:,j).*log(p(:,j)));
end
c=ones(1,col)-e;
w=c./sum(c);
s=w*p';
```

Input VBScript source:

```
Sub divide()
Dim I As Long, J As Long, S As String
Dim Str As String, xlbook As Workbook
Dim N As Long, R As Long, M As Long
Application.ScreenUpdating = False
Application.DisplayAlerts = False
For I = 1 To Range("F65536").End(xlUp).Row
Str = Range("F" & I).Text
If InStr(S, Str) = 0 And Str <> "" Then
S = S & Str & " "
N = N + 1
Workbooks.Add xlWBATWorksheet
Rows(I).Copy ActiveSheet.Rows(N)
R = Range("F:F").Find(Range("F" & I)).Row
M = R
Do
R = Range("F:F").FindNext(Range("F" & R)).Row
If R = M Then Exit Do
N = N + 1
Rows(R).Copy ActiveSheet.Rows(N)
Loop
ActiveWorkbook.SaveAs "C:\Users\25467\Desktop\ICM\51\" & Str & ".XLSX"
ActiveWorkbook.Close
N = 0
Str = ""
```

```
End If
Next
Application.ScreenUpdating = True
Application.DisplayAlerts = True
End Sub
```