Study on the Transmission of Opioids based on Time-series model: Ohio, Pennsylvania, Kentucky, Virginia and West Virginia as a Case Study

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Abstract: Opioid abuse has become one of the most severe and fastest-growing drug problems in the United States in recent years. Many people believe that regulators approve opioids based on their medical use and ignore their addiction. This paper analyzes the stability of drug use diffusion by constructing a time series model and analyzes the spread and characteristics of synthetic opioids and heroin incidents reported between five states and their counties over time. Using the tableau software to convert the five county coordinates into actual locations on the map, determine where the opioids are first used in each state. It analyzes the correlation between various factors and opioid abuse, and judges the main factors affecting the trend of opioid use.

1. Introduction

The United States is experiencing a national crisis on synthetic and non-synthetic opioids, which has a negative impact on health and poses complex challenges to the Federal Bureau of Investigation and the U.S. Drug Enforcement Administration (DEA). At the same time, the crisis has an important impact on many important areas of the U.S. economy. The opioid crisis has spread to all sectors of the American population, resulting in irreparable shortcomings.

According to the survey, in the United States, opioids began to enter the market on a large scale in the late 1990s, and the number of prescriptions is on the rise. From 2011 to 2015, Ohio used 3.8 billion prescription opioids. In 2016, 2.3 million people in the state use prescription painkillers, accounting for one-fifth of the total population.

The ideal state of opioid use is to find a balance point to ensure that such substances are used only in medical and scientific research without being abused. But this balance is often broken, one that is not available when needed, and the other is that opioids are heavily abused. The abuse of opioids is affected by a variety of economic factors.

In response to the crisis, data published by NFLIS were processed to classify opioids into synthetic and non-synthetic opioids. This paper takes Ohio, Kentucky, West Virginia, Virginia, and Pennsylvania as examples.

2. Model introduction

2.1 Draw sequence diagram, ACF and PACF for analysis

For the sake of analysis, opioids are divided into two broad categories: synthetic opioids and non-synthetic opioids. The data on synthetic opioids and non-synthetic opioids were processed to study the transmission characteristics of opioids in five states and their counties. For non-synthetic opioids, the analysis was performed by heroin. Based on the time-series model, the sequence diagrams of synthetic opioids, non-synthetic opioids, heroin and their ACF and PACF are plotted in order to reveal the characteristics of opioid transmission.

2.1.1 Developing trends of Synthetic Opioid Reports over time

Python programming is used to plot how the number of synthetic opioid reports changes with time in five states. The abscissa is time and the ordinate is synthetic opioid reports, as shown in

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Figure 1.

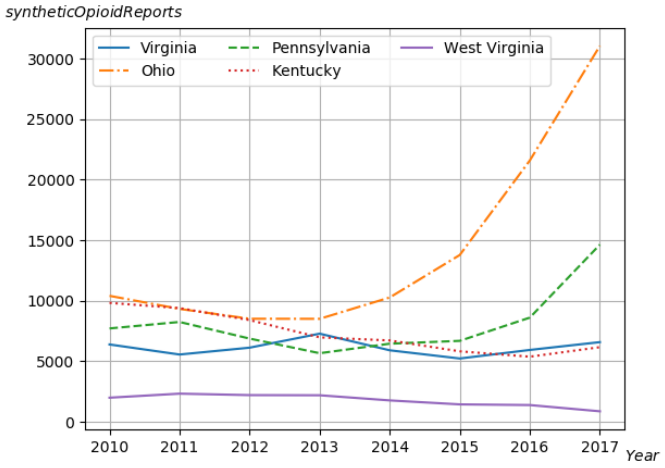

Figure 1 syntheticOpioidReports-Year Sequence Diagram

To illustrate the spread characteristics of synthetic opioid reports in five states, in Figure 1, there are five broken lines representing five states, orange line representing Ohio, green line representing Pennsylvania, blue line representing Virginia, red line representing Kentucky, and purple line representing West Virginia. For Ohio State, the number of synthetic opioids reported increased with the increase of years. For Pennsylvania, the number of reported synthetic opioids increased with the increase of years. For Virginia, the reported number of synthetic opioids fluctuated at the level of 7000 with the increase of years. For Kentucky State, the number of reported synthetic opioids decreased gradually from 10,000 with the increase of years. For West Virginia, the reported number of synthetic opioids fluctuated at the level of 2500 with the increase of years.

2.1.2 Developing trends of non-synthetic Opioid Reports over time

Python programming is used to plot how the number of non-synthetic opioid reports changes with time in five states. The abscissa is time and the ordinate is non-synthetic opioid reports, as shown in Figure 2.

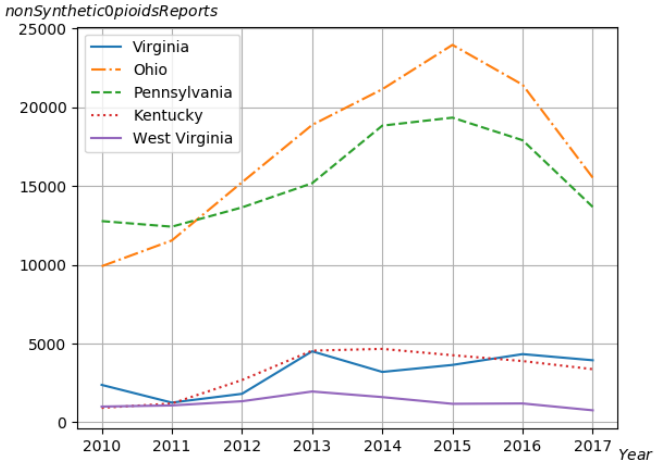

Figure 2 nonSyntheticOpioidReports -Year Sequence Diagram

In Figure 2, five broken lines represent five states. For Ohio and Pennsylvania, the number of non-synthetic opioid reports has increased from 2010 to 2015, and decreased from 2015 to 2017. For Virginia, the number of non-synthetic opioids reports fluctuated at the level of 3500 with the increase of years. For Kentucky, the number of non-synthetic opioids reports has increased slightly with the increase of years. For West Virginia, the number of non-synthetic opioids reports fluctuated

at a level of 1,000 with the increase of years.

2.1.3 Developing trends of Heroin Reports over time

Python programming is used to plot how the number of heroin reports changes with time in five states. The abscissa is time and the ordinate is heroin reports, as shown in Figure 3.

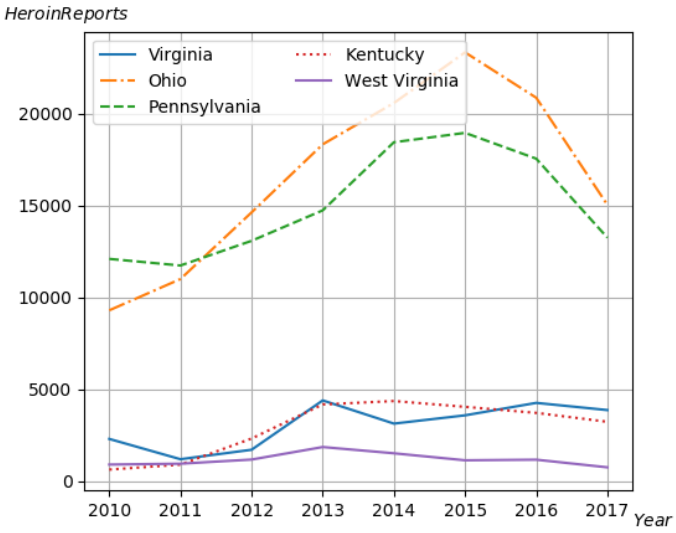

Figure 3 HeroinReports-Year Sequence Diagram

In Figure 3, five broken lines represent five states. For Ohio and Pennsylvania, the number of heroin reports increased from 2010 to 2015, and decreased from 2015 to 2017. For Virginia, the number of heroin reports fluctuated at the 3500 level with the increase of years. For Kentucky, the number of heroin reports increased slightly with the increase of years. For West Virginia, the number of heroin reports fluctuated at the level of 1,000 with the increase of years.

In Figure 2 and 3, the trend of non-synthetic opioids and heroin over time is similar, indicating that heroin is the main component of non-synthetic drugs.

2.1.4 ACF and PACF

First, an ACF and a PACF corresponding to trends in non-synthetic opioids over time in West Virginia were plotted.

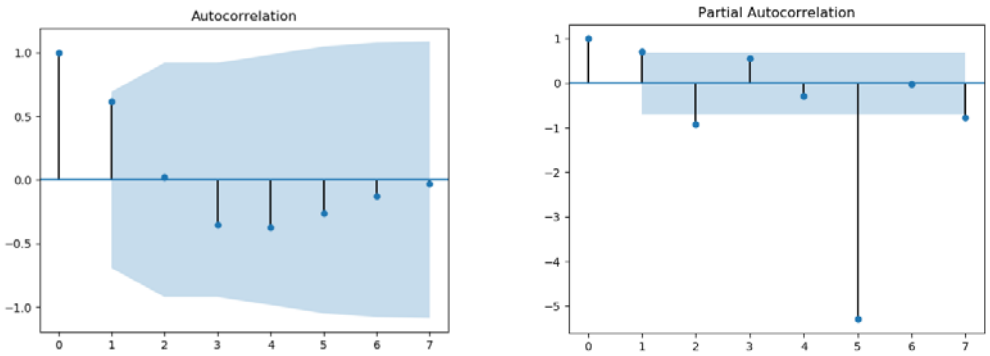

Figure 4 Non-synthetic opioid reports ACF and PACF

In the ACF of Figure 4, the vertical axis decays rapidly to zero, and the non-synthetic opioids in the sequence diagram change smoothly with increasing year, so the number of non-synthetic opioids reports in West Virginia is a stationary sequence.

Similarly, it is also possible to draw the ACF and PACF corresponding to synthetic opioids, non-synthetic opioids and heroin time-series diagram of the other four states and obtain the stability of their propagation.

By constructing the above Time-Series model, it can be concluded that synthetic opioids are basically stable in Virginia and West Virginia, and the number of synthetic opioids is basically maintained at a horizontal line. In 2010-2015, synthetic opioids reports fluctuated in Ohio and Pennsylvania, and 2015 was a turning point. The number of synthetic opioids increased in 2015-2017. Opioids are mainly spread to Ohio and Pennsylvania.

The quantity change of heroin in Ohio and Pennsylvania can be divided into two parts: the trend of growth in 2010-2015 and the trend of decline in 2015-2017, which indicates that heroin was mainly spread to Ohio and Pennsylvania in 2010-2015, and then transferred to other states after 2015. The number of heroin in West Virginia fluctuates up and down a horizontal line, indicating that the entry and diffusion of heroin in the state are roughly equal. Heroin in Kentucky and Virginia grew slightly overall from 2010 to 2017, spreading into the two states.

2.2 Conversion of Federal Information Processing Standard (FIPS) County code

Through the tableau software, I translate Federal Information Processing Standard (FIPS) County code into the actual location on the map. Firstly, I change the data type or geographical role, change the data type to a string, and set the county FIPS 5 geographical role to a county. Secondly, a view is generated.

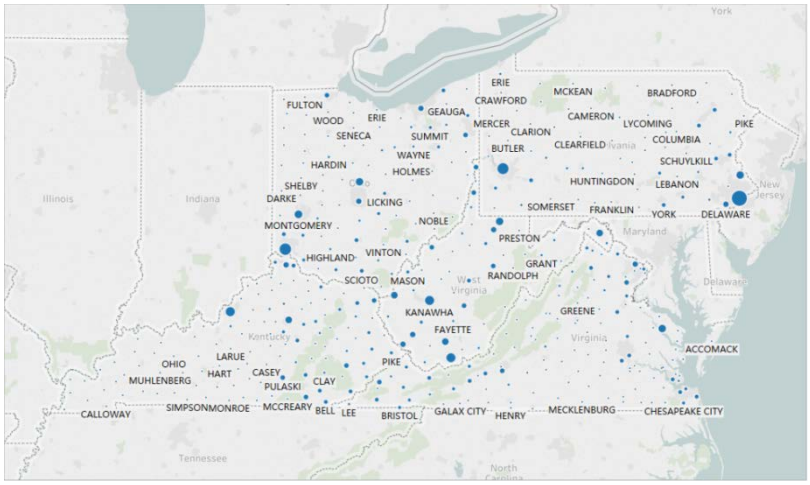

Figure 5 Distribution of opioids in five states in 2010

In Figure 5, the larger the dot is, the darker the color is, the densest the opioid is. Specifically, in Ohio State, opioids were first used in HAMILTON County. In Pennsylvania, opioids were first used in PHILADELPHIA and ALEGHENY counties. In Kentucky, opioids were first used in JEFFERSON County. In Virginia, opioids were first used in RICHMOND. In West Virginia, opioids were first used in MERCER and KANAWHA.

3. Empirical analysis

3.1 Data processing

In order to determine the factors affecting the transmission of opioids, I categorize the data into the groups shown in Table 1.

3.2 Correlation analysis

Correlation analysis was carried out between the various categories of data and the number of opioid reports, and the factors affecting the abuse of opioids were screened. The specific results are shown in Table 2.

As can be seen from Table 2, the correlation coefficient between PA and OH states is relatively high. The correlation coefficients of the three states of VA, PA and OH are relatively uniform. However, for the two states of KY and WV, the correlation coefficient varies greatly, indicating that the use of opioids is only targeted at some of the populations in these two states. Judging from the calculated correlation coefficient, the change is small, indicating that the use of opioids is relatively

common and belongs to the birthplace of opioids. A large change in the correlation coefficient indicates that the trend in the use of opioids has been changing, and the use of opioids in neighboring states also affects the trend of use in the state. According to the table, factors of the school enrollment-population 3 years old and over enrolled in school and the marital status-females 15 years old and over are more prominent. Accordingly, the enrollment of the new generation and marital status are closely connected to the abuse of opioids.

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Table 1 Data classification table

Symbol	Meaning	Symbol	Meaning
A	HOUSEHOLDS BY TYPE	J	RESIDENCE 1 YEAR AGO - Population 1 year and over
B	RELATIONSHIP	K	PLACE OF BIRTH - Total population
C	MARITAL STATUS - Males 15 years and over	L	PLACE OF BIRTH - Foreign born
D	MARITAL STATUS - Females 15 years and over	M	U.S. CITIZENSHIP STATUS - Not a U.S. citizen
E	GRANDPARENTS - Number of grandparents living with own grandchildren under 18 years	N	YEAR OF ENTRY - Native
F	GRANDPARENTS - Number of grandparents responsible for own grandchildren under 18	O	YEAR OF ENTRY - Foreign born
G	SCHOOL ENROLLMENT - Population 3 years and over enrolled in school	P	WORLD REGION OF BIRTH OF FOREIGN BORN - Foreign-born
H	EDUCATIONAL ATTAINMENT - Population 25 years and over	Q	LANGUAGE SPOKEN AT HOME - Population 5 years and over
I	VETERAN STATUS - Civilian population 18 years and over	R	ANCESTRY - Total population

Table 2 Correlation coefficient table

Symbol	VA	PA	OH	KY	WV
A	0.434517	0.54775	0.976164	0.188453	0.70143
B	0.467523	0.848777	0.984789	0.302331	0.609592
C	0.464094	0.889221	0.982325	0.398552	0.08797
D	0.463983	0.849976	0.964447	0.306532	0.837749
E	0.447278	0.869907	0.837565	0.346721	0.451909
F	0.184349	0.869906	0.406208	0.216119	0.527713
G	0.44879	0.944913	0.96655	0.692194	0.645309
H	0.468076	0.914998	0.981277	0.459257	0.05995
I	0.471165	0.8834	0.969136	0.372524	0.217876
J	0.468157	0.841869	0.967108	0.284642	0.614531
K	0.466831	0.852436	0.981066	0.307193	0.690682
L	0.463355	0.926367	0.975793	0.488575	0.212817
M	0.468855	0.921578	0.980245	0.506423	0.033117
N	0.493536	0.882637	0.987727	0.578592	0.271365
O	0.463355	0.926367	0.975793	0.488575	0.212817
P	0.463323	0.926367	0.975793	0.488575	0.212817
Q	0.467622	0.864096	0.970983	0.327136	0.558774
R	0.466831	0.852436	0.981066	0.307193	0.690682