

A Correlative Study on International Healthcare System Variables and Opioid
Consumption Data

by
Katherine F. R. Fan

A THESIS

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the requirements for the
degree of

Honors Baccalaureate of Science in Biology
(Honors Scholar)

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Katherine F. R. Fan for the degree of Honors Baccalaureate of Science in Biology and Honors Baccalaureate of Arts in International Studies presented on May 30, 2018. Title: A Correlative Study on International Healthcare System Variables and Opioid Consumption Data.

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Adriane N. Irwin

The opioid epidemic in the U.S. has had significant impacts on opioid overdose rates, productivity, and healthcare expenditure. Research has drawn attention to the necessity of a more integrated, biopsychosocial approach to treatment of chronic pain, and how it could alleviate the current public health emergency. Previous literature alluded to healthcare system variables as the source of the discrepancy between opioid consumption of the U.S. and that of other countries. Existing data was collected on 16 countries for healthcare system variables and opioid consumption data. A statistical analysis was conducted to determine any correlation between the variables and opioid consumption. Findings from this study indicate that while certain variables appear to have significant correlation coefficients (>0.5) with data from the U.S. included in the analysis, these coefficients become insignificant after removal of the U.S. This is indicative of the U.S. being an outlier in the data set. The one variable that remained significant after removal of the U.S., healthcare spending per capita (correlation coefficient= 0.5, p-value=0.05), has many components to it, and requires further investigation. These results suggest that countries with more centralized healthcare systems are able to provide more cost efficient, integrated care that equates to less opioid consumption.

Key Words: Opioids, healthcare system models, international.
Corresponding e-mail address: fanka@oregonstate.edu

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Honors Baccalaureate of Science in Biology and Honors Baccalaureate of Arts in International Studies project of Katherine F. R. Fan presented on May 30, 2018.

APPROVED:

Adriane N. Irwin, Mentor, representing College of Pharmacy

Raymond Tricker, Committee Member, representing College of Public Health

Rebekah Lancelin, Committee Member, representing International Studies Degree Program

Toni Doolen, Dean, Oregon State University Honors College

I understand that my project will become part of the permanent collection of Oregon State University, Honors College. My signature below authorizes release of my project to any reader upon request.

Katherine F. R. Fan, Author

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A Correlative Study on International Healthcare System Variables and Opioid Consumption Data

1. Introduction

In October 2017, President Donald Trump declared the opioid epidemic a public health emergency¹. While opioid consumption has been on the rise globally since the 1960s², the United States consumes roughly 80% of the world's opioids despite representing less than 5% of the global population³. With 2.1 million people suffering from opioid use disorders, and 42,249 people overdosing on opioids in the U.S. in 2016, it is crucial to understand why the opioid epidemic has developed into the current public health issue⁴. As society has begun to realize the dangerous side effects of opioid use, the prescribing and consumption of opioids have become the subject of significant discussion.

1.1. BACKGROUND

The primary barrier of chronic pain management has been referenced as the misplaced focus of healthcare professionals on a biomedical treatment of pain rather than a biopsychosocial treatment^{5,6}. Biomedical interventions for pain are most commonly surgery and opioid medication. While these can provide some relief, they do not address the multidimensionality of chronic pain. Research conducted by the Institute of Medicine found that \$560-635 billion is lost annually in the United States as a result of the opioid epidemic⁷. This figure is a combination of money lost in healthcare expenditure, as well as loss of productivity. Many people are left unable to go to work, and are debilitated by pain socially, often withdrawing themselves from family and friends. A biopsychosocial

approach to treatment recognizes that pain affects a patient not only physiologically, but also socially, and mentally. All three aspects of the patient's life should be taken into account when discussing treatment options. With increased use of the biopsychosocial approach and a higher level of care coordination between varying healthcare providers, health care professionals would be better able to treat chronic pain.

The broad issue of health care delivery for chronic pain management has been categorized and grouped into two larger themes within the National Health Service in the United Kingdom: issues that deal with the healthcare system, and issues that deal with the healthcare professional⁶. Within healthcare system-related barriers there are the subtopics of: long wait times for appointments in secondary care, short appointment times with general practitioners, and lack of interdisciplinary approach. Within healthcare professional-related barriers, there are: lack of interest and empathy of providers, lack of knowledge in pain management, and lack of communication between healthcare professionals⁶. In the interviews conducted by Muhammad Hadi and his team in the United Kingdom, many people being treated for chronic pain felt that one or many of these variables had a significant effect on their experiences with treatment⁶.

The ideas mentioned within the UK study can also be applied more broadly, and to the United States. Physician education and training, resource allocation, coverage for non-pharmacologic options, and access to care are all components impacted by a country's healthcare system. A Summary of the NIH Pathways to Prevention Workshop highlights these factors, crediting challenges within the healthcare system as the ultimate source of the opioid epidemic. Lack of physician education for an integrative, multidisciplinary approach to chronic pain management, payment structures and

incentives, and fragmentation of care have all contributed to inappropriate opioid prescribing patterns and subsequent misuse⁸.

1.2. HEALTHCARE SYSTEM MODELS

There are four basic healthcare system models used by countries throughout the world: the Beveridge model, the Bismarck Model, the National Health Insurance model, and the out-of-pocket method⁹. Each model outlines the relative amount of influence that the government has in a country's healthcare system, as well as how the system is funded and how care is delivered. These elements include primarily monetary aspects and allocation and accessibility of resources.

1. 2. 1. Beveridge Healthcare System Model

The Beveridge model, frequently referred to as socialized medicine, is defined by health care being fully funded and delivered by the government. In the Beveridge system, the funds come from taxation, and the government owns and operates most hospitals and outpatient clinics. Physicians, healthcare professionals, and support staff are government employees. However, some physicians are private contractors, instead they collect money from the government on a combination of capitation and fee-for-service basis that is negotiated between physician associations and the government¹⁰. Healthcare is viewed as a human right, and is available to every citizen, with primary care physicians being the gatekeeper to specialty care. With the government as the sole provider of healthcare for the population, there is great emphasis on cost efficiency. Spain, New Zealand, and Cuba are all examples of the Beveridge system; however, the

United Kingdom is the most notable as a country operating with a classic Beveridge healthcare system with its National Health Service⁹.

The United Kingdom's National Health Service (NHS) was established in 1946, spearheaded by Aneurin Bevan, the Minister of Health at the time. The NHS sought to provide comprehensive service, financing through taxation, and nationalization of hospitals to British healthcare¹¹. Under the UK healthcare system, every citizen has access to primary care, dental care, community services, and hospitals. Clinical Commissioning Groups (CCGs), comprised of physicians and general practitioners, create health service budgets for patients and are in charge of self-governing their resources. CCGs control 60% of the NHS budget, and more specific services can be provided by hospital trusts and specialty care trusts that act as public sector corporations to manage local healthcare. These trusts simply contract with CCGs for service payment¹⁰. Approved medications in the UK are dispensed primarily free of cost.

The government provides roughly 84% of the cost of health services with 9% being paid out-of-pocket from patients¹². General practitioners, the main healthcare providers for the UK, are paid on a capitation basis and practices are reimbursed monthly for their services¹⁰. Hospitals are either NHS trusts (more centralized) or foundation trusts (more independent). All hospitals contract with CCGs and form healthcare resource groups (HRGs) to be reimbursed by NHS England.

1. 2. 2. Bismarck Healthcare System Model

The Bismarck model is a decentralized form of healthcare, using an insurance system to provide healthcare to the majority of its citizens. In this system, employers and

employees must obtain their own private health insurance, while the rest of the population (unemployed, disabled, etc.) is assigned to insurers. Employees and employers are required to contribute to healthcare funding through payroll deduction. As in the Beveridge system, everyone is covered in the Bismarck system; the major difference is that healthcare is provided by these private, non-profit, insurance companies rather than by the government. Many countries such as the Netherlands, Switzerland, France, Belgium, and Japan use the Bismarck system⁹.

Germany is the classic country model and its healthcare system dates back to 1883. Germany's healthcare is formatted based on the statutory health insurance (SHI), the accident insurance law, and the disability and old-age pension insurance law of 1889¹³. Employees and employers contribute to "sickness funds," the name given to German statutory health insurance companies, and the disabled and long-term unemployed are assigned to a sickness fund¹⁰. The sickness funds are non-profit corporations under public law, essentially creating a decentralized healthcare system. In Germany, there are six types of sickness funds: regional, substitute, company-based, guild, miner/sailor, and agricultural¹⁴. Germans are also able to purchase supplemental policies from private sickness funds for additional services (e.g., dental care). Hospitals in Germany are a varying mix of public, private, non-profit, and private for-profit¹². Office-based physicians and hospitals often negotiate prices and re-imbursement by sickness funds; however, physicians at hospitals are paid salaries. Medications are covered through sickness funds at hospitals and pharmacies. Bismarck healthcare is financed through payroll taxes, pension funds, unemployment offices, and welfare

organizations, with a uniform contribution rate for employees/employers and pensioners/pension funds¹⁴.

1. 2. 3. National Health Insurance Healthcare System Model

National Health Insurance systems involve elements of both Beveridge and Bismarck models. Similarly to the Bismarck system, there is a government-run insurance program to which every citizen is required to contribute; however, there is only one single-payer insurance program that covers everyone, as in the Beveridge system⁹. Healthcare providers are largely private, and are paid on a fee-for-service basis by the government, where the government sets the prices-- this allows for cost containment. The success of this system can be seen in Canada, Taiwan, and South Korea, where the National Health Insurance (NHI) model is used.

Established in 1966 by the Medical Care Act, Canada has one of the most well-known National Health Insurance model systems. Its main principles are portability, comprehensiveness, universality, accessibility, and public administration¹³. Healthcare is provided on a provincial basis, and it is required that the five principles are kept consistently throughout the 13 different territories and provinces in order for a province to receive federal funding for healthcare provision¹². To qualify for receiving federal funds, coverage for medically necessary physician, diagnostic, and hospital services must be provided for all residents¹⁵. These funds come from the Canadian Health Transfer, which accounted for 24% of provincial health spending in 2016-2017.

Healthcare delivery is mostly privatized and almost all hospitals are nonprofit community hospitals. However, with an increased wait time at healthcare providers due

to the complete universality of Canadian coverage, private healthcare is available. Most Canadians do have supplemental private insurance in addition to the national health insurance, in order to provide for some dental services, cosmetic surgery, and outpatient medications¹³. Provincial and territorial insurance plans do, however, cover outpatient prescription medication for senior citizens, people with low income, and those with specific disease states.

Canadian healthcare is financed by personal and corporate taxes, as well as provincial lotteries and sales taxes¹⁰. With the government being the sole source of healthcare funds, budget allocation is extremely well managed. The budget placed on hospitals results in hospitals consistently running at capacity, with long waiting periods for certain procedures.

1. 2. 4. United States Healthcare System

In the United States, healthcare remains widely fragmented. Many working-class Americans receive their health insurance through an employer-group health plan. Employers contract directly with insurance companies, similar to the Bismarck model¹². However, other individuals are covered through entities that functions similar to the Beveridge or National Health Insurance Model.

Organizations such as the Veterans Health Administration and the Indian Health Service are reflective of a more Beveridge healthcare system. Complete coverage is provided for the individuals that they serve⁹. The Indian Health Service is responsible for providing comprehensive healthcare to Native Americans, and has medical centers located in Native American communities. The Veterans Health Administration and

Indian Health Services both have many medical centers and outpatient sites throughout the country. The elderly and disabled are provided healthcare by Medicare, which resembles a National Health Insurance model. The federal government funds Medicare with revenue from primarily payroll taxes and income taxes, and care is provided for those who have been classified as incapable of affording healthcare for themselves¹⁷. Those that are insured through any of these various healthcare plans have varying coverage of care.

Among the majority of the United States' working class, most are insured by employer-group health plans, which operate similarly to the Bismarck model in the sense that employees and employers pay into insurance plans. The two most common types of plans available for insurance through employer-group health plans are Health Maintenance Organizations (HMOs) and Preferred Provider Organizations (PPOs). In an HMO plan, coverage of care can be limited to providers that are contracted with the HMO¹⁶. This system usually allows for higher coordination of care, since primary and secondary healthcare providers are usually located within the same practice. In a PPO plan, the amount of coverage of services typically depends on whether or not a provider is in the plan's network. In order to see a specialist, a referral is needed from a person's primary care provider, unless the patient is willing to pay more¹⁶.

Taxes, premiums, and federal revenues fund publicly financed healthcare programs like Medicare, Medicaid and those for veterans and Native Americans, whereas private health care is paid for by employer/employee premiums. Physicians and primary care providers operate in group practice and can be compensated through insurer fees, capitation contracts, or being paid by major public programs. Most hospitals are non-

profit, with some being for-profit or public, and can be paid by per-service, capitation, per-diem, per-admission, or prospective payment methods. The United States has the highest annual per-capita health expenditure, at \$8,233¹⁵. This wide variation and fragmentation in healthcare coverage for United States citizens likely has a strong effect on chronic pain treatment and subsequent opioid consumption.

Table 1. Summary of Healthcare System Models¹⁰

	Beveridge	Bismarck	NHI	United States
Financer	Government taxes	Employer and employee	Government taxes	Employer and employees; general taxes finance for some
Insurer	Government	Decentralized insurance groups—Statutory Health Insurance	Government	Mostly private insurance groups, government insures some
Hospital ownership	Mostly public, some private	Public (50%), private for-profit (17%), private nonprofit (33%)	Public/private, mostly not-for-profit	Nonprofit (70%), public (15%), for-profit (15%)
Primary Care Provider Payment	Mix capitation /fee for service /pay for performance, salary for some	Fee-for-service	Mostly fee-for-service, some capitation	Mostly fee-for-service, some capitation, some incentives
Example Country	 England	 Germany	 Canada	 United States

1.3. PURPOSE

The purpose of this study is to determine which, if any, healthcare system related variables are statistically significant predictors of opioid consumption in various countries. A secondary goal is to analyze the data at the level of healthcare system models to determine if the significance of these variables translates to significance within certain healthcare system models.

2. Methods

2.1. DATA COLLECTION

Data was collected on 16 variables of 16 different countries from publicly available sources for statistical analysis to determine significance of any correlations between healthcare system variables and opioid consumption. General country data was sourced from the Central Intelligence Agency's World Factbook database for: population, life expectancy, percent of gross domestic product spent on healthcare, number of physicians per 1,000 population, and number of hospital beds per 1,000 population¹⁸. The Commonwealth Fund's International Healthcare System Profile Report of 2016 was used to obtain data for: percent of population over age 65, annual healthcare spending per capita, annual out-of-pocket healthcare spending per capita, annual pharmaceutical spending per capita, average annual number of physician visits per capita, number of MRI machines per 1,000,000 population, number of MRI exams per 1,000 population, average length (days) of a hospital stay, and percentage of adult population that are smokers¹⁰. The International Narcotics Review Board 2016 Technical Report was used for data concerning the manufacture of principal narcotic drugs in 2015¹⁹ the consumption of principal narcotic drugs and calculated consumption of buprenorphine in 2015¹⁹ and the and levels of consumption of narcotic drugs, in defined daily doses for statistical purposed per million inhabitants per day¹⁹. The country-specific data for consumption of narcotic drugs in defined daily doses per million inhabitants per day was used as the response variable, with the variables obtained from the World Factbook and the Commonwealth Fund report used as possible explanatory variables. Table 2 below highlights the variables used for this study and their sources.

Table 2. List of Variable for Analysis and Sources

Variable	Source
Population	CIA World Factbook
Life expectancy (years)	
Percent GDP spent on healthcare (%)	
Physicians per 1,000 population	
Hospital beds per 1,000 population	
Healthcare spending per capita (\$)	Commonwealth Fund International Healthcare System Profiles 2015 Report
Out-of-pocket spending on healthcare per capita (\$)	
Hospital spending per discharge (\$)	
Pharmaceutical spending per capita (\$)	
Average number of physician visits per year	
MRI machines per 1,000,000 population	
MRI exams per 1,000 population	
Average length of hospital stay (days)	
Experienced coordination problem in past two years (% of people surveyed)	
Experienced access barrier due to cost in past year (% of people surveyed)	
Doctor/health care provider discussed treatment options and side effects with patients (% of people surveyed)	
Population adjusted opioid consumption (defined daily doses per 1,000,000 inhabitants per day)	International Narcotics Review Board 2016 Report

2.2. DATA ANALYSIS

Each variable was organized into a table with three categories—CIA World Factbook data, data pertaining to healthcare system resources, and patient experience data. Each country's data was also sorted based on the healthcare system model that they fall under. Countries like the UK, Norway, Italy, Denmark, and Australia are all examples that follow the Beveridge model. Germany, France, Japan, and Switzerland all fall under the Bismarck model. Canada, Taiwan, and South Korea utilize a National Health Insurance model, however, due to lack of variable data on Taiwan and South

Korea, the NHI group was limited to Canada⁹. Other countries with sufficient data to be used in the analysis include the Netherlands, China, Israel, New Zealand, and Sweden—these countries are designated as “Unclassified” for the analysis due to the fact that they contain characteristics of either none or more than one of the given models. While the United States falls under the “Unclassified” group, it was distinguished from the rest for better observation and comparison.

The program R Studio was used to perform a simple linear regression on each variable individually to obtain correlational statistics and avoid effects of confounding variables. These regressions were collated based on the three aforementioned categories for comparison. Due to the breadth of variables used, after correlation coefficients for each pair of variables was determined, a hypothesis test was performed to obtain a p-value for only those variables with a correlation coefficient of 0.5 or higher, and determine if at least one of the variables helps to predict the amount of opioid consumption in the varying countries. The process was then repeated with data for the United States removed from the analysis to determine whether or not the United States has a significant effect on the results as an outlier.

Finally, summary statistics were obtained based on the countries that fall under each model (Beveridge, Bismarck, and NHI). This was to determine whether or not the models themselves reflect the same results as those obtained from the univariate by-country analysis. The results of this would allow for better inferences to be made on which organizational styles and forms of healthcare deliver are indicators of less opioid consumption.

3. Results

3.1. UNITED STATES INCLUDED IN MODELS

The following diagrams represent the analysis of the data set with the United States included in the models. Each separate diagram corresponds to one of the three categories of data—CIA World Factbook information, healthcare system resources, and patient experience data. For each of the following figures, the data of focus are the scatterplots in the rightmost column, and the corresponding correlation coefficients in the bottommost row, located within the orange box. Each of the boxes in the top left to bottom right diagonal represents one of the possible independent variables, and the bottom right variable is always the dependent variable—population adjusted opioid consumption. The correlation coefficient, defined as the strength of the linear relationship between the independent and dependent variables, is considered to be highly correlated at a value 0.5 or higher for this study.

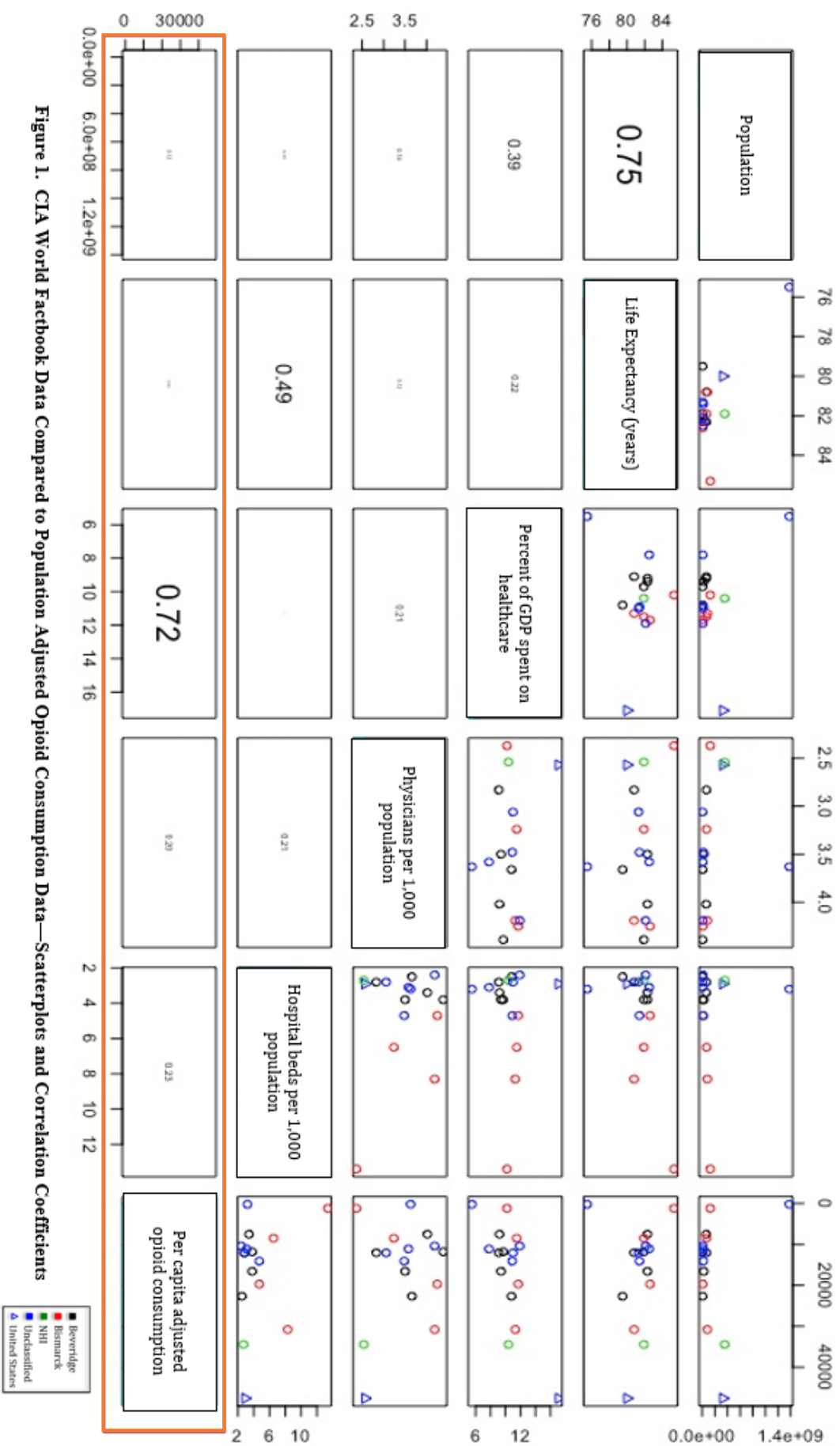


Figure 1. CIA World Factbook Data Compared to Population Adjusted Opioid Consumption Data—Scatterplots and Correlation Coefficients

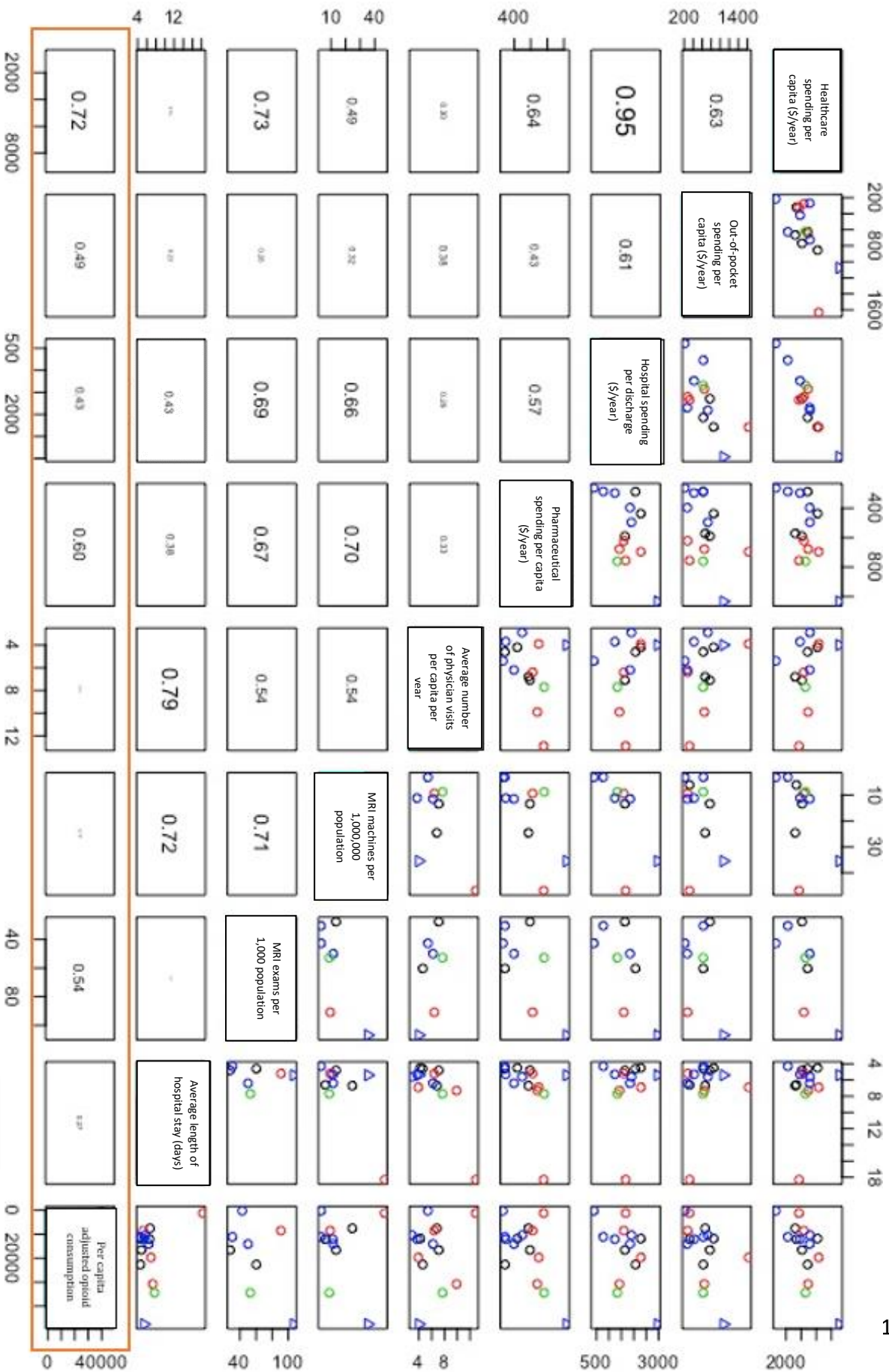


Figure 2. Healthcare System Resource Variables from Commonwealth Fund Data Compared to Population Adjusted Opioid Consumption Data—Scatterplots and Correlation Coefficients

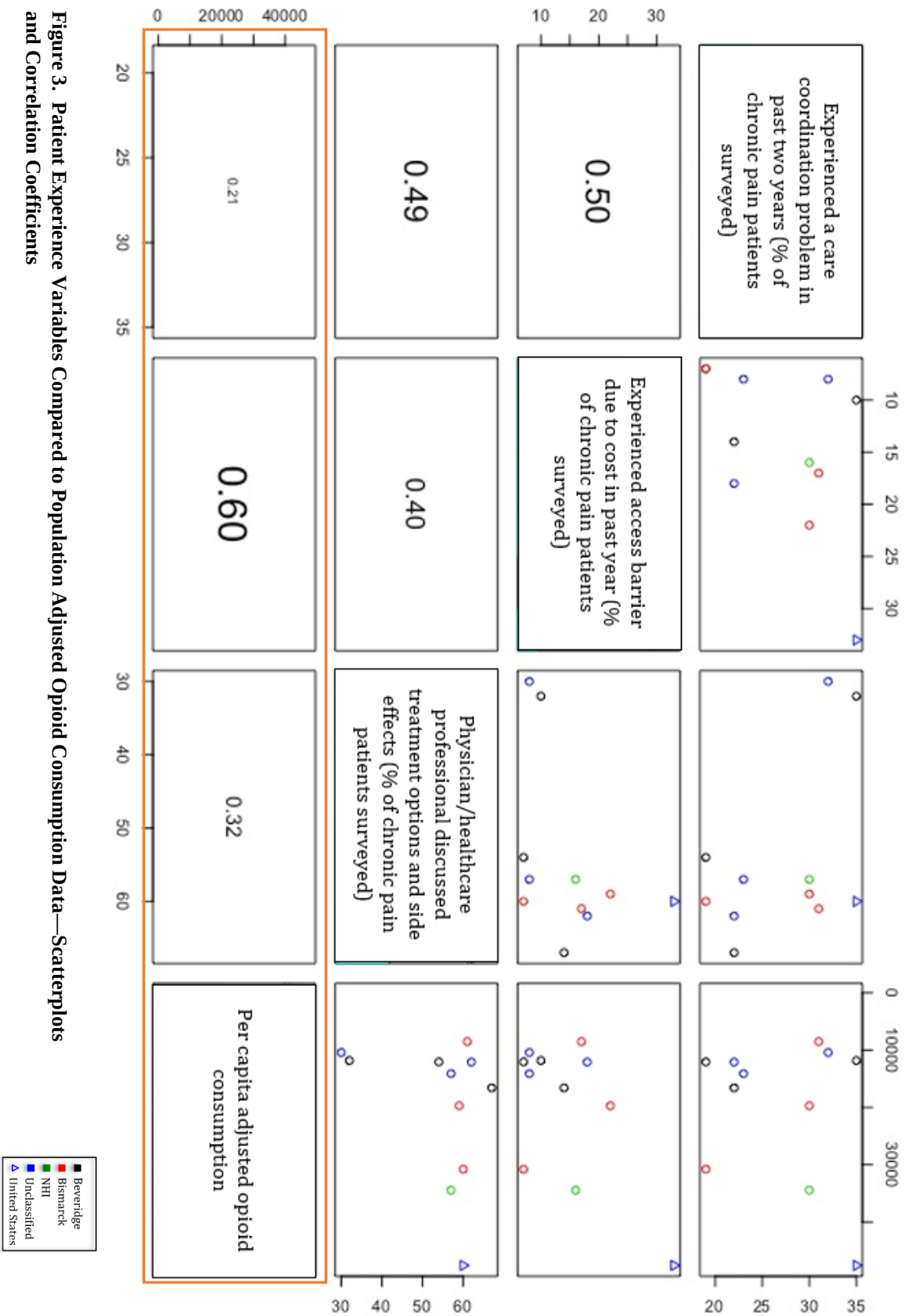


Figure 3. Patient Experience Variables Compared to Population Adjusted Opioid Consumption Data—Scatterplots and Correlation Coefficients

From Figures 1-3, the variables that were extracted for further analysis were those with correlation coefficients of 0.5 or higher: from Figure 1, percent of GDP spent on healthcare; from Figure 2, healthcare spending per capita, pharmaceutical spending per capita, and MRI exams per 1,000,000 population; and from Figure 3, experienced access barrier due to cost in past year. The high correlation coefficients for these variables indicates that these variables have strong relationships with the dependent variable—population adjusted opioid consumption. All selected variables with a correlation coefficient of 0.5 or higher had a p-value between 0.0015-0.171, indicating evidence to suggest they are predictors for population adjusted opioid consumption.

3.2. UNITED STATES REMOVED IN MODELS

In order to determine the effect of the United States as an outlier in the data set, all data for the United States was removed. The same analysis was conducted for the three different groups of variables, and the resulting data are as follows.

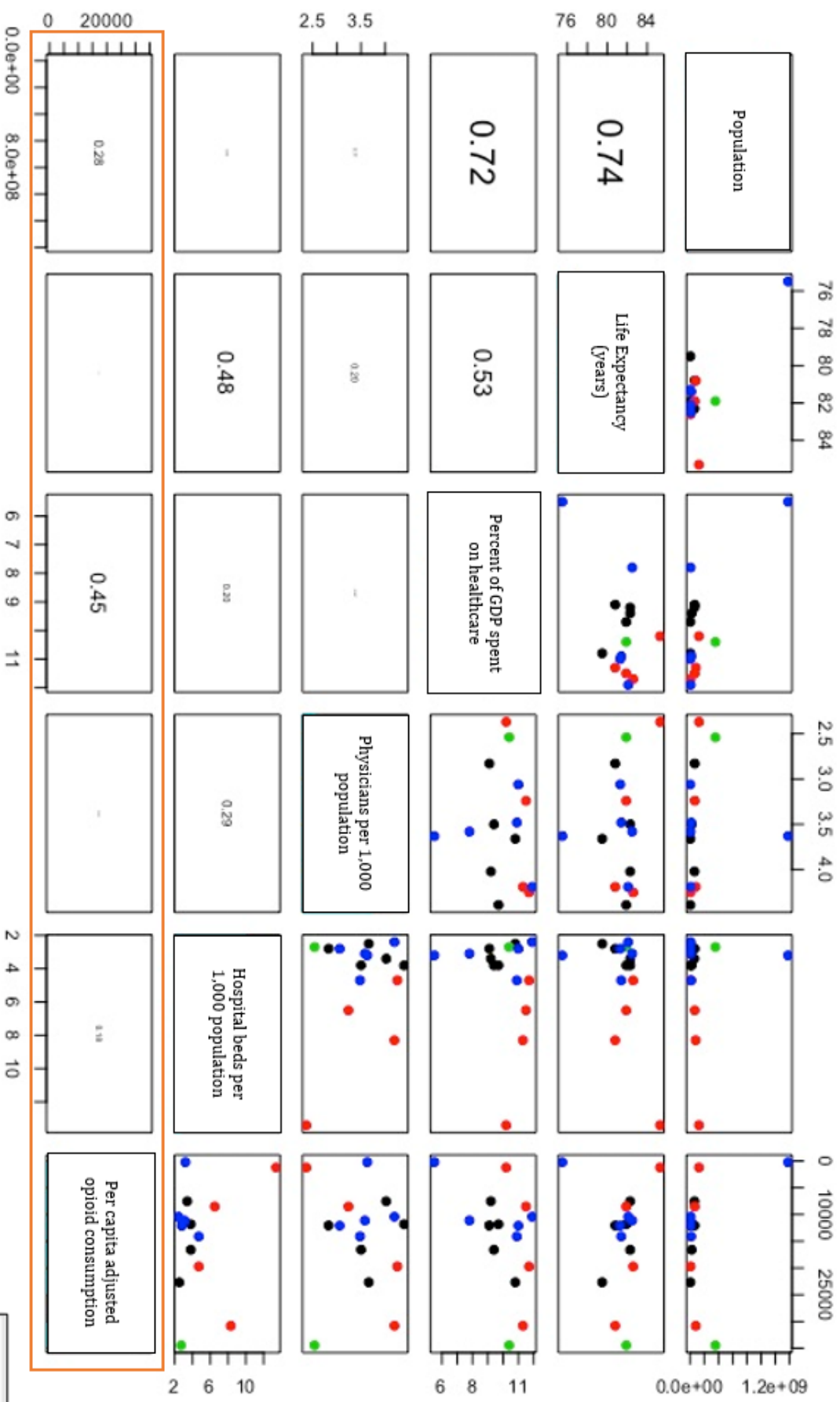
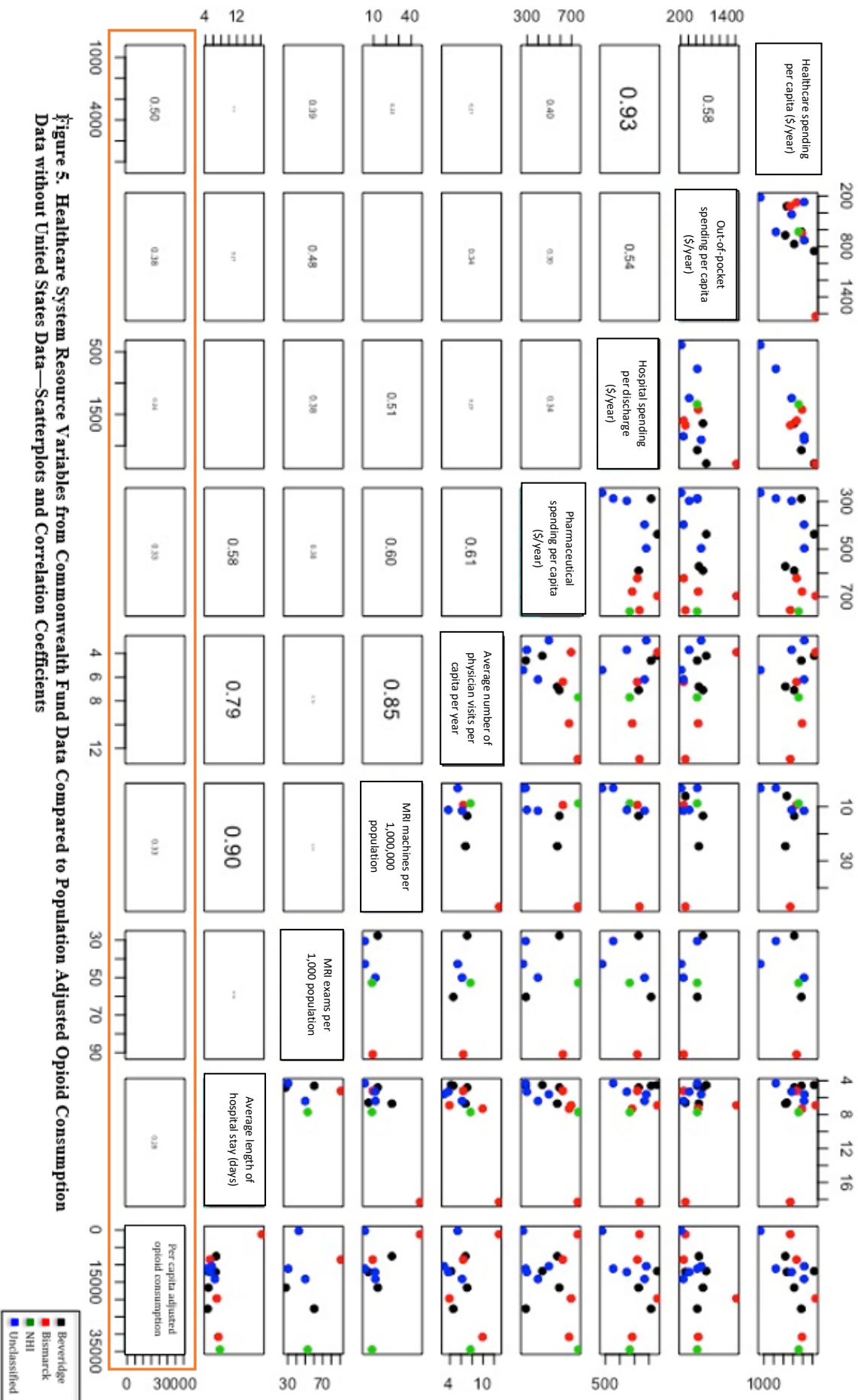


Figure 4. CIA World Factbook Data Compared to Population Adjusted Opioid Consumption Data without United States Data—Scatterplots and Correlation Coefficients



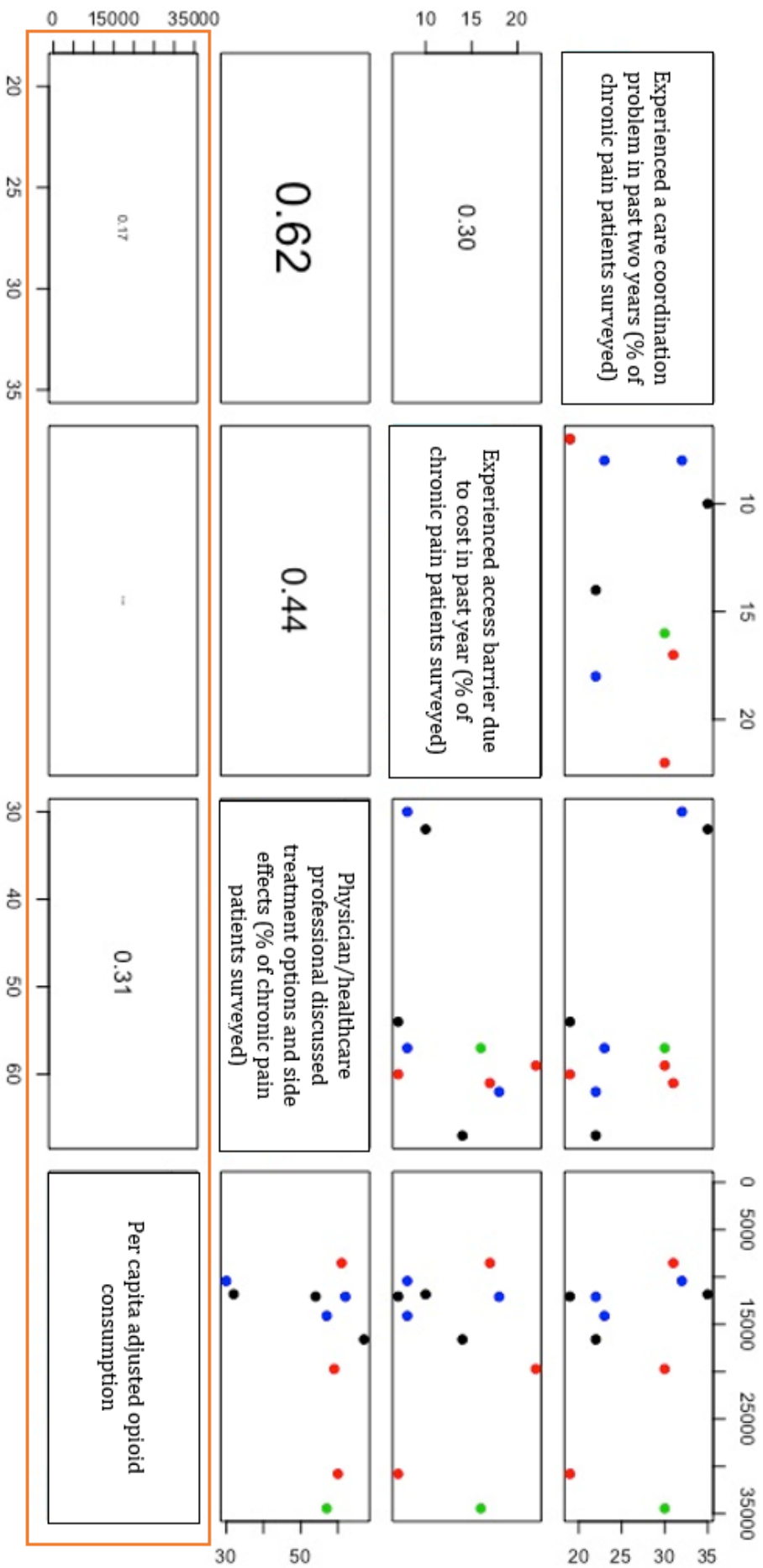


Figure 6. Patient Experience Variables Compared to Population Adjusted Opioid Consumption Data without United States Data—Scatterplots and Correlation Coefficients

The United States being an outlier of the data is evident visually in the scatterplots, as you can see the data shift with the removal of the blue triangle that represents the U.S. It is also noticeable when looking at the numerical data provided from the statistical analysis. Each variable with a high enough (0.5+) correlation coefficient in the analysis with the U.S. is labeled in Table 3 with its corresponding p-value. The coefficient for all but one of the variables drops to below 0.5 after removal of the United States from the analysis, and the corresponding p-values become less significant.

Table 3. Selected Significant Variables with Correlation Coefficients and P-Values both with and without the U.S. Included in the Analysis

Variable	U.S. Included in Model		U.S. Removed from Model	
	Correlation Coefficient	P-Value	Correlation Coefficient	P-Value
Percent of GDP Spent on Healthcare	0.72	<0.01	0.45	0.09
Annual Healthcare Spending per Capita	0.72	<0.01	0.50	0.05
Annual Pharmaceutical Spending per Capita	0.60	0.02	0.23	0.02
Annual MRI Exams per 1,000 Population	0.54	0.17	----	0.98
Experienced Access Barrier due to Cost in Past Year	0.60	0.05	0.07	0.86

After classifying each country included in the analysis as either “Beveridge,” “Bismarck,” “NHI,” or “Unclassified,” the mean of each group was recorded in Table 4 for observation. The NHI and United States columns lack standard deviations due to the fact that those contained only one country. For reference of which models each country was classified under, please see the Appendix on page 29.

Table 4. Selected Significant Variables with Averages of all Countries within each Healthcare System Model and the United States

Variable	Overall	Beveridge	Bismarck	NHI	United States
Percent of GDP Spent on Healthcare (%)	10.47%	9.64%	11.18%	10.4%	17%
Standard Deviation	2.41%	0.69%	0.07%	N/A	N/A
Healthcare Spending per Capita (\$/year)	\$4,480	\$4,314	\$4,830	\$4,569	\$9,086
Standard Deviation	\$1871	\$1213	\$1112	N/A	N/A
Pharmaceutical Spending per Capita (\$/year)	\$544.9	\$471.8	\$688	\$761	\$1,034
Standard Deviation	\$221.9	\$140.2	\$55.21	N/A	N/A
MRI Exams per 1,000 Population per year	57.71	43.95	90.9	52.8	106.9
Standard Deviation	27.99	23.12	N/A	N/A	N/A
Experienced Access Barrier Due to Cost in Past Year	14.55%	10.33%	15.33%	16%	33%
Standard Deviation	7.98%	3.51%	7.64%	N/A	N/A
Population Adjusted Opioid Consumption (defined daily doses/ 1,000,000 inhabitants/day)	16,308	14,137	15,064	34,444	47,580
Standard Deviation	12,422	5,744.9	12,955	N/A	N/A

4. Discussion

The opioid epidemic and its tremendous effects—including over 40,000 deaths in 2016, and billions of dollars lost annually from healthcare costs and loss of productivity—has taken its toll on America²⁰. Due to recent increases in awareness of this major public health emergency, and the fact that the majority of opioid addicts started by first misusing prescription opioids, a negative stigma has been attributed to the

consumption of prescription narcotics. While opioids can be a viable treatment option for those afflicted with chronic pain, the disparity between opioid consumption rates in the United States and those of the next highest countries draws attention to possible causes of how these numbers grew to be so different. The variation between the United States and other countries became more evident with the drastic change in output of the correlation coefficients and p-values of international healthcare system variables as compared to population adjusted opioid consumption data without the United States as compared to with the United States. While many of the selected variables become insignificant after removal of the United States, healthcare spending per capita remains significant.

Prior to the analysis, it was expected that many of the selected variables would have moderate to strong correlations with opioid consumption rates. This is due to previous suggestions that have implicated challenges within the healthcare system regarding access to proper pain management treatment options and integration of care as points of oversight that have led to the development of the opioid epidemic in the United States^{6, 8}. These shortcomings likely have deeper roots in resource and funding allocations within the healthcare system. The results obtained from the analysis including the United States was as expected, with five of the healthcare system related variables showing significance—many of which pertained to spending trends and resource allocation. It was speculated that the United States is an outlier for many of the variables related to costs, and this was confirmed with the loss of significant correlation coefficients with most of the variables after the removal of the United States.

Currently there is no existing literature involving a large-scale analysis of global healthcare system variables and opioid consumption. Articles have compared opioid

consumption trends in the United States and the United Kingdom and attributed the increase to poor access to proper pain treatment and addiction recovery therapy²¹. The NIH Pathways to Prevention Workshop implicated obstacles within healthcare as the source of the opioid epidemic, such as those mentioned by Hadi in his study, however no specific variables have been identified with a direct correlation to the opioid epidemic⁹.

At the forefront of opioid research are ways to manage the current public health crisis, by both decreasing prescribing rates and increasing access to alternative chronic pain treatments, and increasing availability of recovery treatments for those with opioid use disorder. Alternative chronic pain management treatments include non-opioid medications and non-pharmacologic options such as electro-stimulation, physical therapy, and low-level laser therapy²¹. Both treatment options for opioid addiction and access to alternative treatments for chronic pain are key components of managing the opioid epidemic from a biopsychosocial approach and depend heavily on proper allocation of resources and funding.

Opioid addiction recovery programs have been proven to be widely successful in alleviating the burden of those suffering from opioid use disorders as a result of the opioid epidemic, but they lack sufficient support to be more commonly used.

Medication-assisted-therapies (MATs) act by replacing opioids with opioid agonist/antagonist medications that decrease the addictive properties of opioids²². They are commonly administered in conjunction with counseling and other forms of therapy, and have had great success. A 2014 article in the New England Journal of Medicine emphasized the successful treatment of opioid addiction with MATs, and a correlative study conducted in Baltimore, Maryland from 1995-2009 was able to conclude an

association between greater access to MAT programs and reduced heroin overdoses. Deaths as a result of heroin use dropped from 310 in 1999 to 106 in 2008²³. Despite their efficacy, MATs are still not commonly used due to inaccessibility, however, the FDA granted further approval of three major MAT drugs—Suboxone, methadone, and Vivitrol—for more extensive use in February of 2018, so there could be positive effects of increased access and use of MAT programs in the near future^{24, 25}.

Major limitations to the study include data available for analysis and countries included in the analysis. These obstacles hinder the ability to fully apply the findings globally. Many developing countries were unable to be included in the study due to lack of organized healthcare and missing data for many of the variables. Countries with healthcare systems that did not fall under any of the models were assigned to the “Unclassified” group for the analysis.

4.1. CONCLUSION

With 16% of the U.S. population uninsured, and another 9% being underinsured, these are the highest rates in the developed world²¹. Despite the majority of U.S. citizens being covered by private voluntary health insurance, there are still inconsistencies in coverage and access to certain treatments²⁶. The United States has the highest healthcare spending per capita, and the correlation shown between healthcare spending and population adjusted opioid consumption among various developed countries suggests that this could be a predictor for opioid consumption trends. Other countries that utilize more centralized forms of healthcare systems such as the Beveridge or NHI models show dramatically lower healthcare spending per capita. In these countries, costs of healthcare are much more standardized, either regionally or nationally. With the prices either set by

the government or governing physician organizations, these measures of cost containment keep the cost of healthcare low. Furthermore, due to the centralization and coverage of healthcare by the government, it could be possible that these countries allocate more time, energy, and money into providing cost-efficient and integrated healthcare, involving less prescribing of opioids, and resulting in lower rates of consumption and abuse. The immense degree of fragmentation within the healthcare system of the United States could be the starting point of change towards more integrated and cost efficient care.

References

1. Merica, Dan. "Trump declares opioid epidemic a national public health emergency." CNN.com. Published October 26, 2017. Accessed May 29, 2018. <https://www.cnn.com/2017/10/26/politics/donald-trump-opioid-epidemic/index.html>.
2. Lee KF, Ray JB, Dunn GP. Chronic pain management and the surgeon: barriers and opportunities. *J. Am. Coll. Surg.* December 2001; 193(6): 689-701.
3. Gusovsky, Dina. "Americans consume a majority of the world's opioids." Cnbc.com. Published April 27, 2016. Accessed April 24, 2018. <https://www.cnbc.com/2016/04/27/americans-consume-almost-all-of-the-global-opioid-supply.html>.
4. About the U.S. Opioid Epidemic. Hhs.gov. <https://www.hhs.gov/opioids/about-the-epidemic/>. Published 2017. Accessed April 24, 2018.
5. Gatchel RJ, McGeary DD, McGeary CA et al. Interdisciplinary Chronic Pain Management: Past, Present, and Future. *Am. Psychol.* 2014 Feb-Mar; 69(2): 119-130.
6. Hadi MA, Alldred DP, Briggs M, et al. Treated as a number, not treated as a person: a qualitative exploration of the perceived barriers to effective pain management of patients with chronic pain. *BMJ Open.* 2017 Jun 12; 7(6): e016454.
7. Institute of Medicine (US) Committee on Advancing Pain Research, Care, and Education. Relieving pain in America: a blueprint for transforming prevention, care, education, and research. *National Academies Collection.* 2011.
8. Reuben DB, Alvanzo AA, Ashikaga, et al. National Institutes of Health Pathways to Prevention Workshop: The Role of Opioids in the Treatment of Chronic Pain. *Ann. Intern. Med.* 2015; 162:295–300.
9. Health Care Systems—The Four Basic Models. Pbs.org. <https://www.pbs.org/wgbh/pages/frontline/sickaroundtheworld/countries/models.html>. Published April 15, 2008. Accessed April 24, 2018.
10. 2015 International Profiles of Health Care Systems. Commonwealthfund.org. http://www.commonwealthfund.org/~media/files/publications/fund-report/2016/jan/1857_mossialos_intl_profiles_2015_v7.pdf. Published January 2015. Accessed April 24, 2018.
11. Allen D, Raffel MW. *Comparative Health Systems: Descriptive Analyses of Fourteen National Health Systems. Health Services in England.* Pennsylvania State University Publisher. 1984.

12. McCarthy RL, Schafermeyer KW, Plake KS. International healthcare services. *Introduction to Health Care Delivery: A Primer for Pharmacists*. Burlington, MA. Jones and Bartlett Learning; 2017:483-507.
13. Management of Substance Abuse--Opiates. Who.int. http://www.who.int/substance_abuse/facts/opiates/en/. 2018. Accessed April 24, 2018.
14. Busse R, Blumel M. Germany: health system review. *Health Syst. Transit*. 2014; 16(2): 1-296.
15. Why do Adults Misuse Prescription Drugs? Samhsa.gov. https://www.samhsa.gov/data/sites/default/files/report_3210/ShortReport-3210.html. Published July 27, 2017. Accessed April 24, 2018.
16. Health insurance plan and network types: HMOs, PPOs, and more. Healthcare.gov. <https://www.healthcare.gov/choose-a-plan/plan-types/>. Accessed April 24, 2018.
17. How is Medicare funded? Medicare.gov. <https://www.medicare.gov/about-us/how-medicare-is-funded/medicare-funding.html>. Accessed April 27, 2018.
18. The World Factbook. Cia.gov. <https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html>. Accessed April 24, 2018.
19. "Narcotic Drugs 2016." Incb.org. https://www.incb.org/documents/Narcotic-Drugs/Technical-Publications/2016/Narcotic_Drugs_Publication_2016.pdf. Published 2016. Accessed April 24, 2018.
20. Opioids. Drugabuse.gov. <https://www.drugabuse.gov/drugs-abuse/opioids>. Accessed April 24, 2018.
21. Weisberg DF, et al. Prescription opioid misuse in the United States and the United Kingdom: cautionary lessons. *Int. J. Drug Policy*. 2014. Nov; 25(6): 1124-30.
22. Medication and Counseling. Samhsa.gov. <https://www.samhsa.gov/medication-assisted-treatment/treatment>. Published September 28, 2015. Accessed May 14, 2018.
23. Schwartz et al. Opioid agonist treatments and heroin overdose deaths in Baltimore, Maryland, 1995-2009. *Am. J. Pub. Health*. 2013; May; 103(5): 917-22.
24. Kaplan, Sheila. *F.D.A. to Expand Medication-Assisted Therapy for Opioid Addicts*. New York Times. February 25, 2018.
25. Volkow et al. Medication-assisted therapies—tackling the opioid-overdose epidemic. *N. Engl. J. Med*. 2014; 370:2063-2066.

26. Voluntary Health Insurance. Who.int.
http://www.who.int/health_financing/topics/voluntary-health-insurance/en/. Published
2018. Accessed April 24, 2018.

Appendix

	Model	Country	Population	Life expectancy		% GDP spent on healthcare		Physicians/1,000		Hospital beds/1,000		Healthcare expenditure per capita		Out-of-pocket expenditure per capita		Hospital stays per discharge		Pharmaceuticals per capita		Avg annual number of physician visits		MRI machines per 1,000,000		MRI exams per 1,000		Avg length of hospital stay (days)		Experienced coordination of care		Experienced access barriers to treatment options		Population adjusted opioid consumption (defined daily doses/1,000,000 inhabitants/day)		Total opioid consumption (kg)		Consumption of other narcotic drugs			
Beveridge	Australia	23232413	82.3	9.4	3.5	3.8	4115	771	1645	590	7.1	13.4	27.6	4.8	22	14	67	16591	10193	35154.854																			
Beveridge	Denmark	5605948	79.5	10.8	3.66	2.5	4847	625	2070	288	4.6		60.3	4.6				22670	1577	10726.034																			
Beveridge	Italy	62137802	82.3	9.2	4.02	3.4	3209	666		572	6.8	24.6		6.7				7541	7790	99413																			
Beveridge	Norway	5320045	81.9	9.7	4.39	3.8	6170	855	2285	437	4.2			4.5	35	10	32	11824	5281	7953.921																			
Beveridge	UK	65648100	80.8	9.1	2.83	2.8	3364	321				6.1		6.6	19	7	54	12058	71087	93607																			
Bismarck	France	67106161	81.9	11.5	3.24	6.5	4361	277	1600	622	6.4	9.4	90.9	5.2	31	17	61	8520	30868	75874.494																			
Bismarck	Germany	80594017	80.8	11.3	4.19	8.3	4920	649	1423	678	9.9			7.3	19	7	60	30796	46048	539815																			
Bismarck	Japan	126451398	85.3	10.2	2.37	13.4	3713	321	1673	756	12.9	46.9		18.3				1223	13112	32826																			
Bismarck	Switzerland	8236303	82.6	11.7	4.25	4.7	6325	1630	2289	696	3.9			6.9	30	22	59	19715	1497	15650.521																			
Mixture	Netherlands	17084719	81.4	10.9	3.48	4.7	5131	270	1849	397	6.2	11.5	50	6.4	23	8	57	14103	1309	55553.146																			
Mixture	United States	326625791	80	17.1	2.57	2.9	9086	1074	2964	1034	4	35.5	106.9	5.4	35	33	60	47580	173373	493903																			
NHI	Canada	35662368	81.9	10.4	2.54	2.7	4569	623	1338	761	7.7	8.8	52.8	7.7	30	16	57	34444	26115	66217.955																			
	China	1379302771	75.5	5.5	3.63	3.2	636	216	392	263	5.4	3.2	42.7					238	16431	18372.288																			
	Israel	8299706	82.5	7.8	3.58	3.1	2232	627	772	287		3.1	30.5	4.3				11124	1370	13752																			
	New Zealand	4510327	81.3	11	3.06	2.8	3855	420	1239	297	3.7	11.2		5.3	22	18	62	12084	2264	1290.095																			
	Sweden	9960487	82.1	11.9	4.19	2.4	5153	726	1907	496	2.9			5.6	32	8	30	10419	1864	14464.683																			
		from CIA world factbook data						***from 2015 Commonwealth Fund report***												***from Opioid ER report***																			

Personal Statement

The completion of my thesis project has been one of the most beneficial ones throughout my undergraduate career. I spent countless hours reading through journal articles for classes, but this was an experience to understand what it really takes to put the effort into creating that material. While it may not be the quality that my mentor and I had strived to achieve with this project, I am still proud of having completed it.

Some major learning points came in realizing the scope of my knowledge, the inevitable reliance on others, and the great deal of respect in the field of research. I came into this project knowing next to nothing about public health, healthcare systems, and policy. I had to do a great deal of learning in a short amount of time, and my mentor and I both agreed that we should have addressed that earlier on. It's often necessary to outsource statistical analyses to consulting groups, which I did, and it was difficult to be patient waiting for the results. However, my consultant was extremely helpful, and facilitated my project to the best of his ability. I also have a greater grasp on the efforts of communicating with other professionals throughout this process. Whether it was reaching out to Dr. Irwin initially as a possible mentor, working to gain IRB approval, losing committee members due to lack of robustness and assurance of completion of the project, and gaining new committee members on short notice. I so appreciate and respect the individuals who have taken the time to help me with my thesis, even though I wish I had devoted more time and effort into making it into a more in depth, precise piece of work, I am grateful for the experiential learning I have from completing it.

