**2019 MCM**

**Problem C: The Opioid Crisis**

**Background:** The United States is experiencing a national crisis regarding the use of *synthetic* and *nonsynthetic* *opioids,* either for the treatment and management of pain (legal, prescription use) or for recreational purposes (illegal, non-prescription use). Federal organizations such as the Centers for Disease Control (CDC) are struggling to “save lives and prevent negative health effects of this epidemic, such as opioid use disorder, hepatitis, and HIV infections, and neonatal abstinence syndrome.”**[[1]](#footnote-1)** Simply enforcing existing laws is a complex challenge for the Federal Bureau of Investigation (FBI), and the U.S. Drug Enforcement Administration (DEA), among others.

There are implications for important sectors of the U.S. economy as well. For example, if the opioid crisis spreads to all cross-sections of the U.S. population (including the college-educated and those with advanced degrees), businesses requiring precision labor skills, high technology component assembly, and sensitive trust or security relationships with clients and customers might have difficulty filling these positions. Further, if the percentage of people with opioid addiction increases within the elderly, health care costs and assisted living facility staffing will also be affected.

The DEA/National Forensic Laboratory Information System (NFLIS), as part of the Drug Enforcement

Administration's (DEA) Office of Diversion Control, publishes a data-heavy annual report addressing "drug identification results and associated information from drug cases analyzed by federal, state, and local forensic laboratories." The database within NFLIS includes data from crime laboratories that handle over 88% of the nation's estimated 1.2 million annual state and local drug cases. For this problem, we focus on the individual counties located in five (5) U.S. states: Ohio, Kentucky, West Virginia, Virginia, and Tennessee. In the U.S., a *county* is the next lower level of government below each state that has taxation authority.

Supplied with this problem description are several data sets for your use. The first file

(MCM\_NFLIS\_Data.xlsx) contains drug identification counts in years 2010-2017 for narcotic analgesics (synthetic opioids) and *heroin* in each of the counties from these five states as reported to the DEA by crime laboratories throughout each state. A drug identification occurs when evidence is submitted to crime laboratories by law enforcement agencies as part of a criminal investigation and the laboratory’s forensic scientists test the evidence. Typically, when law enforcement organizations submit these samples, they provide location data (county) with their incident reports. When evidence is submitted to a crime laboratory and this location data is not provided, the crime laboratory uses the location of the city/county/state investigating law enforcement organization that submitted the case. For the purposes of this problem, you may assume that the county location data are correct as provided.

The additional seven (7) files are zipped folders containing extracts from the U.S. Census Bureau that represent a common set of *socio-economic factors* collected for the counties of these five states during each of the years 2010-2016 (ACS\_xx\_5YR\_DP02.zip). (Note: The same data were not available for 2017.)

A code sheet is present with each data set that defines each of the variables noted. While you may use other resources for research and background information, THE DATA SETS PROVIDED CONTAIN THE ONLY DATA YOU SHOULD USE FOR THIS PROBLEM.

**Problem:**

**Part 1.** Using the NFLIS data provided, build a mathematical model to describe the spreadand characteristics of the reported synthetic opioid and heroin incidents (cases) in and between the five states and their counties over time. Using your model, identify any possible locations where specific opioid use might have started in each of the five states.

If the patterns and characteristics your team identified continue, are there any specific concerns the U.S. government should have? At what drug identification threshold levels do these occur? Where and when does your model predict they will occur in the future?

**Part 2.** Using the U.S. Census socio-economic data provided, address the following questions:

There are a good number of competing hypotheses that have been offered as explanations as to how opioid use got to its current level, who is using/abusing it, what contributes to the growth in opioid use and addiction, and why opioid use persists despite its known dangers. Is use or trends-in-use somehow associated with any of the U.S. Census socio-economic data provided? If so, modify your model from **Part 1** to include any important factors from this data set.

**Part 3.** Finally, using a combination of your **Part 1** and **Part 2** results, identify a possible strategy for countering the opioid crisis. Use your model(s) to test the effectiveness of this strategy; identifying any significant parameter bounds that success (or failure) is dependent upon.

In addition to your main report, include a 1-2 page memo to the Chief Administrator, DEA/NFLIS Database summarizing any significant insights or results you identified during this modeling effort.

Your submission should consist of:  One-page Summary Sheet,

* One- to Two-page memo,
* Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and memo.
* Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

**Attachments:**

2019\_MCMProblemC\_DATA.zip **-** Includes seven zip folders and the NFLIS\_Data file.

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| --- | --- |
| ACS\_10\_5YR\_DP02.zip | ACS\_11\_5YR\_DP02.zip |
| ACS\_12\_5YR\_DP02.zip | ACS\_13\_5YR\_DP02.zip |
| ACS\_14\_5YR\_DP02.zip | ACS\_15\_5YR\_DP02.zip |
| ACS\_16\_5YR\_DP02.zip | MCM\_NFLIS\_Data.xlsx |

**Glossary:**

**analgesic –** pain relieving medication

**county –** (in the U.S.) an administrative or political subdivision of a state; a region having specific boundaries and some level of governmental authority.

**heroin –** an illegal, euphoria producing, highly addictive analgesic drug processed from morphine (a naturally occurring substance extracted from the seed pods of certain varieties of poppy plants).

**non-synthetic opioids –** a class of drugs made from extracting chemicals in opium leaves, e.g. morphine, codeine, heroin.

**opioids –** pain relieving drugs that are often highly addictive

**socio-economic factors** – factors within a society that describe the relationship between social and economic status and class such as education, income, occupation, and employment.

**synthetic opioid –** man-made opioids

背景：美国在使用合成类和非合成类阿片治疗和管理疼痛（合法、处方使用）或用于娱乐目的（非法、非处方使用）方面正面临国家危机。像疾病控制中心（CDC）这样的联邦组织正在努力“拯救生命并防止这种流行病的负面健康影响，如类阿片使用障碍、肝炎、艾滋病毒感染和新生儿禁欲综合症。”简单地执行现有法律对联邦调查局（FB）来说是一个复杂的挑战。以及美国禁毒局（DEA）。

这对美国经济的重要部门也有影响。例如，如果阿片类危机蔓延到美国人口的所有阶层（包括受过大学教育和拥有高级学位的人），那么需要精确劳动技能、高科技组件组装以及与客户和客户的敏感信任或安全关系的企业可能难以填补这些空缺。ONS。此外，如果老年人中类阿片成瘾的比例增加，医疗保健费用和辅助生活设施人员配备也将受到影响。

DEA/国家法医实验室信息系统（NFLIS），作为毒品执法的一部分

美国联邦政府（DEA）的转移控制办公室发布了一份数据密集的年度报告，阐述了“由联邦、州和地方法医实验室分析的毒品案件中的药物鉴定结果和相关信息”。NFLIS内的数据库包括来自犯罪实验室的数据，这些实验室处理的数据占全国估计的1.2%以上。每年有一百万个州和地方毒品案件。对于这个问题，我们将重点放在美国五（5）个州的个别县：俄亥俄州、肯塔基州、西弗吉尼亚州、弗吉尼亚州和田纳西州。在美国，一个县是下一个较低级别的政府，低于每个拥有税收权限的州。

与此问题描述一起提供的是供您使用的多个数据集。第一个文件

（mcm\_nflis\_data.xlsx）包含这五个州的每个县2010-2017年麻醉镇痛剂（合成类阿片）和海洛因的药物鉴定计数，由每个州的犯罪实验室向DEA报告。当执法机构将证据作为刑事调查的一部分提交给犯罪实验室，并且实验室的法医科学家对证据进行测试时，就会进行药物鉴定。通常，当执法机构提交这些样本时，他们会在事故报告中提供位置数据（县）。当向犯罪实验室提交证据但未提供该位置数据时，犯罪实验室使用提交案件的市/县/州调查执法机构的位置。对于这个问题，您可以假设县位置数据是正确的，如所提供的。

另外七（7）个文件是压缩文件夹，其中包含来自美国人口普查局的摘录，这些摘录代表了2010-2016年这五个州各县收集的一组共同的社会经济因素（acs\_xx\_5yr\_dp02.zip）。（注：2017年无相同数据。）

代码表与定义所记录变量的每个数据集一起出现。虽然您可以将其他资源用于研究和背景信息，但提供的数据集只包含您应该用于此问题的数据。

问题：

第1部分。利用提供的NFLIS数据，建立一个数学模型，描述五个州及其县之间报告的合成类阿片和海洛因事件（案例）随时间的传播和特征。使用你的模型，找出五个州中可能已经开始使用特定阿片类药物的任何可能位置。

如果您的团队确定的模式和特征继续存在，那么美国政府应该有什么具体的担忧吗？在什么样的药物识别阈值水平下会发生这些情况？您的模型预测它们将在何时何地发生？

第2部分。利用提供的美国人口普查社会经济数据，解决以下问题：

关于类阿片的使用如何达到目前的水平、谁在使用/滥用类阿片、对类阿片使用和成瘾的增长有何贡献以及为什么类阿片的使用尽管存在已知的危险，但仍然持续存在，有许多相互竞争的假设作为解释。使用或使用趋势是否与提供的任何美国人口普查社会经济数据有关？如果是这样，请从第1部分修改您的模型，以包含此数据集的任何重要因素。

第3部分。最后，结合第1部分和第2部分的结果，确定一种可能的应对阿片类药物危机的策略。使用您的模型来测试此策略的有效性；识别成功（或失败）所依赖的任何重要参数界限。

除了您的主报告，还包括一份1-2页的备忘录给首席管理员DEA/NFLIS数据库，总结您在建模过程中发现的任何重要见解或结果。

您提交的材料应包括：•一页摘要表，

•一至两页备忘录，

•您的解决方案不超过20页，最多23页，包括摘要和备忘录。

•注意：参考列表和任何附录不计入23页的限制，应在完成解决方案后出现。

1. Centers for Disease Control website, (<https://www.cdc.gov/features/confronting-opioids/index.html>), accessed 4 September 2018. [↑](#footnote-ref-1)