
FIGHTING THE OPIOID EPIDEMIC

USING TIME SERIES ANALYSIS TO EVALUATE IMPACTS OF RECENT PROGRAMS IN THE
STRUGGLE TO REDUCE OPIOID DEPENDENCY IN THE COMMONWEALTH OF KENTUCKY

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FROM THE KY DEPARTMENT OF HEALTH:

In 2016, the Commonwealth lost 1,404 Kentuckians to fatal drug overdoses. Over the past 5 years Kentucky has seen a 38% increase in overdose deaths. Historically among the Substance Use Disorder (SUD) population the number of patients who have one of the common co-morbidities associated with SUD are much greater than patients without an SUD. For example, the state has seen a rapid increase (nearly 115%) in cases of Neonatal Abstinence Syndrome (NAS). Of those cases, Medicaid accounted for over 80%. In 2016, the Centers for Disease Control identified 220 counties in the US most susceptible for HIV outbreak. 54 of those counties are in the commonwealth – that's nearly 25% of the identified hot spots.

<https://www.medicaid.gov/Medicaid-CHIP-Program-Information/By-Topics/Waivers/1115/downloads/ky/health/ky-health-sud-implement-protocol-aprwl-10052018.pdf>

WAIT, WHAT ARE OPIOIDS EXACTLY?

- Opioids describe a class of drugs including opium, opium derivatives, and synthetic substitutes. Poppies have been cultivated since at least 3400 BC in Mesopotamia for their prized opium.
 - Morphine was first isolated and extracted from opium by Friedrich Sertürner in Germany in 1803
 - Until the 20th century, heroin, morphine and other opioids were legal and available without a prescription. Many tinctures from the early 20th century included morphine or its derivatives and were used to treat mood, pain, teething, and colds.
 - Humans have several neuroreceptors that bind to opioid substances. While these receptors are key to the pain response, they also play a role in the reinforcement and reward process in the brain.
 - While they have their place in medicine, they have also proliferated into a public health crisis
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HOW DID WE GET HERE?

- THE CDC IDENTIFIES THREE WAVES OF THE MODERN OPIOID EPIDEMIC:
 - 1996 – PURDUE PHARMACEUTICALS INTRODUCES THEIR NEW OXYCODONE FORMULATION LABELED AS OXYCONTIN. AT THE TIME, PURDUE MARKETED THEIR NEW DRUG AS A NON-ADDICTIVE TREATMENT FOR INTRACTABLE PAIN. SALES BALLOONED FROM \$48M IN 1996 TO NEARLY \$1.1B IN 2000. OTHER MANUFACTURERS SOON FOLLOWED WITH INTRODUCTIONS OF NEW SYNTHETIC OPIOIDS AND NEW DELIVERY MECHANISMS – SUBLINGUAL AND TRANSDERMAL ESPECIALLY.
 - IN 2010, HEROIN, A POPULAR STREET OPIOID, EXPERIENCED A RESURGENCE IN USE AND OVERDOSES. THIS IS WHAT THE CDC CALLS THE BEGINNING OF THE SECOND WAVE
 - IN 2013, FENTANYL, A PRESCRIBED AND VERY POWERFUL SYNTHETIC OPIOID, EMERGED AS A COMMON CAUSE OF OVERDOSE, USHERING IN THE THIRD WAVE. TODAY, SYNTHETIC OPIOIDS ARE THE MOST COMMON OPIOIDS FOUND IN AN OVERDOSE DECEDENT.

WHAT COUNTERMEASURES HAVE BEEN TAKEN?

- 2003: REPRESENTATIVE HAL ROGERS, R-KY, SPONSORED LEGISLATION TO FEDERALLY FUND STATE-RUN PRESCRIPTION DRUG MONITORING PROGRAMS (PDMPS) TO TRACK THE PRESCRIPTION AND SALE OF CONTROLLED SUBSTANCES IN EACH STATE THAT OPTS TO PARTICIPATE
- 2016: 49 STATES AND 1 US TERRITORY HAD PDMP SYSTEMS IN PLACE.
- 2017 : AN ADDITIONAL \$600K OF FEDERAL FUNDS WERE AWARDED TO KENTUCKY TO EDUCATE PRESCRIBERS AND PHARMACISTS ABOUT KENTUCKY'S PDMP, KASPER
- 2018: 47 STATES PARTICIPATE IN SHARING PRESCRIPTION INFORMATION ACROSS STATE LINES
- LATE 2018-CURRENT: US DOJ ESTABLISHES A TASK FORCE TO FOCUS ON ERADICATING (OR AT LEAST MINIMIZING) THE OPIOID SCOURGE IN APPALACHIA. SO FAR, SEVERAL DOZEN ARRESTS HAVE BEEN MADE OF VARIOUS MEDICAL PROFESSIONALS WHO ALLEGEDLY PARTICIPATED IN THE ILLEGAL DISTRIBUTION OF OPIOIDS IN APPALACHIA.

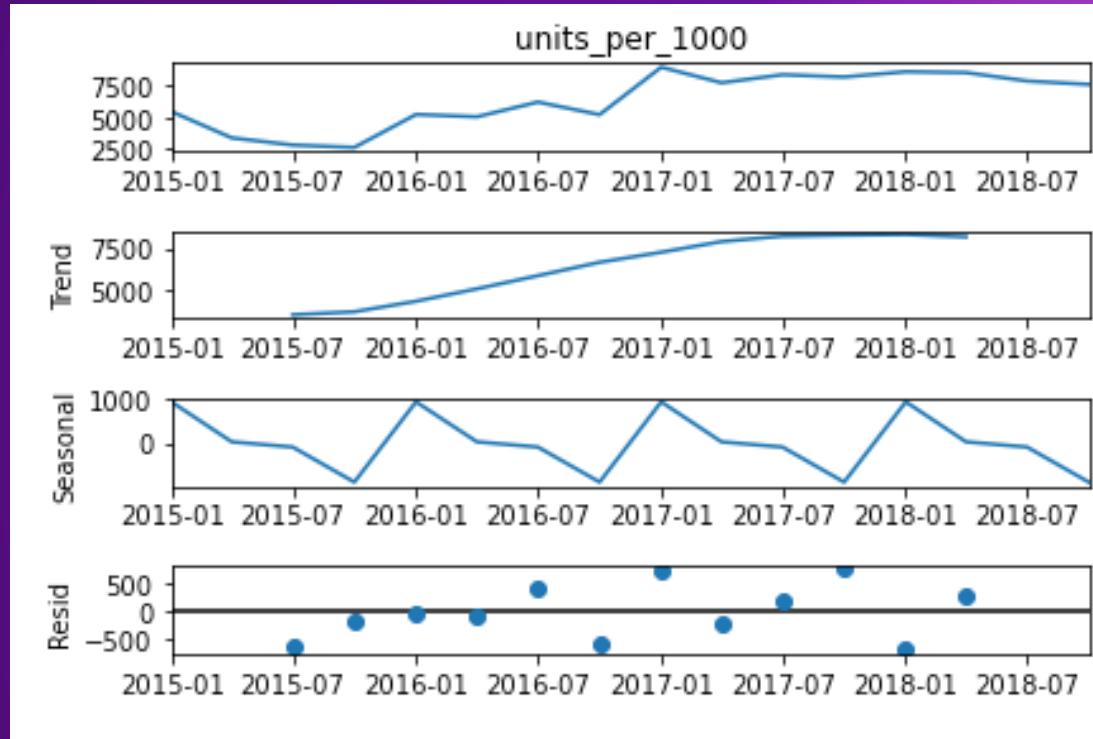
THE HYPOTHESIS

- BECAUSE OF THE INCREASED INTERDICTION IN KENTUCKY, ESPECIALLY SINCE 2018, PRESCRIPTION OPIOID CONSUMPTION SHOULD BE LESS THAN WHAT HISTORICAL DATA WOULD FORECAST.
 - ADDITIONALLY, BECAUSE OF THE INCREASED EFFORT TO RECRUIT AND SPONSOR MEDICAL PROFESSIONALS TO PROVIDE MEDICATION-ASSISTED TREATMENT FOR SUBSTANCE ABUSE, CONSUMPTION OF THE DRUGS USED TO TREAT SUD SHOULD BE GREATER THAN WHAT HISTORICAL DATA WOULD FORECAST.
 - **HYPOTHESIS: NON MAT ACTUAL UNITS PER 1000 SHOULD BE LESS THAN FORECAST. MAT ACTUAL UNITS PER 1000 SHOULD BE GREATER THAN FORECAST**
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THE DATA

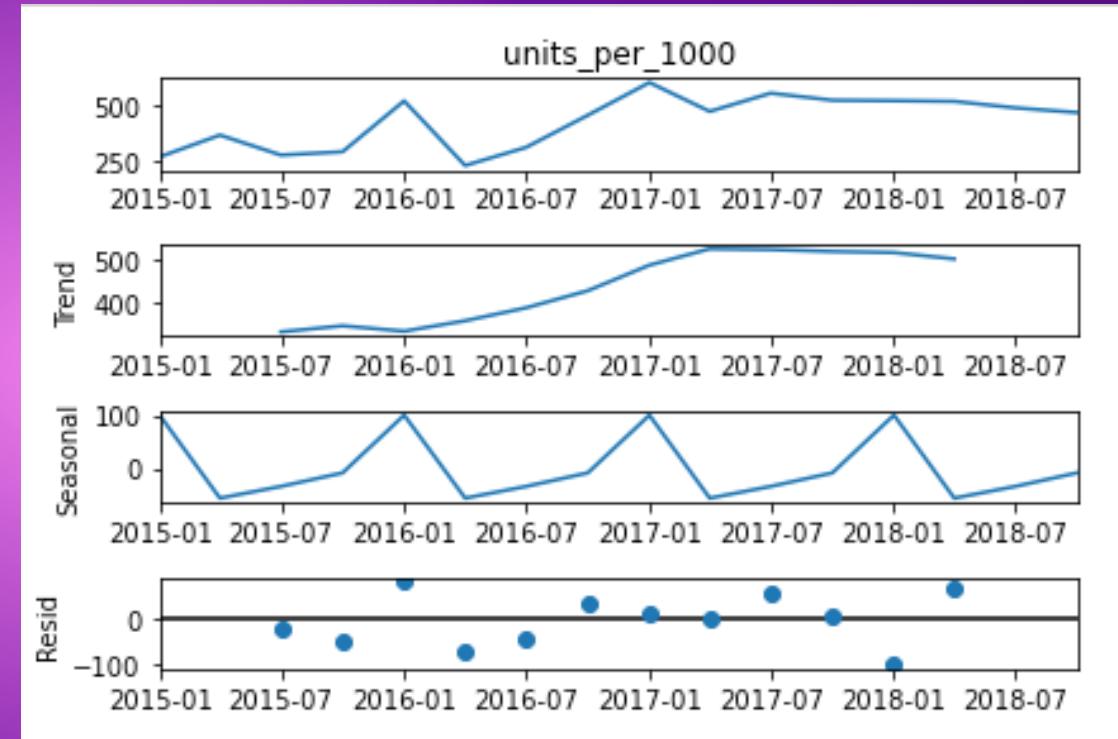
- KENTUCKY MEDICAID PRESCRIPTION AND ENROLLMENT DATA IS AVAILABLE VIA API THROUGH Socrata. DATA IS REPORTED QUARTERLY FOR CLAIMS AND MONTHLY FOR ENROLLMENT
 - DRUG CLASSIFICATION INFORMATION IS AVAILABLE VIA API FROM THE FDA
 - BLENDED THESE THREE DATA ELEMENTS (RX, ENROLLMENT, AND CLASSIFICATION) TO CREATE 2 TIMESERIES DATASETS – ONE FOR NON MAT OPIOIDS, ONE FOR MAT OPIOIDS. CONVERTED ALL MEASURES INTO “UNITS PER 1000”, BASED ON NUMBER OF UNITS REIMBURSED BY MEDICAID AND ENROLLMENT
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TIMESERIES TESTING - DECOMPOSITION



CLASS II NON_MAT

SEASONALITY?



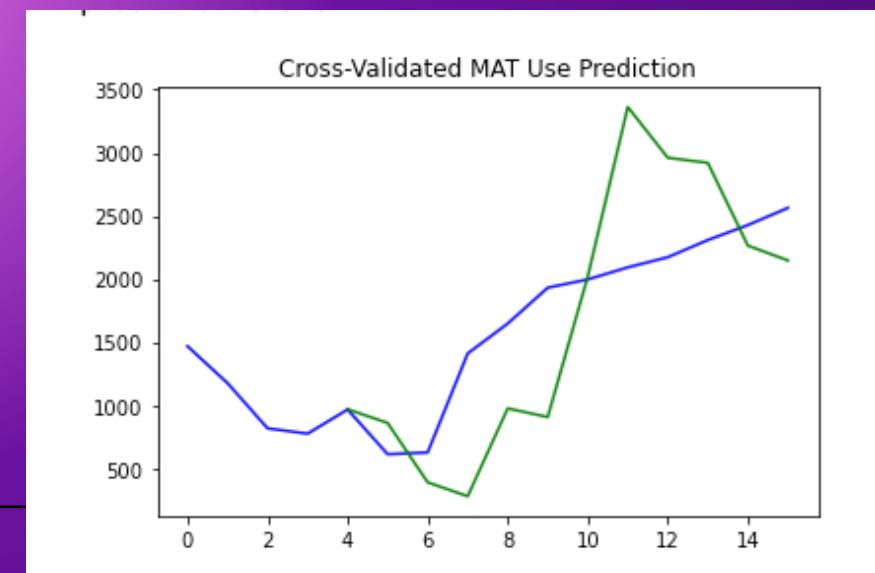
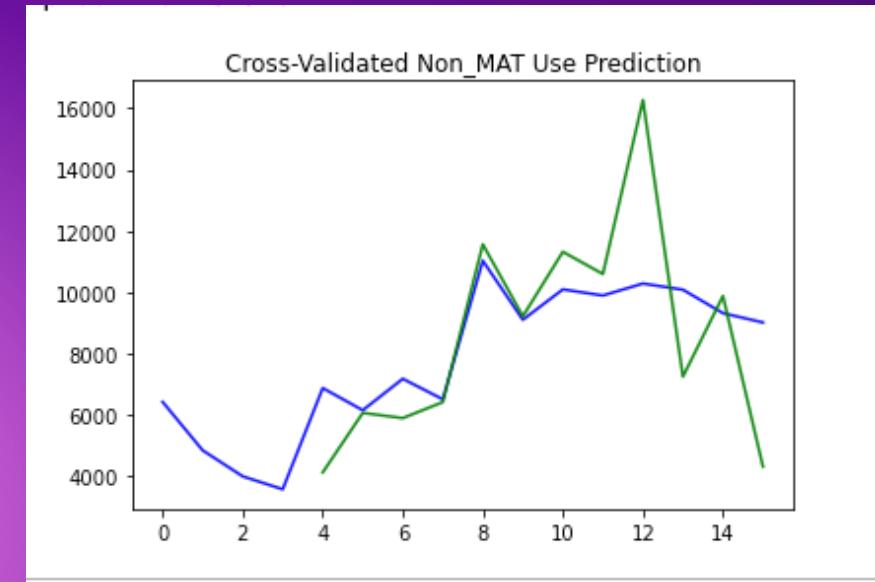
CLASS III NON_MAT

TIMESERIES TESTING – DICKEY-FULLER TEST

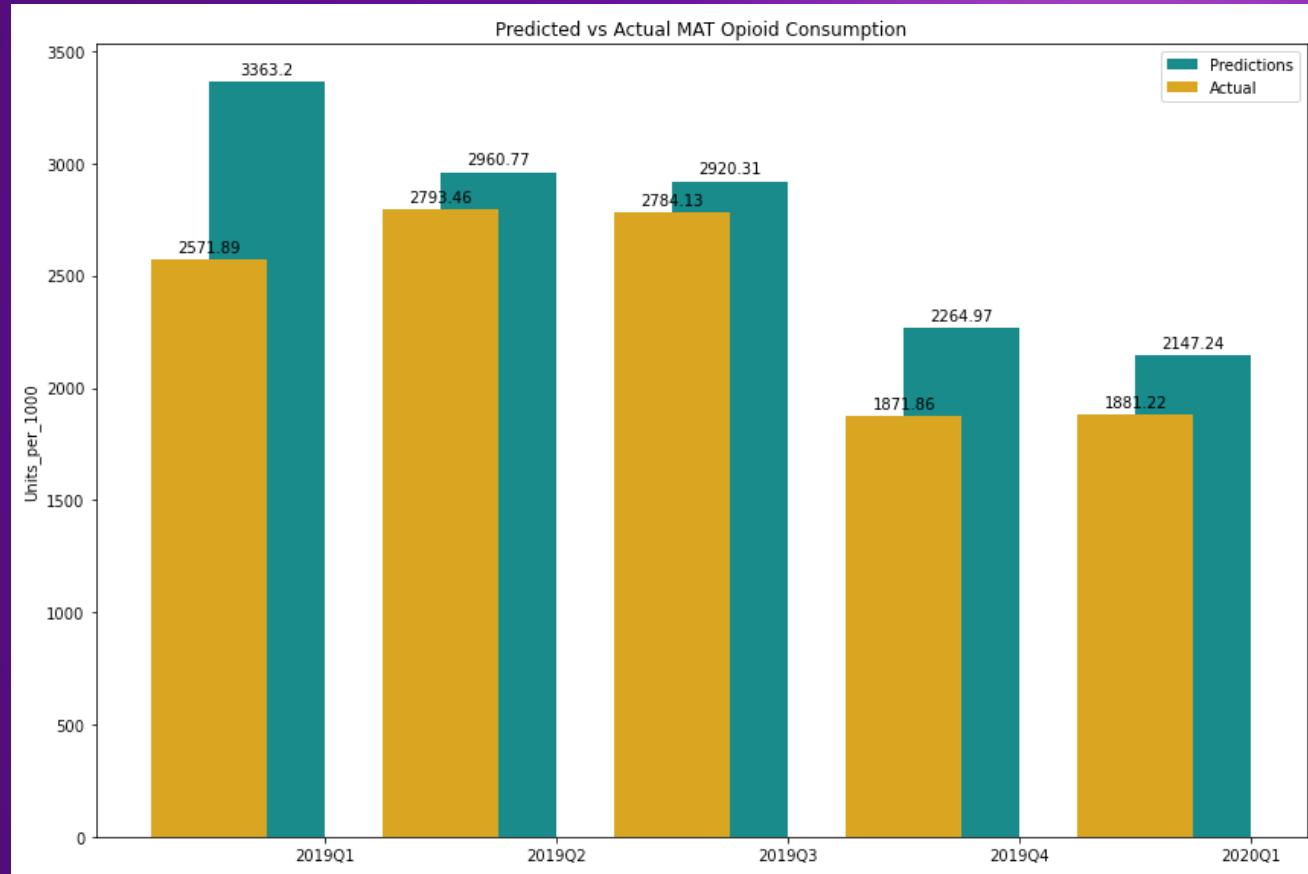
- SPLIT DATA ONLY AS MAT/NON-MAT – SPLITTING BY DEA SCHEDULE DID NOT PROVIDE A VERY ROBUST SET TO WORK FROM
- DICKEY-FULLER IS A METRIC TO EVALUATE STATIONARITY WITHIN A TIMESERIES. STATIONARITY MEANS THAT THE MEAN AND VARIANCE DON'T CHANGE WITHIN THE TIME SERIES
- MAT DATA – VERY LOW P VALUE, LESS THAN 0.05. EXHIBITS SOME STATIONARITY
- NON-MAT DATA – DOES NOT MEET THE CRITERIA FOR STATIONARITY, P VALUE 0.47
- USED DIFFERENCING TO CREATE D' AND D'': D'' EXHIBITS STATIONARITY FOR BOTH DATA SETS AND PROVIDES THE MOST ACCURATE MODEL BASED ON RMSE

MODELING – ARIMA/SARIMA

- USED PMDARIMA LIBRARY TO AUTOMATE GRIDSEARCHING HYPERPARAMETERS TO FIND THE BEST FIT FOR EACH DATASET
- GENERATED 4 QUARTERS OF PREDICTIONS OFF OF A SLIDING 4 MONTH WINDOW THAT ADVANCES WITH EACH ITERATION. WITH ARIMA, FORECASTING BUILDS OFF OF PREVIOUS FORECASTS AND FORECAST ERRORS. SARIMA ADDS A SEASONAL COMPONENT, WHICH GIVEN THE QUARTERLY REPORTING, INCLUDING A SEASONAL FACTOR OF 4 REDUCED RMSE AND IMPROVED RESULTS.



TESTING THE HYPOTHESIS -- MAT

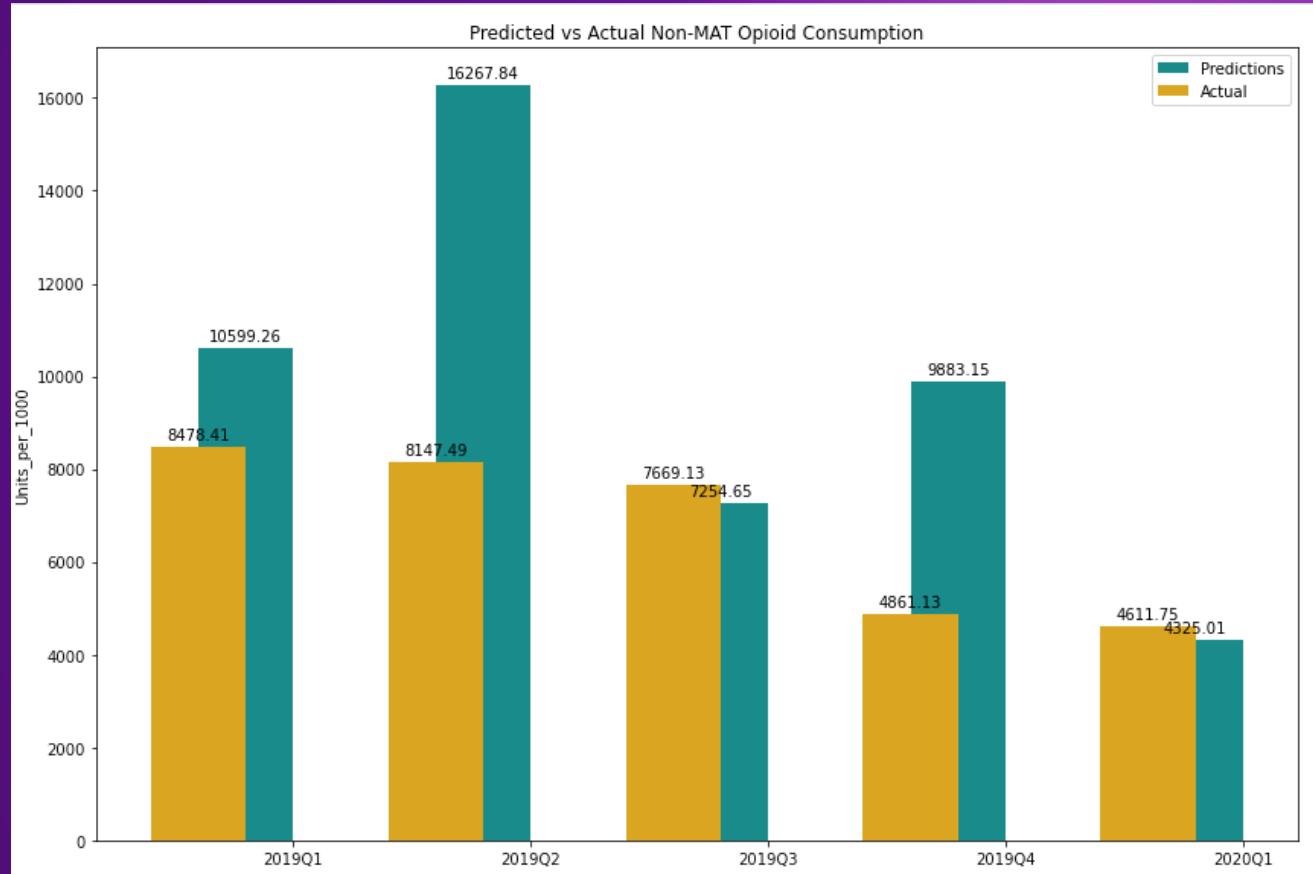


MEDICATED ASSISTED TREATMENT
OPIOIDS :

ACTUALS < PREDICTED.

HYPOTHESIS FAILED

TESTING THE HYPOTHESIS – NON MAT



NON MEDICATED ASSISTED
TREATMENT DRUGS:

ACTUALS < PREDICTED.

HYPOTHESIS PROVEN?!

CONCLUSIONS

WITH THE DATA PUBLICALLY AVAILABLE, IT APPEARS THAT THE STEPS THE COMMONWEALTH IS TAKING TO CURB THE OPIOID EPIDEMIC ARE WORKING! OPIOID CONSUMPTION, WHEN MEASURED BY DOSE, APPEARS TO BE DECREASING ACROSS THE MEDICAID POPULATION.

HOWEVER, THE DATA DID NOT PROVIDE ANY INSIGHT INTO DRUG STRENGTH OR IF A PATIENT SWITCHED FROM ONE OPIOID TO ANOTHER. IT IS POSSIBLE THAT WHILE NUMBER OF DOSES DECREASED, DRUG STRENGTH OF THE DRUGS PRESCRIBED MAY HAVE INCREASED.

FURTHER, KENTUCKY IS STILL LAGGING IN PARTICIPATION IN MEDICATED ASSISTED TREATMENT PROGRAMS, AS CURRENT USE IS BELOW WHAT WAS PREDICTED.

NEXT STEPS

REVIEWING OTHER STATES' DATA, ESPECIALLY IN APPALACHIA, FOR REGIONAL PERSPECTIVE

INCORPORATE FBI ARREST DATA TO LOOK FOR ANY ARREST TRENDS THAT MAY BE PREDICTORS OF OPIOID ABUSE
