The Opioid Safety Initiative and Veteran Suicides

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Abstract: The VA, in response to the growing opioid crisis in the United States, released the OSI in August 2013. In congruence with state-implemented Prescription Drug Monitoring Programs (PDMP), the OSI is a supply-side intervention aimed at reducing the use of opioids in pain-management strategies. Coinciding with the rollout of OSI, the VA opioid prescription rate decreased by 41 percent from the years 2012 to 2017 – a successful reduction in the supply of opioids to veterans. Prior to OSI implementation, veteran suicides aged 18-34 in the year 2012, were 31 per 100,000. In 2016, veteran suicides aged 18-34 were 45 per 100,000, representing a 45 percent increase. Because OSI only affects veterans who use VA health care, the implementation of this policy provides an ideal quasi-experimental setting, where veterans serve as the treatment group and non-veterans act as the control. In this paper, using county-level data from the CDC's National Violent Death Reporting System's restricted access database (NVDRS-RAD), we use a triple difference estimator with county and year fixed effects to investigate OSI's impact on the evolving suicide rates between veterans and civilians, accounting for their corresponding rural-urban places of residence. Our results indicate that a positive and significant causal relationship does exist between OSI and veteran/military suicides, particularly among the rural veteran population.

JEL Codes: I12; I18; D11; D12

Keywords: Opioids, Policy, Suicides, Veteran

1. Introduction:

Throughout the 1990's and into the twenty-first century, the United States has seen a surge of substance abuse disorders, primarily driven by prescription opioids. As a result, from 1999 to 2017, more than 700,000 people have died from a drug overdose, which represents an increase of opioid-related mortality greater than 500 percent (CDC, 2018). The broad detrimental effects of this crisis have been heterogeneous. For example, individuals living in rural areas are 87 percent more likely to receive an opioid prescription compared to individuals in urban areas (Garcia, 2019); this corresponds with opioid-related poisonings rates, which have increased at 3 times the rate of those who live in metropolitan areas (Keyes, et al., 2014). Additionally, veterans have also been particularly susceptible to this crisis with rural veterans faring worse than their urban counterparts (Johnson et al., 2015; McCarthy et al., 2011; Mohamed et al., 2009; Wallace et al., 2006).

In response to the opioid epidemic, policymakers at the state level have implemented Prescription Drug Monitoring Programs (PDMPs) to combat the supply of prescription opioids by deterring patients from "doctor shopping" and enhancing physician accountability in their opioid prescribing practices. In implementing these state-wide programs, policymakers were hoping that such measures would decrease the amounts of opioids prescribed. The implementation of state-wide PDMPs have resulted in successful supply reductions of prescription medication and morphine-equivalent dosages in recent years (Bao et al., 2016; Deyo et al., 2018; Haffajee et al., 2018; Kilby, 2015; Moyo et al., 2017; Suffoletto et al., 2018). However, there is evidence to suggest that these supply-reducing opioid policies unintendedly led to an increase of illicit drug abuse and fatalities (Alpert et al., 2017; Delcher et al., 2017; Kilby, 2015; Meinhofer, 2017)

Although the implementation of state-wide PDMPS appear to have been successful in reducing the dispensing of prescription opioids for the general population, members of the Veteran Affairs (VA)

Health System--which include roughly half of the total veteran population, including 93 percent of service connected veterans, i.e. veterans injured during their service (NCVAS, 2020) and many current military personnel--have not been subject to such state legislation. Because more than one-third of all veterans were prescribed opioids in 2012 – an increase of almost 77 percent since 2004[1] (VA, 2017) – the amount of opioids dispensed at the VA increased at a staggering rate until it hit a peak in 2012 (see Figure 2). The high rates of opioids prescribed led to a high incidence of opioid substance abuse disorder and opioid-related mortality among veterans (Baser et al., 2014; Boehnert et al., 2011; Axelrod, 2013). In an attempt to combat this opioid crisis among veterans, the VA implemented the Opioid Safety Initiative (OSI), which, similar to PDMPs, was primarily designed to curtail the amounts of opioids prescribed, especially high dose prescriptions (higher than 100 morphine-equivalent daily dose), long-term prescriptions, and concomitant prescriptions (e.g. opioids and benzodiazepines) for comorbid maladies. Curtailment initiatives included establishing a database of patients' prescription history, which prevents doctor shopping within the VA and increases physician accountability for opioid prescriptions, increased drug screening among patients, and encouraging physicians to substitute toward alternative pain management practices through VA instituted education programs and directives for physicians. Although launched in five regions in 2012[2] and nationally implemented in 2013, this policy has added additional directives[3] in successive years, including in 2016 when the VA mandated queries into state PDMP databases; before this directive, queries were optional for the physician. Coinciding with the rollout of the policy, the amounts of opioids dispensed immediately began to diminish. From 2012 to 2017, the VA's opioid prescription rate decreased by 41 percent (VA, 2018). Despite the policy's apparent success in

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[1] Study found that over 90% of veterans with chronic pain who had been on opioids for at least 90 days, were still using opioids 1 year later; 80% were still using opioids after the 3.5 year follow up (VA, 2017) https://www.healthquality.va.gov/guidelines/Pain/cot/VADoDOTCPG022717.pdf

[2] These regions were located in Minnesota, which is a state that is not included in our dataset.

[3] See Figure 1, which shows timeline of implementation of OSI and additional directives.

reducing the number of opioids dispensed, there have been accusations within and without the VA Health System[4] that OSI policy encouraged physicians to "cut off" veterans from their pain medications. Because of the high incidence of chronic pain with corresponding high rates of opioid prescriptions among veterans, the curtailment of opioid prescriptions increases the risk of suicide due to increased comorbid mental and physical anguish (e.g. opioid-related withdrawal, increased physical pain, unstable addictions) as a result of increased pain in the absence of analgesic use, as well as forced discontinuation of opioid therapy (Borgschulte et al., 2019; Demidenko et al., 2017; Kuramoto et al., 2012). The veteran population is acutely susceptible to these increased suicide risks (Oquendo and Volkow, 2018), particularly veterans who live in rural areas (Johnson et al., 2015). Thus, it may be possible that in an attempt to help the veteran population through mitigating the opioid epidemic by curtailing opioids, the OSI unintentionally increased suicides among veterans and military personnel.

In this paper, we examine the effect of the Opioid Safety Initiative (OSI) on veteran/military suicides. We investigate causality using a triple difference (DDD) empirical model, using county-level variation in the suicide rates per 100,000 individuals between civilians and veterans/military personnel before and after the implementation of OSI. Because the OSI was implemented at a national level in 2013[5], the variation in the annual evolution of the suicide rates between civilians and veterans/military, along with urban-rural differences, is what identifies our coefficients of interest. The urban-rural distinction is made due to the vast differences in health care options, treatment

[4] In 2011, prior to national OSI implementation, the Minneapolis, St. Cloud, and Fargo VAs pioneered OSI, resulting in reduced high-dose opioid prescriptions by 90% prior to 2014; long-term opioid prescriptions were reduced by 78%. The Star Tribune, a Minneapolis newspaper published "Cut Off – Veterans Struggle to Live with VA's New Painkiller Policy" which quotes several addiction specialists, accusing the VA of creating addicts and then cutting their supply. Additionally, the Government Accountability Office (GAO) alleged that the VA failed to establish "safe" tapering programs. https://www.gao.gov/assets/700/692061.pdf

[5] Veterans and current military personnel who are referred to the VA by their health provider, TRICARE, along with their dependents, are the only population affected by this policy; the vast majority of VA users are veterans.

availability, opioid prescription rates, and cultural norms between these veteran populations; these dissimilarities should result in differential impacts for the effect of OSI on suicide rates among rural and urban veterans.

Other studies point to the discontinuance of prescription drugs as a risk factor for suicide, but these studies do establish a causal link between the two (Demidenko et al., 2017; Kuramoto et al., 2012; Oliva et al., 2020). As we describe in the next section, veterans and military personnel are a population particularly susceptible to increased suicide risk resulting from a loss of prescription analgesics (Toblin et al., 2014; Johannes et al., 2010; Cesur et al., 2019; Baser et al., 2014; Kang et al., 2015).

We first show that just prior to the implementation of OSI, trends in suicides are similar between veterans/military and civilians. However, after the implementation of OSI, suicide rates for veteran/military personnel significantly increase relative to suicide rates for civilians, and this effect is concentrated among rural veterans. Our findings are robust to controlling for different sets of time-variant explanatory variables and applying linear and non-linear functional forms, e.g. OLS and Poisson Quasi-Maximum Likelihood Estimation (QMLE).

Other results indicate that when stricter opioid policies are accompanied by demand-reducing interventions in the form of geographical proximity to addiction treatment centers, suicides decrease, especially among the veteran/military population in rural areas. Additionally, we find that PDMPs increase suicides among both populations in our analysis (veterans/military personnel and civilians), but consistent with Borgschulte et al. (2018), suicides decrease when accompanied by addiction treatment centers. Identification of PDMP effects comes from the variation in state legislature's implementation of PDMPs over time as in Borgschulte et al. (2018), Meinhofer (2018), and Kilby (2015).

1.1 Background: Veterans and Opioids

Although the opioid epidemic has negatively affected Americans across all demographics, perhaps no other group has suffered the ill-effects of opioid substance abuse more than United States veterans and military personnel. Opioid-related overdose mortality rates for veterans are 1.3 to 2.1 times higher than for civilians (Bohnert et al., 2011; Axelrod, 2013) and the prevalence of substance abuse disorder for veterans is almost seven times higher (Baser et al., 2014). In the fiscal year of 2016, it was estimated that approximately 65,000 veterans were treated for opioid addictions (VA Opioid Prescription Policy, 2015) and the overall overdose rate per 100,000 veterans had risen 50 percent, compared to 2010 (Lewei, et al., 2019).

Due to their unique training and experiences (stressful simulations and combat operations), physical and psychological pain is purported to be a primary contributor to the opioid crisis within veteran communities (Bennett et al., 2013; Cesur et al., 2019). An estimated 45% of veterans suffer from chronic pain (Clancy, 2014; Sandbrink, 2017)— a rate that is 3 to 5 times higher when compared to the civilian population (Toblin et al., 2014; Johannes et al., 2010). Among veterans who receive treatment at VA facilities, over 50% suffer from chronic pain (Gironda et al., 2006). Because of these higher pain levels, nearly half of the veteran population diagnosed with non-cancer related pain were prescribed an opioid; 40 percent of those prescriptions were for long term use (Edlund et al. 2014), which increase the likelihood of addiction, relative to those with limited opioid exposure (Edlund et al., 2010).

Veterans who have been involved in combat operations--approximately 2.1 million since 2001 (Wenger et al., 2019)--have a particularly high incidence of physical and psychological pain, which is a strong antecedent to opioid-use disorders (Cesur et al., 2019). Chronic pain is the most common medical issue for veterans returning from combat operations, and nearly 60% of returning veterans suffer from it (VHA, 2013). In the aftermath of major combat operations in Iraq and Afghanistan, the rate of opioid use disorders among veterans has increased by 55% (VA Opioid Prescription Policy, 2015). Combat-related injuries and psychological traumatic experiences (e.g. witnessing death) play a particularly important role in the rate of opioid use disorders among veterans (Cesur et al., 2019). Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) has also allowed millions of servicemembers cheap access to opium supplies during their military deployments; this phenomena, coupled with the VHA's historically lax opioid prescription policies, has significantly contributed to opioid dependence and abuse among the population of veteran and military personnel (Cesur et al., 2019).

Because many veterans suffer from comorbid physical and mental maladies (physical trauma and Post Traumatic Stress Disorder), especially those veterans who have unique experiences in combat, concurrent use of prescription opioids and Central Nervous System (CNS) depressants are relatively common; 27% of veterans who were prescribed opioids were also jointly prescribed benzodiazepines, a CNS depressant (Park et al. 2015). The joint use of opioids and benzodiazepines increase the probability of emergency room visits and inpatient admission due to opioid overdose (Sun et al., 2017). The concurrent use of these medications has been present in roughly half of all veteran opioid overdose deaths (Park et al. 2015).

To taper the destruction caused by overprescribing opiate-derived analgesics to millions of veterans, the Department of Veteran Affairs (VA), acknowledging their role in fueling this opioid epidemic among veterans, instituted the Opioid Safety Initiative (OSI) in 2013 (See Figure 1 for an OSI timeline). Like PDMPs, this initiative is meant to reduce the supply of prescription opioids among veterans; from 2013 through 2017, the VA has reduced their opioid prescription rate by 41% (VA, 2018). The mechanisms by which the VA has reduced the amount of opioids prescribed involves national opioid databases ("OSI Dashboards"), including state PDMP databases where physicians are able to track their patients' medication history, urine drug screening, and alternative forms of chronic pain therapy (Petzel, 2014). Since the implementation of OSI, VA physicians were strongly encouraged, through newly instituted pain management guidelines, to use alternative means to treat pain and to avoid opioid prescriptions where possible (VA, 2014). Although the VA has successfully reduced opioid prescriptions within their national health system, there may be adverse consequences due to their abrupt change in opioid policies. There are multiple reports of physicians within the VA who have rapidly tapered their patients off of opioids – a potentially risky outcome (Demidenko et al., 2017; Dubin et al., 2017) -- and who have set arbitrary dose limits for stable patients who were on chronic opioid treatments (Good, 2017). Additionally, published in the VA/Department of Defense (DOD) Clinical Practice Guideline for Management of Opioid Therapy for Chronic Pain, physicians were instructed to taper opioid therapy patients at a rate of 20 – 50 percent per week (VA, 2010), which is a much higher opioid taper than the 10 percent per month tapering schedule suggested by the CDC (CDC, 2016).

1.2 Background: Veterans and Suicides

Over the same time period as the opioid epidemic, suicides have also increased at a troubling rate. Prior to the year 1999, suicide rates experienced consistent annual declines in each of the previous 13 years (Curtin, et al., 2016). Since then, the age-adjusted suicide rate in the year 2017 was 33% higher when compared to the rate in 1999; between these years, the suicide rate increased in each successive year (Hedegaard, 2018). Suicides involving opioids, i.e. intentional fatal opioid poisonings, were double in the year 2014 what they were in 1999 (Braden et al., 2017). Individuals who suffer from Opioid Use Disorder (OUD) are 13 times more likely to die by suicide (Wilcox et al., 2004) and prescription opioid misuse is significantly associated with suicidal ideation, suicide planning, and suicide attempts (Ashrafioun et al., 2017). Thus, opioid use and abuse may have a causal link to suicides. Opioid-related mortality and suicides are suggested to be two primary causes of the rising mortality rates among middle-aged white non-Hispanic men and women in the United States – a trend reversal after decades of progress (Case and Deaton, 2015).

A common factor in opioid use and suicide is physical pain. As stated earlier, physical pain initiated the opioid epidemic through the wide prescribing and misuse of opiate-derived analgesics before the detrimental effects were widely known (Van Zee, 2009; CBHSQ, 2017). Physical pain is also highly correlated with suicide ideation, suicide attempts, and suicide completion (Fishbain, 1999). The increased risk of suicide is extensive in terms of the source or type of injury resulting in chronic pain; meaning, suicide risk is not dependent on a specific injury or type of chronic pain (Ilgen et al., 2013). In short, physical pain is a risk factor for suicide (Fishbain, 1991; Hooley, 2014), where it is estimated to at least double one's risk of suicide, relative to an individual who does not experience chronic pain (Tang and Crane, 2006). Thus, pain elevates the risk of suicide both indirectly through prescription opioid use and directly through one's diminished quality of life. Although opioids can potentially enhance one's quality of life by alleviating pain, when individuals' use of opioids become abusive, prescription opioid use appear to increase the risk of suicide, on average.

Like the opioid epidemic, the population of veterans and military personnel are acutely vulnerable to the current suicide crisis. Compared to the general population, veteran's risk of suicide is 41 to 61 percent higher (Kang et al., 2015). Because veterans have extremely high rates of opioid substance abuse, and mental and physical pain, particularly post-traumatic stress disorder (PTSD) for those veterans who were deployed in combat operations, veterans are highly susceptible to the risk of suicide (Bryan et al., 2015; Maguen et al., 2011; Kim et al., 2012).

Although opioid substance abuse increases the risk of suicide, forced opioid discontinuation further elevates that risk, especially within the first three months of discontinuation (Talari and Yara, 2020). Citing evidence from an "alarming increase in reports of patient suffering and suicide" due to forced opioid tapering within the VA, the International Stakeholder Community of Pain Experts and Leaders recommend that policy aimed at prohibiting or minimizing forced opioid tapering be enacted, along with other recommendations (Darnall et al., 2019). The OSI encourages physicians to reduce opioid prescriptions and implement tapering programs (VA, 2010); those with mental health and substance abuse disorders are more likely to endure opioid tapering and discontinuation within the VA (Vanderlip et al., 2014). An estimated 75 percent of all clinician initiated opioid discontinuation within the VA were the result of substance abuse-related aberrant behavior exhibited by the patient (Lovejoy et al., 2017). Additionally, there are concerns that physicians have initiated forced opioid tapers to get patients under a dosage threshold for the primary purpose of improving OSI performance measures (Gellad et al., 2017).

1.3 Background: Rural-Urban Differences in Potential Impacts of OSI

According to the VA's Office of Rural Health (ORH), approximately 2.7 million veterans live in rural communities in the United States, which represents 30 percent of the total veteran population (NOSORH, 2014). In comparison, rural civilians only account for 19 percent of the total civilian population (VA's ORH, 2020). Not only do rural veterans make up a comparatively large portion of the total veteran population, but they also have large VA utilization rates. Of the 2.7 million rural veterans, nearly 60 percent receive their health care from the VA, which represents 36 percent of the total VA enrolled population (NOSORH, 2014); of this population, nearly 55 percent suffer from at least one service-connected condition.[6] The rate of VA utilization among rural veterans represents a

[6] The rate of VA enrollment among service connected disabled veterans is over 93 percent (VA, 2017) https://www.va.gov/vetdata/docs/Quickfacts/VA_Utilization_Profile_2017.pdf. With a high rate of VA

significantly higher percentage of VA utilization when compared to the 37 percent enrollment rate for urban veterans (VA's ORH, 2020). Because the overall percentage of VA enrolled users is higher for rural veterans, VA policy will disproportionately impact rural veterans compared to veterans living in urban areas.

Not only do rural veterans have a higher proportion of VA enrolled users, but this population has also been more adversely impacted by the concurrent opioid and suicide crisis, which may exacerbate unintended consequences of OSI implementation, when compared to veterans living in urban communities. When compared to their urban counterparts, veterans living in rural communities are prescribed over 30 percent more opioids per capita; most of these differences between urban-rural opioid prescriptions were for long term use, which OSI was focused on curtailing. After the implementation of OSI, these prescriptions fell by 36 percent (Lund et al., 2019). In addition to higher per capita rates of opioid prescriptions for rural veterans (Hudson et al., 2017; Lund et al., 2019), this population is also more likely to suffer fatal opioid overdoses (GAO, 2018). This is possibly because rural veterans receive medication assisted treatment and other evidenced-based treatments for addiction at a lower rate than urban veterans, despite their higher rates of substance abuse (Edmonds et al., 2020; GAO, 2018; Smalley et al., 2010). In terms of suicide, rural veteran populations are at a higher risk when compared to urban veteran populations, even after controlling for mental health availability. Numerous studies have shown that high rates of suicide and comparatively low rates of treatment for rural veterans[8] had less to do with treatment availability and were more likely determined by economic circumstances, comparatively lower quality of life and rural culture (McCarthy et al., 2012; Mohamed et al., 2009 Teich et al., 2017; Wallace et

enrollment and correspondingly high rates of chronic pain and opioid prescriptions, this population may be heavily impacted by OSI implementation.

[8] Many studies show that rural veterans are less likely than their urban counterparts to utilize mental health services, which includes services for substance abuse disorders.

al., 2006). Thus, the rural population has higher VA utilization rates, opioid prescription rates (which have dramatically decreased following the implementation of OSI), overdose rates, rates of suicide, and lower addiction and mental health treatment utilization rates, compared with their urban counterparts.

2. Data:

To measure the OSI's policy effect on suicides of veteran and military personnel, we collect data from several sources. For our main variable of interest, suicides, we obtained data from the Center for Disease Control's National Violent Death Reporting System's Restricted Access Database (CDC-NVDRS-RAD) which links data from vital records, coroner/medical examiners, and law enforcement agencies in participating states, which includes 17 in our sample; this dataset is the most comprehensive data available for violent deaths including: suicides, homicides, unintentional firearm-related deaths, and violence-related deaths where the intent cannot be determined (NVDRS, 2018). This restricted access database includes over 600 unique data elements, including veteran status and county of residence, at the individual level. For this paper, we aggregated the data to the county-year level and restricted our analysis to 16 states in the year 2010 and 17 states from 2011 to 2016 (data for Ohio became available starting in 2011).[9]

The NVDRS only provides data for counties which record at least one suicide[10] in that county-year; if a county is not represented in the database for a specific year, it is because there is no record of a suicide occurring in that county-year. With this in mind, we added a zero for all counties that were not included in the NVDRS-RAD database for a specific year.

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[9] Currently all 50 states, Puerto Rico, and the District of Columbia participate in the NVDRS.

[10] A death is coded as a suicide if intent can be determined. Because this dataset only includes "violent" deaths, overdoses are not accounted for; this may understate the true amount of suicides if an overdose occurs but intent, e.g. accidental/purposeful cannot be determined.

For population, education levels, demographics, and economic variables for each county-year, we use the American Community Survey (ACS) 5-year estimates, which provide annual estimates of these variables. Prior literature on opioid supply shocks and suicide (Borgschulte, et al., 2019) show that policy aimed at reducing the supply of opioids, when combined with geographical proximity to addiction treatment centers, act to reduce suicide. Therefore, following Borgschulte et al. (2019) and Swensen (2015), we use the Consumer Business Patterns (CBP) to get the number of treatment centers for each county-year. We used NAICS codes 621420 and 623220 to identify inpatient and outpatient treatment centers in each county-year and then summed the two values to get the total number of addiction treatment facilities.

We used the rural-urban continuum code developed by the US Department of Agriculture Economic Research Service (USDA, 2013) to determine the rural-urban distinction for counties in our analysis. Counties are classified based on 9 categories that are determined by their population size and whether they are adjacent to a metropolitan county. As in Kaplan et al. (2012), counties were assigned as urban for classification codes 1-3 (metropolitan counties) and rural for codes 4-9 (non-metropolitan counties).

Finally, to control for other prescription opioid policy supply shocks, we gathered user access date data for Prescription Drug Monitoring Programs from Borgschulte, et al., (2019), the Prescription Drug Abuse Policy System (PDAPS), and the National Alliance for Model State Drug Laws (NAMSDL). For must-access PDMP data, we use data published by Borgschulte, et al., (2019), Buchmueller and Carey (2018), and the New Jersey Prescription Monitoring Program (NJPMP).

3. Empirical Strategy:

Due to the large share of veterans and military personnel who suffer from comorbid ailments (i.e. chronic pain and PTSD) leading to substance abuse disorder, our hypothesis is that veteran opioid user's suicide choices will be affected by the negative supply shock to prescription opioids due to OSI. To investigate this hypothesis, we will use a triple difference (DDD) model. Our treatment group is veterans and military personnel and our control group is non-veterans/civilians. The treatment policy is OSI, where OSI is assumed to only affect the treatment group, veterans and current military personnel (although we acknowledge that the OSI may affect a small subsample of non-veterans, e.g. immediate family members of veterans/current military personnel). Counties vary by urban-rural status.

The unit of observation in our study is a county by year by veteran status. All specifications were weighted by the total county population and standard errors were clustered by county. The regression equation is:

$$suicide/100K = \theta_c + \theta_t + \delta_1 * veteran_v + \delta_2 * veteran_v * rural_c + \delta_3 \sum_{t=2011}^{2016}(\alpha_t * veteran_v) + \delta_4 \sum_{t=2011}^{2016}(\gamma_t * rural_c) + \delta_5 \sum_{t=2011}^{2016}(\rho_t * veteran_v * rural_c) + X_{vct}\pi + \varepsilon_{vct}, \quad (1)$$

where θ_c and θ_t represent county and year fixed effects, respectively and X_{vct} represents time variant variables such as PDMP policy (both PDMPs and mandatory PDMPs), treatment centers (the sum of outpatient and inpatient treatment centers), the interactions between PDMP policy and treatment centers, and estimates for the veteran and civilian population for: percent of populations aged 18-34, percent of populations that are female, percent of populations that are black, unemployment rates, median incomes, and percent of populations that have some college experience for county c, in year t, along with interactions between veteran/military status and rural status for all explanatory variables in the model, including treatment centers and PDMPs. Interacting veteran/military and rural status with all components of the model allows for a more general specification. ρ_t represents the parameter of interest, which measures the causal effect of OSI, by capturing the annual differences in the suicide rate by veteran/military status and rural-urban status. The treatment year is 2013, which is the year that OSI was nationally implemented. This specification allows us to view the OSI's effect on veteran/military suicides in each year, with separate effects for rural and urban counties; that is, this model helps us to view the annual evolution of the policy's effect on veteran and current military personnel suicide, by rural status, where we are interested in the comparative evolution before and after OSI implementation; this is a generalization of the classic triple difference estimator (DDD).

In addition to a linear specification, like Borschulte et al. (2018), we estimate the above equation (1) using a Poisson Quasi-Maximum Likelihood Estimator (QMLE), where the dependent variable is the count of suicides for each county and year. Moksony and Hegedűs (2014) argue that a Poisson regression is the most appropriate specification when estimating the variation of rare events such as suicides (e.g. large number of 0 observations). Because our data is over-dispersed, we estimate using Poisson QMLE, which relaxes the assumption of mean-variance equality With this specification, we run a regression that accounts for veteran/military and civilian populations, offseting each by their respective populations, allowing us to compare the evolution of the annual changes in the number of suicides, while controlling the population for each group; thus, our dependent variable is the log of the suicide rate, with corresponding distributions and assumptions relating to Poisson QMLE regression.

$$log\mu_{vct} = \theta_c + \theta_t + \delta_1 * veteran_v + \delta_2 * veteran_v * rural_c + \delta_3 \sum_{t=2011}^{2016}(\alpha_t * veteran_v) + \delta_4 \sum_{t=2011}^{2016}(\gamma_t * rural_c) + \delta_5 \sum_{t=2011}^{2016}(\rho_t * veteran_v * rural_c) + X_{vct}\pi + \varepsilon_{vct}. \tag{2}$$

Like the linear specification, this regression was weighted by the total county population and standard errors were clustered by county.

4. Trends and Descriptive Statistics:

Graphical analysis (see Figure 3) based on raw suicide rates suggests that civilians offer relevant counterfactuals for veterans and military personnel, had OSI not been implemented, as it appears that the suicide trend for civilians and veteran and military personnel are relatively similar prior to OSI implementation, i.e. the parallel trends assumption appears to be valid; coefficients in our estimation results will confirm this. Figure 3 indicates that annual suicide rates per 100,000 individuals are increasing for both groups. However, the trends begin to diverge in 2013, the year OSI was first implemented; the percentage change in suicides per 100,000 individuals from 2012 (the year before OSI) and 2016 is 42 percent for veterans and 23 percent for civilians.

Table 1 provides descriptive statistics for county-year suicide counts, population, demographics, economic indicators and availability of addiction treatment facilities for both veterans and civilians, differentiated between rural and urban counties of residence. Comparatively, the mean suicides of veteran/military personnel are much smaller than the mean suicides for civilians; this is true independent of urban-rural status. Although the count of suicides is much smaller among veterans and military personnel, those individuals represent only a small fraction of the total population: approximately 10% for a county-year average. Adjusting for the differences in population gives us the suicide rate for veterans/military personnel and civilians. As can be seen from Table 1, veterans/military have a much higher suicide rate than civilians, independent of rural-urban status; the differences in suicides per 100,000 between veterans and civilians is consistent with the literature (Castro and Kintzle, 2014; Kang et al., 2015; Sher and Yehuda, 2015).

Although higher suicide rates are correlated with poor economic conditions (citations), it can be seen in Table 1 that this phenomenon does not exist in our sample: veteran/military personnel consistently have better county-year average economic outcomes, in terms of unemployment and median income, than civilians (7.7% and $34,517.26 compared to 8.8% and 23,305.45). This may be because there are alternative influences affecting veteran/military suicides, as it does not appear that economic indicators favor veterans due to comparative ages or educational attainment. Although veterans have a much lower percentage of the population that would be in the beginning stages of their career and annual earnings, e.g. ages 18-34, they also have a much higher percentage of the population that is in the ages of retirement, e.g. ages 65 and above. However, the low proportion of female veterans may explain some of the differences in economic outcomes.

When differentiating veterans and civilians by urban-rural status, we see that rural veterans/military personnel and civilians have worse outcomes in terms of suicide, economic conditions, and addiction treatment availability when compared to their urban counterparts. For example, the mean suicide rate per 100,000, median income, and unemployment for a rural veteran is 42.68, $30,860, and 8.14 percent, respectively; whereas urban veterans suffer from 33.88 suicides per 100,000, earn $39,318 in median income, and have a 7.18 percent unemployment rate. These differences are consistent with the literature cited above.

Table 2 provides descriptive statistics for county-year suicide counts, population, economic demographics, and addiction treatment centers for both veterans and civilians, differentiated between years prior to and post OSI implementation. As can be seen from Table 2, the pre-post OSI veteran suicide rate increased by 33%, whereas the civilian suicide rate increased by only 11%. Additionally, this increase in the pre-post OSI suicide rate among both groups does not appear to be a product of declining economic circumstances, as there is little change in average income and unemployment that occurred from before to after OSI implementation. This suggests that there may be alternate factors that are driving the relatively stark increase in veteran/military suicides.

5. Results:

The empirical results are displayed in Table 3, where we present the county-year comparative impact of OSI on suicides among veterans/military personnel and civilians. Additionally, we also present estimates for the impact that PDMPs, including mandatory PDMPs, have on veterans/military and civilian suicides. Column 1 in this table presents OLS estimates and column 2 presents estimates for the Poisson QMLE. It has been shown that when opioid policy is accompanied by demand-reducing interventions (e.g. addiction treatment facilities), suicides may decrease following supply-reducing opioid policy (Borgschulte et al., 2018). Therefore, in all our specifications, we interact PDMP opioid policy with the number of treatment centers in each county to account for heterogeneity in the availability of addiction treatment.

Both regressions were weighted by the total population for each county and include county and year fixed effects to control for confounders which threaten identification; county fixed effects control for time-invariant factors and year fixed effects control for secular changes underlying the determinants of suicide. Additionally, because we are comparing the evolution of suicide rates between veteran/military personnel and civilians, our specifications control for any factor that does not differentially impact veterans/military personnel and civilians.

Prior to OSI implementation in 2013, there is no evidence of different suicide evolutions between veterans and civilians with their corresponding rural-urban status, which confirms our parallel trends assumption. That is, it appears that civilians are an appropriate counterfactual for veterans and military personnel. However, after implementation of OSI in 2013, the coefficients in the triple differenceshow a stark and significant increase at the one percent level for each successive year after policy implementation; this result is consistent in both linear and non-linear specifications (OLS and

Poisson QMLE). The initial differences in the veteran/military and civilian suicide rates after OSI is concentrated among rural veterans/military, where the suicide rate for this population increased from 2012 to 2013 by almost 8.5 suicides per 100,000 in our OLS estimates and 50 percent in the Poisson estimates. Comparatively, the only other significant change in the suicide rate was urban civilians, which increased by seven percent in that year, although this was only significant at the ten percent level in our Poisson specification. In 2014 the rural veteran/military suicide rate decreased slightly in the level results but increased by 33 percent in the Poisson results. In that same year, urban veteran suicides begin to increase at a faster rate, which represents the decline – though still statistically significant at the one percent level – in our OLS triple difference coefficient for 2014; the coefficient increases further still in our Poisson estimates. In 2015 and 2016 veteran suicides, both rural and especially urban, markedly increase. Although, in our Poisson specification, urban veterans are not statistically significantly different than urban civilians, whereas they show to have a significant increase above urban and rural civilians in the OLS estimates, significant at the 5 percent (2015) and one percent level (2016).

To summarize the results for estimating the causal impact of OSI on veteran/military suicides, we show that OSI had an immediate effect on suicides for veterans, particularly concentrated among rural veterans, and increased in each year for all veterans. We posit that our results, which showed an increase in veteran suicides over time, can be explained by the evolution of OSI policy. As OSI continued to gain strength, both in decreasing opioid prescribing (see Figure 1), including implementing relatively rapid tapers, and instituting complementary OSI policies which included mandatory inquiries into state PDMP databases (see Figure 2 for timeline of additional policy), veteran suicides continually increased, following the abrupt increase in veteran suicides in 2013, which was particularly concentrated among rural veterans. That is, as more veterans were impacted by opioid diversions due to OSI, suicides among this most susceptible group increased, particularly for rural veterans who are the most relatively disadvantaged group. (compare Figure 2 with Figures 4 and 5)

In addition to OSI, Table 3 shows that PDMPs significantly increases the suicide rate for both veterans/military personnel and civilians. However, unlike the causal estimates for OSI, the results for PDMPs vary depending on the specification. For instance, the level regression indicates that overall suicides increased by an average of 1.341 per 100,000 (significant at the 10 percent level) after the implementation of PDMP policy but the Poisson specification indicates that suicide only increased for individuals living in rural counties, where the average increase in suicides was 25 percent following PDMP implementation; this result is significant at the ten percent level. Our results indicate that mandatory PDMPs did not significantly increase the suicide rate. This non-result could be due to the lack of variation in our sample, as only 5 out of the 17 states had implemented must-access PDMPs during the years of our analysis (2010 – 2016).

Like Borgschulte et al. (2018), we find that when accompanied with increased availability of addiction treatment networks, i.e. additional treatment facilities, the implementation of PDMPs can decrease the suicide rate. It is surmised that when addicts encounter a supply shock of the addictive substance, additional treatment availability incentivizes addiction recovery (Borgschulte et al., 2018). However, our results indicate that this is only statistically significant for the veteran population, particularly rural veterans. The results for the level regression show that when PDMPs are implemented with additional addiction treatment facilities, then suicides among the veteran/military population decrease by an average of 0.1 per 100,000. Although this result is near zero, it is significant at the one percent level. When accompanied by additional treatment centers in rural counties, the implementation of PDMPs can decrease the average rural veteran suicide rate by almost 2 suicides per 100,000 for the OLS specification or by almost 5 percent for the Poisson specification; both of these results are significant at the one percent level. The OLS specification also shows that veteran suicides, especially rural veteran suicides, decrease when mandatory PDMPs are accompanied by additional addiction treatment centers. However, these results are not statistically significant for the Poisson specification.

It is not surprising that our results show that PDMPs influence the veteran population. Approximately 40 percent of rural veterans and 63 percent of urban veterans do not register with the VA. Therefore, this segment of the veteran population would be subject to such policy. To explain the effect that addiction treatment centers have on veterans/military personnel when accompanied by PDMP policy, we posit that because veterans/military personnel suffer from higher rates of chronic pain, opioid abuse, and suicides, additional treatment facilities will have a larger marginal impact on veterans/military personnel than civilians. Additionally, rural veterans suffer from higher rates of chronic pain, opioid substance abuse, and suicides than their urban counterparts; this, coupled with the fact that addiction treatment facilities in rural areas are less available than urban areas, we expect the marginal impact of each treatment center to be larger for rural veterans/military, when compared with their urban counterparts. To summarize, there may be greater increasing returns with each additional addiction treatment facility in rural counties, relative to urban counties and with veterans/military personnel, relative to civilians, due to the reasons cited above.

6. Conclusion:

The opioid epidemic in the United States has had devastating impacts. Perhaps no other demographic has suffered the ill-effects of this crisis more than veterans and current military personnel. The rural veteran/military population has been especially susceptible as they have higher rates of chronic pain, mental ailments, e.g. PTSD and depression, opioid prescriptions, opioid-related substance abuse, and suicides than both the rural non-veteran population and their urban-veteran counterparts.

In this paper, we investigate the causal link between supply-reducing opioid policy and suicide among veterans and current military personnel. We find strong evidence that the introduction of policy diverting prescription opioids will result in an increase of veteran suicides. Like Borgschulte et al. (2018), when supply-reducing opioid policy is accompanied by strong addiction treatment networks, suicides will decrease among the general population. This is especially true for rural veterans, as the marginal impact of additional treatment centers is greater for this demographic. This is likely due to the lack of addiction treatment availability in rural areas, i.e. increasing returns.

To address the issue of barriers to rural treatment, in 2016 the VA's Office of Connected Care, which focuses on improving rural veteran health care through technology, began distributing video-enabled computer tablets to veterans who suffered from mental disorders and faced barriers to access mental health care, due to their place of residence, e.g. rural residence. Using the tablets to conduct mental-telehealth appointments, veterans who were distributed these tablets had higher psychotherapy utilization rates and managed their medications more effectively, compared to veterans who were not distributed tablets (VA, 2018). Although the extrapolation of this result is spurious, it may point to a promising solution of expanding addiction treatment to rural veterans. Our results show that policy directives focused on increasing access and availability to addiction treatment networks, suicides will decrease in the presence of diverted opioids via policy.

Although we show that veteran suicides increase with the implementation of supply-reducing opioid policy, especially when not accompanied by sufficient addiction treatment networks, we believe these negative effects will occur in the short-run. As opioid prescriptions and addiction decrease due to supply-reducing opioid policy, we expect to see less opioid-related abuse and fatalities, including suicides. However, in the short run we expect to see an increase in opioid-related overdose, as veterans substitute towards illicit substances, e.g. heroin and synthetic opioids, and as we have shown, an increase in suicides.

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Federal Healthcare System Experience: VA Implementation, Maintenance, and Evaluation C. Bernie Good MD, MPH Veterans Affairs Pharmacy Benefits Management May, 2017

Appendix:

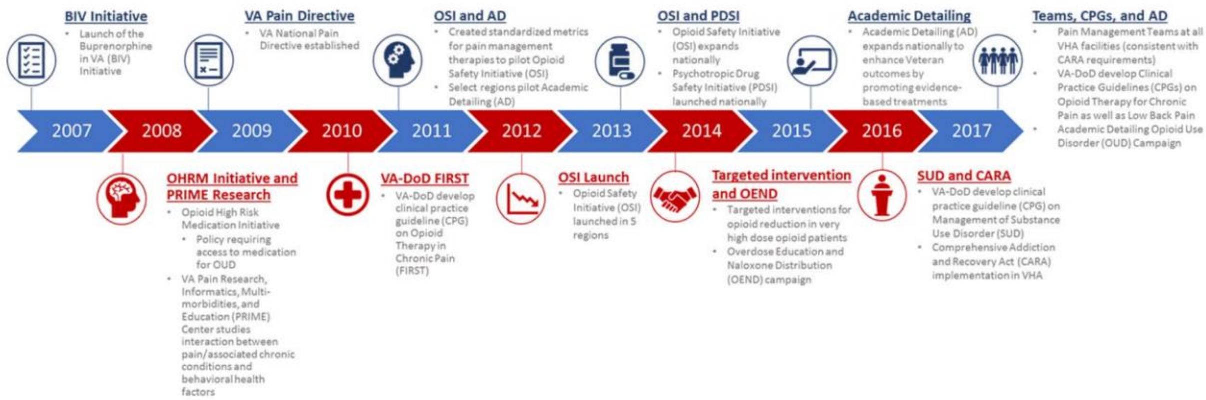


Figure 1: This figure shows a timeline of OSI implementation and additional directives implemented after the national launch of OSI.

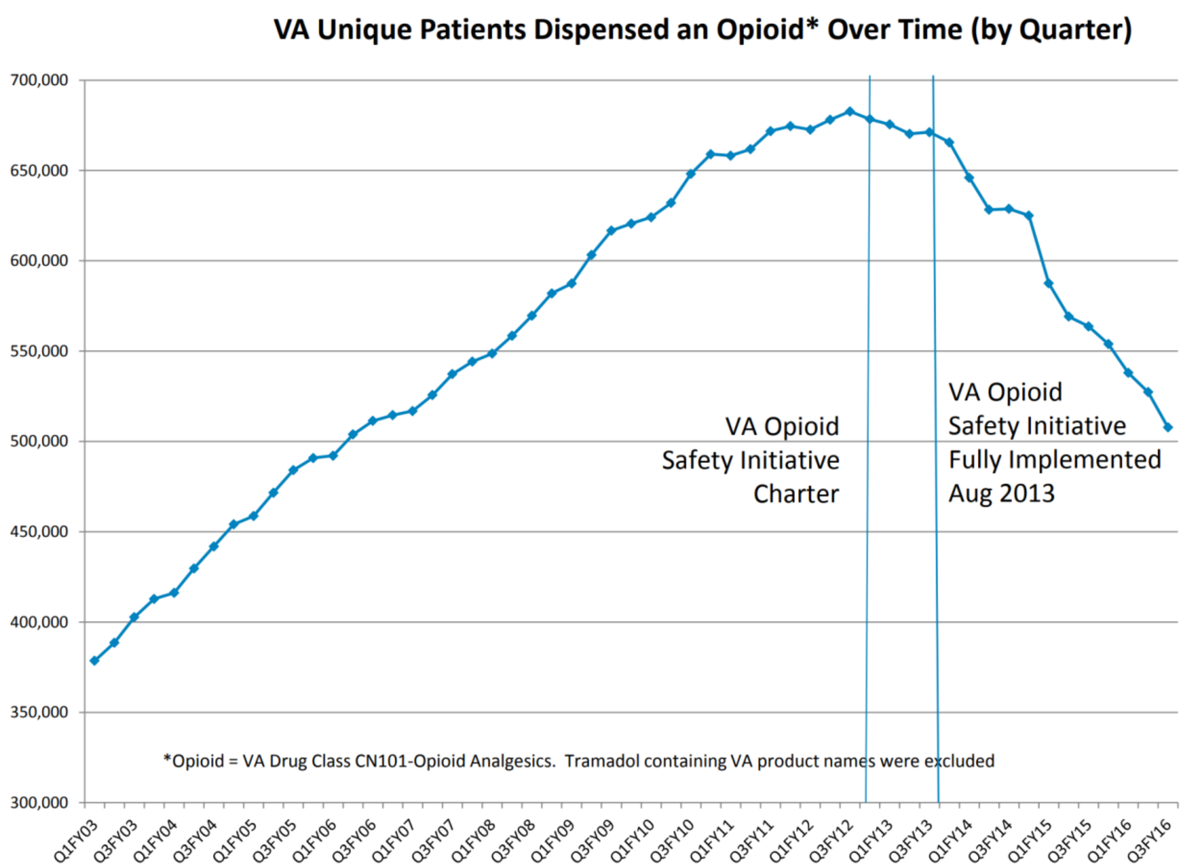


Figure 2: This figure shows the quarterly evolution of unique VA patient opioid prescriptions. As can be seen, unique patient prescriptions hit a max in 2012 and immediately began to diminish after OSI implementation in 2013.

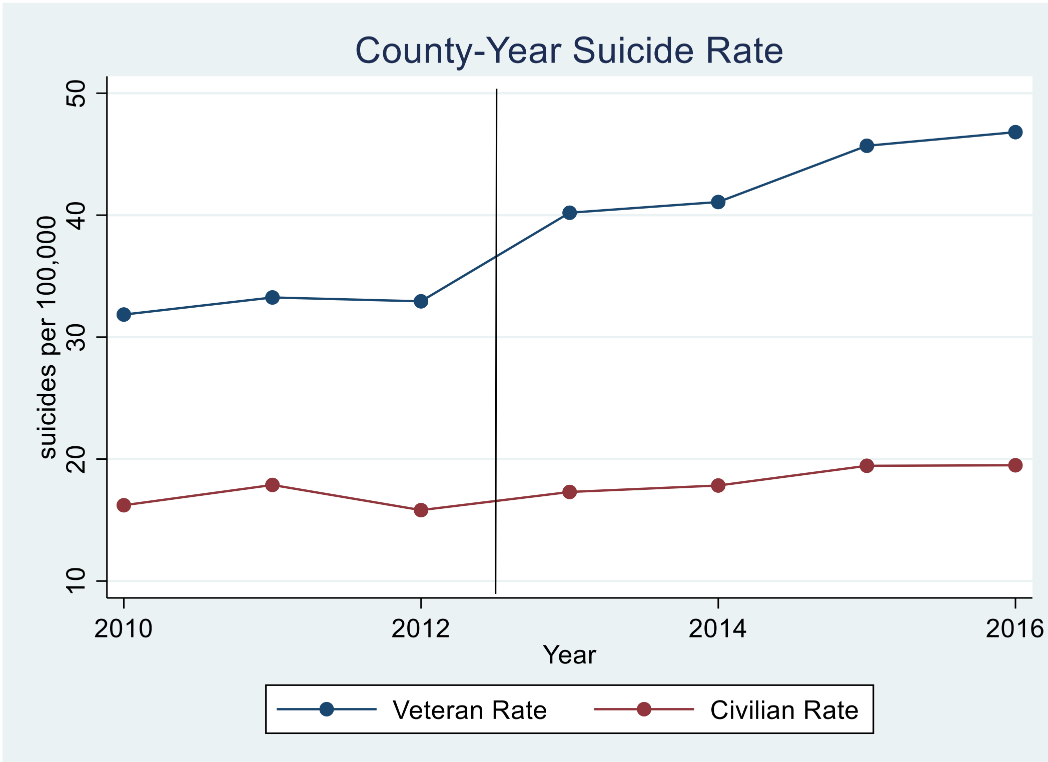


Figure 3 This shows the average county-year suicide trend for veteran/military personnel and civilians.

Table 1: Descriptive Statistics – Suicides, Economic Conditions & Addiction Treatment

Variable Name	**Description** (county-year)	**Veteran** Rural	**Veteran** Urban	**Civilian** Rural	**Civilian** Urban
Suicide	Suicide count	0.80 1.21	3.85 (5.31)	3.22 (3.39)	16.37 (22.40)
Population	Population estimates	2,043 (1,868)	12,349 (14,588)	17,790 (14,911)	119,729 (162,829)
Suicide Rate	Suicide rate per 100,000	42.68 (84.48)	33.88 (37.10)	19.25 (20.43)	15.70 (10.20)
Median Income	Median income	$30,860 ($8,004)	$39,318 ($10,777)	$21,021 ($4,781)	$26,326 ($6,551)
Unemployment	Unemployment rate	8.14% (7.10)	7.18% (4.00)	9.15% (3.91)	8.46% (2.85)
Female	Percent of population that is female	5.8% (3.44)	7.8% (3.74)	55.2% (4.23)	56.9% (2.73)
Age: 18-34	Percent of population that is 18-34 years old	6.2% (4.16)	8% (4.55)	28.3% (5.84)	31% (6.71)
Age: 65+	Percent of population that is 65 year and older	46.2% (10.22)	41.1% (9.72)	18.8% (4.43)	15.6% (3.56)
Bachelors	Percent of population that has a bachelors	17.9% (9.12)	24.9% (11.19)	17% (7.72)	25.6% (11.60)

		Rural	**Urban**
Treatment Centers	Addiction treatment centers	1.51 (2.04)	9.5 (16.51)
Treatment Centers per 100,000	Addiction treatment centers per 100,000	7.85 (9.84)	5.94 (6.08)

Table 1: This table reports descriptive statistics differentiated by veteran-civilian status and rural-urban status for some of the key explanatory variables in our model, namely: county-year suicide counts, population, economic demographics, and addiction treatment facilities.

Table 2: Descriptive Statistics – Pre & Post OSI Implementation

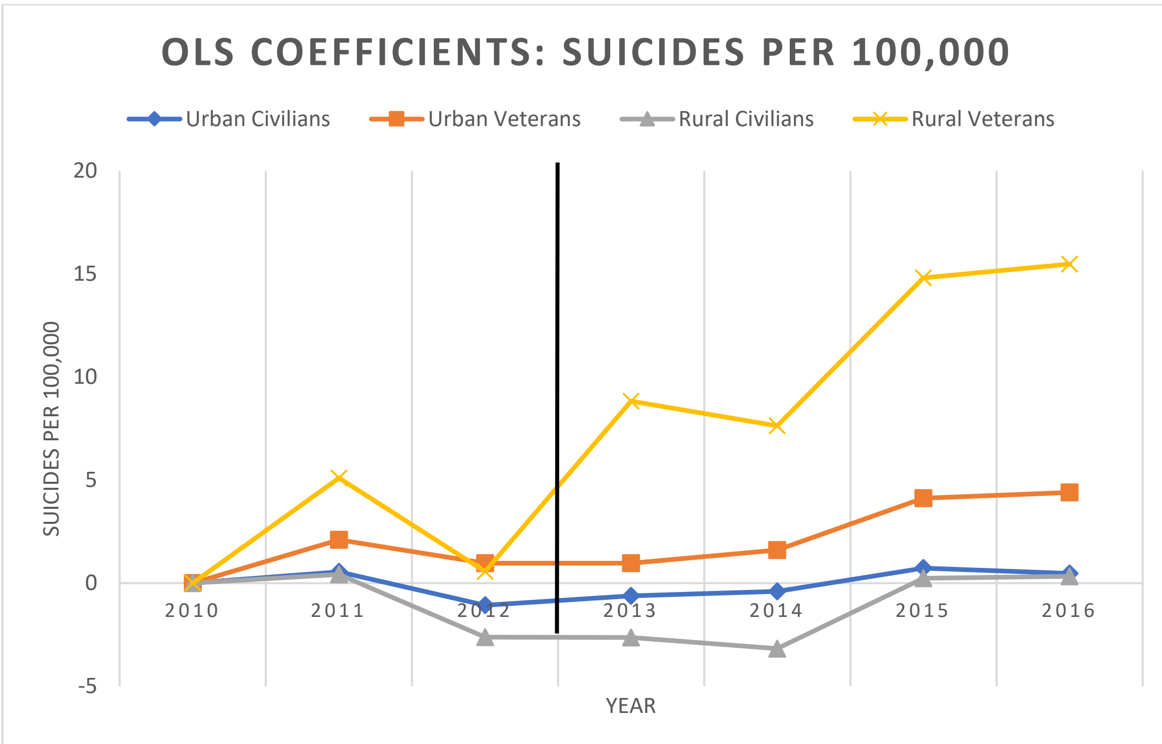
Variable Name	**Description** (county-year)	**Veteran** Pre-OSI	**Veteran** Post-OSI	**Civilian** Pre-OSI	**Civilian** Post-OSI
Suicide	Suicide count	2.00 (3.81)	2.19 (3.95)	7.97 (14.99)	9.48 (17.05)
Population	Population estimates	6,679 (11,308)	6,288 (10,610	59,138 (113792)	63,064 (121604)
Suicide Rate	Suicide rate per 100,000	32.70 (54.46)	43.44 (76.81)	16.65 (17.73)	18.52 (16.26)
Median Income	Median income	$34,143 ($9,969)	$34,724 ($10,344)	$22,876 ($6,210)	$23,593 ($6,161)
Unemployment	Unemployment rate	7.55% (5.75)	7.86% (6.15)	8.76% (3.48)	8.93% (3.53)
Female	Percent of population that is female	6.5% (3.63)	6.8% (3.75)	56.4% (3.83)	55.6% (3.67)
Age: 18-34	Percent of population that is 18-34 years old	6.9% (4.30)	7.1% (4.51)	29.7% (6.48)	29.3% (6.27)
Age: 65+	Percent of population that is 65 year and older	40.8% (9.51)	46.4% (10.26)	16.6% (4.14)	18% (4.42)
Bachelors	Percent of population that has a bachelors	20.5% (10.46)	21.2% (10.75)	20.1% (10.31)	21.1% (10.57)
		Pre-OSI		**Post-OSI**	
Treatment Centers	Addiction treatment centers	4.57 (10.96)		5.19 (12.04)	
Treatment Centers per 100,000	Addiction treatment centers per 100,000	6.7 (9.20)		7.27 (9.56)	

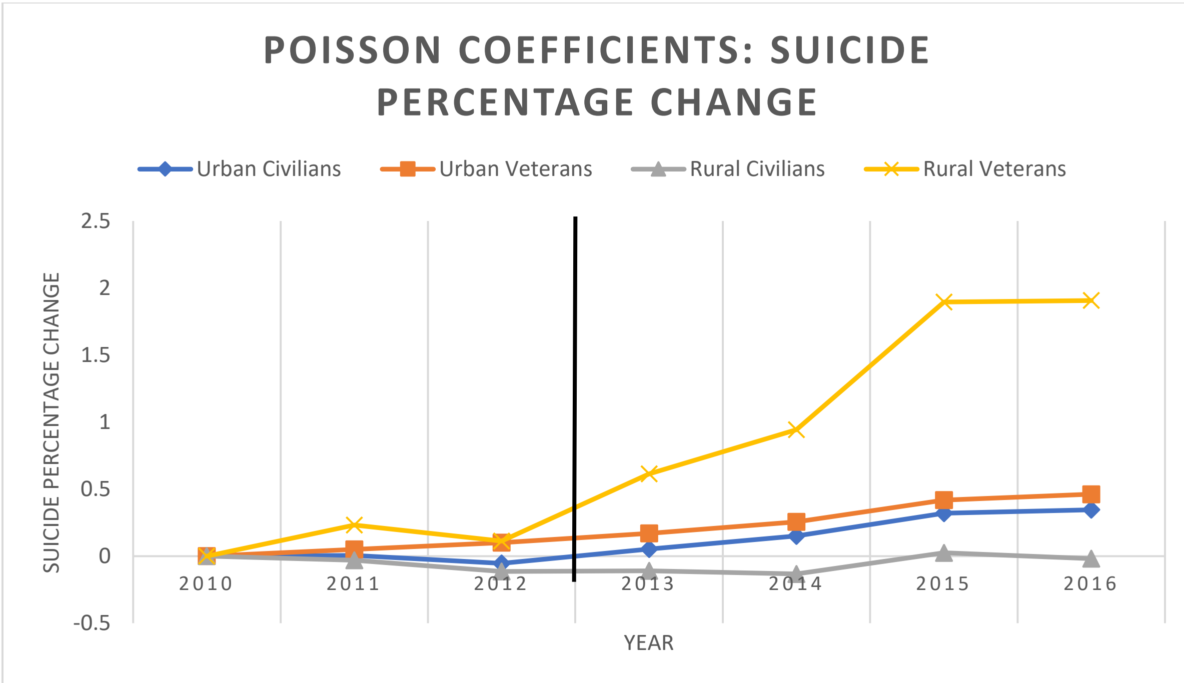
Table 2: This table reports descriptive statistics differentiated by veteran-civilian status and pre-post OSI implementation for some of the key explanatory variables in our model, namely: county-year suicide counts, population, economic demographics, and addiction treatment facilities.

Table 3: Rural Regression Results

	OLS	Poisson QMLE
Dependent Variable	**Suicides/100k**	**Suicide Count**
Variables		
Civilian Suicide Rate by Year (base: 2010)		
2011	0.552	0.005
	(0.519)	(0.064)
2012	-1.072	-0.055
	(0.876)	(0.093)
2013	-0.615	0.051
	(1.049)	(0.090)
2014	-0.401	0.141
	(1.188)	(0.111)
2015	0.729	0.278*
	(1.284)	(0.148)
2016	0.467	0.297*
	(1.523)	(0.171)
Veteran*Year (base: 2010)		
2011	1.549	0.044
	(1.143)	(0.054)
2012	2.047	0.152***
	(1.329)	(0.056)
2013	1.591	0.105*
	(1.371)	(0.061)
2014	2.007	0.086
	(1.543)	(0.081)
2015	3.390**	0.071
	(1.541)	(0.092)
2016	3.932***	0.083
	(1.434)	(0.099)
Rural*Year (base: 2010)		
2011	-0.130	-0.036
	(1.056)	(0.078)
2012	-1.551	-0.066
	(1.522)	(0.110)
2013	-2.018	-0.167
	(1.890)	(0.115)
2014	-2.774	-0.283**
	(2.110)	(0.133)
2015	-0.495	-0.253
	(2.209)	(0.164)

2016	-0.131 (2.542)	-0.315* (0.185)
DDD: Veteran*Year*Rural (base: 2010)		
2011	**2.029** **(2.834)**	**0.185** **(0.116)**
2012	**3.290** **(3.194)**	**0.186** **(0.126)**
2013	**11.099***** **(3.381)**	**0.388***** **(0.139)**
2014	**9.598***** **(3.508)**	**0.438***** **(0.145)**
2015	**9.723***** **(3.516)**	**0.411***** **(0.139)**
2016	**10.279***** **(3.556)**	**0.408***** **(0.143)**
PDMP	1.341* (0.781)	-0.027 (0.089)
PDMP*Veteran	1.878 (1.260)	0.041 (0.102)
PDMP*Rural	2.192 (1.768)	0.221* (0.114)
PDMP*Rural*Veteran	3.946 (2.609)	-0.035 (0.136)
M PDMP	1.820 (1.375)	0.052 (0.081)
M PDMP*Veteran	-0.229 (1.619)	0.024 (0.065)
M PDMP*Rural*Veteran	1.001 (3.150)	-0.121 (0.095)
PDMP*Facilities (t-1)	-0.025 (0.017)	0.001 (0.002)
PDMP*Facilities (t-1)*Vet	-0.077*** (0.023)	-0.004 (0.003)
PDMP*Facilities (t-1) *Rural	0.602 (0.502)	0.013 (0.018)
PDMP*Facilities (t-1)*Vet*Rural	**-1.573***** **(0.572)**	**-0.045***** **(0.016)**
M PDMP*Facilities (t-1)	-0.042 (0.032)	-0.002 (0.002)
M PDMP*Facilities (t-1) *Vet	0.086** (0.038)	-0.001 (0.001)
M PDMP*Facilities (t-1) *Rural	0.193 (0.454)	0.004 (0.011)
M PDMP*Facilities (t-1) *Vet*Rural	-1.111** (0.562)	-0.019 (0.017)


OLS COEFFICIENTS: SUICIDES PER 100,000
Urban Civilians
Urban Veterans
Rural Civilians
Rural Veterans
SUICIDES PER 100,000
20
15
10
5
0
-5
2010
2011
2012
2013
2014
2015
2016
YEAR


POISSON COEFFICIENTS: SUICIDE PERCENTAGE CHANGE
Urban Civilians
Urban Veterans
Rural Civilians
Rural Veterans
SUICIDE PERCENTAGE CHANGE
2.5
2
1.5
1
0.5
0
-0.5
2010
2011
2012
2013
2014
2015
2016
YEAR