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THE OPIOID SAFETY INITIATIVE AND VETERAN SUICIDES

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ABSTRACT

We investigate the relationship between opioid diverting policy and suicides among the veteran population. The opioid epidemic of the past two decades has had devastating health consequences among U.S. veterans and military personnel. In 2013, the Veterans Health Administration (VA) implemented the Opioid Safety Initiative (OSI) with the goal of discouraging prescription opioid dependence among VA patients. Between 2012 and 2017, prescription opioids dispensed by the VA fell 41% (VA, 2018). Because this involved the aggressive curtailing of opioid prescriptions for many VA patients, OSI may have had a detrimental effect on veterans' mental health leading to suicide in extreme cases. In addition, because rural veterans have much higher rates of VA enrollment, more prescription opioid use and abuse, and lower rates of substance abuse and mental health treatment utilization, we expect any effect of OSI on veteran suicides to be concentrated in rural areas. We find that OSI raised the veteran suicide rate relative to the non-veteran ("civilian") rate with rural veterans suffering the lion's share of the increase. We estimate that OSI raised the rural veteran suicide rate by a little over one-third between 2013 and 2018.

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1. Introduction:

Over the last few decades, the United States has seen a surge of substance abuse disorders related to opioids. From 1999 to 2018, almost 450,000 people died from an opioid-related drug overdose; of the 67,367 fatal drug overdoses in 2018, 70 percent were opioid-related (WONDER, 2020). The broad detrimental effects of this crisis have been heterogeneous. For example, individuals living in the most rural areas are 87 percent more likely to receive an opioid prescription than individuals in urban areas (García, 2019); opioid-related poisonings of rural residents have increased at three times the rate of those who live in metropolitan areas (Keyes, et al., 2014). Veterans have also been particularly susceptible to this crisis with rural veterans faring worse than their urban counterparts (Baser et al., 2014; Finlay et al., 2021).

In response to the opioid epidemic, policymakers have implemented measures to limit the supply of prescription opioids by deterring patients from "doctor shopping" and enhancing physician accountability in their opioid prescribing practices. These measures, of which state-level Prescription Drug Monitoring Policies (PDMP's) are a prominent example, have indeed resulted in reductions of prescription opioids 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). Buchmueller and Carey (2018) find that "must-access" PDMP's reduce opioid misuse among Medicare recipients. However, there is also evidence that supply-side restrictions have led to an increase in illicit opioid abuse and fatalities (Alpert, Powell, and Pacula, 2018; Delcher et al., 2016; Meinhofer, 2017).

The Veterans Health Administration (VA)--which includes roughly half of the total veteran population, including 93 percent of service-connected veterans (i.e., those injured during their service) (NCVAS, 2020), as well as many current military personnel—oversaw a staggering increase in the number of individuals treated with opioids from the turn of the century until it hit a peak in 2012 (see Figure 1). From 2004 to 2012, the percentage of veterans prescribed an opioid increased from 18.9 to 33.4 (Mosher et al., 2014). Of all veterans receiving opioid prescriptions in 2012, more than one-third were for longer than 90 days ("chronic use") (VA, 2015). The high percentage of long-term opioid prescriptions among veterans is associated with a high incidence of opioid use disorder (OUD) and opioid-related mortality (Baser et al., 2014; Bohnert et al., 2011; Axelrod, 2013).

In an attempt to combat the growing opioid crisis among veterans, in 2013, the VA implemented the Opioid Safety Initiative (OSI), which was primarily designed to curtail opioids prescriptions, especially high dose prescriptions (a daily dose of more than 100 morphine milligram equivalents, or MME's), long-term prescriptions (greater than 90 days), and concomitant prescriptions (e.g., opioids and benzodiazepines) for comorbid maladies (Sandbrink, 2019; GAO, 2018; Good, 2017).[1] Curtailment initiatives included establishing a database of patients' prescription histories (with a "clinical leader" at each facility tracking metrics to promote safer prescribing; see Lin et al., 2017), increasing drug screening among patients, and encouraging physicians to substitute toward alternative pain management practices through VA-instituted education programs and directives. Additional directives have been added over time.[2] Coinciding with the rollout of the policy, the number of opioids dispensed immediately began to diminish. From 2012 to 2017, the number of unique VA patients prescribed an opioid decreased by 41 percent (VA, 2018); as of the third quarter of 2020, the decrease was 64 percent compared to 2012 (VA, 2021), indicating that the VA continues to aggressively limit the use of prescription opioids among veterans.

In this paper, we examine the effects of OSI on veteran and military personnel suicides. Despite the policy's apparent success in reducing the number of opioids dispensed, there have been accusations from within and without the VA Health System that OSI policy encouraged physicians to "cut off" veterans from their pain medications.[3] The curtailment of opioid prescriptions may increase the risk of suicide due to mental and physical anguish related to withdrawal and physical pain (Borgschulte, Corredor-Waldron, and Marshall, 2018; Demidenko et al., 2017; Kuramoto et al., 2012). Because of the high incidence of chronic pain with corresponding large quantities of prescription opioids dispensed among veterans, this population is acutely susceptible to these increased suicide risks (Oquendo and Volkow, 2018; Johnson et al., 2015; Toblin et al., 2014; Johannes et al., 2010; Cesur, Sabia, and Bradford, 2019; Baser et al., 2014; Kang et al., 2015).

Other studies point to the discontinuance of prescription drugs as a risk factor for suicide and overdose, but these studies do not establish a causal link between these variables (Demidenko et al., 2017; Kuramoto et al., 2012; Oliva et al., 2020). We investigate the question of whether OSI led to an increase in veteran suicides with a triple difference (DDD) empirical model. Our outcome is county-level suicide rates per 100,000 individuals in both non-veteran ("civilian") and veteran/military

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[1] OSI was piloted in 2012 in five small regions in Minnesota, which is a state that is not included in our dataset.
[2] See Figure 2, which shows a timeline of OSI implementation and additional directives.
[3] 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 off 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.

personnel populations. OSI only affected VA users, so civilians serve as a control group in our analysis. We note, however, that opioid prescription among the general population also peaked in 2012 and began falling thereafter.[4] Nevertheless, because of veterans' underlying health conditions, high initial per-capita opioid use rates, and other factors discussed in detail below, we expect the curtailment of opioid prescriptions via OSI to have unique effects on the veteran population relative to civilians.

We further differentiate civilian and veteran populations by urban-rural status. This distinction is made due to the vast differences in health care options, treatment availability, opioid prescription rates, and cultural norms between these populations, which should result in differential impacts of OSI on suicide rates among rural and urban veterans, as we argue in Section 1.3. We exploit the national implementation of OSI in 2013 to identify the effects of OSI on rural and urban veterans relative to their civilian counterparts.

We first show that prior to the implementation of OSI, trends in suicides are similar between veterans/military personnel and civilians. However, after the implementation of OSI, the suicide rate for veteran/military personnel increases relative to the civilian rate, and this effect is concentrated among rural veterans. In the year of implementation (2013), rural veteran suicides increased roughly one-third of the pre-treatment mean relative to the base group (urban civilians); this effect was 37% in 2018. Urban veterans also experienced statistically significant increases in suicides starting in 2015 on the order of 13-21 percent. These findings are robust to controlling for different sets of time-variant explanatory variables and modeling choices, as we show in Section 5.

We also show how OSI is related to other forms of "violent" death (according to the CDC's definition) in Section 5.3. Other violent death types are generally not affected by OSI (as expected), but because suicides compose a large fraction (about 75%) of all violent deaths, OSI has similar effects on all violent deaths to the ones it has on suicides. Because *accidental* overdose deaths are not classified as violent according to the CDC, our data does not contain them. Thus, one concern is that suicides take the place of accidental overdose deaths that would have occurred had veterans not been restricted in their opioid use. For reasons discussed in Section 5.5, we view this as improbable, particularly because veteran overdose deaths rose substantially over our sample period. Since other papers have found that prescription opioid restrictions have led to increases in overdose deaths in the general population (e.g., Alpert, Powell, and Pacula, 2018), it is possible that our results understate the full effect that OSI has had on veteran mortality through 2018.

[4] See, for example, https://www.cdc.gov/drugoverdose/maps/rxrate-maps.html.

2.1 Background: Veterans and Opioids

Opioid-related overdose mortality rates for veterans are nearly twice as high as for civilians (Bohnert et al., 2011) and the prevalence of substance abuse disorders for veterans is almost seven times higher (Baser et al., 2014). In 2015, it was estimated that approximately 68,000 veterans suffered from OUD (Childress, 2016; Connolly, 2018) and the overall overdose rate per 100,000 veterans had risen 50 percent compared to 2010 (Lin et al., 2019).

Physical and psychological trauma stemming from stressful simulations and combat operations appears to contribute to the opioid crisis among veterans (Bennett et al., 2013; Cesur, Sabia, and Bradford, 2019).[5] Veterans are 40% more likely to suffer severe pain than non-veterans (Sandbrink, 2019), and among those treated at VA facilities, over 50% suffer from chronic pain (Daigh, 2015). As of 2011, half of the veteran population diagnosed with chronic non-cancer pain were prescribed an opioid; 57% of those prescriptions were for long-term use (Edlund et al. 2014).

Because many veterans suffer from comorbid physical and mental maladies (e.g., physical trauma and Post Traumatic Stress Disorder, or PTSD), especially those veterans who have combat experience, 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 presence of both types of medications has been present in roughly half of all veteran opioid overdose deaths (Park et al. 2015).

2.2 Background: The Opioid Safety Initiative (OSI)

To mitigate the destruction caused by overprescribing opiate-derived analgesics to millions of veterans, the VA instituted the Opioid Safety Initiative (OSI) nationwide in 2013. This was followed by "Academic Detailing" initiatives in 2014, which provided opioid prescribing education for physicians affiliated with the VA.[6] Next came the Comprehensive Addiction and Recovery Act (CARA) in 2016, which mandated that all physicians within the VA conduct inquiries into state PDMP databases at least once a year for their patients (GAO, 2018). Training for all VA opioid prescribers became mandatory in that year as well (Good, 2017).

[5] Although approximately 2.1 million troops have been deployed to and withdrawn from the Middle East since 2001 (Wenger et al., 2018), overall U.S. force sizes in the Middle East began to decline starting in 2007; the decline was particularly rapid from 2010 to 2012 (Kane, 2016).

[6] Good (2017) writes that physicians who engaged in Academic Detailing decreased their prescribing of high-dose opioids by 58 percent compared with a 34 percent reduction among physicians who did not.

The mechanisms by which the VA may have reduced prescribed opioids includes national opioid databases ("OSI Dashboards"), which utilize the VA's Electronic Health Records and includes state PDMP databases. Physicians are able to track their patients' medication history, urine drug screening, and alternative forms of chronic pain therapy (Petzel, 2014). The VA tracks "key clinical indicators," which include the number of unique patients dispensed an opioid, the number of patients on concomitant prescriptions of benzodiazepines and opioids, unique patients prescribed long-term opioid therapy, and mean daily opioid dosages. Using these metrics, high-risk patients are identified (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 (GAO, 2018; Westanmo et al., 2015; VA, 2020). Physicians within the VA who do not apply the prescribing guidelines initiated by OSI are identified and may be subject to VA counseling, education, or other actions (Petzel, 2014). There is concern within and without the VA that patients who are rapidly tapered from opioids could experience adverse outcomes (Demidenko et al., 2017; Dubin et al., 2017). Some physicians have apparently set arbitrary dose limits for stable patients who were on chronic opioid treatments (Good, 2017). Notably, as published in the VA/Department of Defense (DOD) Clinical Practice Guideline for Management of Opioid Therapy for Chronic Pain, physicians were initially instructed to taper opioid therapy patients at a rate of 20-50 percent per week (VA, 2010; Westanmo, 2015), which is a much higher rate than the 10 percent per month suggested by the CDC (CDC, 2016).

OSI has been highly successful at reducing opioid prescriptions within the VA. Since its rollout, opioid-related prescription measures, including high dose prescriptions, long-term prescriptions, concomitant prescriptions, and the number of unique patients dispensed an opioid have steadily decreased (Sandbrink, 2019; see Figure 1).

2.3 Background: Veterans and Suicides

Over the same time period as the U.S. opioid epidemic grew, suicides also increased at a troubling rate (Curtin, et al., 2016; Hedegaard, 2018; Case and Deaton, 2015). Suicides involving opioids, i.e. intentional fatal opioid poisonings, were twice as high in the year 2014 as they were in 1999 (Braden et al., 2017). As with the opioid epidemic, the population of veterans and military personnel are acutely vulnerable to the current suicide crisis. Compared to the general population, veterans' risk of suicide is 41 to 61 percent higher (Kang et al., 2015; see also Bryan et al., 2015; Maguen et al., 2011; Kim et al., 2012; Ilgen et al., 2013).

Individuals who suffer from 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. Indeed, Eichmeyer and Zhang (2020) find that VA patients who are assigned to primary care providers with a high tendency to prescribe opioids experience an increase in the likelihood of attempted suicide over the next three years. However, forced opioid discontinuation may exacerbate the risk of suicide for vulnerable patients, especially within the first three months of discontinuation (Oliva et al., 2020; Talari and Yara, 2020).[7]

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 policies aimed at prohibiting or minimizing forced opioid tapering be enacted (Darnall et al., 2019). OSI encourages physicians to reduce opioid prescriptions and implement tapering programs (VA, 2010); those veterans with mental health and substance use disorders are more likely to endure opioid tapering and discontinuation within the VA (Oliva et al., 2020; Vanderlip et al., 2014). An estimated 75 percent of all clinician-initiated opioid discontinuations within the VA were the result of substance abuse-related aberrant behavior exhibited by the patient (Lovejoy et al., 2017).[8] 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).

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

Almost 25 percent of the total veteran population live in rural communities (VA's ORH, 2014), while 19 percent of all Americans do (VA's ORD, 2020).[9] Rural veterans also have comparatively high VA utilization rates: nearly 60 percent receive their health care through the VA (VA's ORH, 2014) whereas

[7] Oliva et al. (2020) show that the risk of suicide following opioid discontinuation increases with the length of time engaged in opioid treatment. The hazard ratios for committing suicide after stopping opioid treatment ranged from 2.02 for patients on opioids less than 30 days to 7.99 for patients on opioids 400 days or more. The risk of suicide does not appear to stabilize until 6 to 12 months following opioid discontinuation.

[8] 85 percent of all veterans who discontinued long-term opioid therapy did so for clinician-initiated reasons (Lovejoy et al., 2017).

[9] NOSORH (2014) states that 30% of veterans lived in rural areas and 36% of all enrolled VA veterans were rural veterans (https://nosorh.org/wp-content/uploads/2013/07/NOSORH-Rural-Veterans-Health-Guide-for-SORH.pdf).

only 37 percent of urban veterans do (VA's ORD, 2020).[10] This is one reason we expect VA policy to disproportionately affect rural veterans compared with urban veterans.

Rural veterans have also been more adversely affected by the concurrent opioid and suicide crises. When compared to their urban counterparts, veterans living in rural communities are prescribed over 30 percent more opioids per capita; most of this difference is accounted for by long-term use (Lund et al., 2019), which OSI has focused on curtailing. Higher per capita opioid prescription rates and rural dwelling are both risk factors for opioid use disorder and opioid-related mortality (Chou et al., 2015; Von Korff et al., 2011; Keyes et al., 2014; Turvey et al., 2020). Despite their higher rates of opioid use, rural veterans receive medication-assisted treatment and other evidenced-based treatments for addiction at a lower rate than urban veterans (Edmonds et al., 2020; GAO, 2019; Smalley et al., 2010).

In terms of suicide, the rural veteran population is at higher risk (by 20 - 22 percent) compared to urban veterans, even after controlling for availability of mental health services, such as distance to mental health treatment centers (McCarthy et al., 2012). Several studies have shown that high rates of suicide and comparatively low rates of treatment for rural veterans are a result of not just treatment availability but also factors like economic circumstances, comparatively lower quality of life, and rural culture (McCarthy et al., 2012; Mohamed et al., 2009 Teich et al., 2017; Wallace et al., 2006).[11] Oliva et al. (2020) found that rural veterans are at a greater risk of suicide following opioid discontinuation than urban veterans. In sum, the rural veteran population has higher VA utilization rates, opioid prescription rates (which have dramatically decreased following the implementation of OSI), rates of suicide, and lower addiction and mental health treatment utilization rates compared with their urban counterparts. For these reasons, we allow for different estimates of the effects of OSI on suicides by urban-rural status in our regression analysis.

3. Data

For our main dependent 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

[10] Of the rural veteran population, 56 percent suffer from at least one service-connected condition. The rate of VA enrollment among service-connected disabled veterans is over 93 percent (VA, 2017; see https://www.va.gov/vetdata/docs/Quickfacts/VA_Utilization_Profile_2017.pdf).

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

in participating states. This dataset is the most comprehensive data available for violent deaths, including suicides, homicides, unintentional firearm-related deaths, and violent deaths in which intent cannot be determined (NVDRS, 2018).[12] We examine how OSI affects these other forms of violent death in a supplementary analysis in Section 5.3.

The NVDRS restricted-access database includes veteran status and county of residence for all reported violent deaths. For our analysis below, we aggregated data on individual suicide incidents to the county-year level for veterans and non-veterans separately, as described in the next section. 17 states began participating in NVDRS prior to OSI implementation in 2013, and these are the ones we include in our sample (other states' data became available only after OSI was implemented and are left out).[13] We have data on 16 states starting in 2010 and data on Ohio starting in 2011. When we leave Ohio out of our analysis to have a perfectly balanced panel, our results are very similar to those shown in the paper (available upon request). A map depicting the states in our sample is included in Appendix Figure A1. The NVDRS codes a death as a suicide if intent can be determined. Because this dataset only includes "violent" deaths, accidental overdoses are not accounted for; thus, suicides may be undercounted to the extent that some overdoses are purposeful but intent cannot be determined.

We gather population, demographic, and socio-economic variables for each county-year for both veterans and non-veterans from the American Community Survey (ACS). These variables are discussed in the next section. Prior literature on opioid supply shocks and suicide (Borgschulte, Corredor-Waldron, and Marshall, 2018) shows that policies aimed at reducing the supply of opioids, when combined with geographical proximity to addiction treatment centers, act to reduce suicide.[14] Therefore, following Borgschulte, Corredor-Waldron, and Marshall (2018) and Swensen (2015), we used NAICS codes 621420 and 623220 from the Consumer Business Patterns (CBP) to identify inpatient and outpatient treatment centers in each county-year.

We use the rural-urban continuum code developed by the US Department of Agriculture Economic Research Service (USDA, 2013) to distinguish urban and rural counties in our analysis. Counties are classified based on 9 categories that are determined by their population size and whether

[12] Klugman, Condran, and Wray (2013) find that elected coroners are associated with slightly lower official suicide rates than appointed coroners or medical examiners. However, this does not affect estimates of the social determinants of suicide in their analysis. In our setting, even if rural counties are more likely to have elected coroners, this would likely only affect our estimates of OSI on suicide rates if there were differences by veteran status that changed over time.

[13] States in our sample include Alaska, Colorado, Georgia, Kentucky, Maryland, Massachusetts, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Virginia, and Wisconsin.

[14] See also Corredor-Waldron and Currie (2021), who show that drug-related ER visits are sensitive to the opening and closing of substance abuse treatment facilities and that these effects are largest in under-served areas.

they are adjacent to a metropolitan county. As in Kaplan et al. (2012), we assigned counties 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 over our sample period, we gathered user access date data for Prescription Drug Monitoring Programs from Borgschulte, Corredor-Waldron, and Marshall (2018), the Prescription Drug Abuse Policy System (PDAPS), and the National Alliance for Model State Drug Laws (NAMSDL). For must-access PDMP information, we use data published by Borgschulte, Corredor-Waldron, and Marshall (2018), Buchmueller and Carey (2018), and the New Jersey Prescription Monitoring Program (NJPMP).

4. 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 users' suicide choices will be affected by the negative supply shock to prescription opioids due to OSI. For reasons described above, we expect that rural veterans will be more affected by OSI than urban veterans. To investigate these possibilities, we use a generalized triple difference (DDD) regression model. Our treatment group is veterans and military personnel, and our control group is non-veterans/civilians. The treatment policy is OSI, which only affects those who receive healthcare through the VA. The vast majority of these are veterans/military personnel, though a tiny fraction of civilians receive care through the VA, such as immediate family members (VA, 2017). Some veterans do not receive healthcare through the VA, but we do not observe source of healthcare in our suicide data, and the choice to receive care through the VA may be endogenous with respect to OSI. Thus, we estimate the effect of OSI on the incidence of suicide among all veterans/military personnel relative to non-veterans/civilians (we refer to the former group simply as "veterans" and the latter group as "civilians" below). We then allow the effect of OSI to also vary by whether a suicide victim lived in a rural county.

The specific regression equation in our analysis is as follows:

$$\left(\frac{suicide}{100K}\right)_{vct} = \theta_c + \theta_t + \delta_1 * veteran_v + \delta_2 * veteran_v * rural_c + \sum_{t=2011}^{2018}(\alpha_t * veteran_v) + \sum_{t=2011}^{2018}(\gamma_t * rural_c) + \sum_{t=2011}^{2018}(\rho_t * veteran_v * rural_c) + X_{vct}\pi + \varepsilon_{vct}. \quad (1)$$

The unit of observation in our study is a county by year by veteran status (that is, for each county-year, there are two observations: one is the suicide rate among veterans, the other is the rate among civilians). θ_c and θ_t represent county and year fixed effects, respectively; county fixed effects control for time-invariant differences by county, and year fixed effects control for secular changes underlying the determinants of suicide. The coefficients δ_1 and $\delta_1 + \delta_2$ measure baseline (2010) differences in the suicide rate of urban and rural veterans, respectively, relative to civilians. The α_t terms measure how the suicide rate evolves for urban veterans, relative to urban civilians, over time (2011-2018). The γ_t terms measure how the suicide rate evolves for rural civilians relative to urban civilians over time. Finally, the ρ_t term measures how the suicide rate evolves for rural veterans relative urban veterans, all relative to the same urban-rural difference in civilian suicide rates. The treatment year is 2013, which is the year that OSI was nationally implemented; we are interested in how the parameters α_t, γ_t, and ρ_t evolve prior to and after 2013. Prior to 2013, we can observe whether there are differential pre-treatment trends by (rural) veteran status, which would cast doubt on whether post-treatment effects are truly due to OSI.

We again note that we are identifying the effects of OSI on veterans relative to a civilian population that also experienced a peak in opioid prescriptions in 2012 and then saw a continuous drop starting in 2013. We reason that the effects of opioid diversion should have a stronger effect on veteran than civilian suicides due to: 1) veterans' higher opioid consumption to begin with; 2) veterans' more severe underlying health conditions (some of which contribute to opioid consumption in the first place); and 3) the fact that opioid prescribing (particularly of the long-term variety) among VA patients declined more rapidly after 2012 than it did in the general population (Minigeshi and Frakt, 2018).

In Equation (1), X_{vct} represents a vector of time-variant controls including an indicator for whether a county is located in a state with a PDMP and a separate one for a mandatory PDMP, the number of addiction treatment centers (sum of outpatient and inpatient) in a county, interactions between PDMP indicators and the number of treatment centers; and ACS estimates for both veteran and civilian populations within the county for: percent of the population aged 18-34 (the age group for which the risk of suicide is greatest), percent female, percent black, the unemployment rate, median income, and percent that have some college experience. We also include a full set of interactions between veteran status as well as rural county status and all other controls in the model.[15] All regressions are weighted by total county population and standard errors are clustered by county.

In addition to a linear specification, like Borgschulte et al. (2018), we estimate our model using a Poisson Quasi-Maximum Likelihood Estimator (QMLE), where the dependent variable is the count of suicides for each county and year (with veteran/military and civilian suicides offset by their respective populations). Santos-Silva and Tenreyro (2006, 2011) lay out the attractive properties of this estimator, including that it relies only on the correct specification of the conditional mean and its strong performance under a variety of simulations including data-generating processes with many zeros for the dependent variable.

5. Trends and Descriptive Statistics

Graphical analysis in Figure 3 based on raw suicide rates shows that although the suicide rate is roughly twice as high for urban (rural) veterans as for urban (rural) civilians, trends in suicide rates for all groups are similar prior to 2013. This suggests that civilians offer a reasonable counterfactual for veterans and military personnel in a DD framework. Trends for these groups begin to diverge in 2013, the year of national OSI implementation; in particular, there is a large jump in the suicide rate of rural veterans compared with other groups, and starting in 2015, the gap between urban veterans and both civilian groups also widens.[16] We return to these points below when discussing the results of our formal regression models.

Table 1 provides pre-treatment descriptive statistics for veterans and non-veterans by rural/urban status. The differences in suicides per 100,000 between veterans and civilians shown in this table are consistent with the literature (Castro and Kintzle, 2014; Kang et al., 2015; Sher and Yehuda, 2015).[17] The vast majority of veterans are male, and as a group they are much older than civilians. Bachelor's completion rates are similar across groups, and veterans fare somewhat better on average in terms of labor-market indicators (the unemployment rate and median income), likely owing somewhat to their age and gender profile.[18]

[15] Veteran median income was missing for 380 counties in 2015. These missing values were replaced by the average veteran median income in 2014 and 2016 in their respective counties.
[16] In Appendix Figure A2, we show raw suicide trends for these four groups going back to 2004.
[17] Suicide rates for VA-enrolled veterans are higher than non-VA veterans (VA, 2019).
[18] Poorer economic conditions are associated with higher suicide rates (Denney et al., 2009; Tondo et al., 2006), but at least based on raw averages this would not seem to be the dominant explanation for the veteran-civilian suicide gap.

When looking at veterans and civilians across urban-rural status, we see that rural veterans/military personnel and civilians have worse outcomes in terms of suicide, economic well-being, and addiction treatment availability (at least in terms of the number of treatment facilities in their county) when compared to their urban counterparts. For example, the mean suicide rate per 100,000, median income, and unemployment for rural veterans is 32.74, $30,955, and 8.09 percent, respectively; in comparison, urban veterans suffer from 28.02 suicides per 100,000, earn $41,787 in median income, and have a 7.28 percent unemployment rate. These differences are consistent with the literature cited above.

Table 2 provides descriptive statistics for both veterans and civilians differentiated between periods prior to and post-OSI implementation. The veteran suicide rate per 100,000 prior to OSI was 28.81 and increased to 33.62 after implementation (a 17 percent increase), whereas the civilian suicide rate increased from 13.55 prior to OSI to 15.11 after OSI (a 12 percent increase). Additionally, the large increase in the suicide rate among veterans does not at first blush 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 there are other factors driving the relative increase in veteran/military suicides.

6. Results

6.2 Baseline Results

Our main regression results are displayed in Table 3, where we present the comparative impact of OSI on suicides among veterans/military personnel and civilians. Column 1 in this table shows OLS estimates without any additional controls (X_{vct}) included in the regression equation and column 2 shows the coefficient estimates with the additional controls described in Section 3. Estimates for each of our four groups (urban/rural, civilian/veteran) are plotted for the specification with controls in Figure 4.[19]

OLS estimates without controls show no consistent trend in urban civilian (base group) suicides until after 2013, when suicides increase modestly relative to 2010. When controls are included (column 2), these yearly differences shrink and largely become statistically insignificant. Rural civilians (see the coefficients on year*rural) experience somewhat elevated suicide rates in the years following

[19] Difference-in-differences estimates for rural residents only are displayed in Appendix Table A2.

2010 relative to urban civilians when controls are not included. When controls are included, coefficient signs switch from positive to negative but there is no clear trend in magnitudes after 2010.

With respect to the differential evolution for urban veteran suicides relative to urban civilian suicides, estimates with and without controls tell a very similar story: veteran suicides are elevated in all post-2010 years, but after 2014 the effects jump in magnitude substantially and become statistically significant at the 5% level or better. In the case of column 2 (controls included), the effect in 2015 is 3.68 suicides per 100,000 (a 13% increase relative to the pre-treatment mean); by 2018, the effect is 4.62 (16%). We note that we do not see immediate effects of OSI (implemented in 2013) when it comes to urban veteran suicides. Because of lower VA enrollment and opioid prescription rates among this group, it may be that effects of OSI become evident only after the policy has had a chance to grow in scope, which it did from 2013 to the present as opioid-related prescribing has continually decreased coinciding with Academic Detailing and the implementation of CARA.[20]

Our triple difference estimates, which measure any difference in suicides that rural veterans experience with respect to OSI compared to urban veterans, all relative to the same difference among civilians, are displayed at the end of Table 3. In this case, the findings are quite stark: while year effects prior to 2013 are small and statistically insignificant, they jump greatly in magnitude in 2013 and remain similar through 2016 before waning somewhat in 2017 and 2018. In 2013, the difference in suicides between rural and urban veterans (relative to the urban-rural civilian difference) increased by 11.26 per 100,000 compared with 2010. This represents an increase of 34% relative to the pre-treatment mean for rural veterans. Effects in subsequent years are similar (albeit somewhat smaller) in both specifications through 2016. It is important to note that these effects are on top of estimated effects for all veterans, which increase themselves from 2015 to 2017 and remain relatively large in 2018. This is evident in Figure 4, which shows that rural veteran suicides continue an upward trajectory after 2013 and stabilize after 2016.

The immediate, large effect of OSI on rural veteran suicides in 2013 occurs even though the policy was officially implemented only in August of that year. We believe the reason for this is twofold: first, OSI was chartered by the Under Secretary for Health in August of the previous year after being piloted by several regions in Minnesota (Clancy, 2015). Therefore, physicians were aware that OSI was to be implemented nationwide in 2013. Additionally, from Figure 2, we see that unique patients

[20] From 2012 to 2020, the VA has reduced overall patients dispensed an opioid by 64%, co-prescriptions of opioids and benzodiazepines by 87%, patients on long-term opioids by 70%, and patients on high dose opioid regimens (greater than or equal to 100 MED) by 80% (VA, 2020).

dispensed an opioid reached a maximum point in the fourth quarter of 2012. Starting in the first quarter of 2013, we begin to see reductions in VA opioid prescribing that pre-dated the national implementation of OSI. Hence, it appears that VA physicians were aware of the policy and likely began changing their opioid prescribing behavior in anticipation of OSI throughout the first 7 months of 2013. Second, as described above, suicide risks following opioid discontinuation are highest within the first three months (Demidenko et al., 2017). Furthermore, veterans who were initially forced to taper or discontinue their opioid prescriptions were often the most vulnerable: those with unstable addictions or who had displayed substance-abuse aberrant behavior (Lovejoy et al., 2017). These factors combined suggest the immediate impact of the policy we observe for rural veterans is plausible.

The growing effects of OSI on both urban and rural veteran suicide rates over most of our sample period may be due to the evolution of OSI policy over time. After implementation of OSI in 2013, VA prescription opioid rates, including unique patients receiving opioids, high-dose prescription opioids, concomitant prescribing of opioids and benzodiazepines, and long-term prescription opioids, decline in each successive year; the drastic decrease in these opioid-related metrics, which the VA monitored after OSI implementation, coincide with a greater emphasis on Academic Detailing, which educates VA physicians on VA norms for opioid-related prescribing. As opioid prescriptions continued to decrease, including by way of more tapering and discontinuation programs, an increasing number of veterans likely became affected by the policy, which resulted in a greater number of veteran suicides.

A countervailing force is that the number of veterans exposed to both the lax opioid regime from before OSI and the much stricter one after it should diminish over time. Since the post-OSI regime could help prevent suicides by making it less likely that veterans become dependent on opioids in the first place, suicides could decrease in the long run. This is consistent with the stabilizing of veteran suicides we observe in the last few years (2017-18) of our sample, but more data is needed to evaluate this possibility. We revisit this issue in the Conclusion.

6.3 Poisson Results

Table 4 shows the estimation results from the Poisson QMLE specification both without additional controls (column 1) and with additional controls (column 2) as discussed in Section 3. In this specification, urban civilians (base group) do not see an increase in suicides prior to 2014. Starting in 2014, the suicide trend for urban civilians is upward throughout the remainder of our sample, which is similar to what we find in our baseline OLS specification with no additional controls. When it comes to rural civilians, column 1 shows little different relative to urban civilians but column 2 (with additional controls) suggests that rural civilian suicides are declining relative to urban civilian ones over the course of our sample period.

The main difference between our OLS and Poisson QMLE results is for urban veterans. Whereas we see distinct increases in suicides for urban veterans (relative to civilians) starting in 2015 with our OLS specification, we see no such effects in the Poisson results. However, the triple difference estimates for the Poisson QMLE, which measure any difference in suicides that rural veterans experience compared to urban veterans, all relative to the same difference among civilians, are quite similar to their OLS counterparts. Starting in 2013 and continuing through 2016, these effects are large and statistically significant at the 5% level or better, ranging between 40-45 percent depending on the year and whether additional controls are included. After 2016, as with the OLS results, the coefficients decrease slightly. One caveat is that differences between 2012 and 2013 are smaller and only statistically significant at the 5% level in the Poisson QMLE, whereas they are significant at the 1% level in our baseline OLS results.

6.4 Other Violent Deaths

We have argued that veteran suicides are likely to be affected by OSI due to a high prevalence of serious underlying health conditions and opioid use disorder among this population. However, we do not expect OSI to have first-order effects on other forms of violent deaths, including homicides, "legal intervention" deaths (i.e., involving law enforcement), unintentional firearm deaths, and deaths of undetermined intent. Thus, examining how OSI affects these forms of violent death serves as a falsification check in our analysis. In other words, if OSI is truly responsible for the relative rise in veteran suicides, we would not expect to see OSI associated with a rise in these other forms of violent death. The one potential exception is deaths of undetermined intent, which could contain some overdose deaths that were not ruled a suicide or an unintentional overdose as well as suicides for which not enough evidence was present to label it as such.[21]

Results on other types of violent deaths are contained in Table 5. There are few statistically significant coefficients and no clear trends or patterns for the veteran-by-year or veteran-by-year-by-rural effects in the first three columns of the table (homicides, legal intervention deaths, and unintentional firearm deaths). In the case of deaths of undetermined intent (last column), we do see a few positive and statistically significant DDD coefficients, though we note again that this category of deaths may include some overdose or suicide deaths that would be directly affected by OSI.

[21] NVDRS does not contain data on overdose deaths that were ruled to be unintentional (i.e., these deaths are not classified as "violent" deaths).

In Table 6, we show how OSI affects all violent deaths excluding suicides (column 1) as well as all violent deaths aggregated together (column 2). In the first column, we see that there are no significant pre- or post-OSI year effects for urban veterans. In the case of the triple difference estimates, we see two significant and positive coefficients (in 2014 and 2017) but not the stark and sustained increase starting in 2013 that we observe in the case of suicides. Because suicides make up the lion's share (roughly 75%) of all violent deaths, we expect that the effects of OSI on all violent deaths (including suicides) will mirror those for suicides specifically. This is borne out in the second column of Table 6, where see very similar results to those observed in Table 3.

6.5 Threats to Identification

A potential threat to our identification strategy is the possibility that veteran migration across urban/rural areas coincides with or is caused by OSI. For example, rural veterans may seek additional healthcare services (including substance abuse treatment) to deal with the loss of opioids by migrating to urban areas. Or, as OSI is an opioid diverting policy, it is feasible that rural veterans may migrate to urban communities to access a more robust illicit drug market as a substitute for lost prescription opioids. If such migration occurred according to underlying factors that affect suicide risk, it would call into question our interpretation of results.

To investigate this phenomenon, we regress the percentage of each county's population who are veterans on time and year fixed effects and the interaction between year and rural indicators; the regression was weighted by county veteran population and the standard errors were clustered by county (see Table 7). The results indicate that although veteran populations are declining over time in general (likely due to their much higher age than the civilian population, on average), this decline is no larger in rural areas, as all year by rural interaction terms are essentially zero. This suggests that differential migration across the urban-rural divide is not driving our results.

Lastly, we note that a potential weakness of the results we have presented so far is that the pre-treatment period is relatively short, making it difficult to tell whether the parallel trends assumption is likely to hold in our context. To extend our analysis to an earlier year (2004), we must leave out additional county and state-level covariates from our model due to a lack of data in these years, and we must also interpolate county veteran and non-veteran population numbers between the year 2000 (for which we have Census data) and 2010 (our first year of ACS data). With these caveats, we present the results of our model extending back to 2004 graphically in Figure 5 (full results are available in Appendix Table 1). The rural veteran suicide rate jumps above the others in 2005, but the difference between this and either the rural civilian rate or the urban veteran rate does not change much until 2010, when it falls back to about zero (temporarily). The urban veteran suicide rate grows modestly relative to the urban civilian rate until the last four years in our sample (starting in 2015), when the gap widens as discussed above. Overall, we view the results of our analysis with a long pre-treatment period to be consistent with our earlier findings.

6.6 Discussion

In this sub-section, we attempt to place our results in the literature on opioid policy and suicides. Borgschulte, Corredor-Waldron, and Marshall (2018) found that state PDMP policies have not increased suicides among the white non-Hispanic population over 30 years old. Furthermore, the authors found that when PDMP policy was paired with greater treatment center availability, suicides actually decreased. In contrast to the results of Borgschulte, Corredor-Waldron, and Marshall (2018), we find that opioid diverting policy, specifically OSI, has increased suicides among the rural veteran population substantially and perhaps the urban veteran population more modestly.

We posit that the differences in our results with those in Borgschulte, Corredor-Waldron, and Marshall (2018) are due both to the different populations analyzed as well as the mechanisms of each policy (PDMP's versus OSI). First, as mentioned above, U.S. veterans are perhaps the population that has been most adversely affected by the opioid epidemic. This is due to their higher rates of chronic pain, greater access to prescription opioids, higher rates of substance abuse disorder, lower treatment utilization, and higher rates of suicide; comparing these adverse consequences between urban and rural veterans, rural veterans fare worse still. Second, OSI went beyond creating a database for patients' prescription histories or even mandating that physicians access that database (as was typically the case with PDMP's); it introduced additional measures that led to opioid tapering and discontinuation programs that have been shown to increase the risk of suicide among a vulnerable population.

Bounthavong et al. (2017) find that when VA providers were exposed to Opioid Overdose Education and Naloxone Distribution (OEND) via academic detailing, their prescribing of Naloxone increased, and Bounthavong et al. (2021) find a similar result with respect to a decline in opioid-benzodiazepine co-prescribing. Thus, provider education via academic detailing appears to affect VA provider behavior. Though the purpose of academic detailing was to inform and encourage providers to follow evidence-based practices in managing patients' pain, we know that VA guidelines as of the early part of our sample period were for much more aggressive tapering than is currently recommended by the either the VA or the CDC.

Whatever the reason, tapering among patients who were already on opioid therapy—including long-term and/or high dose prescriptions—has increased under OSI (see, for example, Minegishi et al., 2020). Any negative consequences of this policy must be weighed against the positive effects of reducing the number of veterans exposed to dangerous opioid regimens to begin with. Indeed, Barnett, Olenski, and Jena (2017) and Zhang and Eichmeyer (2021) find that exposure to a high-intensity opioid prescriber in an emergency room setting has long-run effects on opioid use, and the latter study finds effects on the eventual development of an opioid use disorder (OUD) and opioid overdose mortality among VA patients. Thus, there may be long-term benefits of OSI that must be weighed against the cost of increased illicit drug use (including overdose) and suicide risk for vulnerable patients who experience tapering or discontinuation, which tend to be manifest within a short period of time (FDA, 2019; Oliva et al., 2020). We return to this point in the Conclusion.

Lastly, we aim to put our results in context by approximating the ratio of suicides caused by OSI to opioid prescriptions foregone as a result of OSI. This involves a back-of-the-envelope calculation based on our results as well as several figures taken from other papers in the literature. At the peak of VA opioid prescribing in 2012, the number of unique veterans dispensed a prescription opioid was 1,017,826 (Hadlandsmythe et al., 2018). Using estimates from Hadlandsmythe et al. (2018), which uses VA prescription data through 2016, we estimate that 696,919 unique veterans received an opioid prescription from the VA in 2018, which represents an annual average decrease of 53,485 unique veterans receiving an opioid prescription.[22]

Because an estimated 2.7 million rural veterans are enrolled in the VA while 5.2 million urban veterans are (VA's ORH, 2014), and because rural veterans are prescribed 30 percent more opioids per capita, we estimate that 44 percent of the decrease in opioid patients was composed of rural veterans. Furthermore, our own results indicate that rural veteran suicides increased an average of 12.58 per 100,000 from the years 2013 to 2018 as a result of OSI (this figure is obtained from summing the average of the coefficients on the veteran-by-year effects and the rural-by-veterans-by-year effects for 2013-2018). Because there are approximately 4.7 million rural veterans overall (VA's ORH, 2014), average annual suicides among the rural veteran population as a result of OSI is just over 591, or 3,548 suicides as a result of OSI from 2013 to 2018. Therefore, for every 100 rural patients who were not

[22] Using Hadlandsmythe et al. (2018), we calculated average annual decreases for the number of unique veterans receiving an opioid prescription and extrapolated that number to 2017 and 2018 to calculate a total number of unique veterans receiving an opioid prescription in 2018. Of course, this methodology operates under the assumption that VA opioid prescriptions decreased at a constant rate, which is why we consider these estimates "back-of-the-envelope" approximations.

prescribed opioids as a result of OSI, we estimate that there were almost 3 suicides. Following the same methodology for urban veterans (average increase in suicides per 100,000 following OSI of 3.76, representing a total of 3,181 urban veteran suicides from 2013-2018), the ratio of urban veteran suicides to urban opioid patients foregone is approximately 0.02.[23]

Lastly, we address the possibility that some of the additional suicides attributed to OSI are substituting for overdose deaths that would have occurred otherwise during our period of study. Unfortunately, as described earlier, we do not have data on accidental overdose deaths in our data; thus, we cannot examine this question directly. However, we note a few reasons we believe this cannot account for our results. First, Lin et al. (2019) show that the overall opioid overdose death rate among veterans increased by 50 percent from 2010 to 2016, with the entire increase coming from heroin and synthetic opioid (e.g., fentanyl) deaths. This is consistent with the pattern observed in other studies for some individuals to turn to "street" forms of opioids when prescription opioids become harder to obtain; these are often more potent with higher accompanying overdose risk.[24] By comparison, the opioid overdose death rate in the United States as a whole increased by 33% from 2010 to 2015 (Rudd et al., 2016).

Finally, even if some overdose deaths were avoided as a result of the estimated 53,845 veterans not receiving opioids each year in the post-OSI period, it is very likely a small fraction of our estimated increase in suicides. For example, Zhang and Eichmeyer (2021) estimate that exposure to prescription opioids in the emergency room increases the chances of an opioid overdose within 3 years of 0.75 percentage points. If the entire reduction of 53,845 veterans receiving opioids was due to foregone initial prescriptions, this would result in about 40 additional overdose deaths avoided in each year (compared to an increase of 591 suicides). Of course, many of these veterans not receiving opioids would have already been prescribed opioids in the past; for some of these individuals, losing their prescription may very well increase in the risk of overdose due to diversion into illicit opioids, as described above.

7. Conclusions

In this study, we investigate the link between VA supply-reducing opioid policy (OSI) and suicide among veterans and current military personnel. We find evidence that OSI resulted in an increase in

[23] The number of total urban veteran suicides as a result of OSI is obtained by taking the product of the mean coefficient values for urban veteran suicides per capita from 2013 through 2018 and the total number of urban veterans (14.1 million) in 2014.
[24] https://www.cdc.gov/drugoverdose/deaths/synthetic/index.html.

veteran suicides. These effects appear to have grown through 2016 before leveling off in the last few years of our sample period. Our results show that rural veterans specifically have been particularly affected by OSI, with suicides increasing by a little over one-third between 2013 and 2018. These differences are consistent with higher rates of VA enrollment, opioid use, and suicide risk among rural veterans as we have discussed.

The opioid crisis has had tremendous negative consequences among veterans; lower-bound estimates for annual health care costs for veterans with combat exposure alone are upwards of $1.04 billion for prescription painkiller use and $470 million for heroin use (Cesur, Sabia, and Bradford, 2019); the total opioid-related economic burden for the general population in the United States in 2013 was an estimated $78.5 billion (Florence et al., 2016). OSI, which reduced opioid prescribing for both those who entered the VA under the looser former opioid regime as well as newer veterans, may have long-term benefits if it prevents opioid use disorders from occurring in the first place. However, our results suggest there are large benefits of effective countermeasures among rural veterans in the shadow of OSI. The most successful interventions would reduce veteran suicides while continually exposing fewer veterans to potentially dangerous pain mitigation strategies via opioid prescriptions.

Although it is beyond the scope of this paper, we surmise that successful treatment interventions may occur through enhanced addiction treatment and mental health networks. The rural veteran population may especially benefit from this, as they face significant barriers to treatment, which results in lower rates of treatment utilization compared to their urban counterparts (Cully et al., 2010; Edmonds et al., 2020; GAO, 2018; McCarthy et al., 2012; Mohamed et al., 2009; Possemato et al., 2018; Teich et al., 2017). Leung et al. (2019a) find that integration of mental health specialists into primary care clinics (the PC-MHI initiative) increased use of mental health services but that those living farther from their VA clinic were less likely to see a PC-MHI provider. Leung et al. (2019b) find that in small community-based primary care clinics located far from affiliated VA hospitals, same-day mental health services and "warm hand-offs" between primary care providers and mental health specialists are much less likely than in large clinics or small clinics located near VA hospitals.

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 suffer from mental health disorders and faced barriers to mental health care due to their place of residence. Using the tablets to conduct telehealth appointments, veterans who were given these tablets had higher psychotherapy utilization rates and managed their medications more effectively compared to veterans who did not receive them (VA, 2018). Borgschulte, Corredor-Waldron, and Marshall (2018) find that with a sufficient number of treatment centers in a county, suicides decline after the implementation of PDMP's. These results hint at strategies to prevent veteran suicides in the wake of opioid-diverting policy.

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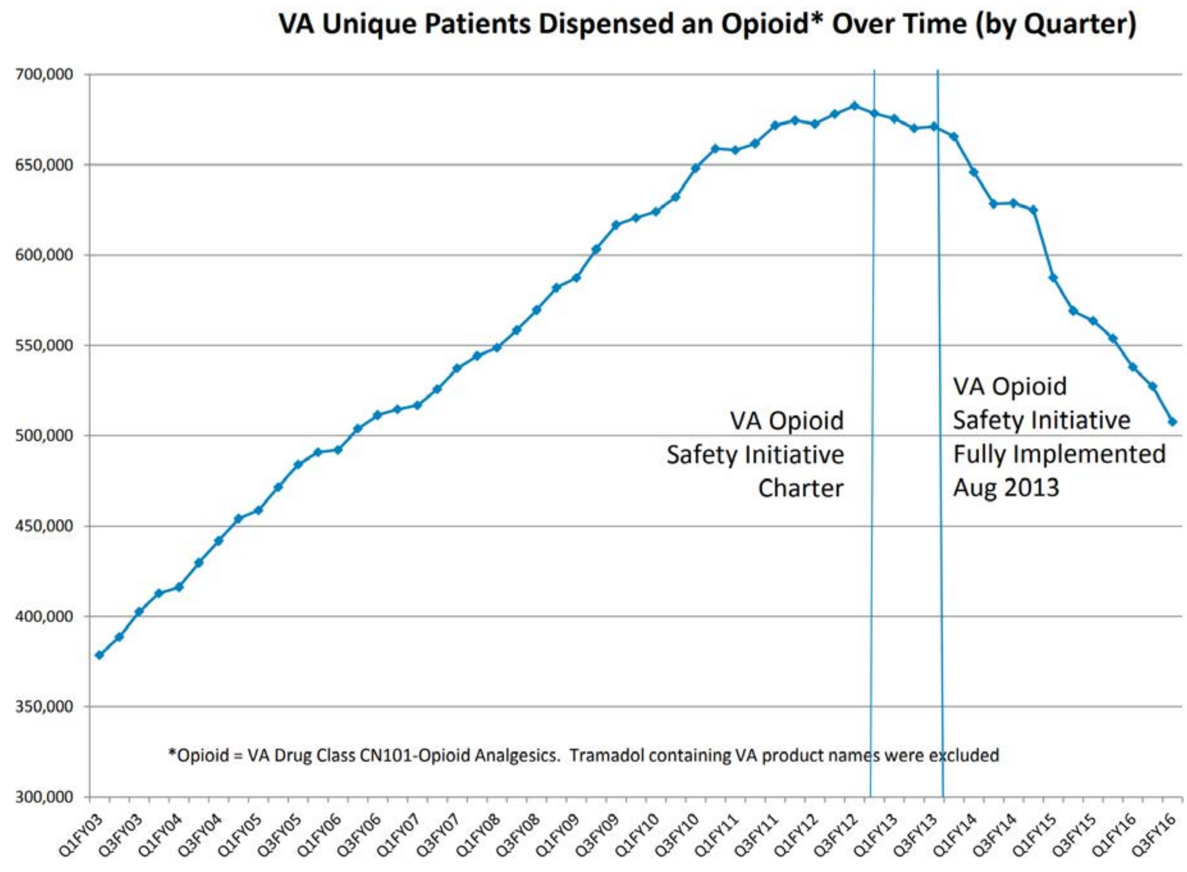

Figure 1: Quarterly evolution of unique VA patient opioid prescriptions (source: Good, 2017)

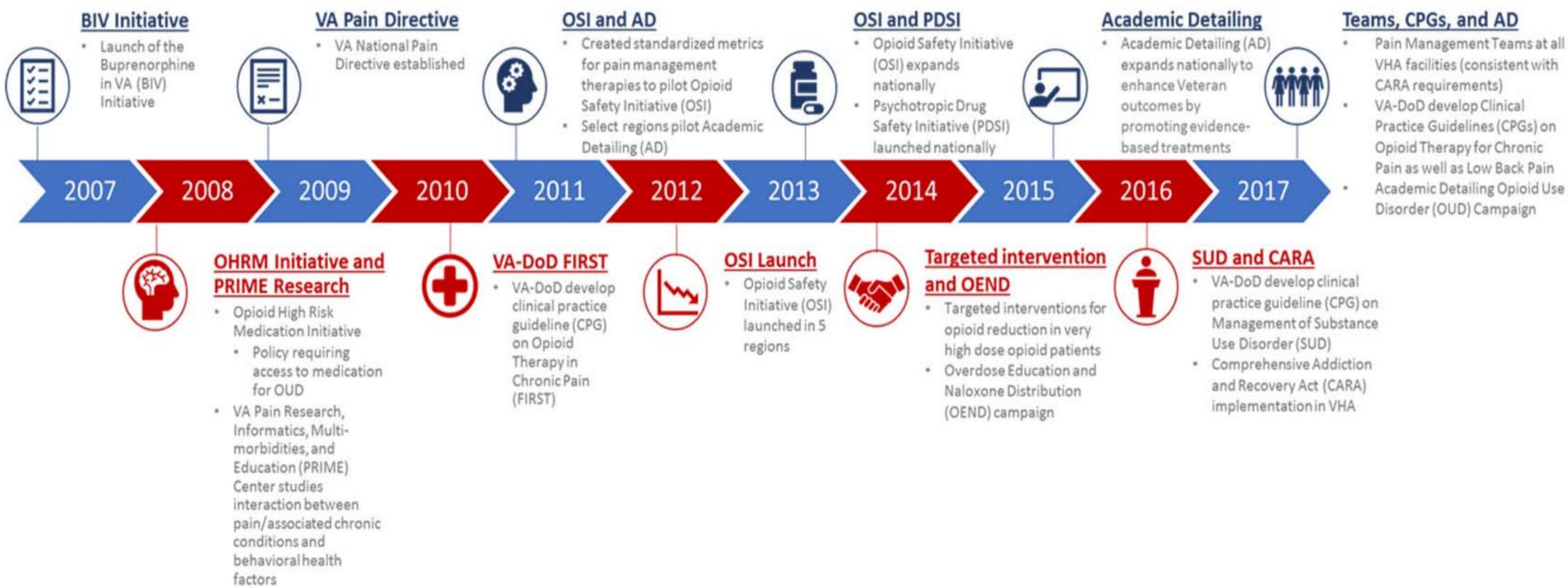

Figure 2: Timeline of VA opioid policies and OSI implementation (source: Sandbrink, 2019)

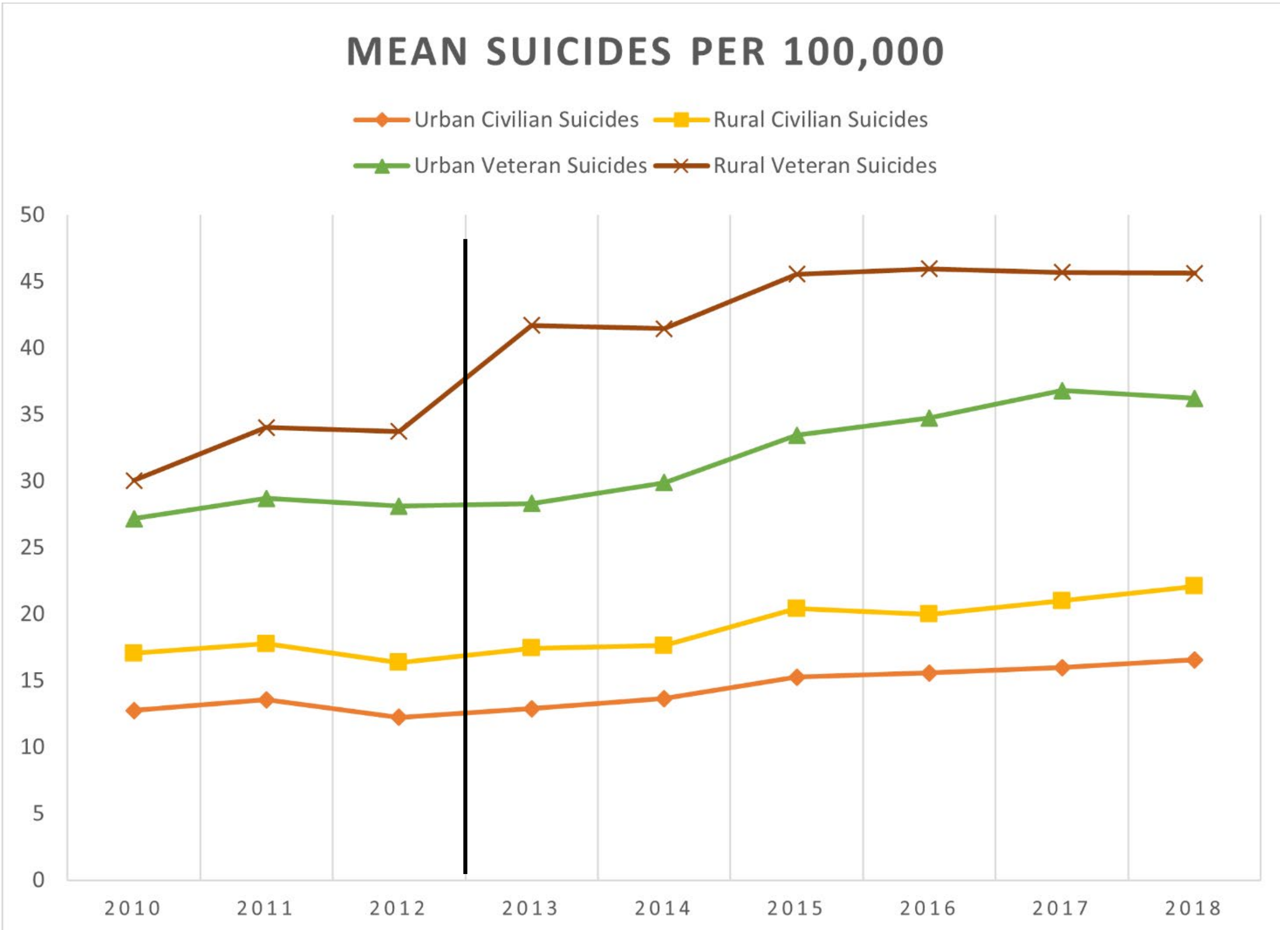

Figure 3 Average county-year suicide trend for veteran/military personnel and civilians, differentiated by urban-rural status, and weighted by total county population.

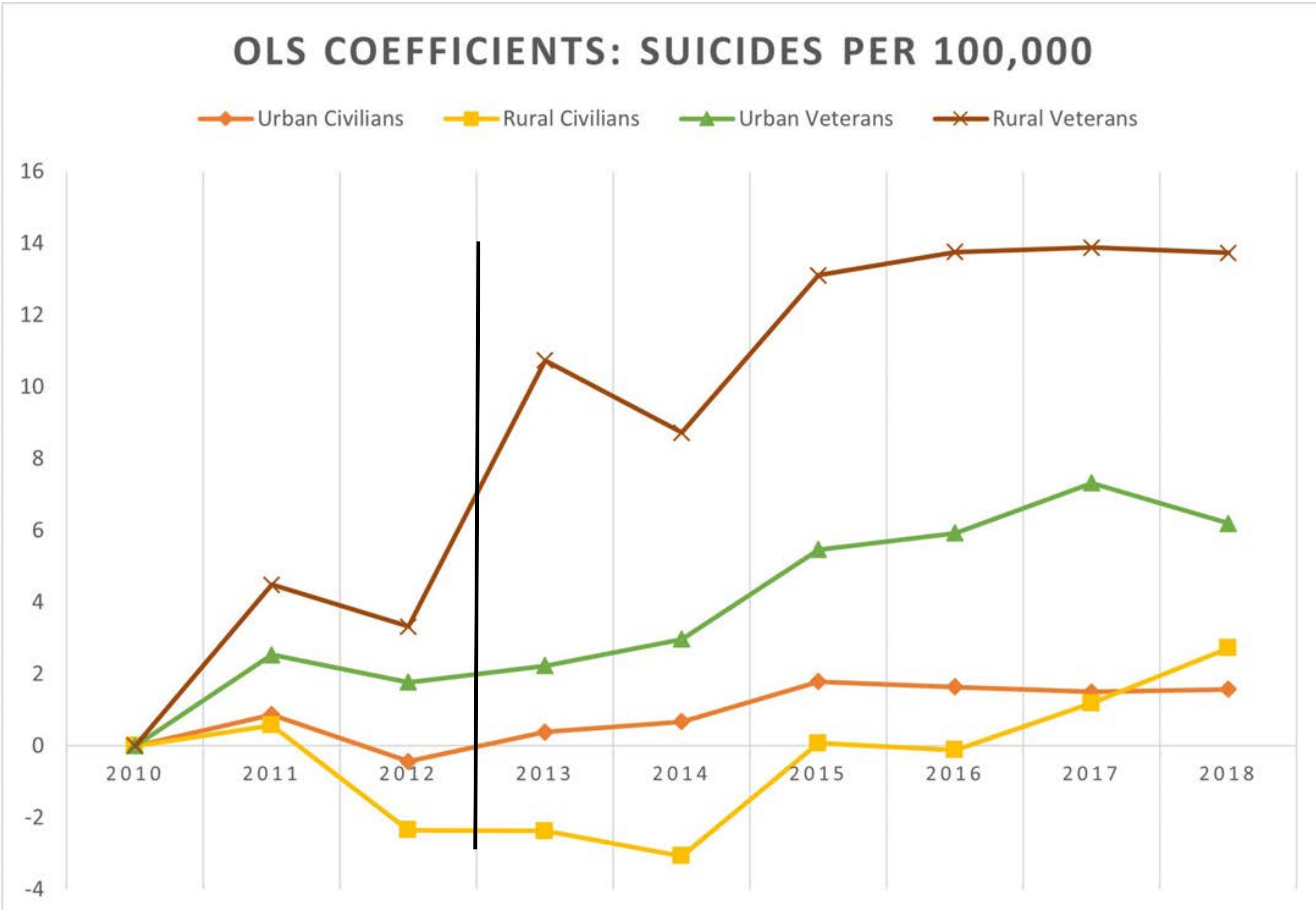

Figure 4: Coefficients from a linear regression of suicides per 100,000 among veterans/military personnel and civilians by urban-rural status. The specification includes right-hand side controls discussed in the text.

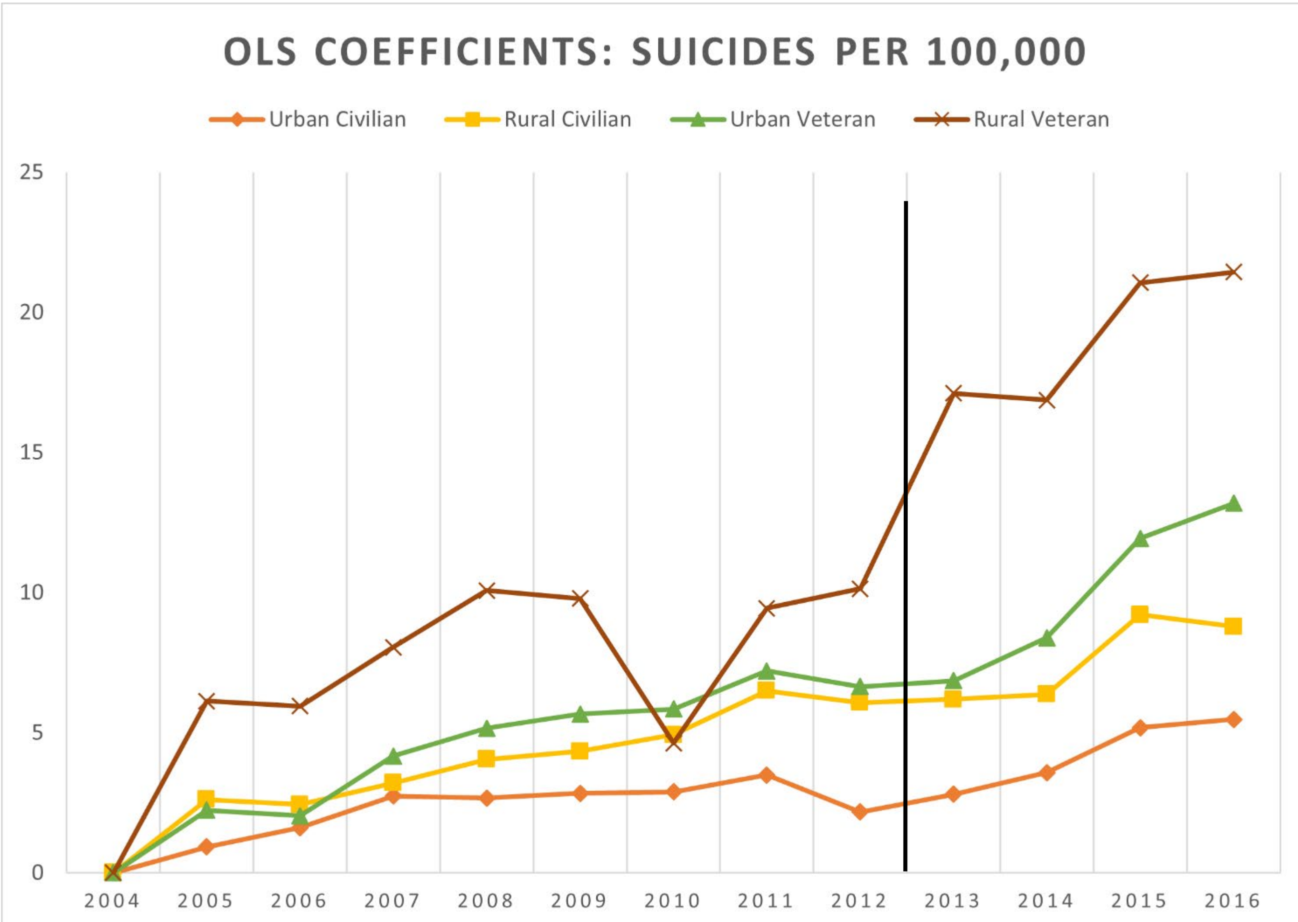

Figure 5: Coefficients from a linear regression of suicides per 100,000 among veterans/military personnel and civilians by urban-rural status. The specification does not include any right-hand side controls besides county and year fixed effects.

Table 1: Descriptive Statistics – By urban/rural status, pre-OSI Period

Variable Description (county-year)	**Veteran**		**Civilian**	
	Rural	**Urban**	**Rural**	**Urban**
Suicide count	1.20 (1.55)	8.38 (7.55)	4.92 (4.15)	35.99 (33.44)
Population estimates	3,642 (2,468)	31,644 (21,723)	29,423 (18,004)	323,817 (246,894)
Suicide rate per 100,000	32.74 (42.96)	28.02 (18.84)	17.05 (13.06)	12.85 (7.39)
Median income	$30,955 (6,386)	$41,787 (11,311)	$20,752 (4,151)	$29,003 (6,750)
Unemployment rate	8.09 (4.83)	7.28 (2.63)	9.25 (3.23)	8.20 (2.22)
Percent of population that is female	5.89 (2.71)	7.69 (3.27)	56.39 (3.24)	57.06 (2.26)
Percent of population that is 18-34 years old	6.58 (3.42)	8.12 (3.47)	29.61 (5.83)	33.12 (5.83)
Percent of population that is 65 year and older	42.22 (7.58)	39.72 (9.30)	17.39 (3.51)	13.60 (2.94)
Percent of population that has a bachelors	18.05 (8.17)	29.55 (10.63)	17.12 (7.20)	32.49 (11.07)

	Rural	**Urban**
Addiction treatment centers	2.43 (2.65)	26.70 (28.18)
Addiction treatment centers per 100,000	7.39 (7.65)	6.85 (4.34)

Note: Summary statistics are weighted by county population. Standard deviations are in parentheses below the mean.

Table 2: Descriptive Statistics – Pre- & Post-OSI Implementation

Variable Description (county-year)	**Veteran** Pre-OSI	**Veteran** Post-OSI	**Civilian** Pre-OSI	**Civilian** Post-OSI
Suicide count	7.33 (7.44)	7.71 (7.84)	30.75 (32.67)	37.72 (36.41)
Population estimates	26,919 (22432)	25,060 (20,839)	274,142 (250,746)	293,415 (267,761)
Suicide rate per 100,000	28.81 (24.69)	33.62 (28.80)	13.55 (8.76)	15.11 (8.40)
Median income	$39,959 (11,387)	$40,226 (11,775)	$27,611 (7,094)	$28,168 (7,133)
Unemployment rate	7.42 (3.13)	7.76 (3.47)	8.37 (2.45)	8.46 (2.61)
Percent of population that is female	7.39 (3.26)	8.03 (3.49)	56.94 (2.46)	56.15 (2.29)
Percent of population that is 18-34 years old	7.86 (3.51)	8.18 (3.71)	32.53 (5.98)	32.12 (5.71)
Percent of population that is 65 year and older	40.15 (9.08)	45.00 (9.78)	14.24 (3.36)	15.50 (3.55)
Percent of population that has a bachelors	27.61 (11.12)	28.46 (11.34)	29.90 (11.99)	31.15 (12.15)

	Pre-OSI	**Post-OSI**
Addiction treatment centers	22.60 (27.27)	25.15 (28.21)
Addiction treatment centers per 100,000	6.94 (5.06)	7.48 (5.18)

Note: Summary statistics are weighted by county population. Standard deviations are in parentheses below the mean.

Table 3: OSI Regression Results (OLS)

	OLS (without controls)	OLS (with controls)
Dependent Variable	**Suicides/100k**	**Suicides/100k**
Variables		
Civilian Suicide Rate by Year (base: 2010)		
2011	0.637**	0.874*
	(0.270)	(0.458)
2012	-0.684*	-0.435
	(0.382)	(0.724)
2013	-0.054	0.383
	(0.349)	(0.813)
2014	0.716**	0.670
	(0.350)	(0.950)
2015	2.331***	1.787*
	(0.375)	(1.062)
2016	2.624***	1.643
	(0.397)	(1.277)
2017	3.035***	1.498
	(0.389)	(1.553)
2018	3.580***	1.573
	(0.372)	(1.841)
Veteran*Year (base: 2010)		
2011	0.732	1.664
	(1.044)	(1.124)
2012	1.469	2.209*
	(1.068)	(1.296)
2013	1.027	1.846
	(1.073)	(1.323)
2014	1.811	2.302
	(1.277)	(1.490)
2015	3.748***	3.680**
	(1.255)	(1.511)
2016	4.742***	4.281***
	(1.228)	(1.426)
2017	6.403***	5.822***
	(1.342)	(1.623)
2018	5.247***	4.620***
	(1.270)	(1.692)
Year*Rural (base: 2010)		
2011	0.991	-0.298
	(0.716)	(0.975)
2012	0.895	-1.914
	(0.802)	(1.313)
2013	1.344*	-2.757*

	(0.810)	(1.606)
2014	0.781 (0.800)	-3.740** (1.826)
2015	2.011** (0.790)	-1.713 (1.949)
2016	1.295 (0.828)	-1.760 (2.255)
2017	1.876** (0.780)	-0.312 (2.659)
2018	2.420*** (0.863)	1.150 (3.112)
DDD: Veteran*Year*Rural (base: 2010)		
2011	**2.536** **(2.695)**	**2.253** **(2.801)**
2012	**2.921** **(2.850)**	**3.466** **(3.107)**
2013	**10.256***** **(2.952)**	**11.263***** **(3.314)**
2014	**9.017***** **(2.984)**	**9.496***** **(3.437)**
2015	**8.424***** **(3.042)**	**9.354***** **(3.437)**
2016	**8.235***** **(3.070)**	**9.590***** **(3.455)**
2017	**5.309*** **(3.086)**	**6.869*** **(3.616)**
2018	**5.289*** **(3.173)**	**6.386*** **(3.717)**

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variable in the linear model is the suicide rate per 100,000 individuals at the county-year level. Both regressions are weighted by the total population in each county and include county and year fixed effects with standard errors clustered by county. Control variables in column 2 include: PDMP indicators, number of inpatient and outpatient addiction treatment centers, interactions between PDMP policies and treatment centers, and estimates of the percentage of the population aged 18-34, female, and black, the unemployment rate, median income, and percentage that have some college experience, all for both veteran and non-veteran populations separately. Finally, all control variables are interacted with veteran and rural county status.

Table 4: OSI Regression Results (Poisson)

	Poisson QMLE (without controls)	Poisson QMLE (with controls)
Dependent Variable	**Suicide Count**	**Suicide Count**
Variables		
Civilian Suicide Rate by Year (base: 2010)		
2011	0.018 (0.024)	0.014 (0.053)
2012	-0.066 (0.048)	-0.024 (0.077)
2013	-0.011 (0.030)	0.099 (0.078)
2014	0.061* (0.033)	0.199** (0.099)
2015	0.175*** (0.065)	0.344** (0.136)
2016	0.192*** (0.070)	0.379** (0.154)
2017	0.226*** (0.070)	0.411** (0.172)
2018	0.268*** (0.063)	0.422** (0.191)
Veteran*Year (base: 2010)		
2011	0.004 (0.048)	0.050 (0.053)
2012	0.087* (0.049)	0.145*** (0.055)
2013	0.037 (0.055)	0.096* (0.057)
2014	0.002 (0.075)	0.078 (0.076)
2015	-0.008 (0.084)	0.062 (0.088)
2016	0.010 (0.089)	0.075 (0.095)
2017	0.016 (0.096)	0.076 (0.108)
2018	-0.032 (0.081)	0.024 (0.095)
Year*Rural (base: 2010)		
2011	-0.012 (0.048)	-0.024 (0.069)
2012	0.041 (0.069)	-0.063 (0.094)

2013	0.010 (0.060)	-0.179* (0.102)
2014	-0.053 (0.058)	-0.304** (0.118)
2015	-0.000 (0.078)	-0.288* (0.149)
2016	-0.062 (0.085)	-0.367** (0.165)
2017	-0.020 (0.080)	-0.316* (0.180)
2018	-0.037 (0.080)	-0.294 (0.201)
DDD: Veteran*Year*Rural (base: 2010)		
2011	**0.193* (0.112)**	**0.187 (0.115)**
2012	**0.151 (0.114)**	**0.200 (0.122)**
2013	**0.326*** (0.126)**	**0.405*** (0.136)**
2014	**0.370*** (0.132)**	**0.446*** (0.141)**
2015	**0.326** (0.127)**	**0.408*** (0.133)**
2016	**0.306** (0.131)**	**0.394*** (0.137)**
2017	**0.207 (0.135)**	**0.298** (0.147)**
2018	**0.256* (0.133)**	**0.344** (0.143)**

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variable in the Poisson QMLE specification is the count of suicides at the county-year level. Both regressions are weighted by the total population in each county and include county and year fixed effects with standard errors clustered by county. Control variables in column 2 include: PDMP indicators, number of inpatient and outpatient addiction treatment centers, interactions between PDMP policies and treatment centers, and estimates for the percentage of the population aged 18-34, female, and black, the unemployment rate, median income, and percentage that have some college experience, all for both veteran and non-veteran populations separately. Finally, all control variables are interacted with veteran and rural county status.

Table 5: OSI Regression Results (OLS with Controls)

	OLS	OLS	OLS	OLS
Dependent Variable	**Homicides/ 100K**	**Legal Intervention Deaths/100k**	**Unintentional Firearm Deaths/100K**	**Undetermined Intent Deaths/100K**
Variables				
Civilian Suicide Rate by Year (base: 2010)				
2011	0.062 (0.234)	0.016 (0.050)	0.022 (0.028)	-1.147** (0.486)
2012	-0.937*** (0.357)	-0.082 (0.073)	0.040 (0.039)	-1.693** (0.686)
2013	-0.915*** (0.352)	-0.119 (0.091)	0.069 (0.046)	-2.133** (0.958)
2014	-1.146*** (0.416)	-0.065 (0.094)	0.052 (0.052)	-2.355** (1.161)
2015	0.549 (0.423)	-0.006 (0.100)	0.021 (0.058)	-1.945* (1.166)
2016	1.183** (0.471)	0.056 (0.117)	0.012 (0.075)	-1.077 (1.116)
2017	1.532*** (0.549)	0.149 (0.139)	-0.048 (0.102)	-1.409 (1.393)
2018	1.232* (0.661)	0.303* (0.173)	-0.099 (0.132)	-1.567 (1.601)
Veteran*Year (base: 2010)				
2011	-0.260 (0.447)	-0.090 (0.147)	0.132 (0.084)	0.217 (0.339)
2012	0.351 (0.468)	-0.060 (0.123)	0.161* (0.082)	-0.741 (0.516)
2013	0.497 (0.527)	0.148 (0.142)	0.002 (0.073)	-0.216 (0.375)
2014	0.145 (0.531)	0.040 (0.153)	0.086 (0.103)	-0.877** (0.369)
2015	0.019 (0.685)	-0.040 (0.161)	0.017 (0.089)	-0.607* (0.367)
2016	-0.572 (0.602)	0.066 (0.174)	0.123 (0.098)	-0.192 (0.435)
2017	-0.957 (0.610)	0.134 (0.176)	-0.042 (0.096)	-0.175 (0.379)
2018	-0.900 (0.712)	-0.155 (0.169)	0.095 (0.109)	0.514 (0.546)
Year*Rural (base: 2010)				
2011	0.683	-0.097	0.021	1.456***

	(0.451)	(0.099)	(0.083)	(0.551)
2012	0.586 (0.609)	0.099 (0.139)	-0.122 (0.103)	1.674** (0.730)
2013	0.378 (0.678)	0.211 (0.178)	-0.231* (0.123)	2.107** (1.003)
2014	0.318 (0.787)	0.121 (0.188)	-0.285** (0.134)	1.941 (1.201)
2015	-0.154 (0.788)	0.264 (0.204)	-0.210 (0.136)	1.434 (1.212)
2016	-0.070 (0.845)	0.204 (0.231)	-0.122 (0.146)	0.801 (1.181)
2017	-1.486 (0.958)	0.011 (0.293)	-0.159 (0.175)	1.139 (1.462)
2018	-0.421 (1.139)	0.000 (0.360)	-0.129 (0.206)	0.753 (1.670)
DDD: Veteran*Year* Rural (base: 2010)				
2011	**-0.011** **(1.036)**	**0.053** **(0.288)**	**0.154** **(0.257)**	**-0.429** **(0.670)**
2012	**0.360** **(1.142)**	**0.528** **(0.418)**	**0.000** **(0.239)**	**1.315** **(0.802)**
2013	**0.652** **(1.221)**	**-0.033** **(0.353)**	**0.841**** **(0.331)**	**0.398** **(0.690)**
2014	**0.472** **(1.228)**	**0.490** **(0.416)**	**0.009** **(0.276)**	**1.796**** **(0.750)**
2015	**-0.410** **(1.328)**	**0.236** **(0.383)**	**-0.050** **(0.257)**	**1.825**** **(0.799)**
2016	**0.104** **(1.269)**	**0.092** **(0.413)**	**0.031** **(0.327)**	**1.133** **(0.850)**
2017	**2.002** **(1.279)**	**0.475** **(0.445)**	**-0.072** **(0.234)**	**1.453*** **(0.838)**
2018	**0.214** **(1.387)**	**0.089** **(0.389)**	**0.147** **(0.289)**	**0.744** **(0.877)**
Pre-Treatment Weighted Means	**4.458** **(7.453)**	**0.287** **(1.983)**	**0.174** **(1.677)**	**2.385** **(5.531)**

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variables in these OLS specifications are deaths from homicides, legal interventions (e.g. involving law enforcement), unintentional firearms, and deaths with undetermined intent at the county-year level. All regressions are weighted by the total population in each county and include county and year fixed effects with standard errors clustered by county. Control variables include: PDMP indicators, number of inpatient and outpatient addiction treatment centers, interactions between PDMP policies and treatment centers, and estimates for the percentage of the population aged 18-34, female, and black, the unemployment rate, median income, and percentage that have some college experience, all for both veteran and non-veteran populations separately. Finally, all control variables are interacted with veteran and rural county status.

Table 6: OSI Regression Results (OLS with controls)

	OLS	OLS
Dependent Variable	**All Violent Deaths Excluding Suicides/100K**	**All Violent Deaths/100K**
Variables		
Civilian Suicide Rate by Year (base: 2010)		
2011	-1.047* (0.574)	-0.172 (0.771)
2012	-2.672*** (0.793)	-3.107*** (1.155)
2013	-3.098*** (1.020)	-2.715** (1.362)
2014	-3.514*** (1.258)	-2.844* (1.601)
2015	-1.381 (1.196)	0.406 (1.637)
2016	0.175 (1.174)	1.818 (1.769)
2017	0.224 (1.475)	1.722 (2.162)
2018	-0.131 (1.732)	1.442 (2.533)
Veteran*Year (base: 2010)		
2011	0.000 (0.589)	1.664 (1.284)
2012	-0.289 (0.769)	1.920 (1.493)
2013	0.431 (0.711)	2.276 (1.507)
2014	-0.606 (0.712)	1.696 (1.709)
2015	-0.612 (0.893)	3.068 (1.898)
2016	-0.575 (0.783)	3.706** (1.726)
2017	-1.041 (0.671)	4.781** (1.876)
2018	-0.447 (0.758)	4.173** (1.960)
Year*Rural (base: 2010)		

2011	2.063***	1.766
	(0.756)	(1.280)
2012	2.236**	0.323
	(0.975)	(1.693)
2013	2.466**	-0.292
	(1.242)	(2.100)
2014	2.095	-1.644
	(1.475)	(2.355)
2015	1.334	-0.379
	(1.436)	(2.401)
2016	0.812	-0.947
	(1.455)	(2.673)
2017	-0.494	-0.807
	(1.792)	(3.200)
2018	0.203	1.353
	(2.091)	(3.725)
DDD: Veteran*Year*Rural (base: 2010)		
2011	**-0.234**	**2.019**
	(1.293)	**(3.190)**
2012	**2.203**	**5.669**
	(1.477)	**(3.517)**
2013	**1.858**	**13.122*** **
	(1.483)	**(3.762)**
2014	**2.768***	**12.264*** **
	(1.518)	**(3.837)**
2015	**1.600**	**10.954*** **
	(1.719)	**(3.966)**
2016	**1.360**	**10.950*** **
	(1.617)	**(3.960)**
2017	**3.859** **	**10.728*** **
	(1.600)	**(4.003)**
2018	**1.194**	**7.580***
	(1.651)	**(4.155)**
Pre-Treatment Weighted Means	**7.303**	**28.500**
	(10.223)	**(23.424)**

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variables in these linear models are all violent deaths rate per 100,000 individuals excluding suicides and all violent deaths rate per 100,000 individuals including suicides at the county-year level. Both regressions are weighted by the total population in each county and include county and year fixed effects with standard errors clustered by county. Control variables include: PDMP indicators, number of inpatient and outpatient addiction treatment centers, interactions between PDMP policies and treatment centers, and estimates for the percentage of the population aged 18-34, female, and black, the unemployment rate, median income, and percentage that have some college experience, all for both veteran and non-veteran populations separately. Finally, all control variables are interacted with veteran and rural county status.

Table 7: Veteran Migration Regression Results

	OLS
Dependent Variable	**Percent Veteran**
Variables	
Year (base: 2010)	
2011	-0.003***
	(<0.001)
2012	-0.005***
	(<0.001)
2013	-0.009***
	(<0.001)
2014	-0.012***
	(<0.001)
2015	-0.015***
	(<0.001)
2016	-0.018***
	(<0.001)
2017	-0.022***
	(<0.001)
2018	-0.024***
	(<0.001)
Rural*Year (base: 2010)	
2011	<0.001
	(<0.001)
2012	<0.001
	(<0.001)
2013	-<0.001
	(0.001)
2014	-<0.001
	(0.001)
2015	-<0.001
	(0.001)
2016	-0.001
	(0.001)
2017	-0.001
	(0.001)
2018	-0.001
	(0.001)

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variable is the percent of a county's population that is made up of veterans and military personnel; this regression is weighted by total county population and includes county and year fixed effects.

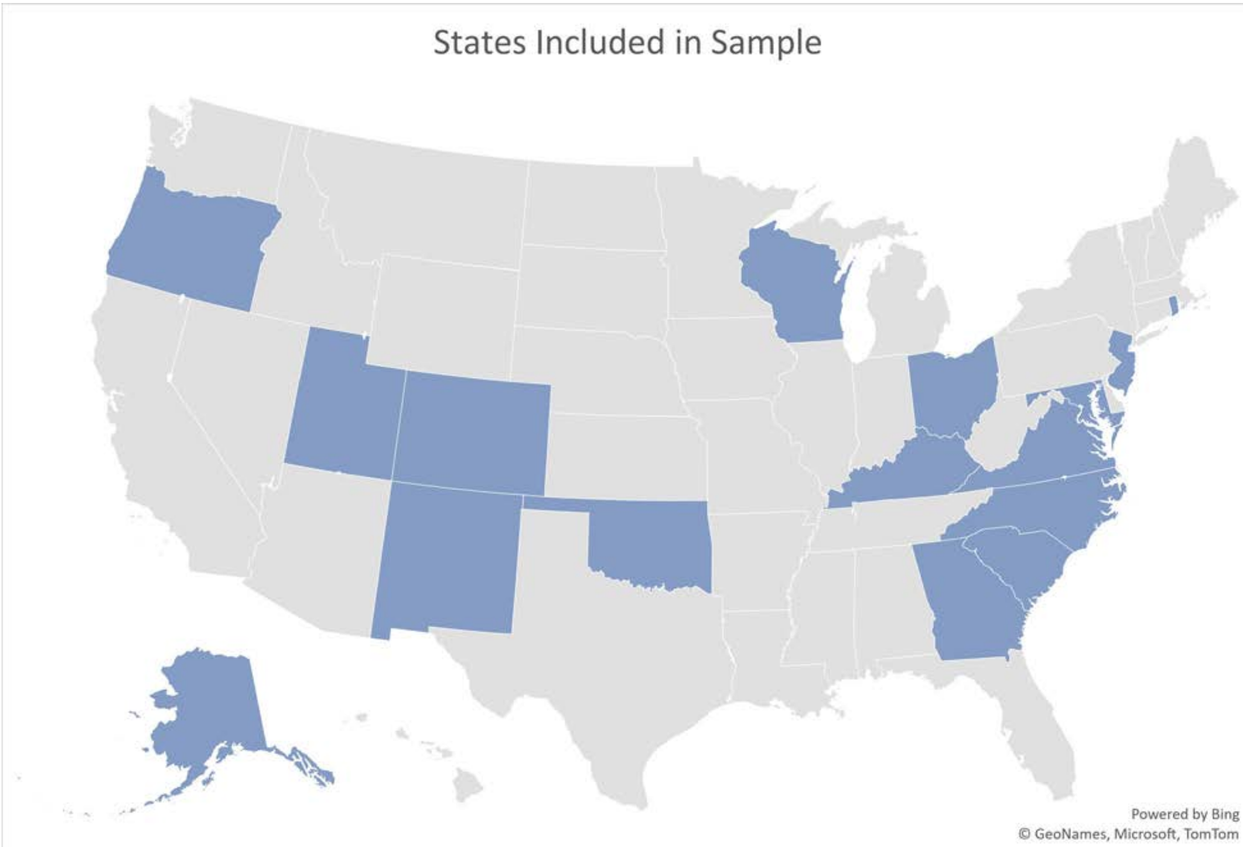

Figure A1 States in our sample are highlighted in blue.

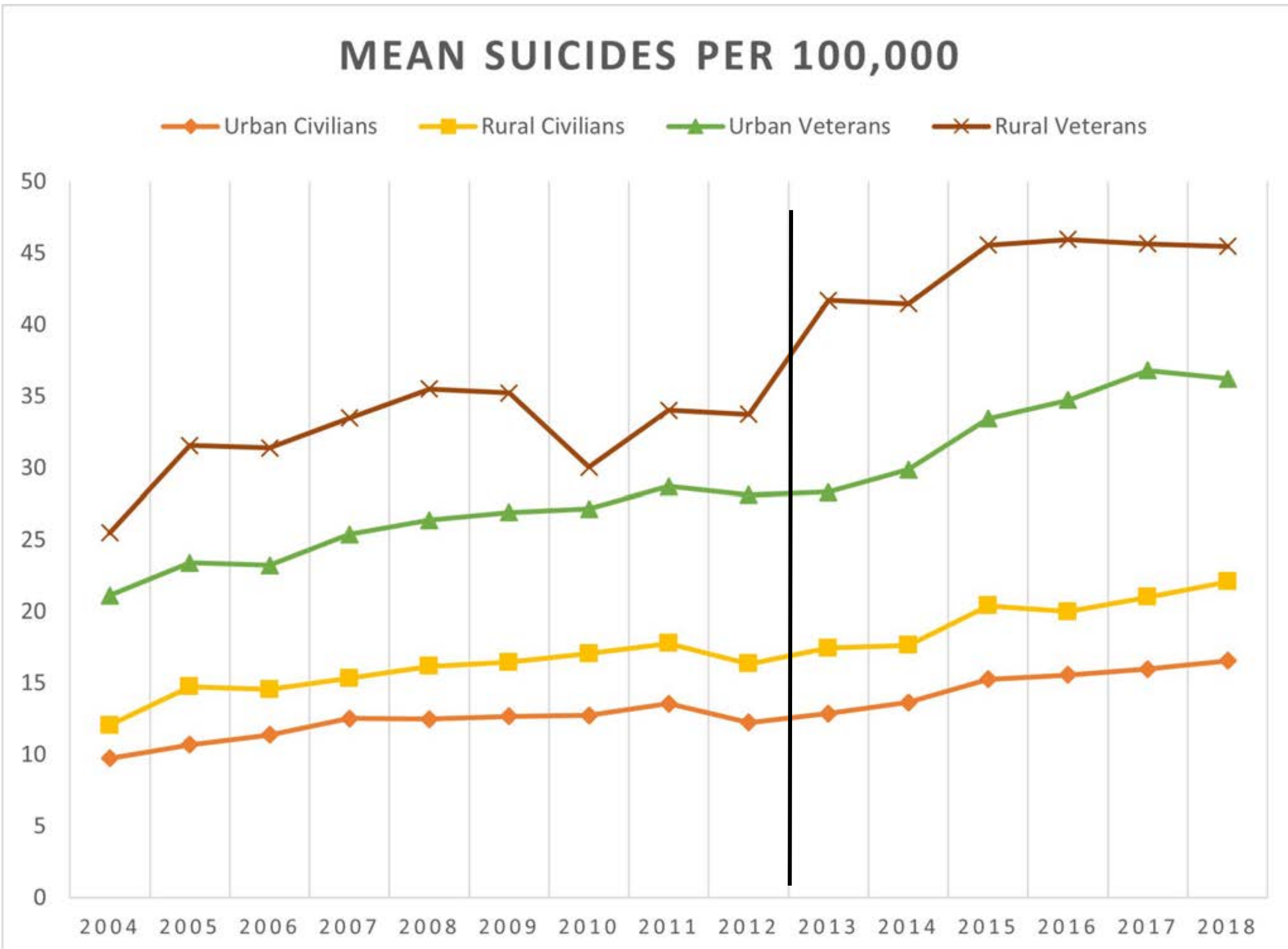

Figure A2 Average county-year suicide trend for veteran/military personnel and civilians, differentiated by urban-rural status, and weighted by total county population.

Table A1: OSI Regression Results (longer time horizon)

	OLS (without controls)
Dependent Variable	**Suicide Rate/100K**
Variables	
Civilian Suicide Rate by Year (base: 2004)	
2005	0.931** (0.431)
2006	1.616*** (0.412)
2007	2.743*** (0.479)
2008	2.671*** (0.481)
2009	2.845*** (0.458)
2010	2.906*** (0.488)
2011	3.543*** (0.538)
2012	2.221*** (0.596)
2013	2.851*** (0.579)
2014	3.620*** (0.541)
2015	5.234*** (0.592)
2016	5.527*** (0.588)
2017	5.936*** (0.582)
2018	6.481*** (0.570)
Veteran*Year (base: 2004)	
2005	1.331 (1.006)
2006	0.449 (1.017)
2007	1.455 (1.121)
2008	2.507** (1.032)
2009	2.866** (1.140)

2010	3.022***
	(1.122)
2011	3.754***
	(1.025)
2012	4.491***
	(1.097)
2013	4.049***
	(1.039)
2014	4.833***
	(1.259)
2015	6.770***
	(1.260)
2016	7.764***
	(1.146)
2017	9.426***
	(1.350)
2018	8.269***
	(1.228)
Year*Rural (base: 2004)	
2005	1.754**
	(0.768)
2006	0.878
	(0.740)
2007	0.529
	(0.816)
2008	1.445*
	(0.789)
2009	1.562**
	(0.784)
2010	2.120***
	(0.817)
2011	3.109***
	(0.894)
2012	3.011***
	(0.968)
2013	3.460***
	(0.962)
2014	2.899***
	(0.922)
2015	4.124***
	(0.933)
2016	3.409***
	(0.961)
2017	4.002***
	(0.912)
2018	4.530***
	(0.968)
DDD: Veteran*Year*Rural	

(base: 2004)	
2005	**2.052**
	(2.593)
2006	**2.941**
	(2.496)
2007	**3.261**
	(2.513)
2008	**3.392**
	(2.556)
2009	**2.452**
	(2.535)
2010	**-3.481**
	(2.650)
2011	**-0.946**
	(2.466)
2012	**-0.560**
	(2.498)
2013	**6.775****
	(2.748)
2014	**5.536****
	(2.808)
2015	**4.943***
	(2.892)
2016	**4.753**
	(2.894)
2017	**1.786**
	(3.005)
2018	**1.691**
	(3.098)

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variable in the linear model is the suicide rate per 100,000 individuals at the county-year level. This regression is weighted by the total population in each county and include county and year fixed effects with standard errors clustered by county.

Table A2: OSI Regression Results (OLS) for Rural Counties

	OLS (without controls)	OLS (with controls)
Dependent Variable	**Suicides/100k**	**Suicides/100k**
Variables		
Rural Civilian Suicide Rate by Year (base: 2010)		
2011	1.628**	0.595
	(0.663)	(0.861)
2012	0.211	-2.333**
	(0.705)	(1.099)
2013	1.290*	-2.374*
	(0.731)	(1.391)
2014	1.497**	-3.105**
	(0.719)	(1.564)
2015	4.342***	0.018
	(0.695)	(1.639)
2016	3.919***	-0.207
	(0.727)	(1.862)
2017	4.911***	1.040
	(0.677)	(2.165)
2018	5.999***	2.520
	(0.779)	(2.514)
Rural Veteran Suicide Rate: Year*Veteran (base: 2010)		
2011	**3.268**	**3.896**
	(2.485)	**(2.565)**
2012	**4.390***	**5.678****
	(2.642)	**(2.823)**
2013	**11.283*****	**13.152*****
	(2.750)	**(3.046)**
2014	**10.827*****	**11.915*****
	(2.697)	**(3.119)**
2015	**12.172*****	**13.186*****
	(2.772)	**(3.115)**
2016	**12.976*****	**14.071*****
	(2.814)	**(3.161)**
2017	**11.712*****	**12.958*****
	(2.779)	**(3.244)**
2018	**10.536*****	**11.333*****
	(2.909)	**(3.321)**

Note: *p<0.1, **p<0.05, ***p<0.01. The dependent variable in the linear model is the suicide rate per 100,000 individuals at the rural county-year level. Both regressions are weighted by the total population in each county and include county and year fixed effects with standard errors clustered by county. Control variables in column 2 include: PDMP indicators, number of inpatient and outpatient addiction treatment centers, interactions between PDMP policies and treatment centers, and estimates for the percentage of the population aged 18-34, female, and black, the unemployment rate, median income, and percentage that have some college experience, all for both veteran and non-veteran populations separately. Finally, all control variables are interacted with veteran and rural county status.