INSTITUTE FOR DEFENSE ANALYSES

Bayesian Methods for Comparing Army National Guard (ARNG) and General Population (GP) Suicide Rates

James Bishop
Susan Clark-Sestak
Jacqueline Du Bois
David Graham
Michael Guggisberg
Nate Latshaw
Allen Wang

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INSTITUTE FOR DEFENSE ANALYSES
4850 Mark Center Drive
Alexandria, Virginia 22311-1882

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For More Information:
Dr. James Bishop, RSM
jbishop@ida.org, 703-845-6701
ADM John C. Harvey, Jr., USN (Ret), Director, SFRD
jharvey@ida.org, 703-575-4530

I N S T I T U T E F O R D E F E N S E A N A L Y S E S

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Executive Summary

In this briefing, the Institute for Defense Analyses seeks to compare suicide rates between Army National Guard (ARNG) and the general population (GP). The ARNG and GP differ in age, sex, and geographic distributions, which complicates the task of comparing them. The rarity of suicide events further complicates statistical comparison, especially at subnational levels of geography. Without accounting for the population differences mentioned, ARNG membership was associated with 81% greater odds of dying by suicide between 2010 and 2016. However, accounting for age and sex differences reduces those relative odds to 30%; further accounting for geographic distribution reduces the odds to 26%. At the county level, the ARNG and GP suicide data specific to a given county generally do not give us a large enough sample to make statistical comparisons of suicide rates. To address this sample size problem, we employ hierarchical Bayesian estimation, which uses flexible assumptions on the distribution of suicide rates across counties. We find that ARNG and GP suicide rates exhibit very similar spatial patterns, but that ARNG rates tend to be closer to or below GP rates where GP rates are high. There are multiple potential explanations for the spatial patterns we observe, which we plan to evaluate in further research.

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Bayesian Methods for Comparing Army National Guard (ARNG) and General Population (GP) Suicide Rates

Dave Graham, Project Leader

James Bishop, Presenter
Susan Clark-Sestak
Jacqueline Du Bois
Michael Guggisberg
Nate Latshaw
Allen Wang

30 June 2018

We have three principal research questions

What is the relative suicide risk associated with ARNG membership?

How much of this risk is explained by age, sex, and geographic differences?

How does this risk vary over age, sex, and geography?

We have one principal methodological question

How should a researcher compare the frequency of an event between two populations?

The question seems straightforward

Complications abound

Our job is to account for these complications

IDA 2

Our application is to ARNG suicide

Our event is suicide

Our populations are, from 2010 to 2015:

- The Army National Guard (ARNG)
- The general U.S. population (GP)
- Restricted to groups with sufficient ARNG representation: males 15-54 and females 15-44

Each observation is a "person-year"

We have 2.1 million ARNG and 891 million GP person-years

IDA 3

Population differences complicate comparison

Population size - ARNG is about 0.24% the size of the GP

Demographic shares – ARNG is younger and more male

Geographic population distribution – ARNG members are more likely to live in areas with higher rates

Rarity of suicide – 618 ARNG suicides in our data compared to 146,370 in the GP

IDA 4

Calculating rates accounts for population size

Rates are more informative than counts

The ARNG suicide rate is 29.7 per 100,000 person-years

The GP suicide rate is 16.4 per 100,000 person-years

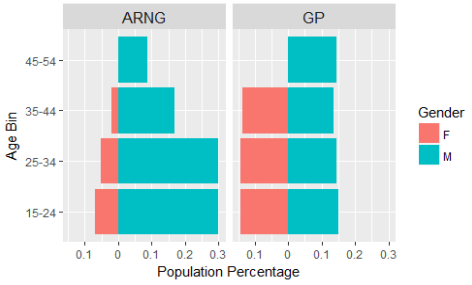
This implies an odds ratio of **1.81**

From 2010-2016, being in the ARNG was associated with 81% greater odds of dying by suicide

IDA 5

Rate standardization accounts for age and gender

The ARNG is younger and more male than the GP



To address this, we weight the ARNG rates in each demographic group by the group's GP share

This is called "rate standardization"

IDA 6

Age and sex explain the majority of the rate gap

Standardization allows us to answer:

What would the odds ratio be if the ARNG had the same age and sex distribution as the GP?

Standardization yields an odds ratio of **1.30**

The decrease in odds ratio from 1.81 to 1.30 means that age and sex distribution explains 62.4% of the rate gap

IDA 7

Standardization accounts for geographic distribution

The share of Guardsmen in the GP varies geographically

If the share tends to be higher where ARNG and GP rates are higher, this could explain the higher ARNG rate

We standardize for county population in the same way as age and sex – weight the ARNG rates by GP shares

What would the odds ratio be if the ARNG had the same geographic distribution as the GP? **1.71**

Same age, sex, and geographic distribution? **1.26**

We endeavor to compare rates at the county level

We want finer comparisons than nation-level rates

Our sponsor provided event-level data for the ARNG with home-of-record zip code

The Centers for Disease Control and Prevention offers county-level data

To aggregate the ARNG data to the county level, we use a zip code-county crosswalk from the U.S. Department of Housing and Urban Development

Odds ratios fail to be informative

Suppose in county X we observe:

0 suicides out of 800 ARNG person-years

12 suicides out of 100,000 GP person-years

Odds ratio = **0.00**

This odds ratio by itself is not informative

Frequentist inference also fails to be informative

We want a statistical, not just descriptive, comparison for county X

How likely would we be to observe a difference at least as extreme as if the ARNG and GP rates were the same?

```
> fisher.test(matrix(c(0,800,12,100000),2,2))

        Fisher's Exact Test for Count Data

data:  matrix(c(0, 800, 12, 1e+05), 2, 2)
p-value = 1
alternative hypothesis: true odds ratio is not equal to 1
95 percent confidence interval:
  0.0000 45.0928
sample estimates:
odds ratio
         0
```

100% of the time!

We need a new method for county-level comparisons

County-level comparisons are important to inform ARNG suicide prevention resource allocation

Over 80% of counties in our data are like county X: zero ARNG suicides

The typical county's suicide rates are not sufficient for statistical inference, even with 6 years of data

We "pool" information over counties to increase the information available for each county

We use hierarchical Bayes

The hierarchical Bayes method (R package **rstanarm**) pools and returns county-specific rate estimates for the ARNG and GP

Each county's ARNG and GP suicide rates each come from an unknown distribution that we seek to estimate

We specify prior distributions and let the data revise them

We use Markov Chain Monte Carlo to estimate the model

Our estimates are necessarily uncertain

The following maps present point estimates of suicide rates and odds ratios at the county level

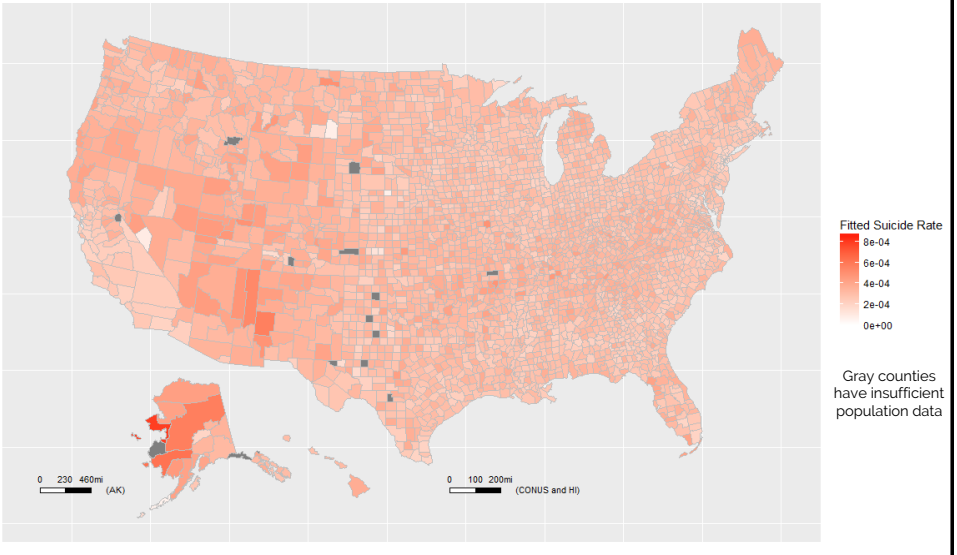
These estimates have statistical uncertainty

Our goal is to identify broad geographic patterns that may not obey state lines

Our goal is not to compare individual counties or forecast their rates

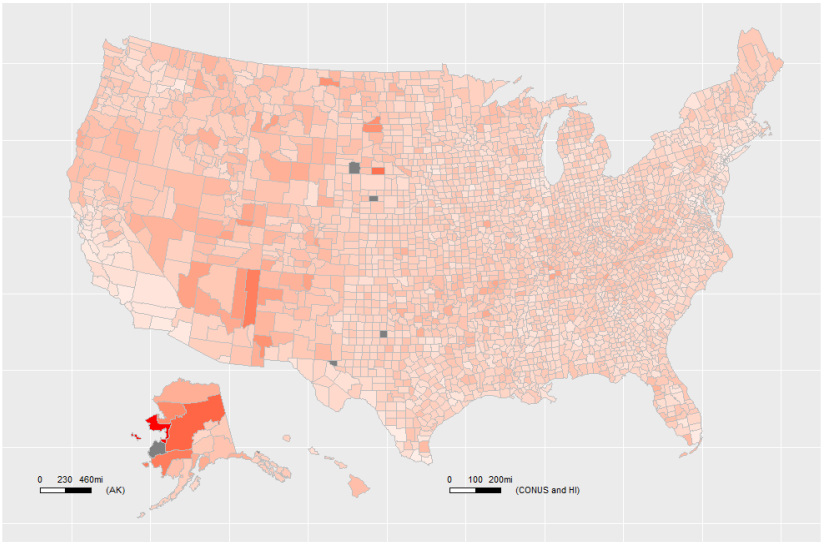
IDA 14

ARNG Suicide Rate Point Estimates



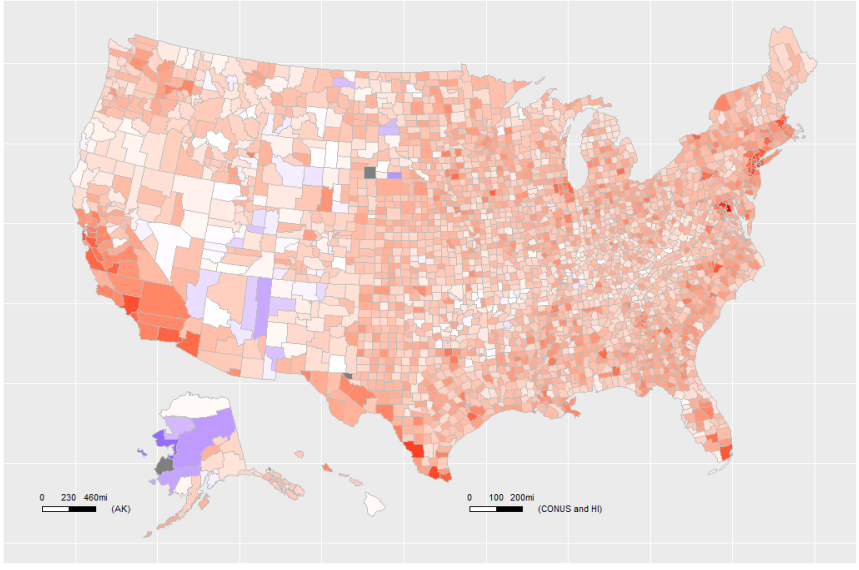
IDA 15

GP Suicide Rate Point Estimates



IDA 16

ARNG-GP Odds Ratios by County



IDA 17

The hierarchical Bayes results offer four takeaways

ARNG and GP rates are positively correlated across space

Suicide rates are higher in the Mountain West

ARNG rates higher than GP rates in most counties

Where rates are high, ARNG rates are closer to or below GP rates

Potential explanations for our observations abound

We can only speculate as to the reasons for our observations

Perhaps ARNG units or state program managers with high suicide rates exert greater effort in reducing them

Perhaps the ARNG population is more homogeneous than the general population (in an unaccounted-for way)

Perhaps it's an artifact of the model

We can use hierarchical Bayes like our other methods

We can also use our Bayes results to make nation-level comparisons like we did using only rate standardization

This allows us to account for the rarity of suicide

Using hierarchical Bayes, we estimate an ARNG-GP odds ratio of **1.51**

Further accounting for age and sex yields **1.27**

Further accounting for geographic distribution yields **1.11**

We offer three overall takeaways

Comparing rates between different populations can be deceptively complicated

Accounting for population differences and the rarity of suicide reduces the increased odds of suicide associated with ARNG membership from 81% to 11%

There are geographic patterns in suicide rates and odds ratios that warrant explanation

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James Bishop, Susan Clark-Sestak, Jacqueline Du Bois, David Graham, Michael Guggisberg, Nate Latshaw, Allen Wang

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In this briefing, we estimate the relative suicide risk associated with Army National Guard (ARNG) membership, the extent to which demographic and geographic distribution explain that relative risk, and how that relative risk varies demographically and geographically. Estimating relative risk introduces a variety of complicating factors that we seek to address. We find a higher risk of suicide among ARNG members, most of which is explained by the high proportion and high suicide rate of young males in the ARNG. Geographical distribution also explains a small part of the higher risk of suicide in the ARNG. Across geography, we observe that ARNG and general population suicide rates are highly correlated, both being higher in the Mountain West. We also observe that the relative suicide risk associated with ARNG membership tends to be lower where suicide rates are higher.

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