

# Bayesian Data Analysis Project

add group members names: ...

```
knitr::opts_chunk$set(warning = FALSE, message = FALSE, error = TRUE)
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr      1.1.4      v readr      2.1.5
## v forcats    1.0.0      v stringr   1.5.1
## v ggplot2    3.5.1      v tibble    3.2.1
## v lubridate  1.9.3      v tidyr     1.3.1
## v purrr      1.0.2
## -- Conflicts ----- tidyverse_conflicts() --
## x purrr::%||%() masks base::%||%()
## x dplyr::filter() masks stats::filter()
## x dplyr::lag() masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
theme_set(theme_bw())
require(extraDistr) #need for rdunif
```

```
## Loading required package: extraDistr
##
## Attaching package: 'extraDistr'
##
## The following object is masked from 'package:purrr':
##
##      rdunif
```

```
library(dplyr)
```

## Introduction

In our world today, mental health has become more crucial and suicide remains a significant public health concern worldwide, with rates varying across regions due to complex social, economic, and cultural factors. Therefore, understanding the geographic distribution of suicide rates is important for the development of targeted mental health policies and preventative measures. Although where we live in the world largely affects our mental and physical lifestyles, there has not been many studies done on the geographical characteristics of suicide rates and mental well-being.

In this study, we apply a Bayesian hierarchical model with a conditionally autoregressive (CAR) prior to investigate spatial patterns in suicide rates across countries, stratified by sex groups. We will be using a Poisson likelihood to obtain a prior distribution. After which, inferential analysis will be done using Monte Carlo Markov Chain (MCMC) done in Stan.

This research specifically focuses on two recent years, 2019 and 2021, to investigate any observable changes in suicide patterns potentially influenced by global events like the COVID-19 pandemic. Our main research question is: Are there identifiable spatial clusters of high suicide rates, and do these rates differ between 2019 and 2021?

This approach allows us to identify high-risk regions, quantify uncertainty, and better understand how neighboring countries may influence each other's suicide rates, providing valuable insights for data-informed mental health interventions.

## Literature Review

## Dataset and Data Cleaning

Dataset Name: Crude Suicide Rate (Per 100,000 Population) Source: <https://www.who.int/data/gho/data/themes/mental-health/suicide-rates> Description: The raw dataset has notable features like country, age group, sex, and suicide rate (per 100,000 people) that can be extracted.

Location: Country name Period: Year Dim1: Sex ("Female", "Both sexes", "Male") FactValueNumeric: Number of suicide deaths in a year, divided by the population and multiplied by 100 000 (as indicated in the original data source) FactValueNumericLow: Low estimate FactValueNumericHigh: High estimate

Note: The FactValueNumeric data are estimates of the number of suicides. "The estimates are derived from the WHO Global Health Estimates (GHE)" [data source]. However, some countries may not have an accurate way of recording the exact number of deaths, potentially leading to inaccurate estimations. Hence there is a high and low in the death rates. "For countries without high-quality death registration data, cause of death estimates are calculated using other data, including household surveys with verbal autopsy, sample or sentinel registration systems, special studies" [data source].

```
data_raw = read.csv("suicide_rate_raw.csv", header = TRUE)
head(data_raw)
```

```
##      IndicatorCode                                Indicator ValueType
## 1      SDGSUICIDE Crude suicide rates (per 100 000 population)      text
## 2      SDGSUICIDE Crude suicide rates (per 100 000 population)      text
## 3      SDGSUICIDE Crude suicide rates (per 100 000 population)      text
## 4      SDGSUICIDE Crude suicide rates (per 100 000 population)      text
## 5      SDGSUICIDE Crude suicide rates (per 100 000 population)      text
## 6      SDGSUICIDE Crude suicide rates (per 100 000 population)      text
##      ParentLocationCode      ParentLocation Location.type SpatialDimValueCode
## 1              AMR              Americas      Country          VCT
## 2              EMR Eastern Mediterranean      Country          OMN
## 3              EMR Eastern Mediterranean      Country          PSE
## 4              EMR Eastern Mediterranean      Country          JOR
## 5              EMR Eastern Mediterranean      Country          KWT
## 6              EMR Eastern Mediterranean      Country          SYR
##                                     Location Period.type Period
## 1              Saint Vincent and the Grenadines      Year    2021
## 2              Oman      Year    2021
## 3 occupied Palestinian territory, including east Jerusalem      Year    2021
## 4              Jordan      Year    2021
## 5              Kuwait      Year    2021
## 6              Syrian Arab Republic      Year    2021
##      IsLatestYear Dim1.type      Dim1 Dim1ValueCode Dim2.type      Dim2
```

```

## 1      true      Sex Female      SEX_FMLE Age Group All age groups (total)
## 2      true      Sex Female      SEX_FMLE Age Group All age groups (total)
## 3      true      Sex Female      SEX_FMLE Age Group All age groups (total)
## 4      true      Sex Female      SEX_FMLE Age Group All age groups (total)
## 5      true      Sex Female      SEX_FMLE Age Group All age groups (total)
## 6      true      Sex Female      SEX_FMLE Age Group All age groups (total)
##      Dim2ValueCode Dim3.type Dim3 Dim3ValueCode DataSourceDimValueCode
## 1 AGEGROUP_YEARSALL      NA      NA      NA      NA
## 2 AGEGROUP_YEARSALL      NA      NA      NA      NA
## 3 AGEGROUP_YEARSALL      NA      NA      NA      NA
## 4 AGEGROUP_YEARSALL      NA      NA      NA      NA
## 5 AGEGROUP_YEARSALL      NA      NA      NA      NA
## 6 AGEGROUP_YEARSALL      NA      NA      NA      NA
##      DataSource FactValueNumericPrefix FactValueNumeric FactValueUoM
## 1      NA      NA      0.00      NA
## 2      NA      NA      0.21      NA
## 3      NA      NA      0.23      NA
## 4      NA      NA      0.29      NA
## 5      NA      NA      0.34      NA
## 6      NA      NA      0.26      NA
##      FactValueNumericLowPrefix FactValueNumericLow FactValueNumericHighPrefix
## 1      NA      0.00      NA
## 2      NA      0.12      NA
## 3      NA      0.14      NA
## 4      NA      0.18      NA
## 5      NA      0.25      NA
## 6      NA      0.16      NA
##      FactValueNumericHigh      Value FactValueTranslationID FactComments
## 1      0.00 0.0 [0.0-0.0]      NA      NA
## 2      0.34 0.2 [0.1-0.3]      NA      NA
## 3      0.36 0.2 [0.1-0.4]      NA      NA
## 4      0.43 0.3 [0.2-0.4]      NA      NA
## 5      0.39 0.3 [0.2-0.4]      NA      NA
## 6      0.42 0.3 [0.2-0.4]      NA      NA
##      Language      DateModified
## 1      EN 2025-01-10T08:00:00.000Z
## 2      EN 2025-01-10T08:00:00.000Z
## 3      EN 2025-01-10T08:00:00.000Z
## 4      EN 2025-01-10T08:00:00.000Z
## 5      EN 2025-01-10T08:00:00.000Z
## 6      EN 2025-01-10T08:00:00.000Z

```

*#filter out "both sexes" to avoid duplication*

```

data = as.data.frame(data_raw |> select(Location, Period, Dim1, FactValueNumeric, FactValueNumericLow,
unique(data$Period)

```

```

## [1] 2021 2020 2019 2018 2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007
## [16] 2006 2005 2004 2003 2002 2001 2000

```

```

unique(data$Location)

```

```

## [1] "Saint Vincent and the Grenadines"
## [2] "Oman"

```

## [3] "occupied Palestinian territory, including east Jerusalem"  
## [4] "Jordan"  
## [5] "Kuwait"  
## [6] "Syrian Arab Republic"  
## [7] "Egypt"  
## [8] "Maldives"  
## [9] "United Arab Emirates"  
## [10] "Sao Tome and Principe"  
## [11] "Jamaica"  
## [12] "Lebanon"  
## [13] "Brunei Darussalam"  
## [14] "Saudi Arabia"  
## [15] "Grenada"  
## [16] "Qatar"  
## [17] "Azerbaijan"  
## [18] "Peru"  
## [19] "Bahamas"  
## [20] "Indonesia"  
## [21] "Honduras"  
## [22] "Myanmar"  
## [23] "Panama"  
## [24] "Armenia"  
## [25] "Barbados"  
## [26] "Türkiye"  
## [27] "Tunisia"  
## [28] "Algeria"  
## [29] "Tajikistan"  
## [30] "Antigua and Barbuda"  
## [31] "Saint Lucia"  
## [32] "Georgia"  
## [33] "Papua New Guinea"  
## [34] "Nigeria"  
## [35] "Bahrain"  
## [36] "Dominican Republic"  
## [37] "Iraq"  
## [38] "Belize"  
## [39] "Greece"  
## [40] "Mauritania"  
## [41] "Seychelles"  
## [42] "Nicaragua"  
## [43] "Philippines"  
## [44] "Puerto Rico"  
## [45] "Eswatini"  
## [46] "Congo"  
## [47] "Equatorial Guinea"  
## [48] "Turkmenistan"  
## [49] "China"  
## [50] "Senegal"  
## [51] "Viet Nam"  
## [52] "Guyana"  
## [53] "Democratic People's Republic of Korea"  
## [54] "Kyrgyzstan"  
## [55] "Uruguay"  
## [56] "Italy"

## [57] "Haiti"  
## [58] "Uzbekistan"  
## [59] "Belgium"  
## [60] "Singapore"  
## [61] "Benin"  
## [62] "Zambia"  
## [63] "Fiji"  
## [64] "Botswana"  
## [65] "India"  
## [66] "Brazil"  
## [67] "Japan"  
## [68] "Burundi"  
## [69] "Mexico"  
## [70] "Guinea-Bissau"  
## [71] "Zimbabwe"  
## [72] "Cote d'Ivoire"  
## [73] "Gabon"  
## [74] "Luxembourg"  
## [75] "South Sudan"  
## [76] "Chile"  
## [77] "Angola"  
## [78] "Malawi"  
## [79] "Ecuador"  
## [80] "Ireland"  
## [81] "Argentina"  
## [82] "El Salvador"  
## [83] "Rwanda"  
## [84] "Burkina Faso"  
## [85] "Spain"  
## [86] "Nepal"  
## [87] "Costa Rica"  
## [88] "Cameroon"  
## [89] "Democratic Republic of the Congo"  
## [90] "Bosnia and Herzegovina"  
## [91] "Namibia"  
## [92] "Suriname"  
## [93] "Canada"  
## [94] "Iceland"  
## [95] "Togo"  
## [96] "Central African Republic"  
## [97] "Denmark"  
## [98] "United Kingdom of Great Britain and Northern Ireland"  
## [99] "Bulgaria"  
## [100] "Venezuela (Bolivarian Republic of)"  
## [101] "Netherlands (Kingdom of the)"  
## [102] "Mozambique"  
## [103] "Romania"  
## [104] "Lesotho"  
## [105] "Republic of Korea"  
## [106] "Samoa"  
## [107] "Slovakia"  
## [108] "Montenegro"  
## [109] "Portugal"  
## [110] "New Zealand"

## [111] "Mauritius"  
## [112] "Germany"  
## [113] "Sweden"  
## [114] "Switzerland"  
## [115] "Norway"  
## [116] "Eritrea"  
## [117] "Australia"  
## [118] "Bangladesh"  
## [119] "Colombia"  
## [120] "Cyprus"  
## [121] "Malaysia"  
## [122] "Uganda"  
## [123] "Timor-Leste"  
## [124] "Albania"  
## [125] "Ghana"  
## [126] "Iran (Islamic Republic of)"  
## [127] "Sudan"  
## [128] "Morocco"  
## [129] "Afghanistan"  
## [130] "Bolivia (Plurinational State of)"  
## [131] "Israel"  
## [132] "Kenya"  
## [133] "Lao People's Democratic Republic"  
## [134] "Libya"  
## [135] "Cambodia"  
## [136] "United Republic of Tanzania"  
## [137] "Yemen"  
## [138] "Mali"  
## [139] "Guatemala"  
## [140] "Finland"  
## [141] "Czechia"  
## [142] "Trinidad and Tobago"  
## [143] "Serbia"  
## [144] "Cuba"  
## [145] "Austria"  
## [146] "France"  
## [147] "Poland"  
## [148] "Sri Lanka"  
## [149] "Kazakhstan"  
## [150] "Vanuatu"  
## [151] "United States of America"  
## [152] "Republic of Moldova"  
## [153] "Estonia"  
## [154] "Croatia"  
## [155] "Cabo Verde"  
## [156] "Hungary"  
## [157] "Latvia"  
## [158] "Belarus"  
## [159] "Thailand"  
## [160] "Solomon Islands"  
## [161] "Slovenia"  
## [162] "Chad"  
## [163] "Niger"  
## [164] "Gambia"

```
## [165] "Ethiopia"
## [166] "Pakistan"
## [167] "Bhutan"
## [168] "Guinea"
## [169] "Tonga"
## [170] "Madagascar"
## [171] "North Macedonia"
## [172] "Liberia"
## [173] "Kiribati"
## [174] "Micronesia (Federated States of)"
## [175] "Mongolia"
## [176] "South Africa"
## [177] "Lithuania"
## [178] "Russian Federation"
## [179] "Ukraine"
## [180] "Malta"
## [181] "Sierra Leone"
## [182] "Comoros"
## [183] "Paraguay"
## [184] "Somalia"
## [185] "Djibouti"
```

```
head(data)
```

```
##                               Location Period  Dim1
## 1                Saint Vincent and the Grenadines  2021 Female
## 2                                Oman  2021 Female
## 3 occupied Palestinian territory, including east Jerusalem  2021 Female
## 4                                Jordan  2021 Female
## 5                                Kuwait  2021 Female
## 6                Syrian Arab Republic  2021 Female
##   FactValueNumeric FactValueNumericLow FactValueNumericHigh
## 1                0.00                0.00                0.00
## 2                0.21                0.12                0.34
## 3                0.23                0.14                0.36
## 4                0.29                0.18                0.43
## 5                0.34                0.25                0.39
## 6                0.26                0.16                0.42
```

```
nrow(data)
```

```
## [1] 8140
```

```
max(data$FactValueNumeric)
```

```
## [1] 95.2
```

```
min(data$FactValueNumeric)
```

```
## [1] 0
```

The dataset consists of 8140 observations.

filter data to only include 2019 and 2021

```
suicide_2019 <- filter(data, Period == 2019)
suicide_2021 <- filter(data, Period == 2021)
```

## Data Analysis

As we have obtained the cleaned data for suicide rates in 2019 and 2021, we can now declare a prior model from information obtained historically.