ANALYZING THE IMPACT OF COVID 19 USING THE COVID 19 PACKAGE IN R

INTRODUCTION

This report analyzes the impact of COVID-19 using the COVID19 package in R. The objective is to explore temporal trends, identify peak periods, and compare patterns in confirmed cases and deaths to better understand how the pandemic evolved over time.

Data Source and Tools

- **Data Source:** COVID19 R package
- **Variables:** Confirmed cases, deaths
- **Tools:** RStudio, R Markdown, ggplot2, dplyr

LOADING LIBRARY

```
library(COVID19)
```

```
## Warning: package 'COVID19' was built under R version 4.5.2
```

```
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.5.2
```

```
## Warning: package 'ggplot2' was built under R version 4.5.2
```

```
## Warning: package 'dplyr' was built under R version 4.5.2
```

```
## Warning: package 'lubridate' was built under R version 4.5.2
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
## ✓ dplyr     1.1.4     ✓ readr     2.1.5
## ✓ forcats   1.0.0     ✓ stringr   1.5.1
## ✓ ggplot2   4.0.1     ✓ tibble    3.3.0
## ✓ lubridate 1.9.4     ✓ tidyr     1.3.1
## ✓ purrr     1.0.4
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to be
come errors
```

```
library(lubridate)
```

```
"COVID19" %in% installed.packages()[, "Package"]
```

```
## [1] TRUE
```

```
"tidyverse" %in% installed.packages()[, "Package"]
```

```
## [1] TRUE
```

```
"lubridate" %in% installed.packages()[, "Package"]
```

```
## [1] TRUE
```

Data Overview

An initial inspection of the dataset was performed to understand its structure and key variables.

```
covid_global <- covid19()
```

```
## We have invested a lot of time and effort in creating COVID-19 Data
## Hub, please cite the following when using it:
##
##   Guidotti, E., Ardia, D., (2020), "COVID-19 Data Hub", Journal of Open
##   Source Software 5(51):2376, doi: 10.21105/joss.02376
##
## The implementation details and the latest version of the data are
## described in:
##
##   Guidotti, E., (2022), "A worldwide epidemiological database for
##   COVID-19 at fine-grained spatial resolution", Sci Data 9(1):112, doi:
##   10.1038/s41597-022-01245-1
## To print citations in BibTeX format use:
##  > print(citation('COVID19'), bibtex=TRUE)
##
## To hide this message use 'verbose = FALSE'.
```

```
head(covid_global)
```

```
##         id       date confirmed deaths recovered tests vaccines
## 1 8320791a 2020-03-13         2     NA        NA  <NA>     <NA>
## 2 8320791a 2020-03-14         2     NA        NA  <NA>     <NA>
## 3 8320791a 2020-03-15         2     NA        NA  <NA>     <NA>
## 4 8320791a 2020-03-16         2     NA        NA  <NA>     <NA>
## 5 8320791a 2020-03-17         8     NA        NA  <NA>     <NA>
## 6 8320791a 2020-03-18         9     NA        NA  <NA>     <NA>
##   people_vaccinated people_fully_vaccinated hosp icu vent school_closing
## 1                NA                      NA   NA  NA   NA             NA
## 2                NA                      NA   NA  NA   NA             NA
## 3                NA                      NA   NA  NA   NA             NA
## 4                NA                      NA   NA  NA   NA             NA
## 5                NA                      NA   NA  NA   NA             NA
## 6                NA                      NA   NA  NA   NA             NA
##   workplace_closing cancel_events gatherings_restrictions transport_closing
## 1                NA            NA                      NA                NA
## 2                NA            NA                      NA                NA
## 3                NA            NA                      NA                NA
## 4                NA            NA                      NA                NA
## 5                NA            NA                      NA                NA
## 6                NA            NA                      NA                NA
##   stay_home_restrictions internal_movement_restrictions
## 1                     NA                             NA
## 2                     NA                             NA
## 3                     NA                             NA
## 4                     NA                             NA
## 5                     NA                             NA
## 6                     NA                             NA
##   international_movement_restrictions information_campaigns testing_policy
## 1                                  NA                    NA             NA
## 2                                  NA                    NA             NA
## 3                                  NA                    NA             NA
## 4                                  NA                    NA             NA
## 5                                  NA                    NA             NA
## 6                                  NA                    NA             NA
##   contact_tracing facial_coverings vaccination_policy elderly_people_protection
## 1              NA               NA                 NA                        NA
## 2              NA               NA                 NA                        NA
## 3              NA               NA                 NA                        NA
## 4              NA               NA                 NA                        NA
## 5              NA               NA                 NA                        NA
## 6              NA               NA                 NA                        NA
##   government_response_index stringency_index containment_health_index
## 1                        NA               NA                       NA
## 2                        NA               NA                       NA
## 3                        NA               NA                       NA
## 4                        NA               NA                       NA
## 5                        NA               NA                       NA
## 6                        NA               NA                       NA
##   economic_support_index administrative_area_level administrative_area_level_1
## 1                     NA                         1              Grand Princess
## 2                     NA                         1              Grand Princess
## 3                     NA                         1              Grand Princess
## 4                     NA                         1              Grand Princess
## 5                     NA                         1              Grand Princess
```

```
## 6                     NA                           1              Grand Princess
##   administrative_area_level_2 administrative_area_level_3 latitude longitude
## 1                          NA                          NA       NA        NA
## 2                          NA                          NA       NA        NA
## 3                          NA                          NA       NA        NA
## 4                          NA                          NA       NA        NA
## 5                          NA                          NA       NA        NA
## 6                          NA                          NA       NA        NA
##   population iso_alpha_3 iso_alpha_2 iso_numeric iso_currency key_local
## 1       3533        <NA>        <NA>          NA         <NA>        NA
## 2       3533        <NA>        <NA>          NA         <NA>        NA
## 3       3533        <NA>        <NA>          NA         <NA>        NA
## 4       3533        <NA>        <NA>          NA         <NA>        NA
## 5       3533        <NA>        <NA>          NA         <NA>        NA
## 6       3533        <NA>        <NA>          NA         <NA>        NA
##   key_google_mobility key_apple_mobility key_jhu_csse key_nuts key_gadm
## 1                <NA>               <NA>         <NA>       NA     <NA>
## 2                <NA>               <NA>         <NA>       NA     <NA>
## 3                <NA>               <NA>         <NA>       NA     <NA>
## 4                <NA>               <NA>         <NA>       NA     <NA>
## 5                <NA>               <NA>         <NA>       NA     <NA>
## 6                <NA>               <NA>         <NA>       NA     <NA>
```

Italy-specific data

```
covid_italy <- covid19(country = "Italy")
```

```
## We have invested a lot of time and effort in creating COVID-19 Data
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##
##   Guidotti, E., Ardia, D., (2020), "COVID-19 Data Hub", Journal of Open
##   Source Software 5(51):2376, doi: 10.21105/joss.02376
##
## The implementation details and the latest version of the data are
## described in:
##
##   Guidotti, E., (2022), "A worldwide epidemiological database for
##   COVID-19 at fine-grained spatial resolution", Sci Data 9(1):112, doi:
##   10.1038/s41597-022-01245-1
## To print citations in BibTeX format use:
##  > print(citation('COVID19'), bibtex=TRUE)
##
## To hide this message use 'verbose = FALSE'.
```

```
head(covid_italy)
```

```
##         id       date confirmed deaths recovered tests vaccines
## 1 03dcf038 2020-02-24       229      7         1  4324     <NA>
## 2 03dcf038 2020-02-25       322     10         1  8623     <NA>
## 3 03dcf038 2020-02-26       400     12         3  9587     <NA>
## 4 03dcf038 2020-02-27       650     17        45 12014     <NA>
## 5 03dcf038 2020-02-28       888     21        46 15695     <NA>
## 6 03dcf038 2020-02-29      1128     29        50 18661     <NA>
##   people_vaccinated people_fully_vaccinated hosp icu vent school_closing
## 1                NA                     NA  127  26   NA             -3
## 2                NA                     NA  150  35   NA             -3
## 3                NA                     NA  164  36   NA             -3
## 4                NA                     NA  304  56   NA             -3
## 5                NA                     NA  409  64   NA             -3
## 6                NA                     NA  506 105   NA             -3
##   workplace_closing cancel_events gatherings_restrictions transport_closing
## 1                -3            -2                     -4                 0
## 2                -3            -2                     -4                 0
## 3                -3            -2                     -4                 0
## 4                -3            -2                     -4                 0
## 5                -3            -2                     -4                 0
## 6                -3            -2                     -4                 0
##   stay_home_restrictions internal_movement_restrictions
## 1                     -2                            -1
## 2                     -2                            -1
## 3                     -2                            -1
## 4                     -2                            -1
## 5                     -2                            -1
## 6                     -2                            -1
##   international_movement_restrictions information_campaigns testing_policy
## 1                                   3                     2              1
## 2                                   3                     2              1
## 3                                   3                     2              2
## 4                                   3                     2              2
## 5                                   3                     2              2
## 6                                   3                     2              2
##   contact_tracing facial_coverings vaccination_policy elderly_people_protection
## 1               2                0                  0                        -3
## 2               2                0                  0                        -3
## 3               2                0                  0                        -3
## 4               2                0                  0                        -3
## 5               2                0                  0                        -3
## 6               2                0                  0                        -3
##   government_response_index stringency_index containment_health_index
## 1                     49.74           64.35                    56.85
## 2                     49.74           64.35                    56.85
## 3                     51.82           64.35                    59.23
## 4                     51.82           64.35                    59.23
## 5                     51.82           64.35                    59.23
## 6                     51.82           64.35                    59.23
##   economic_support_index administrative_area_level administrative_area_level_1
## 1                      0                         1                       Italy
## 2                      0                         1                       Italy
## 3                      0                         1                       Italy
## 4                      0                         1                       Italy
## 5                      0                         1                       Italy
```

```
## 6                     0                         1                       Italy
##   administrative_area_level_2 administrative_area_level_3 latitude longitude
## 1                          NA                          NA       43        12
## 2                          NA                          NA       43        12
## 3                          NA                          NA       43        12
## 4                          NA                          NA       43        12
## 5                          NA                          NA       43        12
## 6                          NA                          NA       43        12
##   population iso_alpha_3 iso_alpha_2 iso_numeric iso_currency key_local
## 1   60421760         ITA          IT         380          EUR        NA
## 2   60421760         ITA          IT         380          EUR        NA
## 3   60421760         ITA          IT         380          EUR        NA
## 4   60421760         ITA          IT         380          EUR        NA
## 5   60421760         ITA          IT         380          EUR        NA
## 6   60421760         ITA          IT         380          EUR        NA
##           key_google_mobility key_apple_mobility key_jhu_csse key_nuts key_gadm
## 1 ChIJA9KNRIL-1BIRb15jJFz1LOI              Italy           IT       NA      ITA
## 2 ChIJA9KNRIL-1BIRb15jJFz1LOI              Italy           IT       NA      ITA
## 3 ChIJA9KNRIL-1BIRb15jJFz1LOI              Italy           IT       NA      ITA
## 4 ChIJA9KNRIL-1BIRb15jJFz1LOI              Italy           IT       NA      ITA
## 5 ChIJA9KNRIL-1BIRb15jJFz1LOI              Italy           IT       NA      ITA
## 6 ChIJA9KNRIL-1BIRb15jJFz1LOI              Italy           IT       NA      ITA
```

Region_level data for italy

```
covid_italy_regions <- covid19(country = "Italy", level = 2)
```

```
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##
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##   Source Software 5(51):2376, doi: 10.21105/joss.02376
##
## The implementation details and the latest version of the data are
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##
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##   COVID-19 at fine-grained spatial resolution", Sci Data 9(1):112, doi:
##   10.1038/s41597-022-01245-1
## To print citations in BibTeX format use:
##  > print(citation('COVID19'), bibtex=TRUE)
##
## To hide this message use 'verbose = FALSE'.
```

```
head(covid_italy_regions)
```

```
##         id       date confirmed deaths recovered tests vaccines
## 1 07945170 2020-02-24         0      0         0    58       NA
## 2 07945170 2020-02-25         0      0         0    89       NA
## 3 07945170 2020-02-26         0      0         0   114       NA
## 4 07945170 2020-02-27         0      0         0   141       NA
## 5 07945170 2020-02-28         0      0         0   169       NA
## 6 07945170 2020-02-29         0      0         0   189       NA
##   people_vaccinated people_fully_vaccinated hosp icu vent school_closing
## 1                NA                     NA    0   0   NA             -3
## 2                NA                     NA    0   0   NA             -3
## 3                NA                     NA    0   0   NA             -3
## 4                NA                     NA    0   0   NA             -3
## 5                NA                     NA    0   0   NA             -3
## 6                NA                     NA    0   0   NA             -3
##   workplace_closing cancel_events gatherings_restrictions transport_closing
## 1                -3            -2                     -4                 0
## 2                -3            -2                     -4                 0
## 3                -3            -2                     -4                 0
## 4                -3            -2                     -4                 0
## 5                -3            -2                     -4                 0
## 6                -3            -2                     -4                 0
##   stay_home_restrictions internal_movement_restrictions
## 1                     -2                            -1
## 2                     -2                            -1
## 3                     -2                            -1
## 4                     -2                            -1
## 5                     -2                            -1
## 6                     -2                            -1
##   international_movement_restrictions information_campaigns testing_policy
## 1                                   3                     2              1
## 2                                   3                     2              1
## 3                                   3                     2              2
## 4                                   3                     2              2
## 5                                   3                     2              2
## 6                                   3                     2              2
##   contact_tracing facial_coverings vaccination_policy elderly_people_protection
## 1               2                0                  0                        -3
## 2               2                0                  0                        -3
## 3               2                0                  0                        -3
## 4               2                0                  0                        -3
## 5               2                0                  0                        -3
## 6               2                0                  0                        -3
##   government_response_index stringency_index containment_health_index
## 1                    -49.74           -64.35                   -56.85
## 2                    -49.74           -64.35                   -56.85
## 3                    -51.82           -64.35                   -59.23
## 4                    -51.82           -64.35                   -59.23
## 5                    -51.82           -64.35                   -59.23
## 6                    -51.82           -64.35                   -59.23
##   economic_support_index administrative_area_level administrative_area_level_1
## 1                      0                         2                       Italy
## 2                      0                         2                       Italy
## 3                      0                         2                       Italy
## 4                      0                         2                       Italy
## 5                      0                         2                       Italy
```

```
## 6                    0                          2                       Italy
##   administrative_area_level_2 administrative_area_level_3 latitude longitude
## 1       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 2       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 3       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 4       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 5       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 6       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
##   population iso_alpha_3 iso_alpha_2 iso_numeric iso_currency key_local
## 1    1215538         ITA          IT         380          EUR        06
## 2    1215538         ITA          IT         380          EUR        06
## 3    1215538         ITA          IT         380          EUR        06
## 4    1215538         ITA          IT         380          EUR        06
## 5    1215538         ITA          IT         380          EUR        06
## 6    1215538         ITA          IT         380          EUR        06
##           key_google_mobility                      key_apple_mobility
## 1 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 2 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 3 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 4 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 5 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 6 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
##   key_jhu_csse key_nuts key_gadm
## 1         ITH4     ITH4  ITA.7_1
## 2         ITH4     ITH4  ITA.7_1
## 3         ITH4     ITH4  ITA.7_1
## 4         ITH4     ITH4  ITA.7_1
## 5         ITH4     ITH4  ITA.7_1
## 6         ITH4     ITH4  ITA.7_1
```

Data Cleaning and Pre-processing

This section describes the steps taken to prepare the COVID-19 dataset for analysis. Data cleaning is essential to ensure accuracy, consistency, and reliability of the results.

Convert date column

The date variable was converted to Date format to enable proper time-series analysis and chronological plotting.

```
covid_italy <- covid_italy %>%
  mutate(date = as.Date(date))
```

Handle missing values

Missing values in key variables were addressed to avoid computational errors and biased results. Any missing observations in confirmed cases, deaths, and recoveries were replaced with zero.

```
covid_italy <- covid_italy %>%
  replace_na(list(
    confirmed = 0,
    deaths = 0,
    recovered = 0
  ))
```

Check Structure

The structure and summary statistics of the cleaned dataset were examined to verify that variables were correctly formatted and values were within expected ranges.

```
str(covid_italy)
```

```
## 'data.frame':    1697 obs. of  47 variables:
##  $ id                                 : chr  "03dcf038" "03dcf038" "03dcf038" "03dcf038"
...
##  $ date                               : Date, format: "2020-02-24" "2020-02-25" ...
##  $ confirmed                          : int  229 322 400 650 888 1128 1694 2036 2502 3089
...
##  $ deaths                             : int  7 10 12 17 21 29 34 52 79 107 ...
##  $ recovered                          : int  1 1 3 45 46 50 83 149 160 276 ...
##  $ tests                              :integer64 4324 8623 9587 12014 15695 18661 21127 23
345 ...
##  $ vaccines                           :integer64 NA NA NA NA NA NA NA NA ...
##  $ people_vaccinated                  : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ people_fully_vaccinated            : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ hosp                               : int  127 150 164 304 409 506 779 908 1263 1641 ...
##  $ icu                                : int  26 35 36 56 64 105 140 166 229 295 ...
##  $ vent                               : int  NA NA NA NA NA NA NA NA NA NA ...
##  $ school_closing                     : int  -3 -3 -3 -3 -3 -3 -3 -3 -3 -3 ...
##  $ workplace_closing                  : int  -3 -3 -3 -3 -3 -3 -3 -3 -3 -3 ...
##  $ cancel_events                      : int  -2 -2 -2 -2 -2 -2 -2 -2 -2 2 ...
##  $ gatherings_restrictions            : int  -4 -4 -4 -4 -4 -4 -4 -4 -4 -4 ...
##  $ transport_closing                  : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ stay_home_restrictions             : int  -2 -2 -2 -2 -2 -2 -2 -2 -2 -2 ...
##  $ internal_movement_restrictions     : int  -1 -1 -1 -1 -1 -1 -1 -2 -2 -2 ...
##  $ international_movement_restrictions: int  3 3 3 3 3 3 3 3 3 3 ...
##  $ information_campaigns              : int  2 2 2 2 2 2 2 2 2 2 ...
##  $ testing_policy                     : int  1 1 2 2 2 2 2 2 2 2 ...
##  $ contact_tracing                    : int  2 2 2 2 2 2 2 2 2 2 ...
##  $ facial_coverings                   : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ vaccination_policy                 : int  0 0 0 0 0 0 0 0 0 0 ...
##  $ elderly_people_protection          : int  -3 -3 -3 -3 -3 -3 -3 -3 -3 -3 ...
##  $ government_response_index          : num  49.7 49.7 51.8 51.8 51.8 ...
##  $ stringency_index                   : num  64.3 64.3 64.3 64.3 64.3 ...
##  $ containment_health_index           : num  56.9 56.9 59.2 59.2 59.2 ...
##  $ economic_support_index             : num  0 0 0 0 0 0 0 0 0 0 ...
##  $ administrative_area_level          : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ administrative_area_level_1        : chr  "Italy" "Italy" "Italy" "Italy" ...
##  $ administrative_area_level_2        : logi  NA NA NA NA NA NA ...
##  $ administrative_area_level_3        : logi  NA NA NA NA NA NA ...
##  $ latitude                           : num  43 43 43 43 43 43 43 43 43 43 ...
##  $ longitude                          : num  12 12 12 12 12 12 12 12 12 12 ...
##  $ population                         : int  60421760 60421760 60421760 60421760 60421760
60421760 60421760 60421760 60421760 60421760 ...
##  $ iso_alpha_3                        : chr  "ITA" "ITA" "ITA" "ITA" ...
##  $ iso_alpha_2                        : chr  "IT" "IT" "IT" "IT" ...
##  $ iso_numeric                        : int  380 380 380 380 380 380 380 380 380 380 ...
##  $ iso_currency                       : chr  "EUR" "EUR" "EUR" "EUR" ...
##  $ key_local                          : logi  NA NA NA NA NA NA ...
##  $ key_google_mobility                : chr  "ChIJA9KNRIL-1BIRb15jJFz1LOI" "ChIJA9KNRIL-1B
IRb15jJFz1LOI" "ChIJA9KNRIL-1BIRb15jJFz1LOI" "ChIJA9KNRIL-1BIRb15jJFz1LOI" ...
##  $ key_apple_mobility                 : chr  "Italy" "Italy" "Italy" "Italy" ...
##  $ key_jhu_csse                       : chr  "IT" "IT" "IT" "IT" ...
##  $ key_nuts                           : logi  NA NA NA NA NA NA ...
##  $ key_gadm                           : chr  "ITA" "ITA" "ITA" "ITA" ...
```

```
summary(covid_italy)
```

```
##       id                 date              confirmed            deaths
##  Length:1697        Min.   :2020-02-24   Min.   :     229   Min.   :     7
##  Class :character   1st Qu.:2021-04-23   1st Qu.: 3935703   1st Qu.:118699
##  Mode  :character   Median :2022-06-21   Median :17959329   Median :167842
##                     Mean   :2022-06-21   Mean   :15073189   Mean   :142496
##                     3rd Qu.:2023-08-19   3rd Qu.:25933956   3rd Qu.:191182
##                     Max.   :2024-10-16   Max.   :26927813   Max.   :197931
##
##    recovered            tests              vaccines         people_vaccinated
##  Min.   :       1   Min.   :     4324   Min.   :     7191   Min.   :    7191
##  1st Qu.: 3351461   1st Qu.: 56565755   1st Qu.: 81145083   1st Qu.:43974156
##  Median :17191557   Median :224629636   Median :137861570   Median :50868106
##  Mean   :14560193   Mean   :172029526   Mean   :108187421   Mean   :42458936
##  3rd Qu.:25625820   3rd Qu.:274638086   3rd Qu.:144498266   3rd Qu.:50933118
##  Max.   :26509811   Max.   :283626833   Max.   :144608839   Max.   :50936719
##                                         NA's   :      659   NA's   :659
##  people_fully_vaccinated      hosp            icu              vent
##  Min.   :      32        Min.   :  127   Min.   :  17.0   Min.   : NA
##  1st Qu.:40170894        1st Qu.: 2003   1st Qu.:  80.0   1st Qu.: NA
##  Median :49949074        Median : 4283   Median : 234.0   Median : NA
##  Mean   :40080682        Mean   : 8032   Mean   : 669.1   Mean   :NaN
##  3rd Qu.:50019983        3rd Qu.: 9760   3rd Qu.: 570.0   3rd Qu.: NA
##  Max.   :50023978        Max.   :38507   Max.   :4068.0   Max.   : NA
##  NA's   :659                                              NA's   :1697
##  school_closing    workplace_closing cancel_events   gatherings_restrictions
##  Min.   :-3.0000   Min.   :-3.000    Min.   :-2.00   Min.   :-4.000
##  1st Qu.: 0.0000   1st Qu.: 2.000    1st Qu.: 0.00   1st Qu.: 0.000
##  Median : 1.0000   Median : 2.000    Median : 2.00   Median : 1.000
##  Mean   : 0.9395   Mean   : 1.256    Mean   : 1.17   Mean   : 1.443
##  3rd Qu.: 2.0000   3rd Qu.: 2.000    3rd Qu.: 2.00   3rd Qu.: 4.000
##  Max.   : 3.0000   Max.   : 3.000    Max.   : 2.00   Max.   : 4.000
##  NA's   :655       NA's   :655       NA's   :655     NA's   :655
##  transport_closing stay_home_restrictions internal_movement_restrictions
##  Min.   :-1.0000   Min.   :-2.0000        Min.   :-2.0000
##  1st Qu.: 0.0000   1st Qu.:-2.0000        1st Qu.:-2.0000
##  Median : 1.0000   Median :-1.0000        Median : 0.0000
##  Mean   : 0.8205   Mean   :-0.5374        Mean   :-0.5912
##  3rd Qu.: 2.0000   3rd Qu.: 1.0000        3rd Qu.: 0.0000
##  Max.   : 2.0000   Max.   : 2.0000        Max.   : 2.0000
##  NA's   :655       NA's   :655            NA's   :655
##  international_movement_restrictions information_campaigns testing_policy
##  Min.   :0.000                       Min.   :2             Min.   :1.000
##  1st Qu.:2.000                       1st Qu.:2             1st Qu.:2.000
##  Median :3.000                       Median :2             Median :3.000
##  Mean   :2.299                       Mean   :2             Mean   :2.693
##  3rd Qu.:3.000                       3rd Qu.:2             3rd Qu.:3.000
##  Max.   :3.000                       Max.   :2             Max.   :3.000
##  NA's   :655                         NA's   :655           NA's   :655
##  contact_tracing facial_coverings vaccination_policy elderly_people_protection
##  Min.   :2       Min.   :-4.000   Min.   :0.000      Min.   :-3.000
##  1st Qu.:2       1st Qu.:-4.000   1st Qu.:0.000      1st Qu.: 2.000
##  Median :2       Median :-3.000   Median :5.000      Median : 3.000
##  Mean   :2       Mean   :-1.265   Mean   :3.119      Mean   : 2.669
##  3rd Qu.:2       3rd Qu.: 2.000   3rd Qu.:5.000      3rd Qu.: 3.000
##  Max.   :2       Max.   : 3.000   Max.   :5.000      Max.   : 3.000
```

```
##  NA's   :655     NA's   :655      NA's   :655        NA's   :655
##  government_response_index stringency_index containment_health_index
##  Min.   :41.67             Min.   :18.52    Min.   :44.05
##  1st Qu.:61.85             1st Qu.:53.70    1st Qu.:62.50
##  Median :73.44             Median :68.98    Median :73.21
##  Mean   :67.41             Mean   :60.46    Mean   :68.20
##  3rd Qu.:79.43             3rd Qu.:75.46    3rd Qu.:80.06
##  Max.   :82.97             Max.   :93.52    Max.   :85.42
##  NA's   :655               NA's   :655      NA's   :655
##  economic_support_index administrative_area_level administrative_area_level_1
##  Min.   : 0.00          Min.   :1                Length:1697
##  1st Qu.:50.00          1st Qu.:1                Class :character
##  Median :75.00          Median :1                Mode  :character
##  Mean   :61.88          Mean   :1
##  3rd Qu.:75.00          3rd Qu.:1
##  Max.   :75.00          Max.   :1
##  NA's   :655
##  administrative_area_level_2 administrative_area_level_3    latitude
##  Mode:logical                Mode:logical                Min.   :43
##  NA's:1697                   NA's:1697                   1st Qu.:43
##                                                          Median :43
##                                                          Mean   :43
##                                                          3rd Qu.:43
##                                                          Max.   :43
##
##    longitude    population       iso_alpha_3        iso_alpha_2
##  Min.   :12   Min.   :60421760   Length:1697        Length:1697
##  1st Qu.:12   1st Qu.:60421760   Class :character   Class :character
##  Median :12   Median :60421760   Mode  :character   Mode  :character
##  Mean   :12   Mean   :60421760
##  3rd Qu.:12   3rd Qu.:60421760
##  Max.   :12   Max.   :60421760
##
##   iso_numeric  iso_currency       key_local      key_google_mobility
##  Min.   :380   Length:1697        Mode:logical   Length:1697
##  1st Qu.:380   Class :character   NA's:1697      Class :character
##  Median :380   Mode  :character                  Mode  :character
##  Mean   :380
##  3rd Qu.:380
##  Max.   :380
##
##  key_apple_mobility key_jhu_csse       key_nuts         key_gadm
##  Length:1697        Length:1697        Mode:logical   Length:1697
##  Class :character   Class :character   NA's:1697      Class :character
##  Mode  :character   Mode  :character                  Mode  :character
##
##
##
##
```

DESCRIPTIVE STATISTICS

Summary statistics for italy

Summary of Pre-processing Steps

✓ Date variables formatted correctly

✓ Missing values handled consistently

✓ Dataset structure validated

Outcome: The dataset is now clean, reliable, and suitable for descriptive, temporal, and comparative COVID-19 analyses.

```
summary(covid_italy %>%
          select(where(is.numeric)))
```

```
##    confirmed            deaths         recovered            tests
##  Min.   :     229   Min.   :     7   Min.   :       1   Min.   :     4324
##  1st Qu.: 3935703   1st Qu.:118699   1st Qu.: 3351461   1st Qu.: 56565755
##  Median :17959329   Median :167842   Median :17191557   Median :224629636
##  Mean   :15073189   Mean   :142496   Mean   :14560193   Mean   :172029526
##  3rd Qu.:25933956   3rd Qu.:191182   3rd Qu.:25625820   3rd Qu.:274638086
##  Max.   :26927813   Max.   :197931   Max.   :26509811   Max.   :283626833
##
##     vaccines          people_vaccinated  people_fully_vaccinated      hosp
##  Min.   :     7191   Min.   :    7191   Min.   :      32        Min.   :  127
##  1st Qu.: 81145083   1st Qu.:43974156   1st Qu.:40170894        1st Qu.: 2003
##  Median :137861570   Median :50868106   Median :49949074        Median : 4283
##  Mean   :108187421   Mean   :42458936   Mean   :40080682        Mean   : 8032
##  3rd Qu.:144498266   3rd Qu.:50933118   3rd Qu.:50019983        3rd Qu.: 9760
##  Max.   :144608839   Max.   :50936719   Max.   :50023978        Max.   :38507
##  NA's   :      659   NA's   :659        NA's   :659
##       icu              vent      school_closing    workplace_closing
##  Min.   :  17.0   Min.   : NA    Min.   :-3.0000   Min.   :-3.000
##  1st Qu.:  80.0   1st Qu.: NA    1st Qu.: 0.0000   1st Qu.: 2.000
##  Median : 234.0   Median : NA    Median : 1.0000   Median : 2.000
##  Mean   : 669.1   Mean   :NaN    Mean   : 0.9395   Mean   : 1.256
##  3rd Qu.: 570.0   3rd Qu.: NA    3rd Qu.: 2.0000   3rd Qu.: 2.000
##  Max.   :4068.0   Max.   : NA    Max.   : 3.0000   Max.   : 3.000
##                   NA's   :1697   NA's   :655       NA's   :655
##  cancel_events   gatherings_restrictions transport_closing
##  Min.   :-2.00   Min.   :-4.000          Min.   :-1.0000
##  1st Qu.: 0.00   1st Qu.: 0.000          1st Qu.: 0.0000
##  Median : 2.00   Median : 1.000          Median : 1.0000
##  Mean   : 1.17   Mean   : 1.443          Mean   : 0.8205
##  3rd Qu.: 2.00   3rd Qu.: 4.000          3rd Qu.: 2.0000
##  Max.   : 2.00   Max.   : 4.000          Max.   : 2.0000
##  NA's   :655     NA's   :655             NA's   :655
##  stay_home_restrictions internal_movement_restrictions
##  Min.   :-2.0000        Min.   :-2.0000
##  1st Qu.:-2.0000        1st Qu.:-2.0000
##  Median :-1.0000        Median : 0.0000
##  Mean   :-0.5374        Mean   :-0.5912
##  3rd Qu.: 1.0000        3rd Qu.: 0.0000
##  Max.   : 2.0000        Max.   : 2.0000
##  NA's   :655            NA's   :655
##  international_movement_restrictions information_campaigns testing_policy
##  Min.   :0.000                       Min.   :2             Min.   :1.000
##  1st Qu.:2.000                       1st Qu.:2             1st Qu.:2.000
##  Median :3.000                       Median :2             Median :3.000
##  Mean   :2.299                       Mean   :2             Mean   :2.693
##  3rd Qu.:3.000                       3rd Qu.:2             3rd Qu.:3.000
##  Max.   :3.000                       Max.   :2             Max.   :3.000
##  NA's   :655                         NA's   :655           NA's   :655
##  contact_tracing facial_coverings vaccination_policy elderly_people_protection
##  Min.   :2       Min.   :-4.000   Min.   :0.000      Min.   :-3.000
##  1st Qu.:2       1st Qu.:-4.000   1st Qu.:0.000      1st Qu.: 2.000
##  Median :2       Median :-3.000   Median :5.000      Median : 3.000
##  Mean   :2       Mean   :-1.265   Mean   :3.119      Mean   : 2.669
##  3rd Qu.:2       3rd Qu.: 2.000   3rd Qu.:5.000      3rd Qu.: 3.000
##  Max.   :2       Max.   : 3.000   Max.   :5.000      Max.   : 3.000
```

```
##  NA's   :655     NA's   :655      NA's   :655        NA's   :655
##  government_response_index stringency_index containment_health_index
##  Min.   :41.67             Min.   :18.52    Min.   :44.05
##  1st Qu.:61.85             1st Qu.:53.70    1st Qu.:62.50
##  Median :73.44             Median :68.98    Median :73.21
##  Mean   :67.41             Mean   :60.46    Mean   :68.20
##  3rd Qu.:79.43             3rd Qu.:75.46    3rd Qu.:80.06
##  Max.   :82.97             Max.   :93.52    Max.   :85.42
##  NA's   :655               NA's   :655      NA's   :655
##  economic_support_index administrative_area_level    latitude    longitude
##  Min.   : 0.00          Min.   :1                 Min.   :43   Min.   :12
##  1st Qu.:50.00          1st Qu.:1                 1st Qu.:43   1st Qu.:12
##  Median :75.00          Median :1                 Median :43   Median :12
##  Mean   :61.88          Mean   :1                 Mean   :43   Mean   :12
##  3rd Qu.:75.00          3rd Qu.:1                 3rd Qu.:43   3rd Qu.:12
##  Max.   :75.00          Max.   :1                 Max.   :43   Max.   :12
##  NA's   :655
##    population        iso_numeric
##  Min.   :60421760   Min.   :380
##  1st Qu.:60421760   1st Qu.:380
##  Median :60421760   Median :380
##  Mean   :60421760   Mean   :380
##  3rd Qu.:60421760   3rd Qu.:380
##  Max.   :60421760   Max.   :380
##
```

Total cases,deaths, recoveries

This section summarizes the overall impact of COVID-19 in Italy by calculating the cumulative totals of confirmed cases, deaths, and recoveries.

```
covid_italy %>%
  summarise(
    total_cases = max(confirmed),
    total_deaths = max(deaths),
    total_recovered = max(recovered)
  )
```

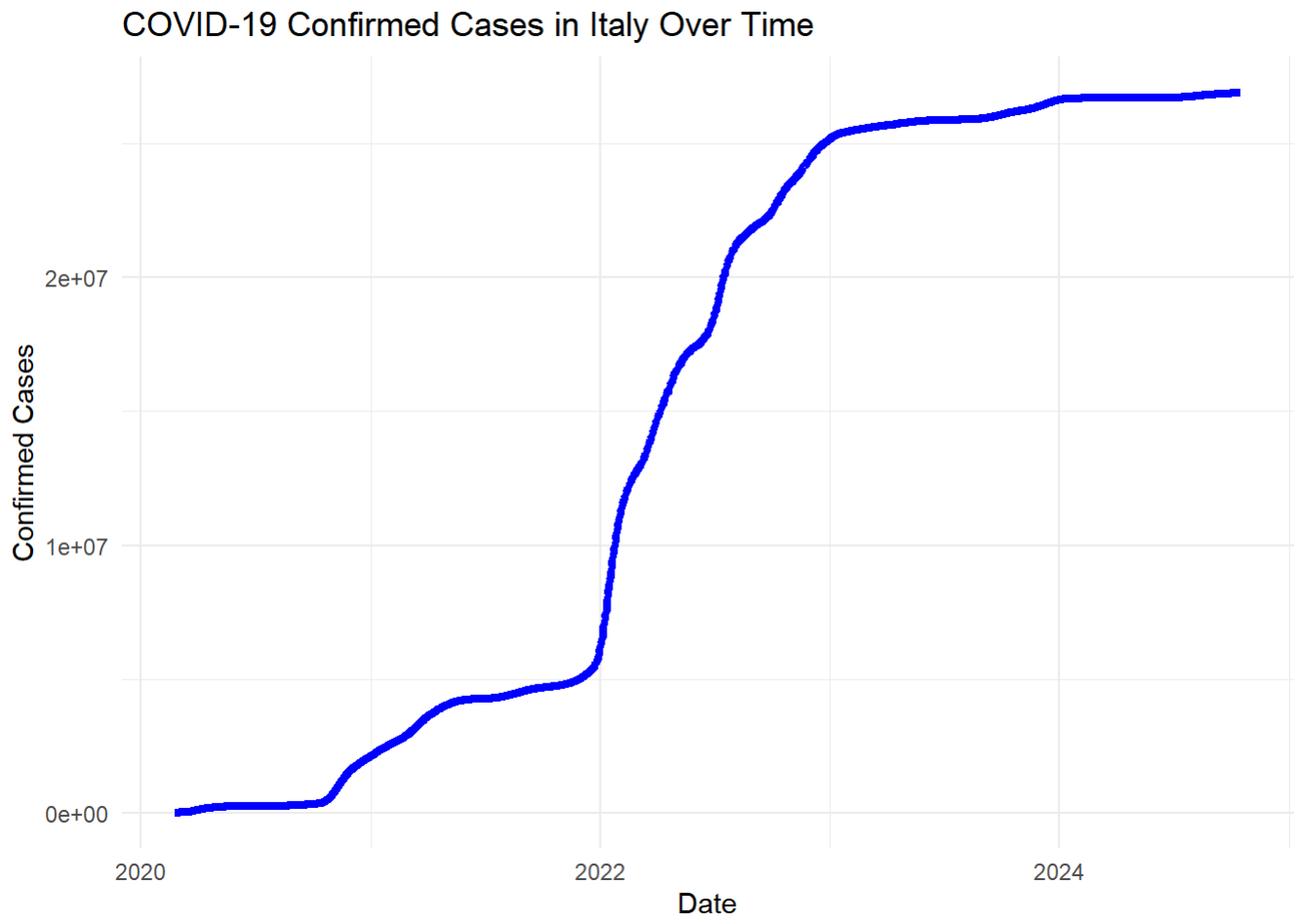
```
##   total_cases total_deaths total_recovered
## 1    26927813       197931        26509811
```

Temporal trends(Time-Series Analysis)

Daily confirmed cases over time(italy)

This time-series plot illustrates how confirmed COVID-19 cases in Italy evolved over time.

```
print(ggplot(covid_italy, aes(x = date, y = confirmed)) +
  geom_line(color = "blue",linewidth = 1.5) +
  labs(
    title = "COVID-19 Confirmed Cases in Italy Over Time",
    x = "Date",
    y = "Confirmed Cases"
  ) +
  theme_minimal())
```



REPORT ON COVID-19 CONFIRMED CASES

The curve shows a continuous upward trajectory, reflecting the cumulative nature of confirmed cases.

An initial slow increase is observed in early 2020, corresponding to the early phase of the pandemic.

A sharp and steep rise occurs around late 2021 to early 2022, indicating a period of intense transmission.

Following this surge, the curve begins to flatten, suggesting a reduction in the rate of new infections.

From 2023 onwards, the growth becomes more gradual, indicating improved control of the pandemic.

COMPARATIVE ANALYSIS

Country-Level Comparison: Italy vs France

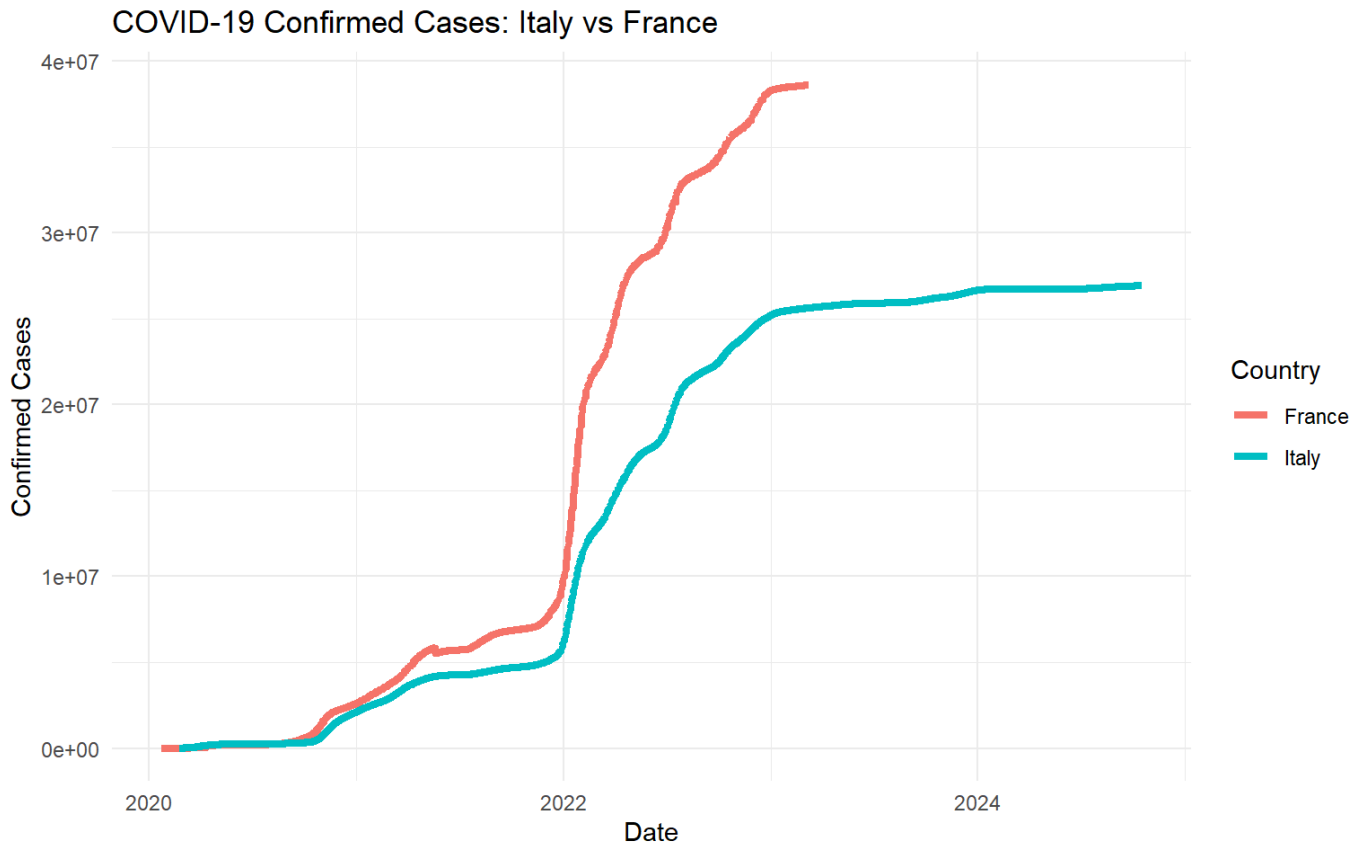
This section compares confirmed COVID-19 cases between Italy and France to assess differences in pandemic progression.

```
library(dplyr)

covid_compare <- covid_global %>%
  filter(
    administrative_area_level_1 %in% c("Italy", "France")
  )
```

```
covid_compare$date <- as.Date(covid_compare$date)
```

```
ggplot(
  covid_compare,
  aes(
    x = as.Date(date),
    y = confirmed,
    color = administrative_area_level_1
  )
) +
  geom_line(linewidth =1.5 ) +
  labs(
    title = "COVID-19 Confirmed Cases: Italy vs France",
    x = "Date",
    y = "Confirmed Cases",
    color = "Country",

  ) +
  theme_minimal()
```

```
## Warning: Removed 125 rows containing missing values or values outside the scale range
## (`geom_line()`).
```



REPORT ON COVID 19 CONFIRMED CASES ITALY VS FRANCE Both Italy and France exhibit a steady increase in confirmed cases over time, consistent with cumulative reporting.

An initial slow growth phase is observed during early 2020.

A sharp rise in cases occurs around late 2021 to early 2022 in both countries, indicating major pandemic waves.

France shows a steeper increase during this period, reaching a higher cumulative total than Italy.

After 2022, both curves begin to flatten, suggesting a reduction in the rate of new infections.

Interpretation

Both countries exhibit similar temporal patterns, including multiple waves of infection. However, differences in peak magnitudes and timing suggest variations in national responses, population dynamics, and health system capacities.

```
unique(covid_compare$administrative_area_level_1)
```

```
## [1] "France" "Italy"
```

```
#covid_global <- covid19()
#unique(covid_global$administrative_area_level_1)
```

Comparing REGIONS IN ITALY

Inspecting the dataset and listing unique regions ensures that regional-level data are correctly structured and available for comparison.

```
head(covid_italy_regions)
```

```
##         id       date confirmed deaths recovered tests vaccines
## 1 07945170 2020-02-24         0      0         0    58       NA
## 2 07945170 2020-02-25         0      0         0    89       NA
## 3 07945170 2020-02-26         0      0         0   114       NA
## 4 07945170 2020-02-27         0      0         0   141       NA
## 5 07945170 2020-02-28         0      0         0   169       NA
## 6 07945170 2020-02-29         0      0         0   189       NA
##   people_vaccinated people_fully_vaccinated hosp icu vent school_closing
## 1                NA                     NA    0   0   NA             -3
## 2                NA                     NA    0   0   NA             -3
## 3                NA                     NA    0   0   NA             -3
## 4                NA                     NA    0   0   NA             -3
## 5                NA                     NA    0   0   NA             -3
## 6                NA                     NA    0   0   NA             -3
##   workplace_closing cancel_events gatherings_restrictions transport_closing
## 1                -3            -2                     -4                 0
## 2                -3            -2                     -4                 0
## 3                -3            -2                     -4                 0
## 4                -3            -2                     -4                 0
## 5                -3            -2                     -4                 0
## 6                -3            -2                     -4                 0
##   stay_home_restrictions internal_movement_restrictions
## 1                     -2                            -1
## 2                     -2                            -1
## 3                     -2                            -1
## 4                     -2                            -1
## 5                     -2                            -1
## 6                     -2                            -1
##   international_movement_restrictions information_campaigns testing_policy
## 1                                   3                     2              1
## 2                                   3                     2              1
## 3                                   3                     2              2
## 4                                   3                     2              2
## 5                                   3                     2              2
## 6                                   3                     2              2
##   contact_tracing facial_coverings vaccination_policy elderly_people_protection
## 1               2                0                  0                        -3
## 2               2                0                  0                        -3
## 3               2                0                  0                        -3
## 4               2                0                  0                        -3
## 5               2                0                  0                        -3
## 6               2                0                  0                        -3
##   government_response_index stringency_index containment_health_index
## 1                    -49.74          -64.35                   -56.85
## 2                    -49.74          -64.35                   -56.85
## 3                    -51.82          -64.35                   -59.23
## 4                    -51.82          -64.35                   -59.23
## 5                    -51.82          -64.35                   -59.23
## 6                    -51.82          -64.35                   -59.23
##   economic_support_index administrative_area_level administrative_area_level_1
## 1                      0                         2                       Italy
## 2                      0                         2                       Italy
## 3                      0                         2                       Italy
## 4                      0                         2                       Italy
## 5                      0                         2                       Italy
```

```
## 6                     0                         2                       Italy
##   administrative_area_level_2 administrative_area_level_3 latitude longitude
## 1       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 2       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 3       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 4       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 5       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
## 6       Friuli Venezia Giulia                        <NA> 46.14675  13.29992
##   population iso_alpha_3 iso_alpha_2 iso_numeric iso_currency key_local
## 1    1215538         ITA          IT         380          EUR        06
## 2    1215538         ITA          IT         380          EUR        06
## 3    1215538         ITA          IT         380          EUR        06
## 4    1215538         ITA          IT         380          EUR        06
## 5    1215538         ITA          IT         380          EUR        06
## 6    1215538         ITA          IT         380          EUR        06
##           key_google_mobility                      key_apple_mobility
## 1 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 2 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 3 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 4 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 5 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
## 6 ChIJ67q-XqQzekcRgHyQFYcJBwE Autonomous Region Friuli-Venezia Giulia
##   key_jhu_csse key_nuts key_gadm
## 1         ITH4     ITH4  ITA.7_1
## 2         ITH4     ITH4  ITA.7_1
## 3         ITH4     ITH4  ITA.7_1
## 4         ITH4     ITH4  ITA.7_1
## 5         ITH4     ITH4  ITA.7_1
## 6         ITH4     ITH4  ITA.7_1
```

Which regions are available

```
unique(covid_italy_regions$administrative_area_level_2)
```

```
##  [1] "Friuli Venezia Giulia" "P.A. Bolzano"          "Molise"
##  [4] "Campania"              "Veneto"                "Basilicata"
##  [7] "Lazio"                 "Lombardia"             "P.A. Trento"
## [10] "Piemonte"              "Valle d'Aosta"         "Sicilia"
## [13] "Marche"                "Calabria"              "Liguria"
## [16] "Umbria"                "Emilia-Romagna"        "Abruzzo"
## [19] "Puglia"                "Toscana"               "Sardegna"
```

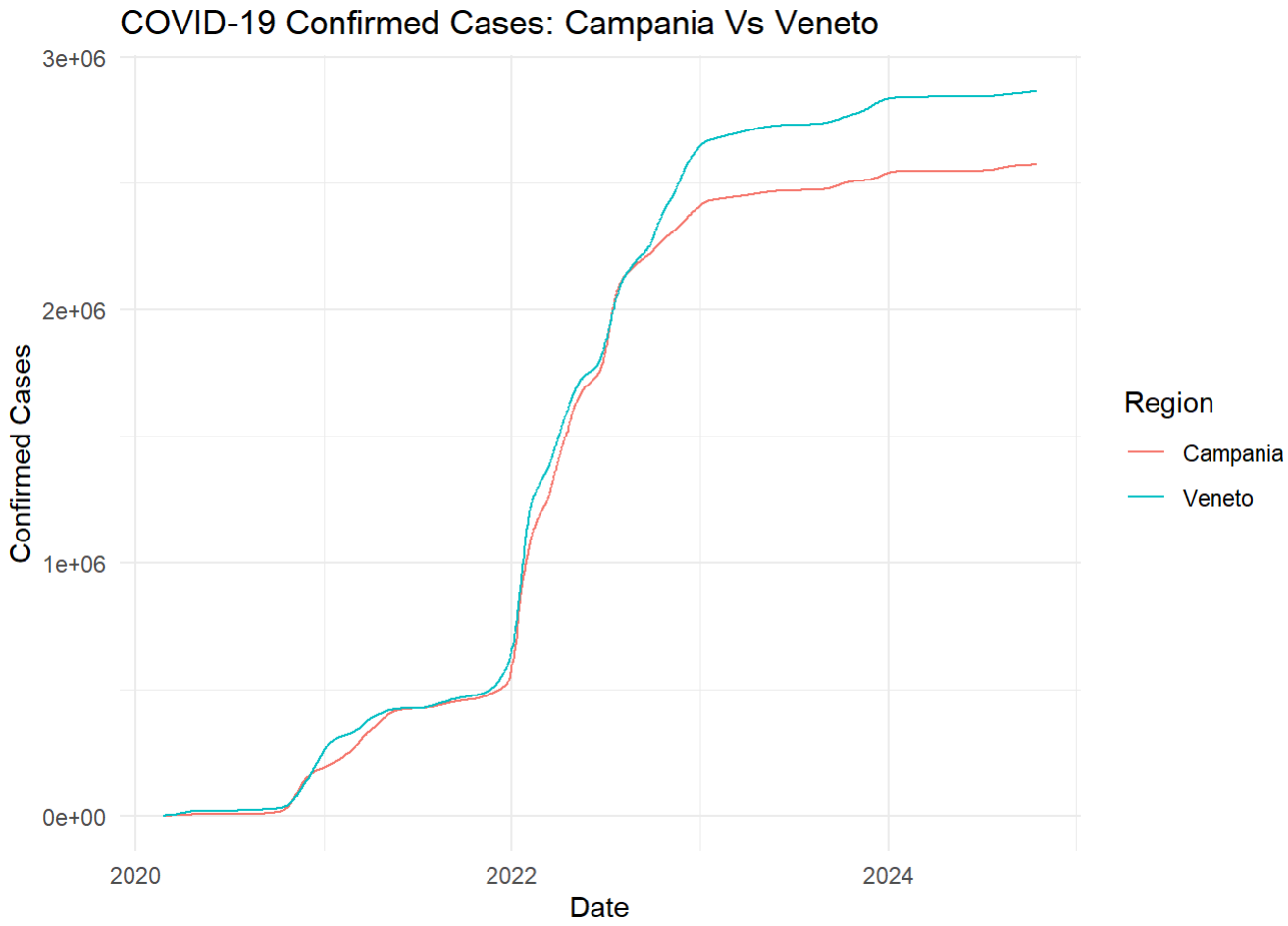
```
selected_regions=c("Campania","Veneto")
```

Filter data to those two regions

```
covid_regions_compare=covid_italy_regions%>%
  filter(administrative_area_level_2%in%selected_regions)%>%
  mutate(date=as.Date(date))
```

Line Plot(Region Comparison)

```
ggplot(
  covid_regions_compare,
  aes(
    x=date,
    y=confirmed,
    color=administrative_area_level_2
  ))+
  geom_line()+
      labs(
        title = "COVID-19 Confirmed Cases: Campania Vs Veneto",
        x="Date",
        y="Confirmed Cases",
        color="Region"
      )+
        theme_minimal()
```



REPORT ON COVID-19 CONFIRMED CASES CAMPANIA VS VENETO Both regions exhibit a steady cumulative increase in confirmed cases throughout the study period.

An initial slow growth phase is visible during early 2020, followed by multiple waves of accelerated transmission.

A pronounced surge around late 2021 to early 2022 is observed in both regions, corresponding to major pandemic waves.

After this surge, the curves begin to flatten, indicating a slowdown in the rate of new infections.

Confirmed cases vs recovery cases Germany

```
covid_germany=covid19(country = "Germany")%>%
  mutate(date=as.Date(date))
```

```
## We have invested a lot of time and effort in creating COVID-19 Data
## Hub, please cite the following when using it:
##
##   Guidotti, E., Ardia, D., (2020), "COVID-19 Data Hub", Journal of Open
##   Source Software 5(51):2376, doi: 10.21105/joss.02376
##
## The implementation details and the latest version of the data are
## described in:
##
##   Guidotti, E., (2022), "A worldwide epidemiological database for
##   COVID-19 at fine-grained spatial resolution", Sci Data 9(1):112, doi:
##   10.1038/s41597-022-01245-1
## To print citations in BibTeX format use:
##  > print(citation('COVID19'), bibtex=TRUE)
##
## To hide this message use 'verbose = FALSE'.
```

```
head(covid_germany)
```

```
##         id       date confirmed deaths recovered tests vaccines
## 1 42079406 2020-01-02         1      0         1  <NA>     <NA>
## 2 42079406 2020-01-23         2      0         2  <NA>     <NA>
## 3 42079406 2020-01-27        NA     NA        NA  <NA>     <NA>
## 4 42079406 2020-01-28         4      0         4  <NA>     <NA>
## 5 42079406 2020-01-29         6      0         6  <NA>     <NA>
## 6 42079406 2020-01-30        NA     NA        NA  <NA>     <NA>
##   people_vaccinated people_fully_vaccinated hosp icu vent school_closing
## 1                NA                     NA   NA  NA   NA              0
## 2                NA                     NA   NA  NA   NA              0
## 3                NA                     NA   NA  NA   NA              0
## 4                NA                     NA   NA  NA   NA              0
## 5                NA                     NA   NA  NA   NA              0
## 6                NA                     NA   NA  NA   NA              0
##   workplace_closing cancel_events gatherings_restrictions transport_closing
## 1                 0             0                      0                 0
## 2                 0             0                      0                 0
## 3                 0             0                      0                 0
## 4                 0             0                      0                 0
## 5                 0             0                      0                 0
## 6                 0             0                      0                 0
##   stay_home_restrictions internal_movement_restrictions
## 1                      0                             0
## 2                      0                             0
## 3                      0                             0
## 4                      0                             0
## 5                      0                             0
## 6                      0                             0
##   international_movement_restrictions information_campaigns testing_policy
## 1                                   0                    0              0
## 2                                   0                    0              0
## 3                                   0                    1              1
## 4                                   0                    1              1
## 5                                   0                    1              1
## 6                                   0                    1              1
##   contact_tracing facial_coverings vaccination_policy elderly_people_protection
## 1               0                0                   0                        0
## 2               2                0                   0                        0
## 3               2                0                   0                        0
## 4               2                0                   0                        0
## 5               2                0                   0                        0
## 6               2                0                   0                        0
##   government_response_index stringency_index containment_health_index
## 1                      0.00            0.00                     0.00
## 2                      6.25            0.00                     7.14
## 3                     11.46            5.56                    13.10
## 4                     11.46            5.56                    13.10
## 5                     11.46            5.56                    13.10
## 6                     11.46            5.56                    13.10
##   economic_support_index administrative_area_level administrative_area_level_1
## 1                      0                         1                     Germany
## 2                      0                         1                     Germany
## 3                      0                         1                     Germany
## 4                      0                         1                     Germany
## 5                      0                         1                     Germany
```

```
## 6                     0                         1                     Germany
##   administrative_area_level_2 administrative_area_level_3 latitude longitude
## 1                          NA                          NA       51         9
## 2                          NA                          NA       51         9
## 3                          NA                          NA       51         9
## 4                          NA                          NA       51         9
## 5                          NA                          NA       51         9
## 6                          NA                          NA       51         9
##   population iso_alpha_3 iso_alpha_2 iso_numeric iso_currency key_local
## 1   82905782         DEU          DE         276          EUR        NA
## 2   82905782         DEU          DE         276          EUR        NA
## 3   82905782         DEU          DE         276          EUR        NA
## 4   82905782         DEU          DE         276          EUR        NA
## 5   82905782         DEU          DE         276          EUR        NA
## 6   82905782         DEU          DE         276          EUR        NA
##           key_google_mobility key_apple_mobility key_jhu_csse key_nuts key_gadm
## 1 ChIJa76xwh5ymkcRW-WRjmtd6HU            Germany           DE       NA      DEU
## 2 ChIJa76xwh5ymkcRW-WRjmtd6HU            Germany           DE       NA      DEU
## 3 ChIJa76xwh5ymkcRW-WRjmtd6HU            Germany           DE       NA      DEU
## 4 ChIJa76xwh5ymkcRW-WRjmtd6HU            Germany           DE       NA      DEU
## 5 ChIJa76xwh5ymkcRW-WRjmtd6HU            Germany           DE       NA      DEU
## 6 ChIJa76xwh5ymkcRW-WRjmtd6HU            Germany           DE       NA      DEU
```

```
sum(is.na(covid_germany$confirmed))
```

```
## [1] 12
```

```
nrow(covid_germany)
```

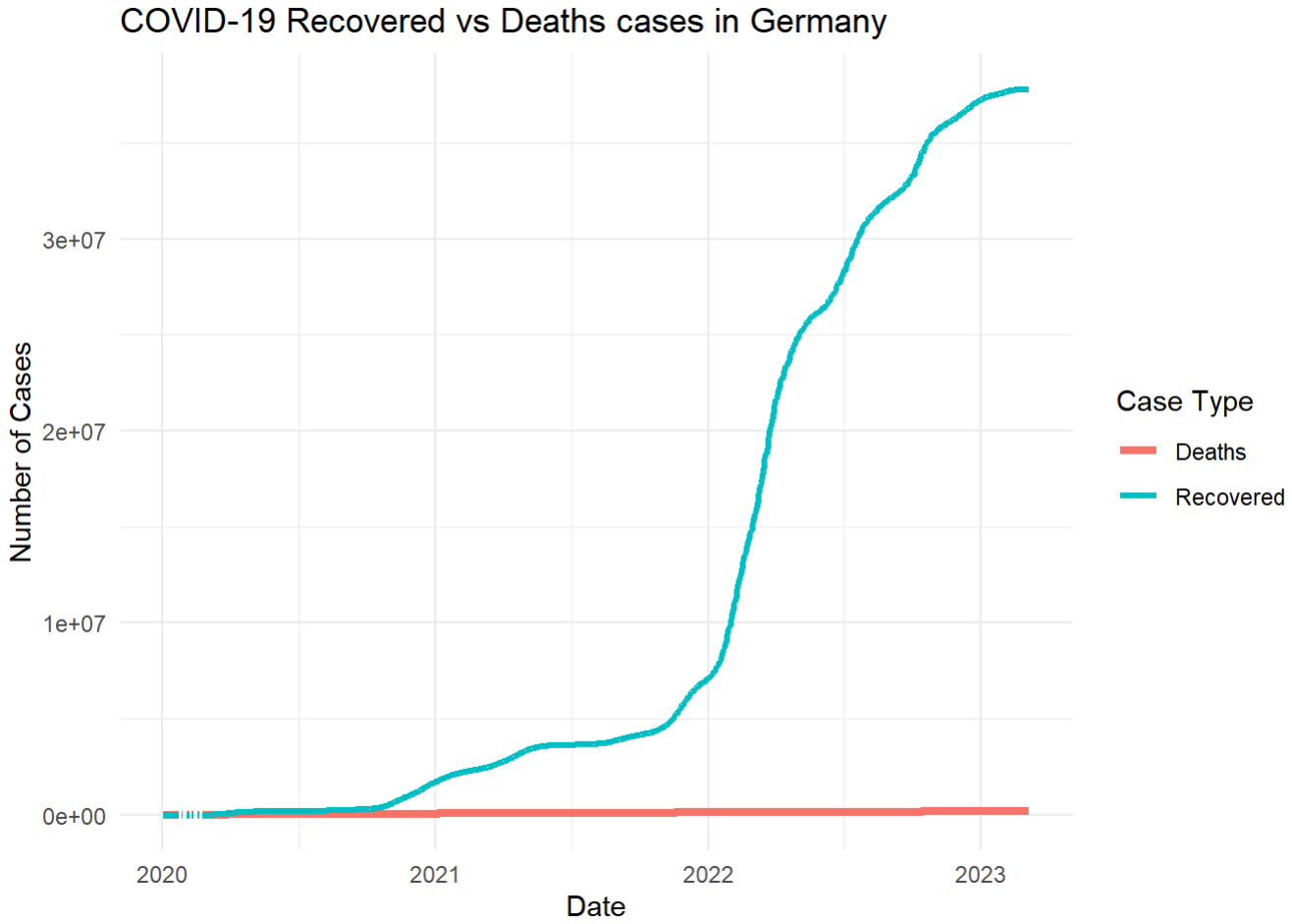
```
## [1] 1138
```

```
sum(is.na(covid_germany$deaths))
```

```
## [1] 12
```

```
 ggplot(
   covid_germany,
   aes(date))+
  geom_line(aes(y=deaths,color="Deaths"),linewidth = 1.5)+
  geom_line(aes(y=recovered,color="Recovered"),linewidth = 1.2)+
  labs(
    title="COVID-19 Recovered vs Deaths cases in Germany",
    x="Date",
    y="Number of Cases",
    color="Case Type"
  )+
 theme_minimal()
```

```
## Warning: Removed 1 row containing missing values or values outside the scale range
## (`geom_line()`).
## Removed 1 row containing missing values or values outside the scale range
## (`geom_line()`).
```



REPORT ON COVID 19 RECOVERED VS DEATH CASES IN GERMANY The substantial gap between recovered and death cases indicates that the majority of infected individuals in Germany recovered from COVID-19. The rapid increase in recoveries during later periods suggests improvements in clinical treatment, vaccination coverage, and overall healthcare response. The relatively flat death curve reflects a lower fatality rate, especially in later stages of the pandemic.

Geographical Distribution

```
library(dplyr)
library(maps)
```

```
## Warning: package 'maps' was built under R version 4.5.2
```

```
##
## Attaching package: 'maps'
```

```
## The following object is masked from 'package:purrr':
##
##     map
```

```
library(ggplot2)
```

Load COVID-19 Global Data

```
head(covid_global)
```

```
##         id       date confirmed deaths recovered tests vaccines
## 1 8320791a 2020-03-13         2     NA        NA  <NA>     <NA>
## 2 8320791a 2020-03-14         2     NA        NA  <NA>     <NA>
## 3 8320791a 2020-03-15         2     NA        NA  <NA>     <NA>
## 4 8320791a 2020-03-16         2     NA        NA  <NA>     <NA>
## 5 8320791a 2020-03-17         8     NA        NA  <NA>     <NA>
## 6 8320791a 2020-03-18         9     NA        NA  <NA>     <NA>
##   people_vaccinated people_fully_vaccinated hosp icu vent school_closing
## 1                NA                      NA   NA  NA   NA             NA
## 2                NA                      NA   NA  NA   NA             NA
## 3                NA                      NA   NA  NA   NA             NA
## 4                NA                      NA   NA  NA   NA             NA
## 5                NA                      NA   NA  NA   NA             NA
## 6                NA                      NA   NA  NA   NA             NA
##   workplace_closing cancel_events gatherings_restrictions transport_closing
## 1                NA            NA                      NA                NA
## 2                NA            NA                      NA                NA
## 3                NA            NA                      NA                NA
## 4                NA            NA                      NA                NA
## 5                NA            NA                      NA                NA
## 6                NA            NA                      NA                NA
##   stay_home_restrictions internal_movement_restrictions
## 1                     NA                             NA
## 2                     NA                             NA
## 3                     NA                             NA
## 4                     NA                             NA
## 5                     NA                             NA
## 6                     NA                             NA
##   international_movement_restrictions information_campaigns testing_policy
## 1                                  NA                    NA             NA
## 2                                  NA                    NA             NA
## 3                                  NA                    NA             NA
## 4                                  NA                    NA             NA
## 5                                  NA                    NA             NA
## 6                                  NA                    NA             NA
##   contact_tracing facial_coverings vaccination_policy elderly_people_protection
## 1              NA               NA                 NA                        NA
## 2              NA               NA                 NA                        NA
## 3              NA               NA                 NA                        NA
## 4              NA               NA                 NA                        NA
## 5              NA               NA                 NA                        NA
## 6              NA               NA                 NA                        NA
##   government_response_index stringency_index containment_health_index
## 1                        NA               NA                       NA
## 2                        NA               NA                       NA
## 3                        NA               NA                       NA
## 4                        NA               NA                       NA
## 5                        NA               NA                       NA
## 6                        NA               NA                       NA
##   economic_support_index administrative_area_level administrative_area_level_1
## 1                     NA                         1                Grand Princess
## 2                     NA                         1                Grand Princess
## 3                     NA                         1                Grand Princess
## 4                     NA                         1                Grand Princess
## 5                     NA                         1                Grand Princess
```

```
## 6                     NA                           1              Grand Princess
##   administrative_area_level_2 administrative_area_level_3 latitude longitude
## 1                          NA                          NA       NA        NA
## 2                          NA                          NA       NA        NA
## 3                          NA                          NA       NA        NA
## 4                          NA                          NA       NA        NA
## 5                          NA                          NA       NA        NA
## 6                          NA                          NA       NA        NA
##   population iso_alpha_3 iso_alpha_2 iso_numeric iso_currency key_local
## 1       3533        <NA>        <NA>          NA         <NA>        NA
## 2       3533        <NA>        <NA>          NA         <NA>        NA
## 3       3533        <NA>        <NA>          NA         <NA>        NA
## 4       3533        <NA>        <NA>          NA         <NA>        NA
## 5       3533        <NA>        <NA>          NA         <NA>        NA
## 6       3533        <NA>        <NA>          NA         <NA>        NA
##   key_google_mobility key_apple_mobility key_jhu_csse key_nuts key_gadm
## 1                <NA>               <NA>         <NA>       NA     <NA>
## 2                <NA>               <NA>         <NA>       NA     <NA>
## 3                <NA>               <NA>         <NA>       NA     <NA>
## 4                <NA>               <NA>         <NA>       NA     <NA>
## 5                <NA>               <NA>         <NA>       NA     <NA>
## 6                <NA>               <NA>         <NA>       NA     <NA>
```

Total Confirmed cases per country

```
library(dplyr)
covid_summary <- covid_global %>%
  group_by(administrative_area_level_1) %>%
  summarise(
    total_cases = ifelse(
      all(is.na(confirmed)),
      NA,
      max(confirmed, na.rm = TRUE)
    ),
    .groups = "drop"
  )%>%
  rename(country=administrative_area_level_1)

covid_summary
```

```
## # A tibble: 236 × 2
##    country             total_cases
##    <chr>                     <int>
##  1 Afghanistan              209451
##  2 Albania                  334457
##  3 Algeria                  270697
##  4 American Samoa             8321
##  5 Andorra                   47890
##  6 Angola                   105288
##  7 Anguilla                   3904
##  8 Antigua and Barbuda        9106
##  9 Argentina              10044957
## 10 Armenia                  447308
## # ℹ 226 more rows
```

Remove Areas with no data

```
covid_summary <- covid_summary %>%
  filter(!is.na(total_cases))
```

Get World Map Data

```
world <- map_data("world")
head(world)
```

```
##        long      lat group order region subregion
## 1 -69.89912 12.45200     1     1  Aruba      <NA>
## 2 -69.89571 12.42300     1     2  Aruba      <NA>
## 3 -69.94219 12.43853     1     3  Aruba      <NA>
## 4 -70.00415 12.50049     1     4  Aruba      <NA>
## 5 -70.06612 12.54697     1     5  Aruba      <NA>
## 6 -70.05088 12.59707     1     6  Aruba      <NA>
```

```
map_data <- left_join(
  world,
  covid_summary,
  by = c("region" = "country")

)
```

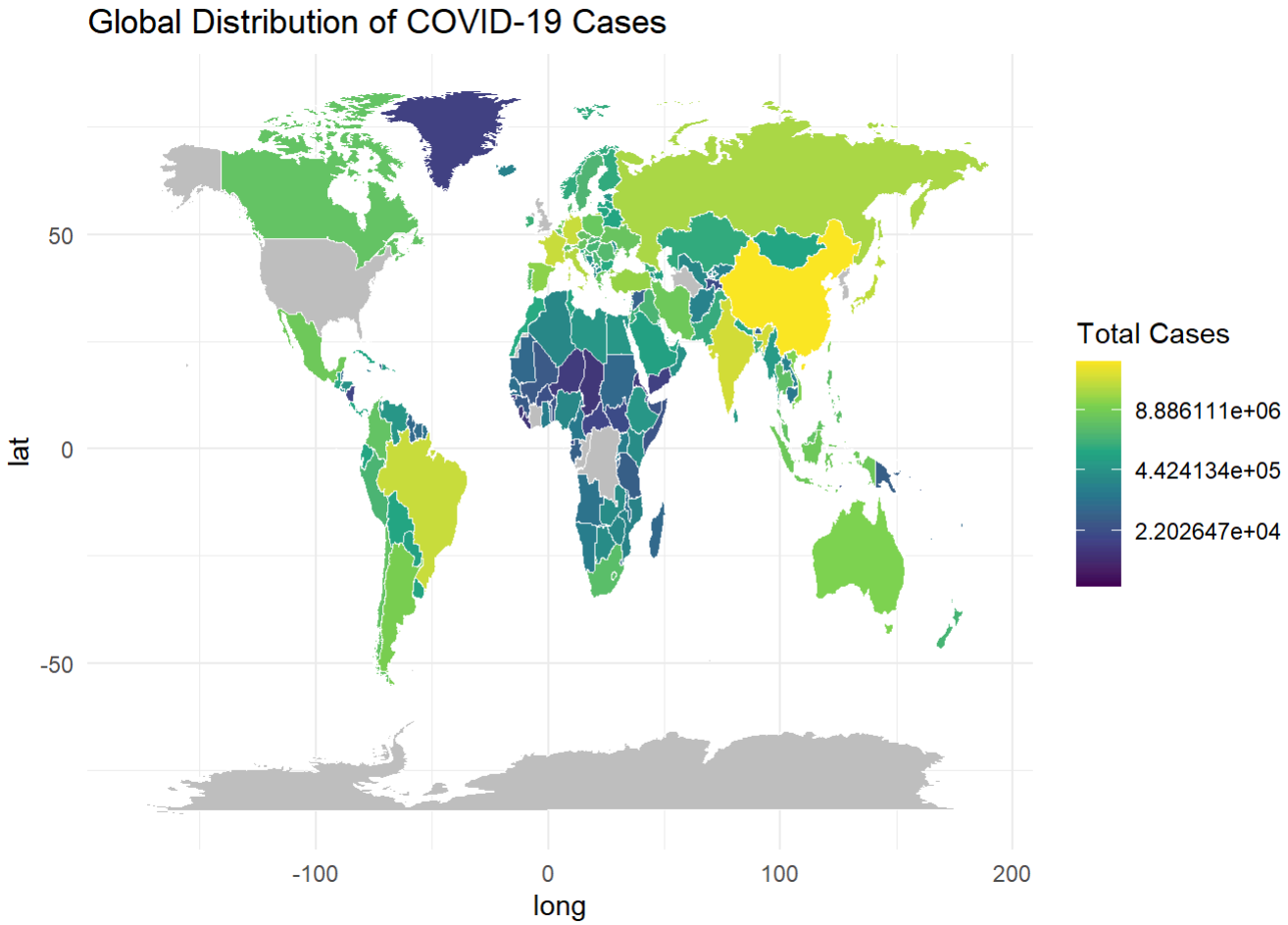
Merge COVID DATA WITH MAP DATA

```
map_data <- left_join(
  world,
  covid_summary,
  by = c("region" = "country")
)
```

Geographical Distribution

```
ggplot(map_data, aes(long, lat, group = group, fill = total_cases)) +
  geom_polygon(color = "white", size = 0.1) +
  scale_fill_viridis_c(
    na.value = "grey",
    trans = "log",
    name = "Total Cases"
  ) +
  theme_minimal() +
  labs(
    title = "Global Distribution of COVID-19 Cases"
  )
```

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## ℹ Please use `linewidth` instead.
## This warning is displayed once per session.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



REPORT ON GLOBAL DISTRIBUTION OF COVID 19 CASES Observed Patterns

High case concentrations are observed in North America, Europe, South Asia, and parts of South America.

Countries with large populations and extensive testing capacity show higher cumulative case counts.

Several regions in Africa and smaller island nations display lower reported case numbers.

The use of a logarithmic color scale enhances visibility across countries with very different case magnitudes.

INTERPRETATION

The uneven color distribution highlights the global heterogeneity of the COVID-19 pandemic. Differences in reported cases may reflect not only transmission intensity but also population size, testing strategies, healthcare infrastructure, and reporting practices. Regions with lighter colors may not necessarily have lower transmission but could reflect underreporting or limited testing capacity.