Covid-19 exploratory analysis

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```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.2.1     v purrr   0.3.3
## v tibble  2.1.3     v dplyr   0.8.3
## v tidyr   1.0.0     v stringr 1.4.0
## v readr   1.3.1     v forcats 0.4.0
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(reshape2)
```

```
##
## Attaching package: 'reshape2'
```

```
## The following object is masked from 'package:tidyr':
##
##     smiths
```

```
library(doParallel)
```

```
## Loading required package: foreach
```

```
##
## Attaching package: 'foreach'
```

```
## The following objects are masked from 'package:purrr':
##
##     accumulate, when
```

```
## Loading required package: iterators
```

```
## Loading required package: parallel
```

```
path <- '/Users/saurajyotikar/Documents/git_startup/COVID-19/csse_covid_19_data/csse_covid_19_time_serie
setwd(path)
fname_usa <- 'time_series_covid19_confirmed_US.csv'
fname_glo <- 'time_series_covid19_confirmed_global.csv'
d_usa <- read_csv(fname_usa)
```

```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   iso2 = col_character(),
##   iso3 = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Combined_Key = col_character()
## )
```

```
## See spec(...) for full column specifications.
```

```
d_glo <- read_csv(fname_glo)
```

```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   `Province/State` = col_character(),
##   `Country/Region` = col_character()
## )
## See spec(...) for full column specifications.
```

```
d_usa
```

```
## # A tibble: 3,253 x 91
##       UID iso2  iso3  code3  FIPS Admin2 Province_State Country_Region   Lat
##     <dbl> <chr> <chr> <dbl> <dbl> <chr>  <chr>          <chr>          <dbl>
##  1 1.60e1 AS    ASM      16    60 <NA>   American Samoa US             -14.3
##  2 3.16e2 GU    GUM     316    66 <NA>   Guam           US              13.4
##  3 5.80e2 MP    MNP     580    69 <NA>   Northern Mari~ US              15.1
##  4 6.30e2 PR    PRI     630    72 <NA>   Puerto Rico    US              18.2
##  5 8.50e2 VI    VIR     850    78 <NA>   Virgin Islands US              18.3
##  6 8.40e7 US    USA     840  1001 Autau~ Alabama        US              32.5
##  7 8.40e7 US    USA     840  1003 Baldw~ Alabama        US              30.7
##  8 8.40e7 US    USA     840  1005 Barbo~ Alabama        US              31.9
##  9 8.40e7 US    USA     840  1007 Bibb   Alabama        US              33.0
## 10 8.40e7 US    USA     840  1009 Blount Alabama        US              34.0
## # ... with 3,243 more rows, and 82 more variables: Long_ <dbl>,
## #   Combined_Key <chr>, `1/22/20` <dbl>, `1/23/20` <dbl>, `1/24/20` <dbl>,
## #   `1/25/20` <dbl>, `1/26/20` <dbl>, `1/27/20` <dbl>, `1/28/20` <dbl>,
## #   `1/29/20` <dbl>, `1/30/20` <dbl>, `1/31/20` <dbl>, `2/1/20` <dbl>,
## #   `2/2/20` <dbl>, `2/3/20` <dbl>, `2/4/20` <dbl>, `2/5/20` <dbl>,
## #   `2/6/20` <dbl>, `2/7/20` <dbl>, `2/8/20` <dbl>, `2/9/20` <dbl>,
## #   `2/10/20` <dbl>, `2/11/20` <dbl>, `2/12/20` <dbl>, `2/13/20` <dbl>,
## #   `2/14/20` <dbl>, `2/15/20` <dbl>, `2/16/20` <dbl>, `2/17/20` <dbl>,
## #   `2/18/20` <dbl>, `2/19/20` <dbl>, `2/20/20` <dbl>, `2/21/20` <dbl>,
## #   `2/22/20` <dbl>, `2/23/20` <dbl>, `2/24/20` <dbl>, `2/25/20` <dbl>,
## #   `2/26/20` <dbl>, `2/27/20` <dbl>, `2/28/20` <dbl>, `2/29/20` <dbl>,
## #   `3/1/20` <dbl>, `3/2/20` <dbl>, `3/3/20` <dbl>, `3/4/20` <dbl>,
## #   `3/5/20` <dbl>, `3/6/20` <dbl>, `3/7/20` <dbl>, `3/8/20` <dbl>,
## #   `3/9/20` <dbl>, `3/10/20` <dbl>, `3/11/20` <dbl>, `3/12/20` <dbl>,
## #   `3/13/20` <dbl>, `3/14/20` <dbl>, `3/15/20` <dbl>, `3/16/20` <dbl>,
## #   `3/17/20` <dbl>, `3/18/20` <dbl>, `3/19/20` <dbl>, `3/20/20` <dbl>,
## #   `3/21/20` <dbl>, `3/22/20` <dbl>, `3/23/20` <dbl>, `3/24/20` <dbl>,
## #   `3/25/20` <dbl>, `3/26/20` <dbl>, `3/27/20` <dbl>, `3/28/20` <dbl>,
## #   `3/29/20` <dbl>, `3/30/20` <dbl>, `3/31/20` <dbl>, `4/1/20` <dbl>,
## #   `4/2/20` <dbl>, `4/3/20` <dbl>, `4/4/20` <dbl>, `4/5/20` <dbl>,
## #   `4/6/20` <dbl>, `4/7/20` <dbl>, `4/8/20` <dbl>, `4/9/20` <dbl>,
## #   `4/10/20` <dbl>
```

```
d_glo
```

```
## # A tibble: 264 x 84
##    `Province/State` `Country/Region`   Lat  Long `1/22/20` `1/23/20` `1/24/20`
##    <chr>            <chr>            <dbl> <dbl>     <dbl>     <dbl>     <dbl>
##  1 <NA>             Afghanistan       33    65            0         0         0
```

```
##  2 <NA>             Albania           41.2  20.2          0         0         0
##  3 <NA>             Algeria           28.0   1.66         0         0         0
##  4 <NA>             Andorra           42.5   1.52         0         0         0
##  5 <NA>             Angola           -11.2  17.9          0         0         0
##  6 <NA>             Antigua and Bar~  17.1 -61.8          0         0         0
##  7 <NA>             Argentina        -38.4 -63.6          0         0         0
##  8 <NA>             Armenia           40.1  45.0          0         0         0
##  9 Australian Capi~ Australia        -35.5 149.           0         0         0
## 10 New South Wales  Australia        -33.9 151.           0         0         0
## # ... with 254 more rows, and 77 more variables: `1/25/20` <dbl>,
## #   `1/26/20` <dbl>, `1/27/20` <dbl>, `1/28/20` <dbl>, `1/29/20` <dbl>,
## #   `1/30/20` <dbl>, `1/31/20` <dbl>, `2/1/20` <dbl>, `2/2/20` <dbl>,
## #   `2/3/20` <dbl>, `2/4/20` <dbl>, `2/5/20` <dbl>, `2/6/20` <dbl>,
## #   `2/7/20` <dbl>, `2/8/20` <dbl>, `2/9/20` <dbl>, `2/10/20` <dbl>,
## #   `2/11/20` <dbl>, `2/12/20` <dbl>, `2/13/20` <dbl>, `2/14/20` <dbl>,
## #   `2/15/20` <dbl>, `2/16/20` <dbl>, `2/17/20` <dbl>, `2/18/20` <dbl>,
## #   `2/19/20` <dbl>, `2/20/20` <dbl>, `2/21/20` <dbl>, `2/22/20` <dbl>,
## #   `2/23/20` <dbl>, `2/24/20` <dbl>, `2/25/20` <dbl>, `2/26/20` <dbl>,
## #   `2/27/20` <dbl>, `2/28/20` <dbl>, `2/29/20` <dbl>, `3/1/20` <dbl>,
## #   `3/2/20` <dbl>, `3/3/20` <dbl>, `3/4/20` <dbl>, `3/5/20` <dbl>,
## #   `3/6/20` <dbl>, `3/7/20` <dbl>, `3/8/20` <dbl>, `3/9/20` <dbl>,
## #   `3/10/20` <dbl>, `3/11/20` <dbl>, `3/12/20` <dbl>, `3/13/20` <dbl>,
## #   `3/14/20` <dbl>, `3/15/20` <dbl>, `3/16/20` <dbl>, `3/17/20` <dbl>,
## #   `3/18/20` <dbl>, `3/19/20` <dbl>, `3/20/20` <dbl>, `3/21/20` <dbl>,
## #   `3/22/20` <dbl>, `3/23/20` <dbl>, `3/24/20` <dbl>, `3/25/20` <dbl>,
## #   `3/26/20` <dbl>, `3/27/20` <dbl>, `3/28/20` <dbl>, `3/29/20` <dbl>,
## #   `3/30/20` <dbl>, `3/31/20` <dbl>, `4/1/20` <dbl>, `4/2/20` <dbl>,
## #   `4/3/20` <dbl>, `4/4/20` <dbl>, `4/5/20` <dbl>, `4/6/20` <dbl>,
## #   `4/7/20` <dbl>, `4/8/20` <dbl>, `4/9/20` <dbl>, `4/10/20` <dbl>
```

```
d1_usa <- d_usa %>% pivot_longer(
     cols = 12:ncol(d_usa),
     names_pattern = '(.*)/*',
     names_to = "dated",
     values_to = "cases_confirmed",
     values_drop_na = F
 )
#view(d1_usa)
```

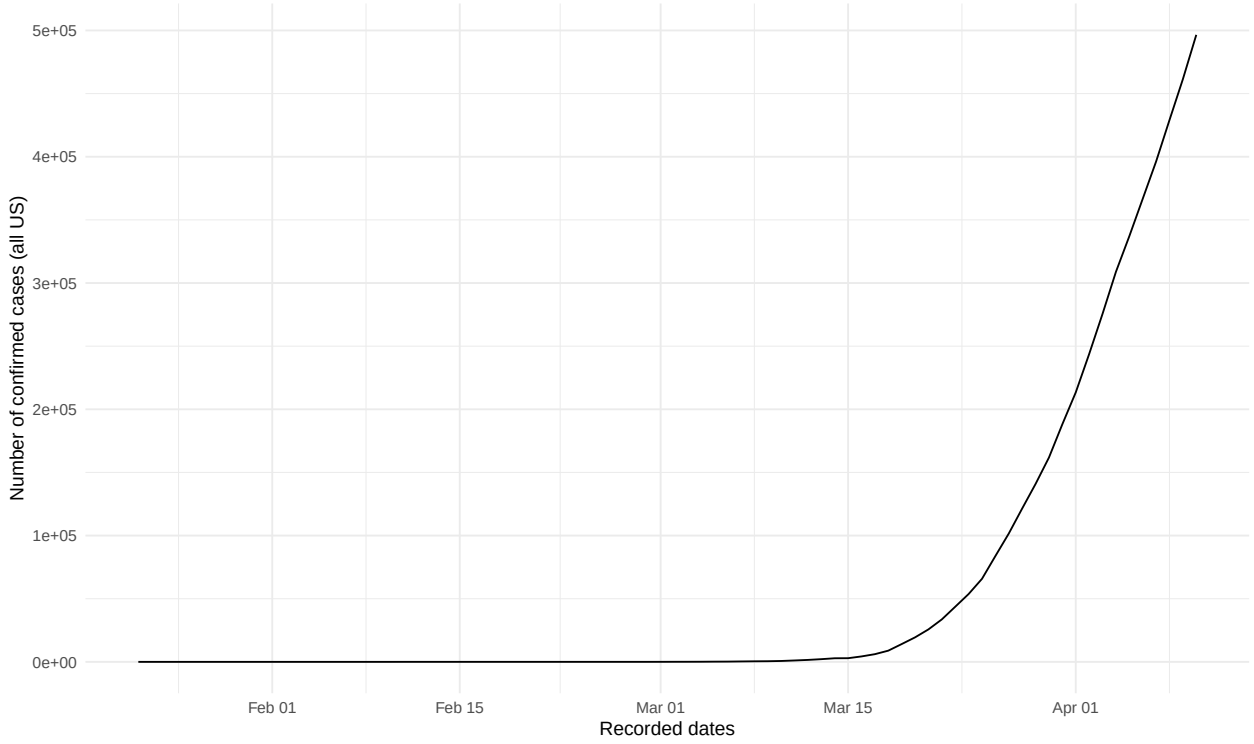
```
d2_usa <- d1_usa %>%
  group_by(dated) %>%
  summarise(n_cases_confirmed=sum(cases_confirmed)) %>%
  mutate(dated = as.Date(dated, format="%m/%d/%y")) %>%
  ungroup()

d2_usa
```

```
## # A tibble: 80 x 2
##    dated      n_cases_confirmed
##    <date>                 <dbl>
##  1 2020-01-22                 1
##  2 2020-01-23                 1
##  3 2020-01-24                 2
##  4 2020-01-25                 2
##  5 2020-01-26                 5
```

```
##  6 2020-01-27                5
##  7 2020-01-28                5
##  8 2020-01-29                5
##  9 2020-01-30                5
## 10 2020-01-31                7
## # ... with 70 more rows
```

```r
ggplot(d2_usa, aes(dated, n_cases_confirmed)) +
  geom_line() +
  xlab('Recorded dates') +
  scale_y_continuous('Number of confirmed cases (all US)') +
  theme_minimal()
```



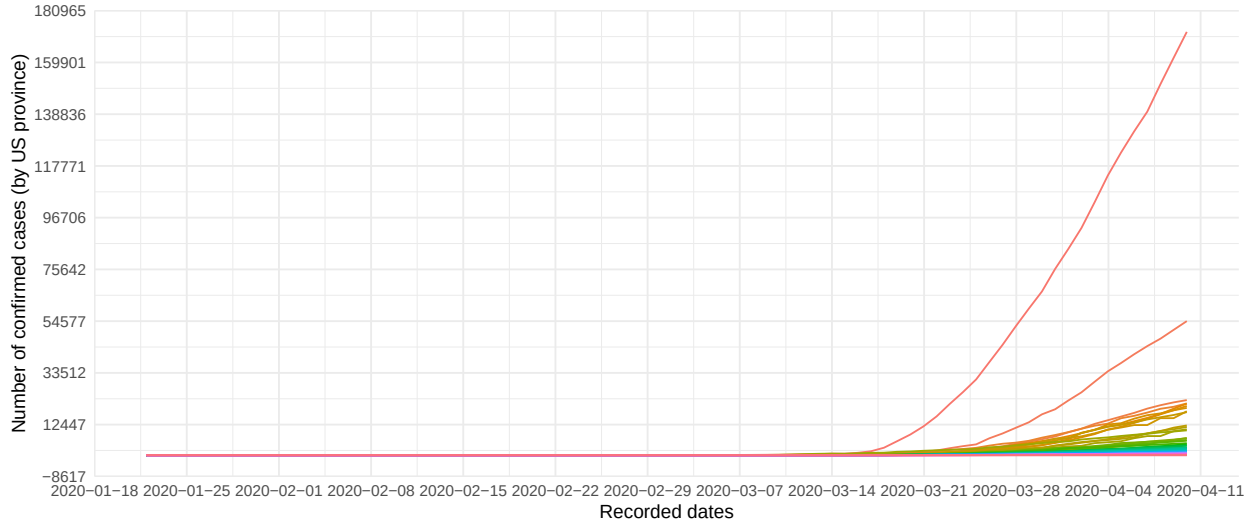

```r
d3_usa <- d1_usa %>%
  group_by(Province_State, dated) %>%
  summarise(n_cases_confirmed=sum(cases_confirmed)) %>%
  mutate(dated = as.Date(dated, "%m/%d/%y")) %>%
  ungroup()

# ordering the provinces on number of confirmed cases, descending
province_order_desc <- d3_usa %>%
  filter(dated==max(dated)) %>%
  arrange(desc(n_cases_confirmed)) %>%
  select(Province_State) %>%
  c()

d3_usa <- d3_usa %>%
  mutate(Province_State =
           fct_relevel(Province_State,
                       levels = c(province_order_desc)))
```

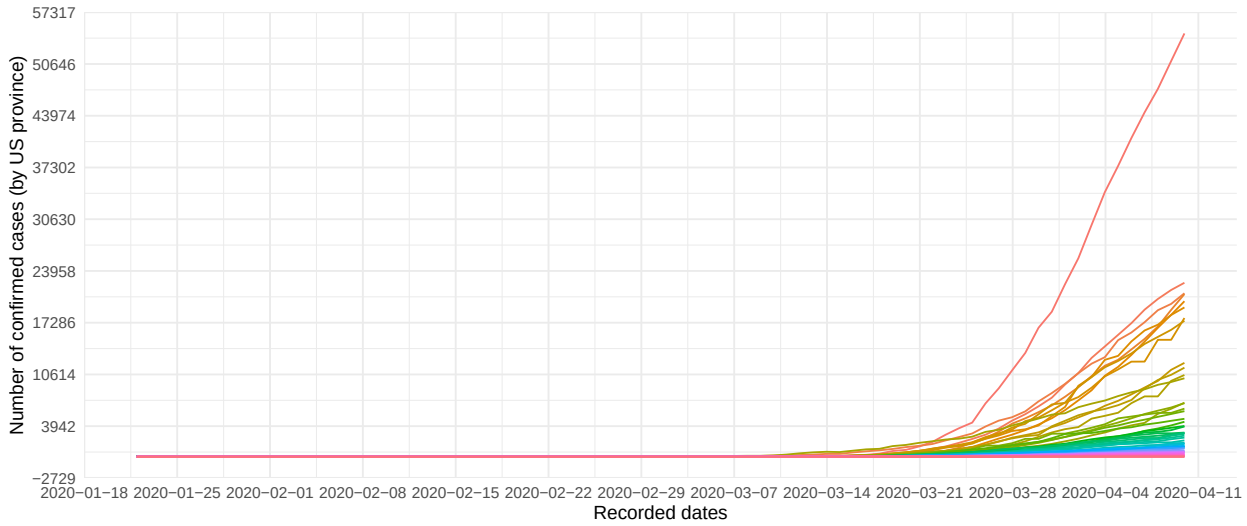
```
## Warning: Outer names are only allowed for unnamed scalar atomic inputs
```

```
ggplot(d3_usa, aes(dated, n_cases_confirmed, colour = Province_State)) +
  geom_line() +
  scale_x_date('Recorded dates',
               breaks = function(x) seq.Date(from = min(x),
                                             to = max(x),
                                             by = "1 week")) +
  scale_y_continuous('Number of confirmed cases (by US province)',
                     breaks = function (x) round(seq.int(from = min(x),
                                to = max(x),
                                length.out = 10))) +
  theme_minimal() +
  theme(legend.position = "bottom",
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 6))
```




```
d4_usa <- d3_usa %>%
  filter(!Province_State %in% c('New York'))
ggplot(d4_usa, aes(dated, n_cases_confirmed, colour = Province_State)) +
  geom_line() +
  scale_x_date('Recorded dates',
               breaks = function(x) seq.Date(from = min(x),
                                             to = max(x),
                                             by = "1 week")) +
  scale_y_continuous('Number of confirmed cases (by US province)',
                     breaks = function (x) round(seq.int(from = min(x),
                                to = max(x),
                                length.out = 10))) +
  theme_minimal() +
  theme(legend.position = "bottom",
```

```
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 6))
```




```
d1_glo <- d_glo %>% pivot_longer(
     cols = 12:ncol(d_glo),
     names_pattern = '(.*)/*',
     names_to = "dated",
     values_to = "cases_confirmed",
     values_drop_na = F
 )
d1_glo
```

```
## # A tibble: 19,272 x 13
##    `Province/State` `Country/Region`   Lat  Long `1/22/20` `1/23/20` `1/24/20`
##    <chr>            <chr>            <dbl> <dbl>     <dbl>     <dbl>     <dbl>
##  1 <NA>             Afghanistan         33    65         0         0         0
##  2 <NA>             Afghanistan         33    65         0         0         0
##  3 <NA>             Afghanistan         33    65         0         0         0
##  4 <NA>             Afghanistan         33    65         0         0         0
##  5 <NA>             Afghanistan         33    65         0         0         0
##  6 <NA>             Afghanistan         33    65         0         0         0
##  7 <NA>             Afghanistan         33    65         0         0         0
##  8 <NA>             Afghanistan         33    65         0         0         0
##  9 <NA>             Afghanistan         33    65         0         0         0
## 10 <NA>             Afghanistan         33    65         0         0         0
## # ... with 19,262 more rows, and 6 more variables: `1/25/20` <dbl>,
## #   `1/26/20` <dbl>, `1/27/20` <dbl>, `1/28/20` <dbl>, dated <chr>,
## #   cases_confirmed <dbl>
```

```
d2_glo <- d1_glo %>%
  group_by(`Country/Region`, dated) %>%
```

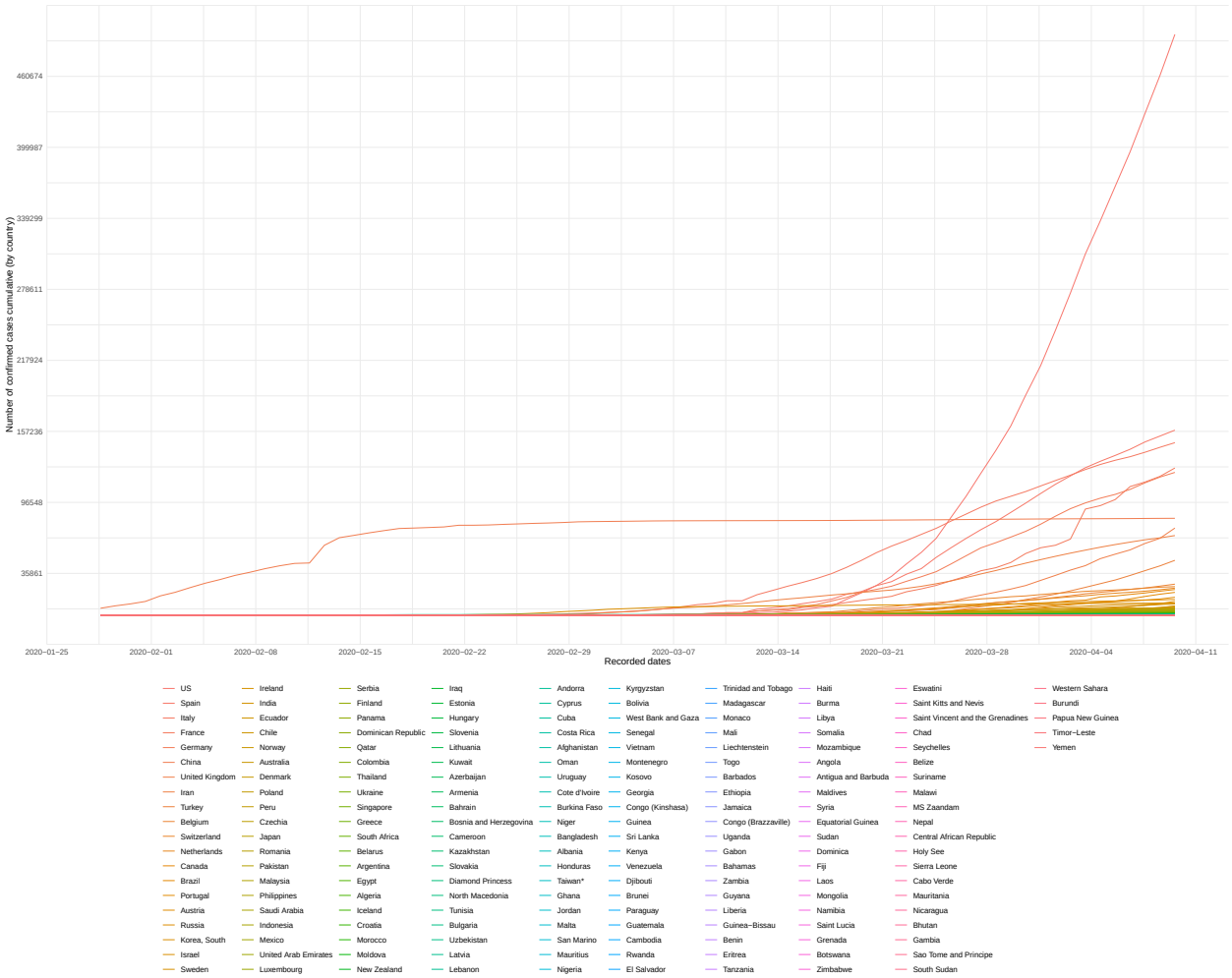
```
  summarise(n_cases_confirmed=sum(cases_confirmed)) %>%
  mutate(dated = as.Date(dated, format="%m/%d/%y")) %>%
  ungroup()
#tmp <- d2_usa %>% mutate('Country/Region' = 'United States')
#d2_glo <- rbind(tmp, d2_glo)
#d2_glo

country_order_desc <- d2_glo %>%
  filter(dated==max(dated)) %>%
  arrange(desc(n_cases_confirmed)) %>%
  select(`Country/Region`) %>%
  c()

d3_glo <- d2_glo %>%
  mutate(`Country/Region` =
           fct_relevel(`Country/Region`,
                       levels = c(country_order_desc)))
```

```
## Warning: Outer names are only allowed for unnamed scalar atomic inputs
```

```
ggplot(d3_glo, aes(dated, n_cases_confirmed, colour = `Country/Region`)) +
  geom_line() +
  scale_x_date('Recorded dates',
               breaks = function(x) seq.Date(from = min(x),
                                             to = max(x),
                                             by = "1 week")) +
  scale_y_continuous('Number of confirmed cases cumulative (by country)',
                     breaks = function (x) round(seq.int(from = min(x),
                                 to = max(x),
                                 length.out = 10))) +
  theme_minimal() +
  theme(legend.position = "bottom",
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 20))
```




```
d3_glo
```

```
## # A tibble: 13,505 x 3
##    `Country/Region` dated      n_cases_confirmed
##    <fct>            <date>                 <dbl>
##  1 Afghanistan      2020-01-29                 0
##  2 Afghanistan      2020-01-30                 0
##  3 Afghanistan      2020-01-31                 0
##  4 Afghanistan      2020-02-01                 0
##  5 Afghanistan      2020-02-10                 0
##  6 Afghanistan      2020-02-11                 0
##  7 Afghanistan      2020-02-12                 0
##  8 Afghanistan      2020-02-13                 0
##  9 Afghanistan      2020-02-14                 0
## 10 Afghanistan      2020-02-15                 0
## # ... with 13,495 more rows
```

```
d3_glo %>%
  group_by(`Country/Region`) %>%
  arrange(dated) %>%
  mutate(n_bydateirmed = ifelse(dated != min(d3_glo$dated),
                                n_cases_confirmed -
                                  d3_glo[which(d3_glo$dated == dated &
```

```
                                                    d3_glo$`Country/Region` == `Country/Region`),
                                                "n_cases_confirmed"], 0))
```

```
## # A tibble: 13,505 x 4
## # Groups:   Country/Region [185]
##    `Country/Region`    dated      n_cases_confirmed n_bydateirmed
##    <fct>               <date>                 <dbl> <list>
##  1 Afghanistan         2020-01-29                 0 <dbl [1]>
##  2 Albania             2020-01-29                 0 <dbl [1]>
##  3 Algeria             2020-01-29                 0 <dbl [1]>
##  4 Andorra             2020-01-29                 0 <dbl [1]>
##  5 Angola              2020-01-29                 0 <dbl [1]>
##  6 Antigua and Barbuda 2020-01-29                 0 <dbl [1]>
##  7 Argentina           2020-01-29                 0 <dbl [1]>
##  8 Armenia             2020-01-29                 0 <dbl [1]>
##  9 Australia           2020-01-29                 6 <dbl [1]>
## 10 Austria             2020-01-29                 0 <dbl [1]>
## # ... with 13,495 more rows
```

```
d4_glo <- d3_glo

d4_glo <- d4_glo %>%
  mutate(`Country/Region` = as.character(`Country/Region`)) %>%
  as.data.frame()

cl <- makeCluster(parallel::detectCores())
registerDoParallel(cl)

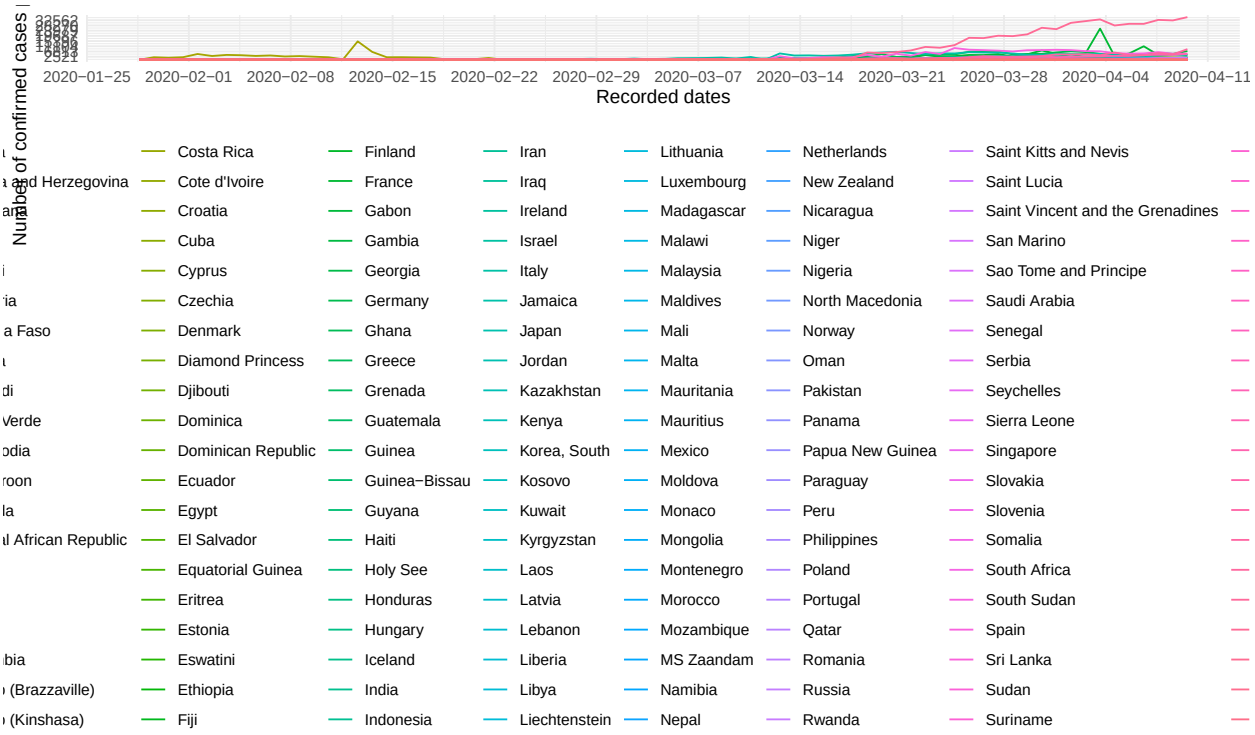
tmp = foreach (i = 1:nrow(d4_glo), .combine = 'c', .inorder=T) %dopar% {
  cty = as.character(d4_glo[i,'Country/Region'])
  dt = d4_glo [i, 'dated']
  dts = d4_glo[order(as.Date(d4_glo[which(d4_glo$`Country/Region` == cty), 'dated'])),'dated']
  dt_pos = which(dts == dt)
  if (dt_pos > 1){
    prev_dt = dts[dt_pos-1]
    d4_glo[i,'n_cases_confirmed'] - d4_glo[which(d4_glo[,'Country/Region'] == cty &
                                                   d4_glo[,'dated'] == prev_dt),'n_cases_confirmed']
  }else{
    0
  }
}
stopCluster(cl)

d4_glo$n_bydate = unlist(tmp)

d4_glo <- d4_glo %>%
  mutate(`Country/Region` = as.factor(`Country/Region`))

ggplot(d4_glo, aes(dated, n_bydate, colour = `Country/Region`)) +
  geom_line() +
  scale_x_date('Recorded dates',
               breaks = function(x) seq.Date(from = min(x),
                                             to = max(x),
                                             by = "1 week")) +
```

```
  scale_y_continuous('Number of confirmed cases per date (by country)',
                     breaks = function (x) round(seq.int(from = min(x),
                                to = max(x),
                                length.out = 10))) +
  theme_minimal() +
  theme(legend.position = "bottom",
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 20))
```



adding smoother

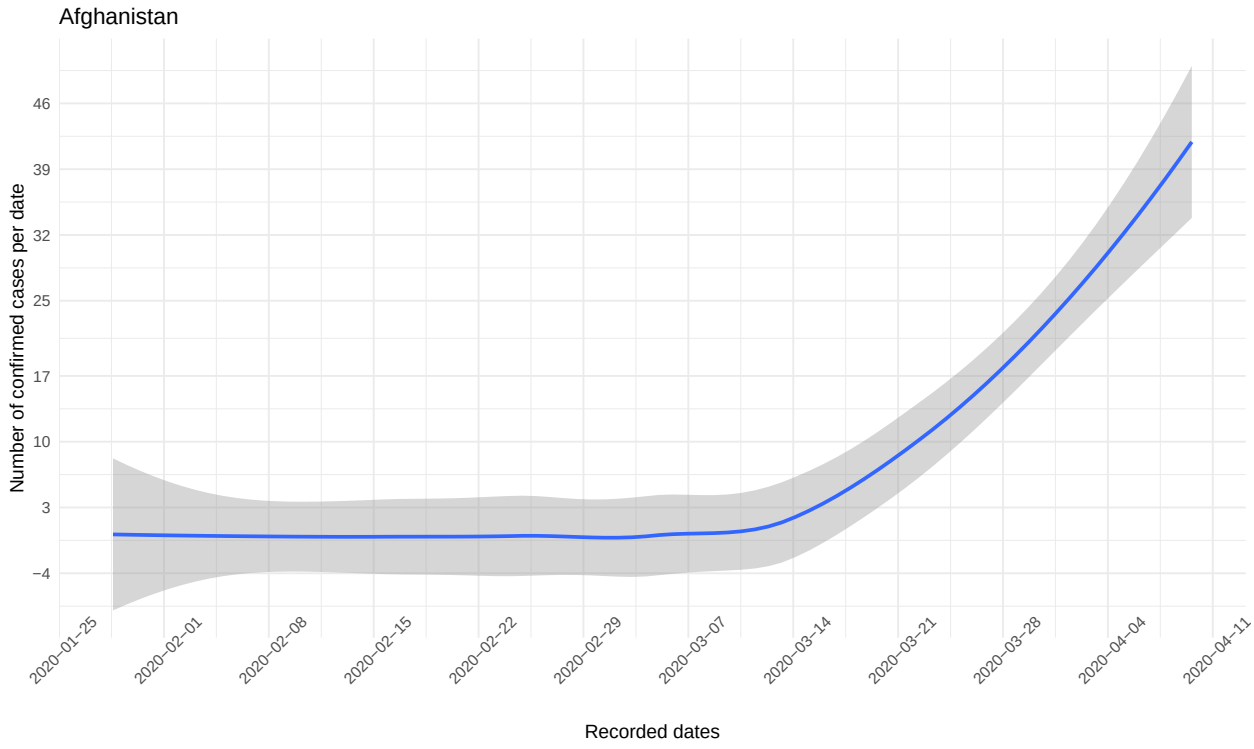
```
ggplot(d4_glo, aes(dated, n_bydate, colour = `Country/Region`)) +
  geom_smooth() +
  scale_x_date('Recorded dates',
               breaks = function(x) seq.Date(from = min(x),
                                             to = max(x),
                                             by = "1 week")) +
  scale_y_continuous('Number of confirmed cases per date (by country)',
                     breaks = function (x) round(seq.int(from = min(x),
                                to = max(x),
                                length.out = 10))) +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45),
        legend.position = "bottom",
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 20))
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

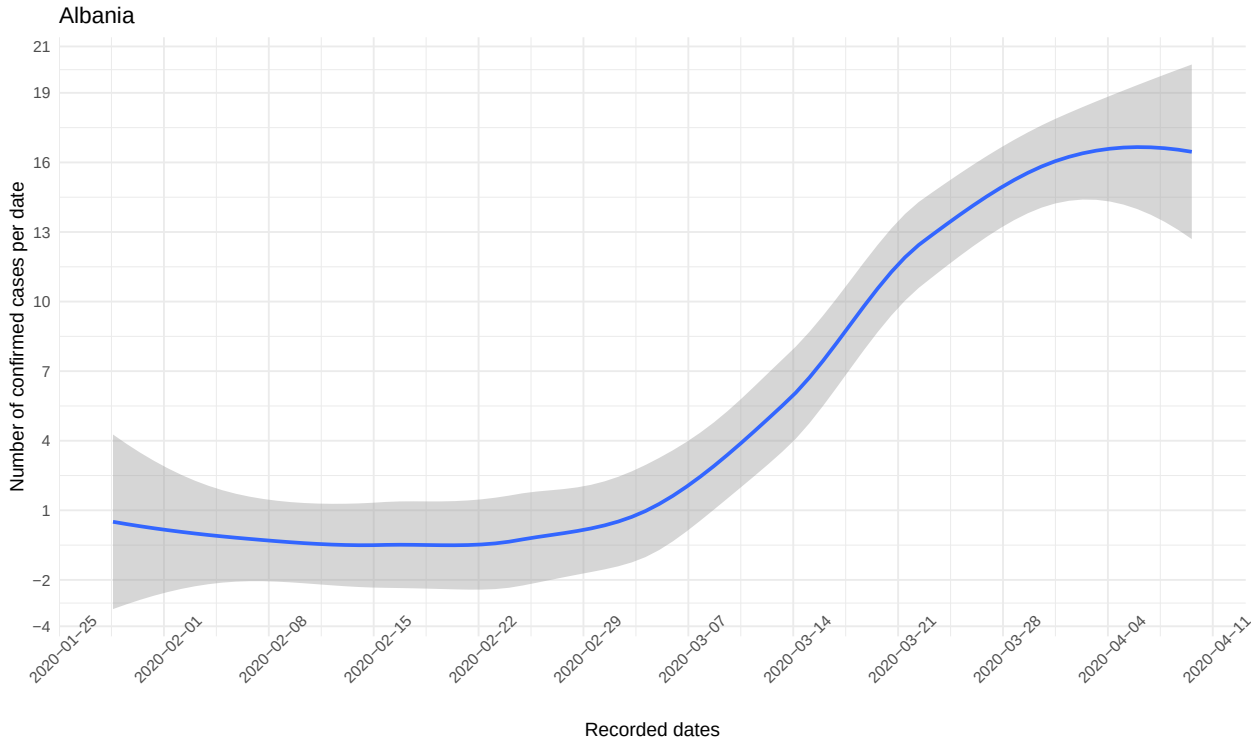

```
cty_uq = unique(d4_glo$`Country/Region`)
for (i in 1:length(cty_uq)) {
  df <- d4_glo %>% filter(`Country/Region` == cty_uq[i])

  plt <- ggplot(df, aes(dated, n_bydate)) +
  geom_smooth() +
  ggtitle(cty_uq[i]) +
  scale_x_date('Recorded dates',
               breaks = function(x) seq.Date(from = min(x),
                                             to = max(x),
                                             by = "1 week")) +
  scale_y_continuous('Number of confirmed cases per date',
                     breaks = function (x) round(seq.int(from = min(x),
                                to = max(x),
                                length.out = 10))) +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45),
        legend.position = "bottom",
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 20))
  print(plt)
}
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```




```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

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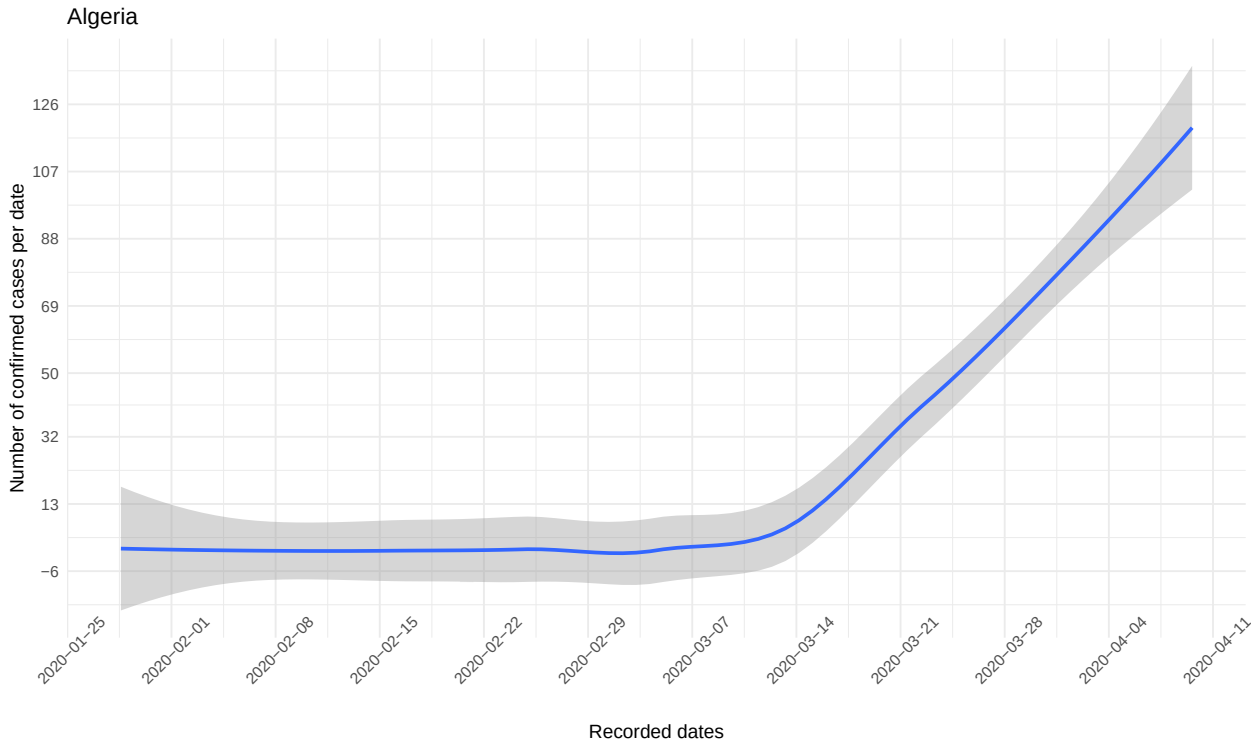


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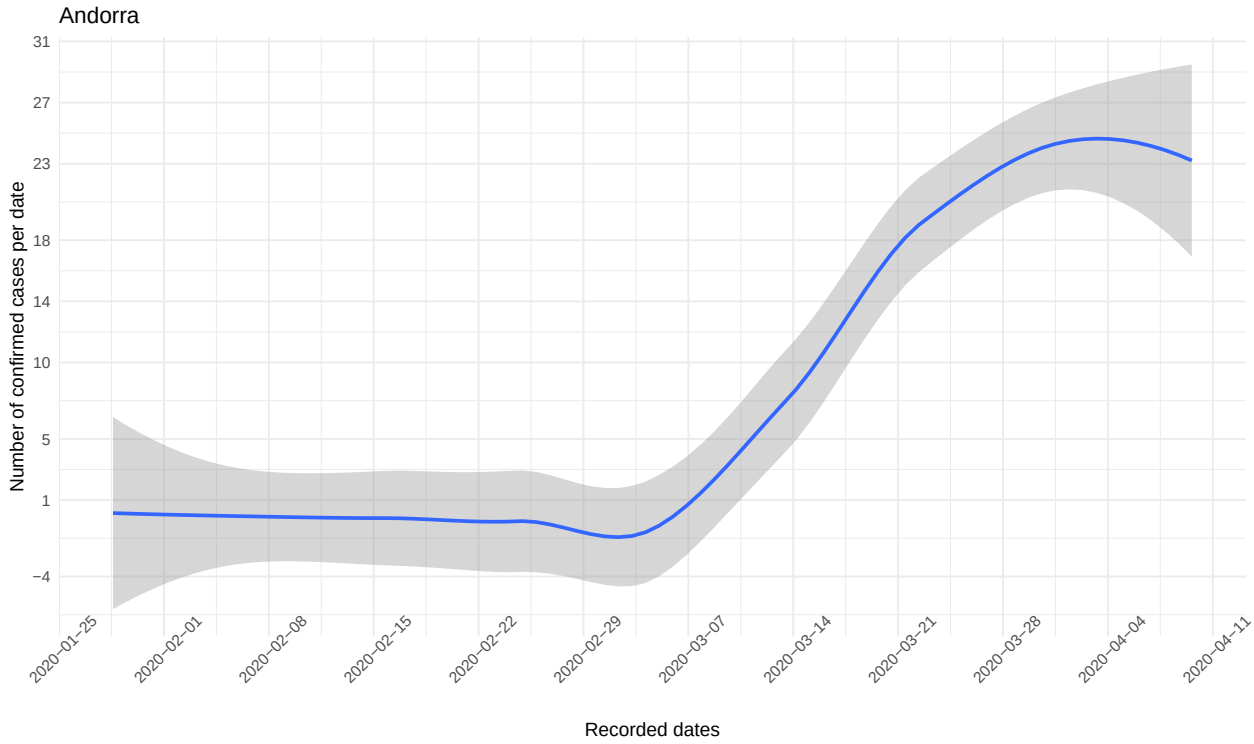


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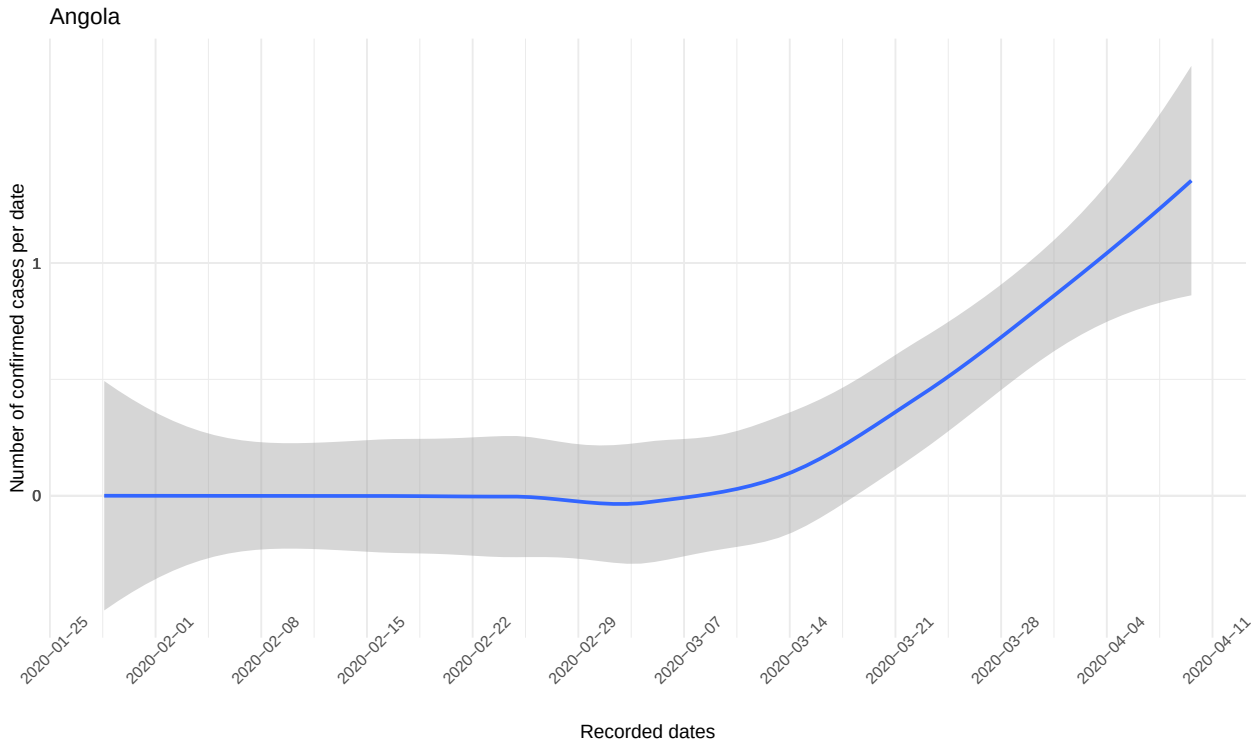


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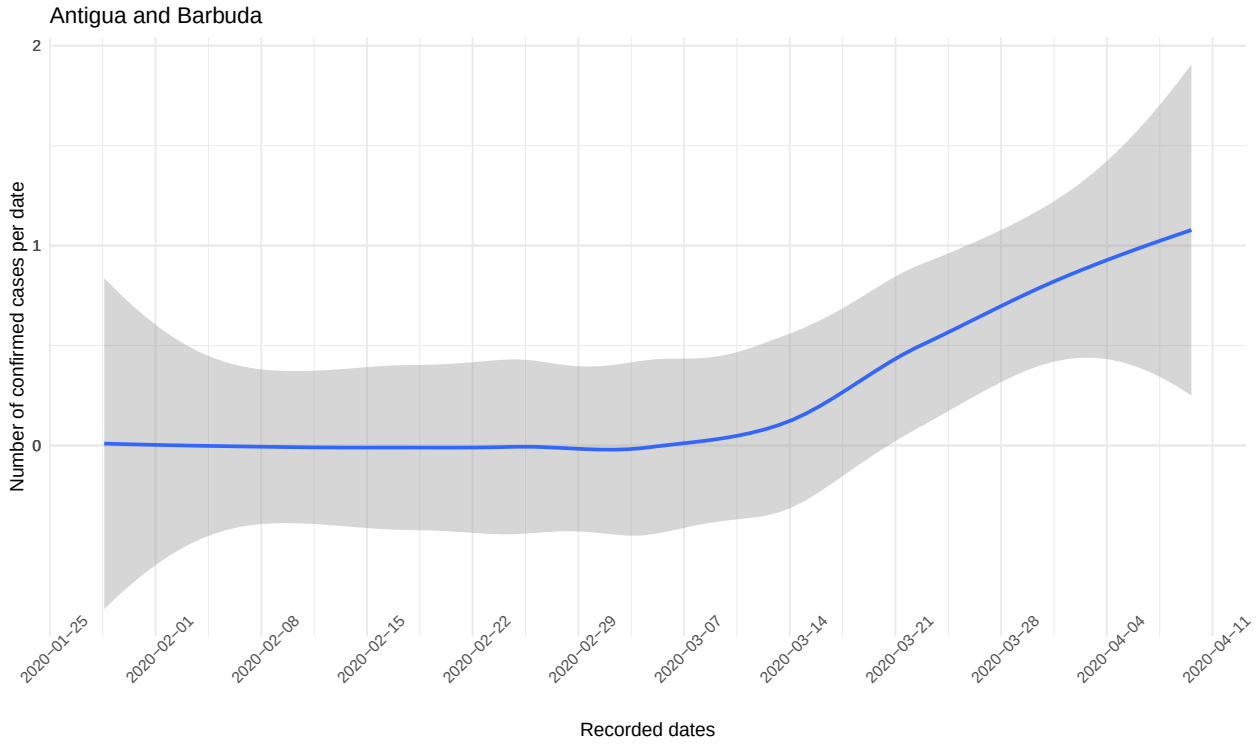


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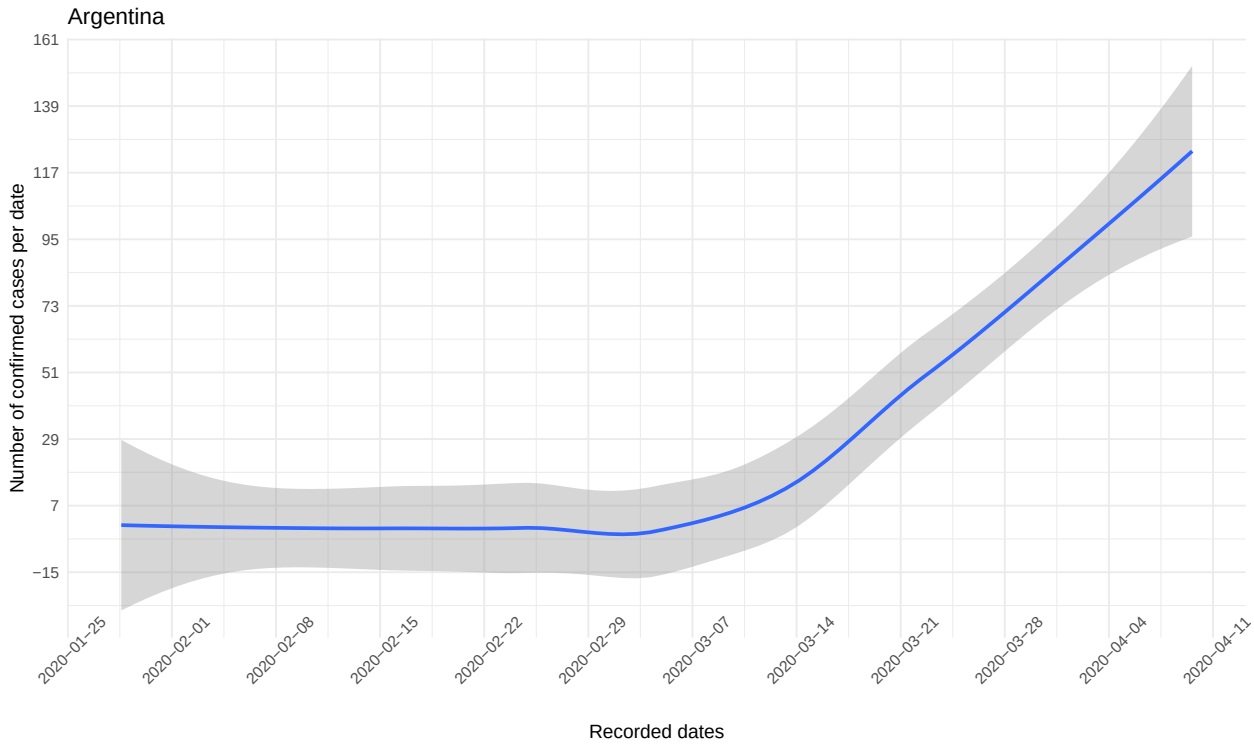


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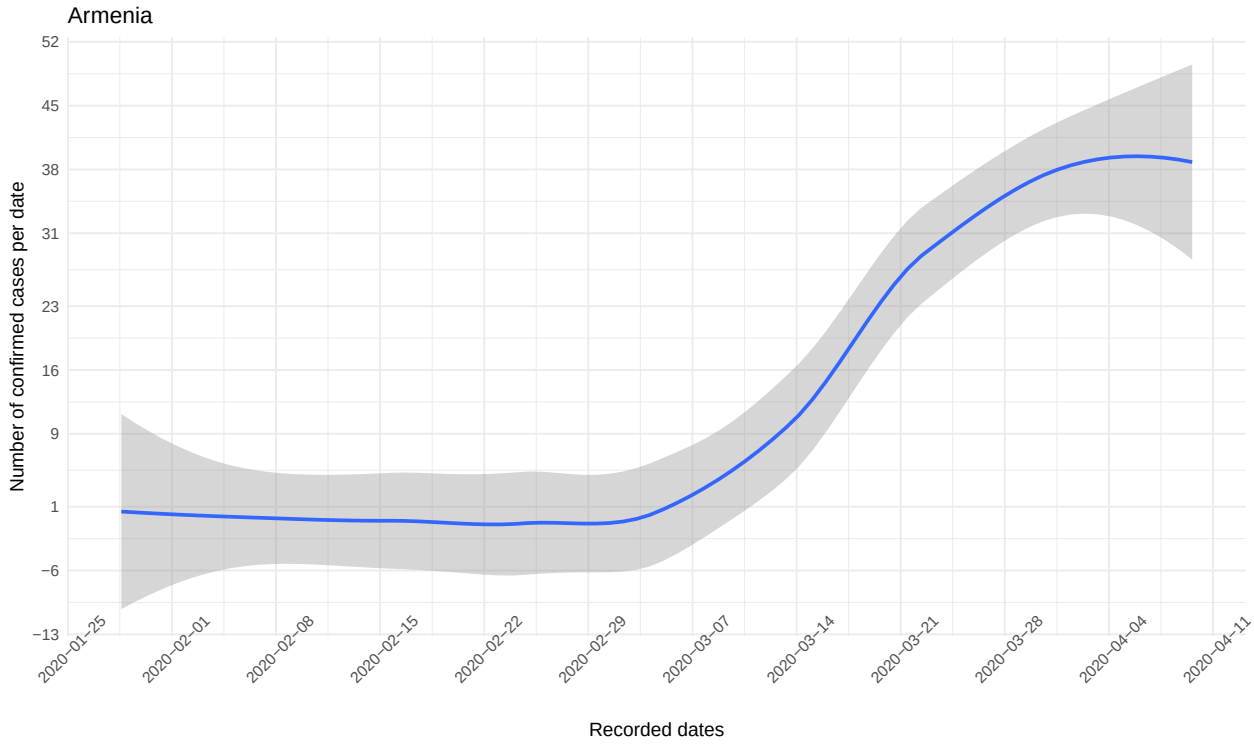


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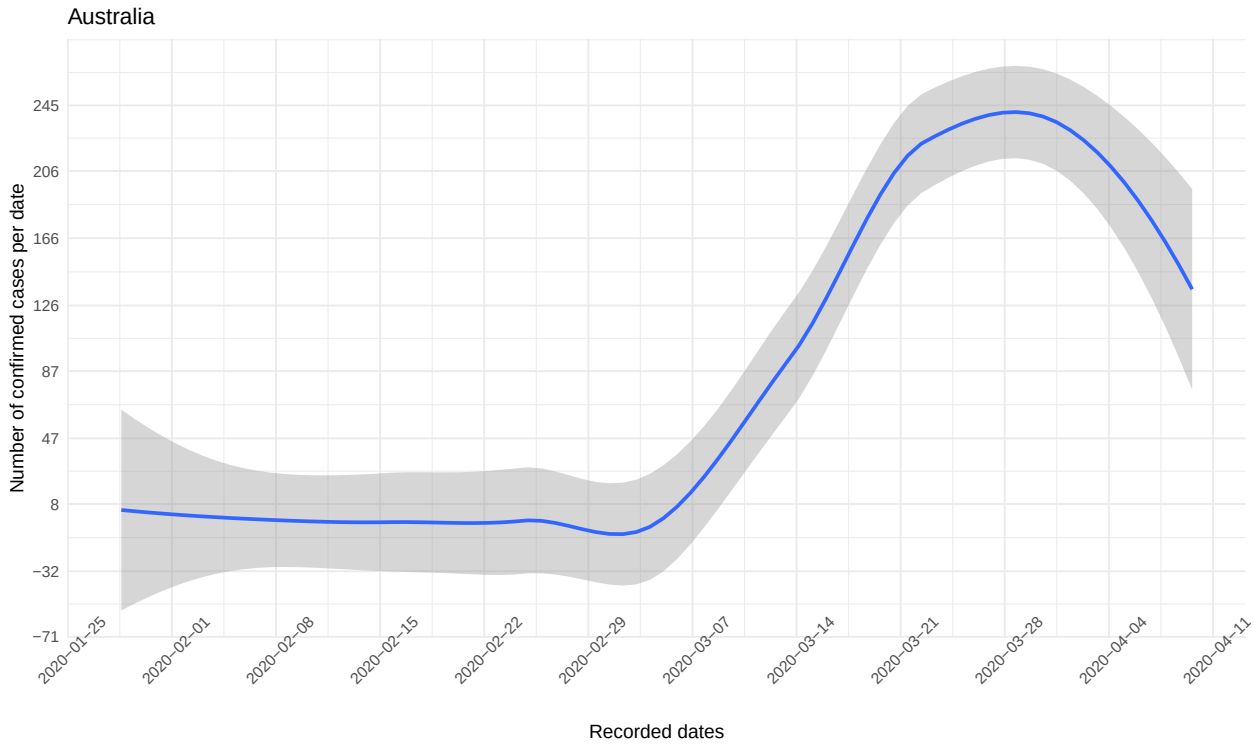


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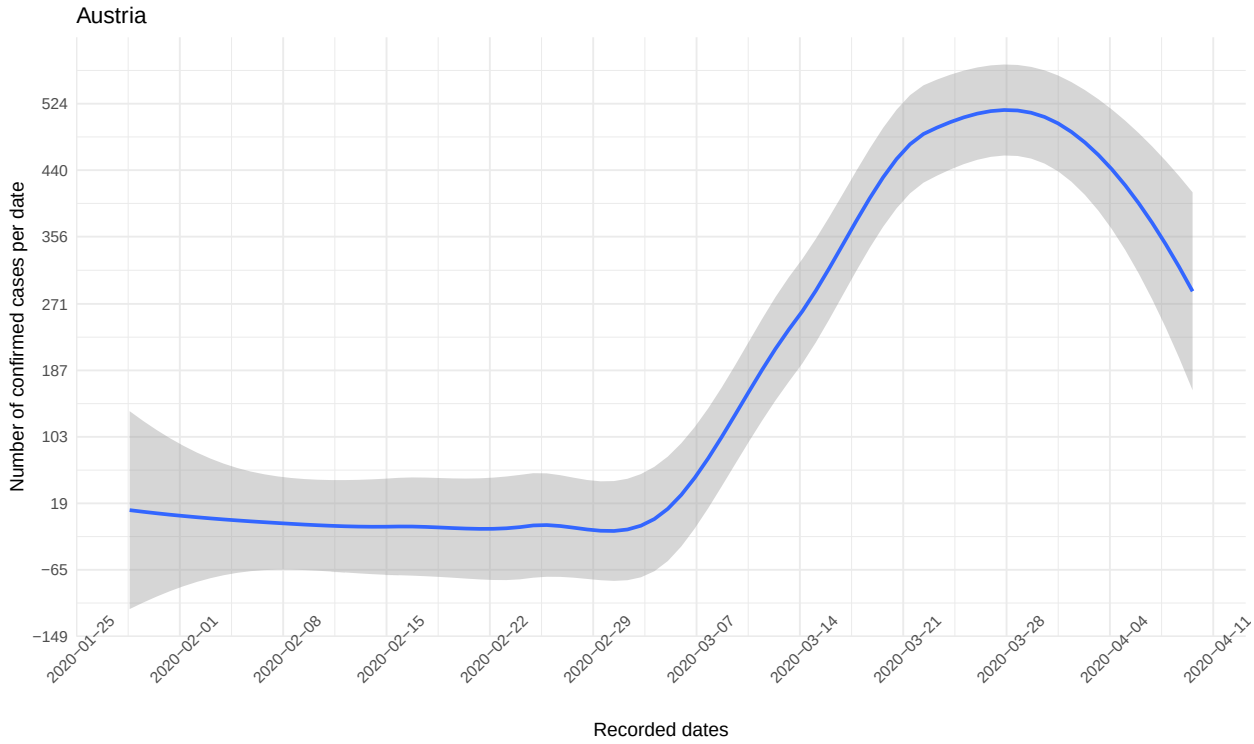


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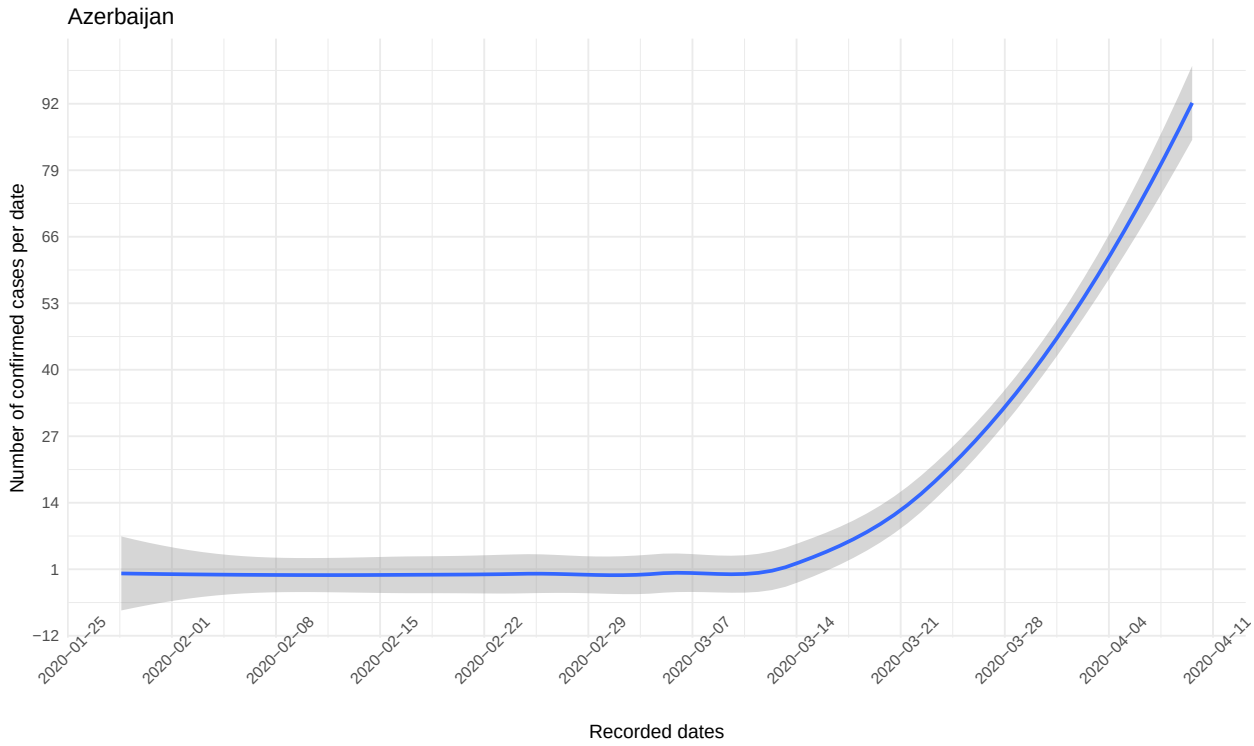


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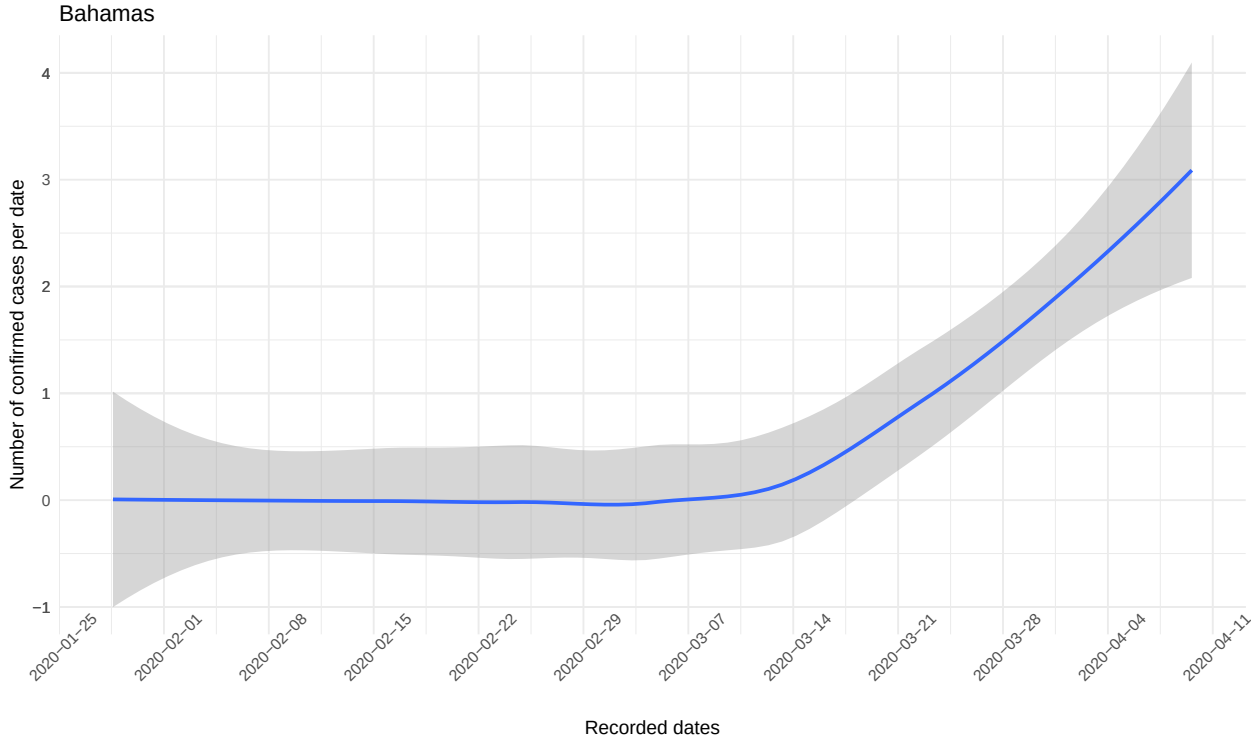


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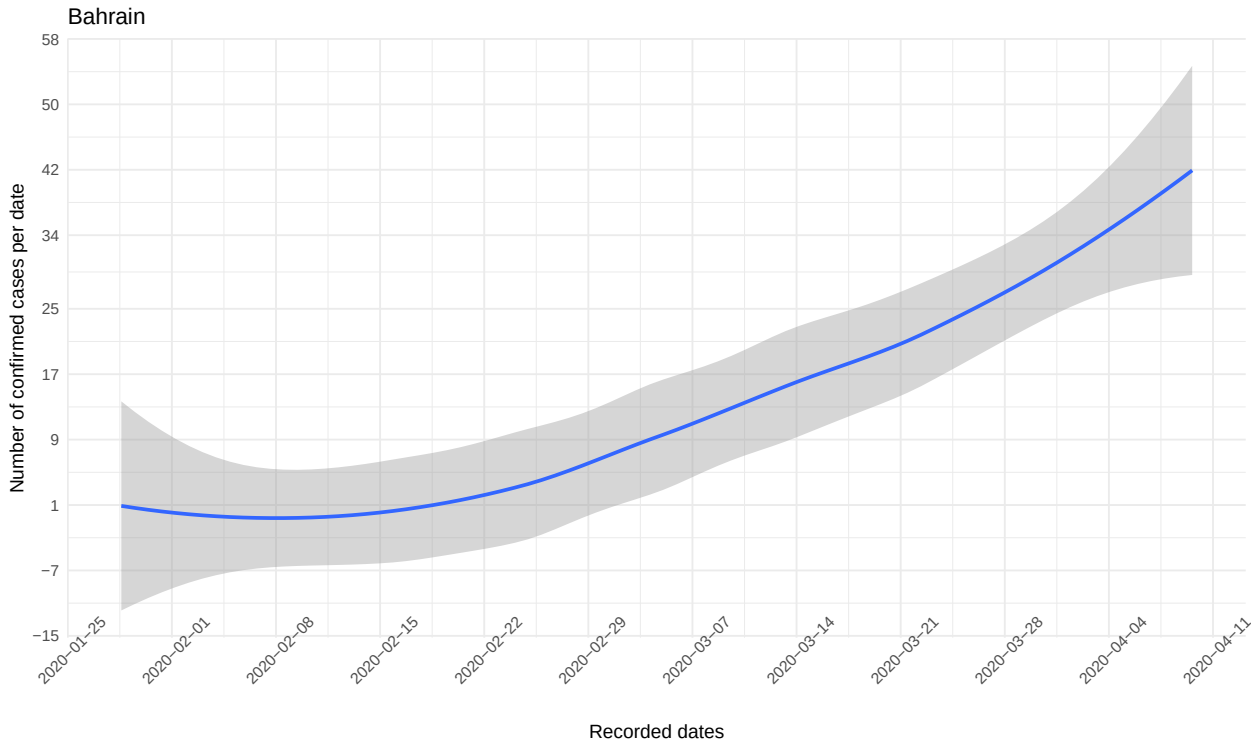


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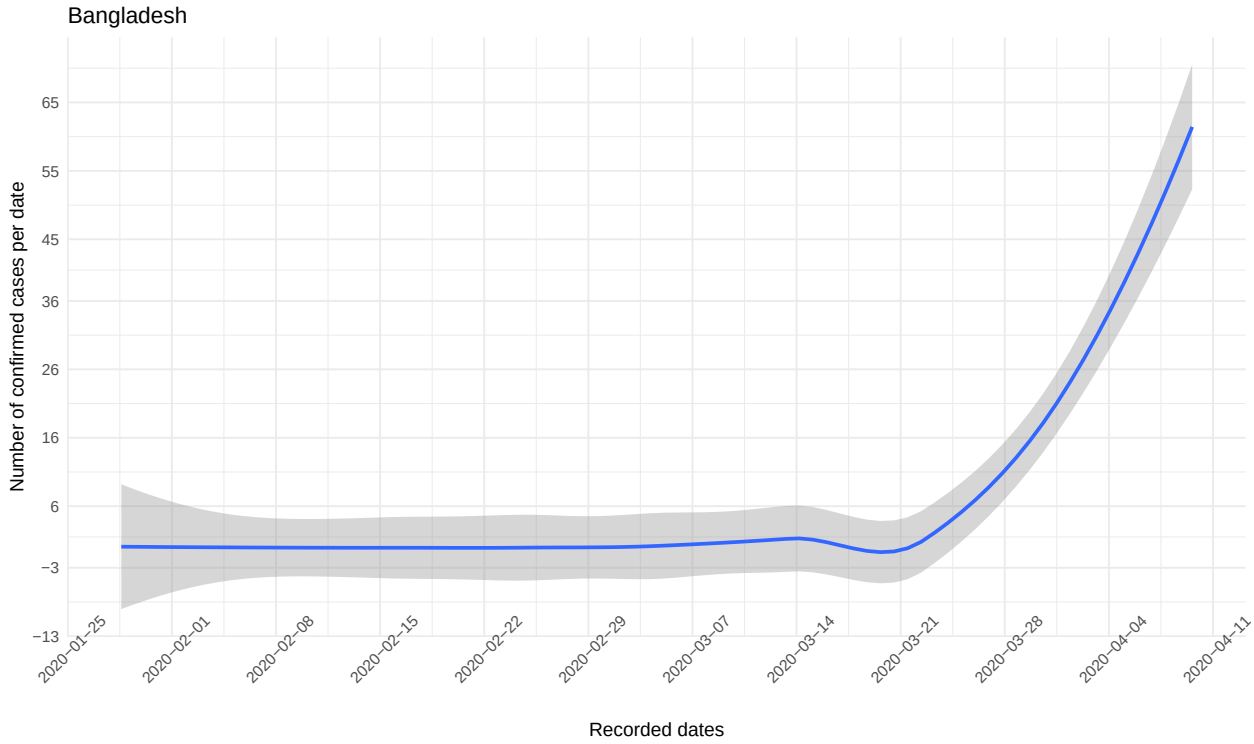


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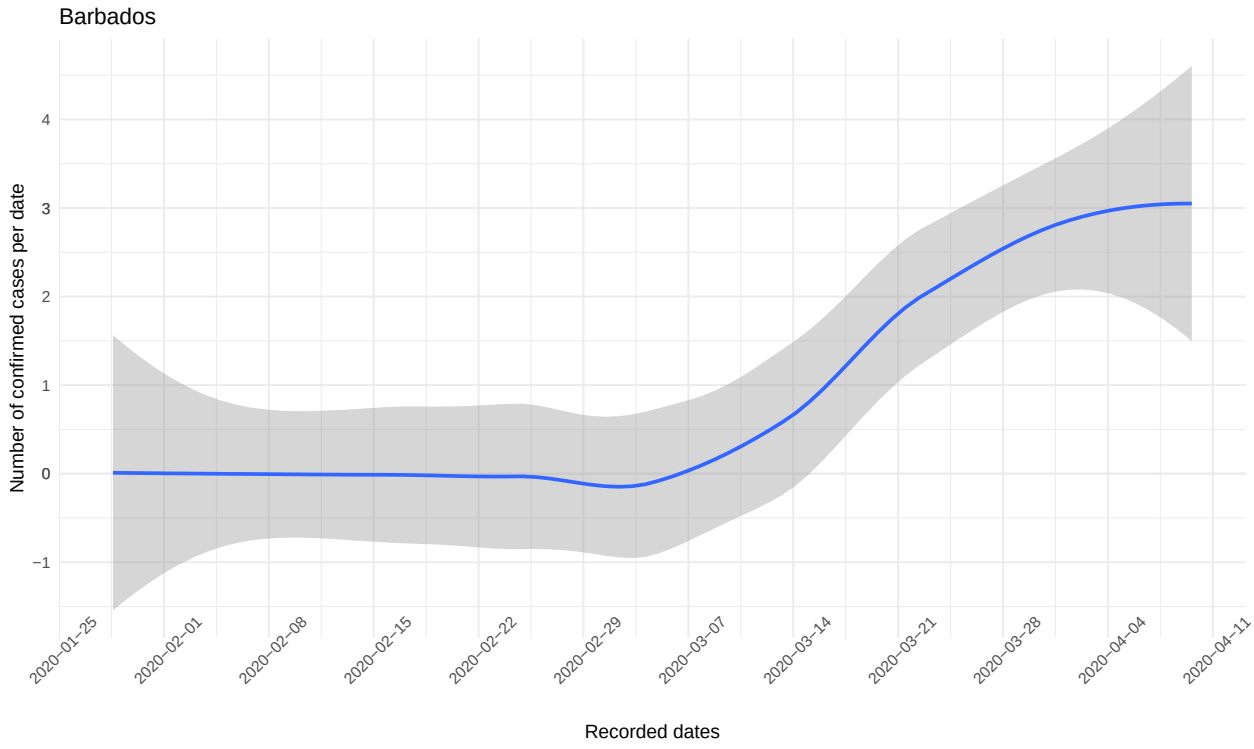


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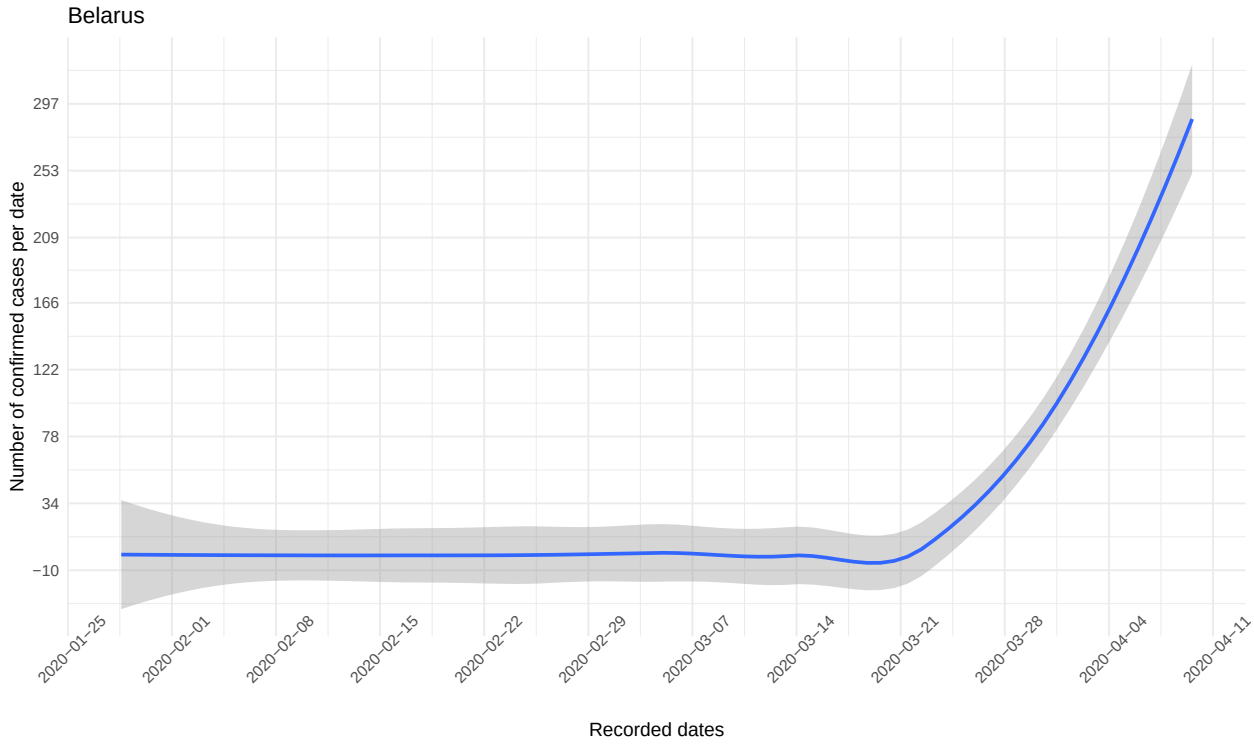


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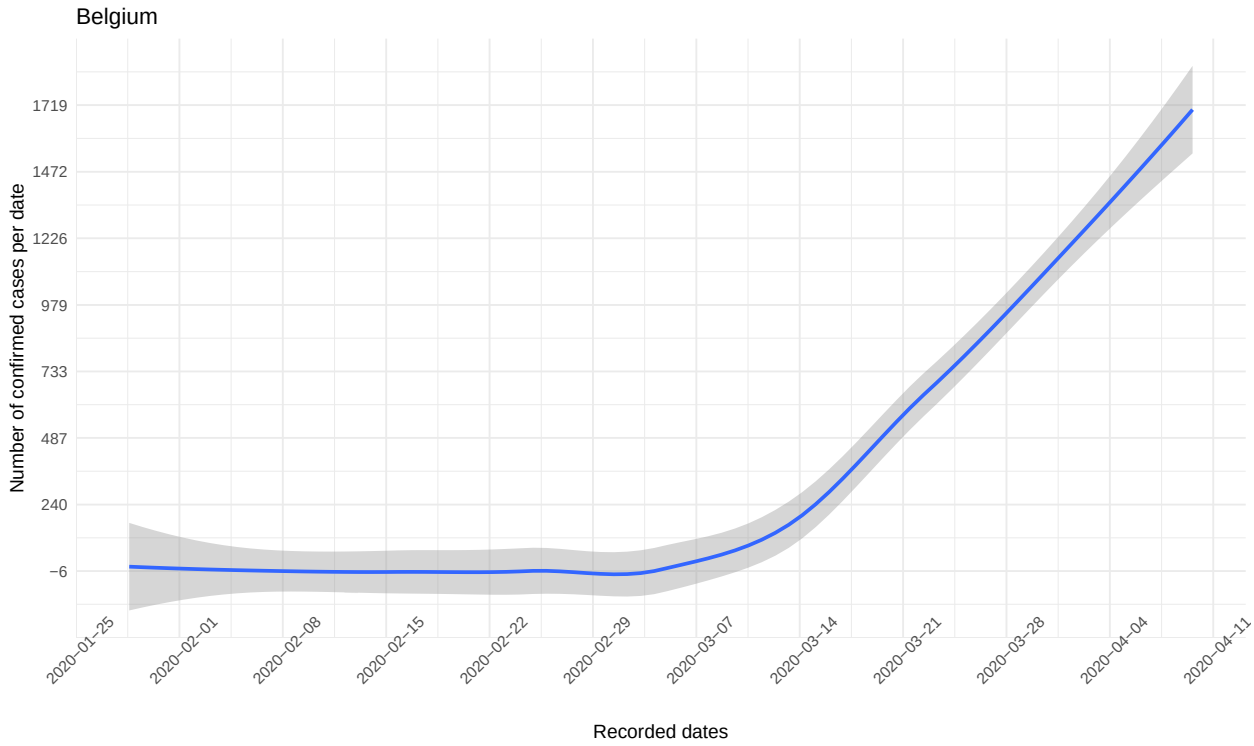


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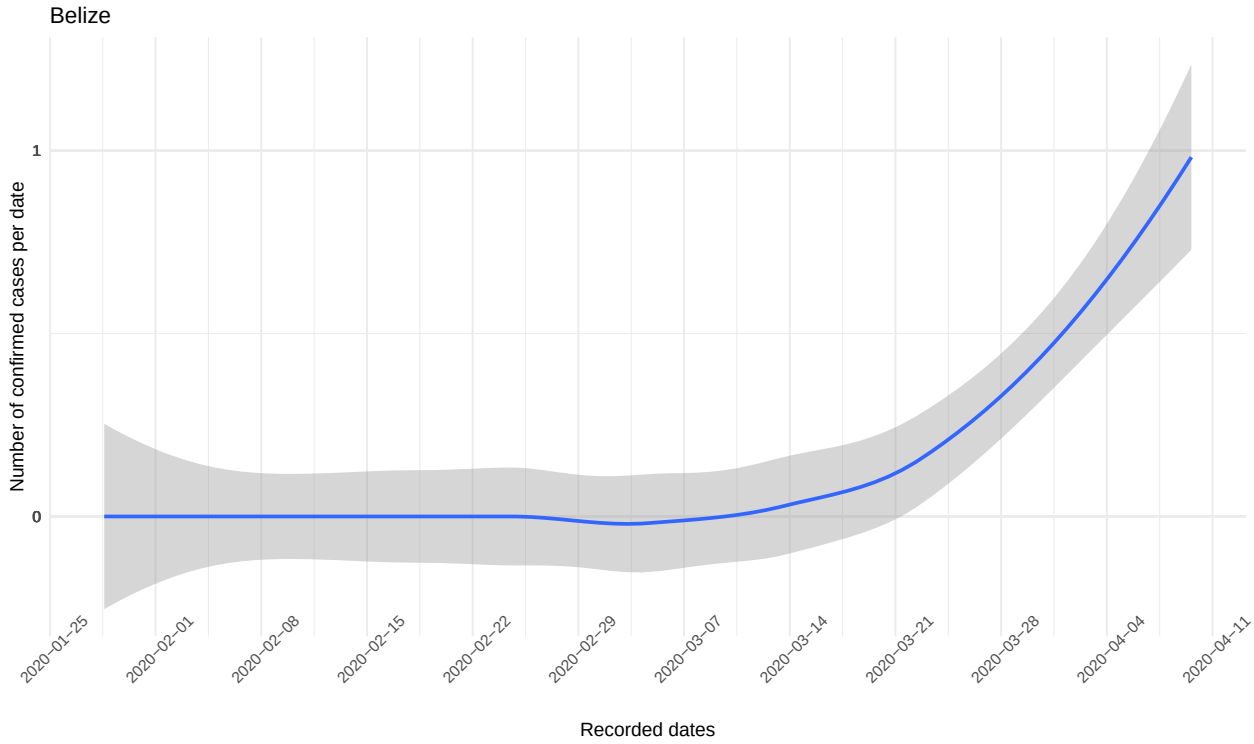


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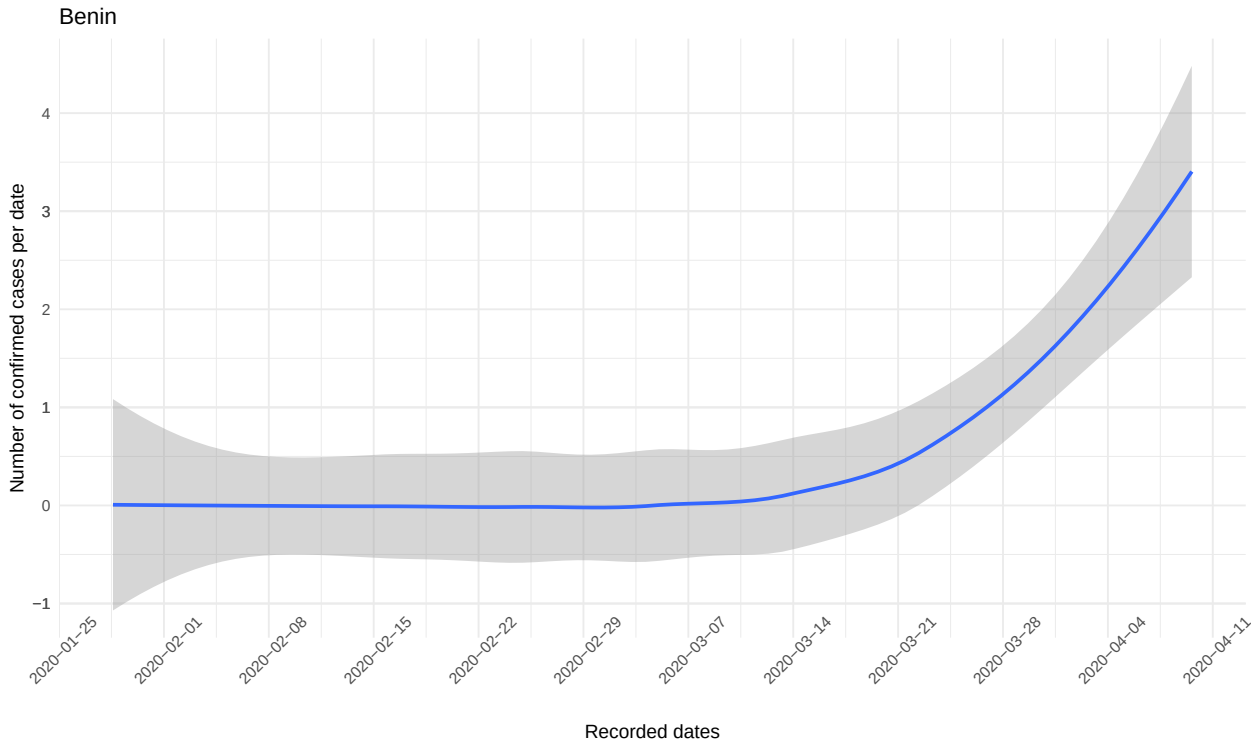


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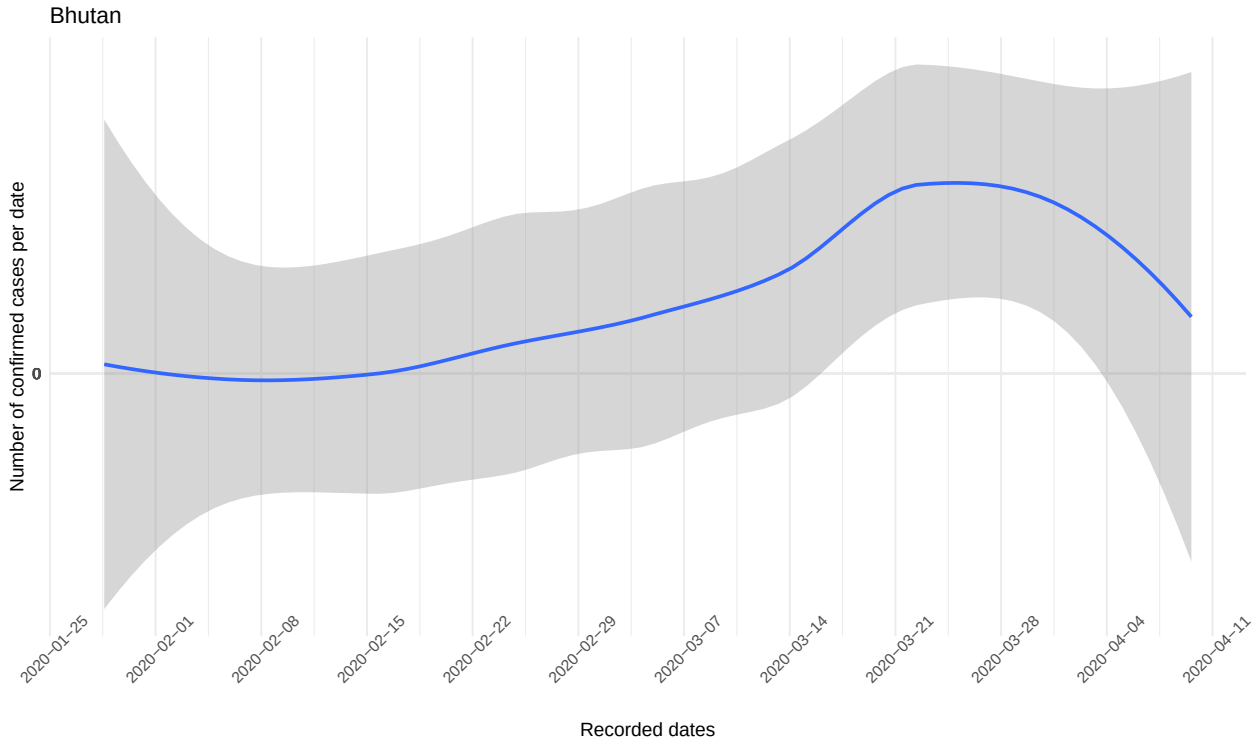


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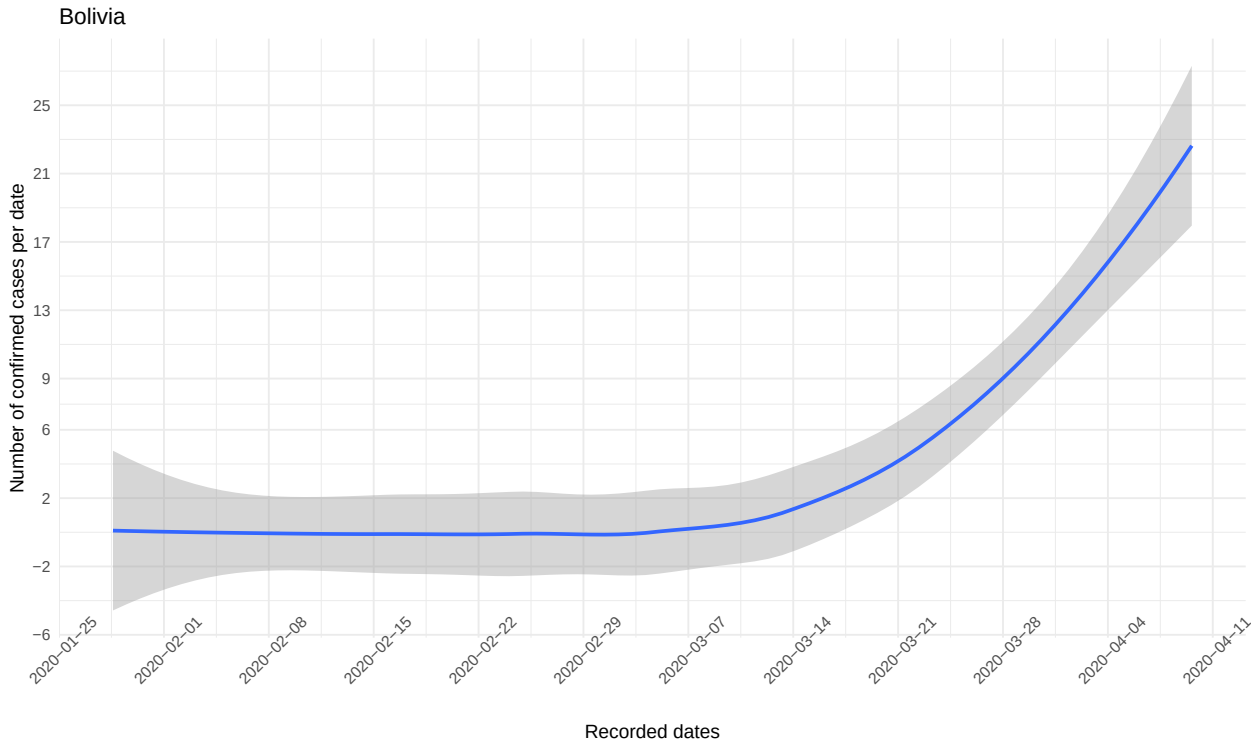


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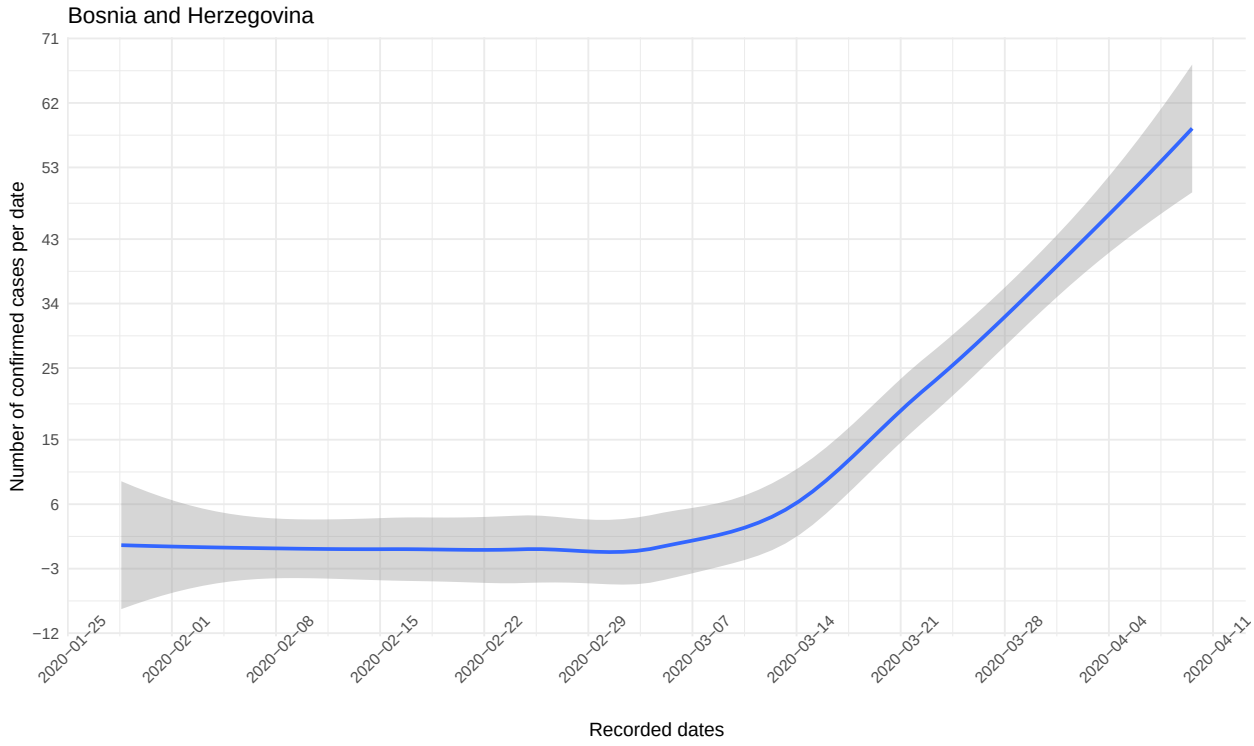


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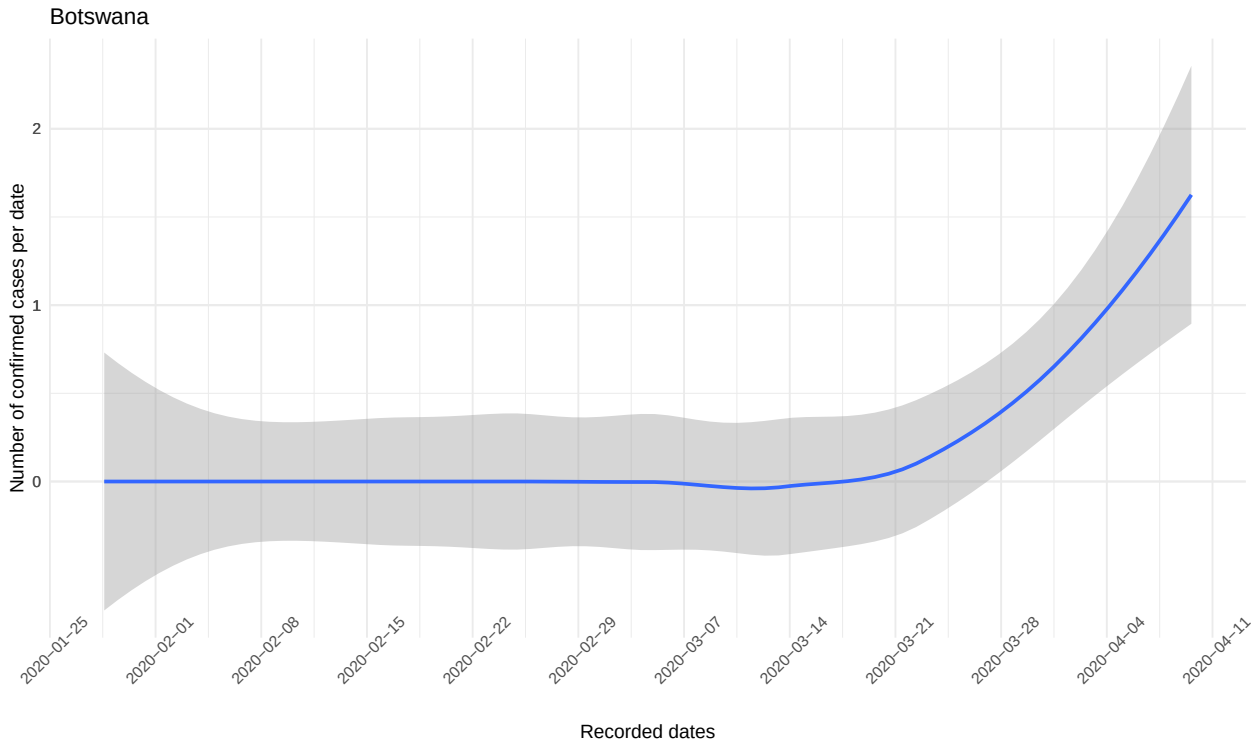


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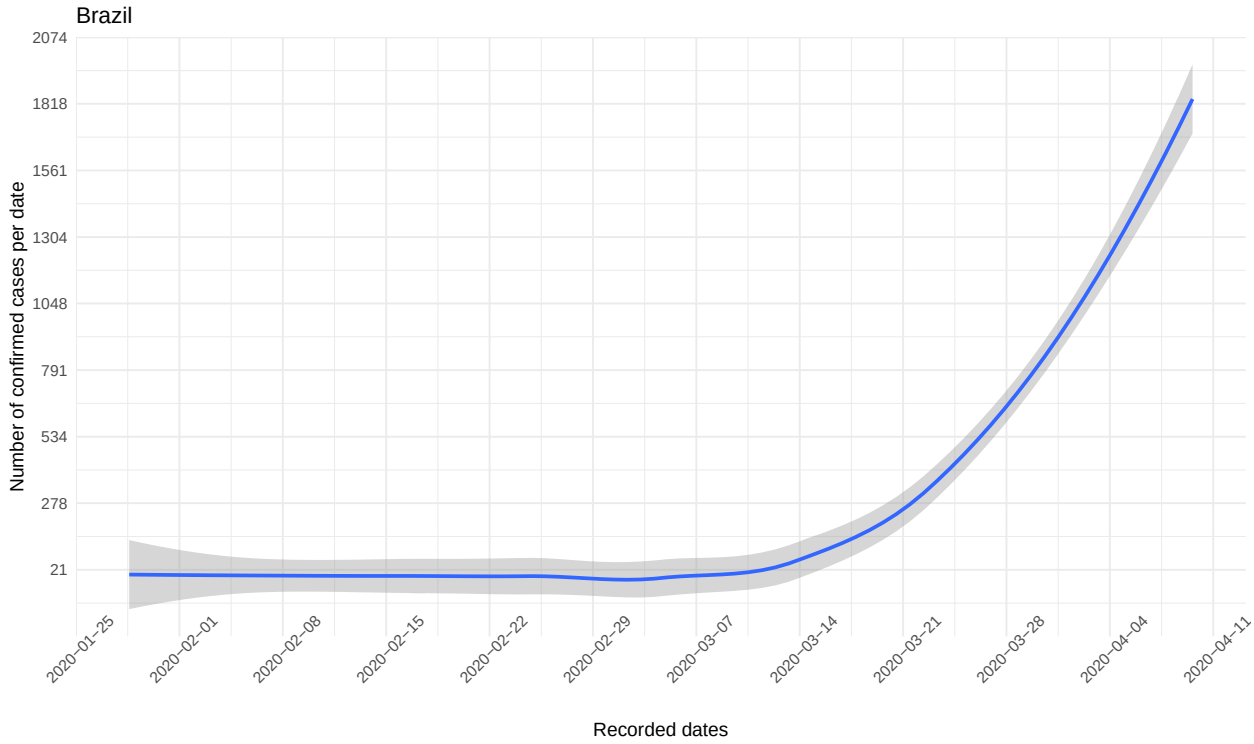


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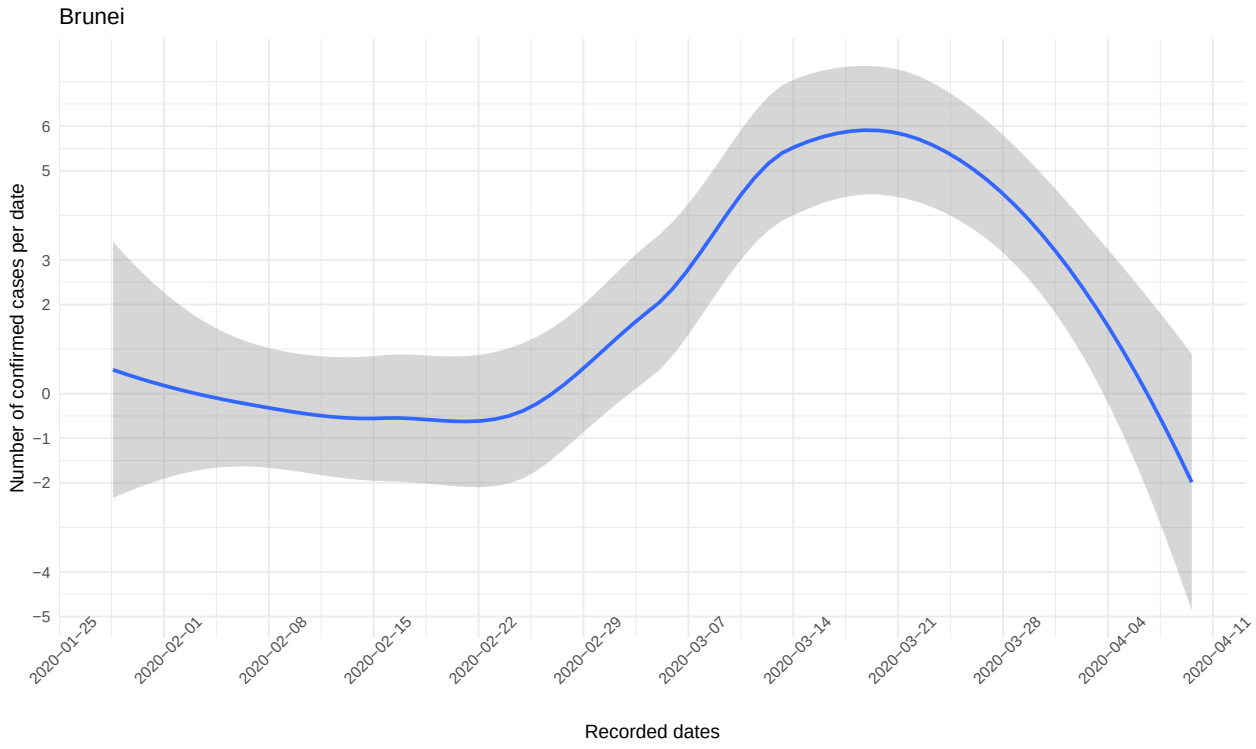


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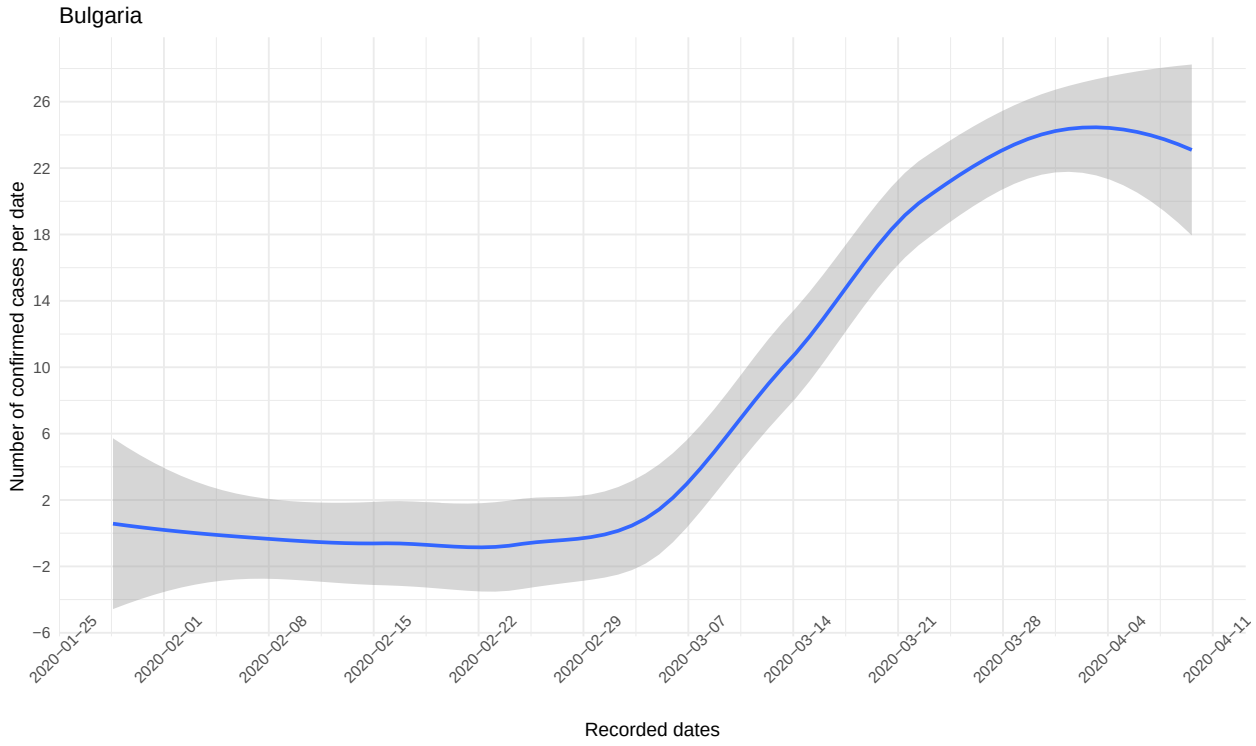


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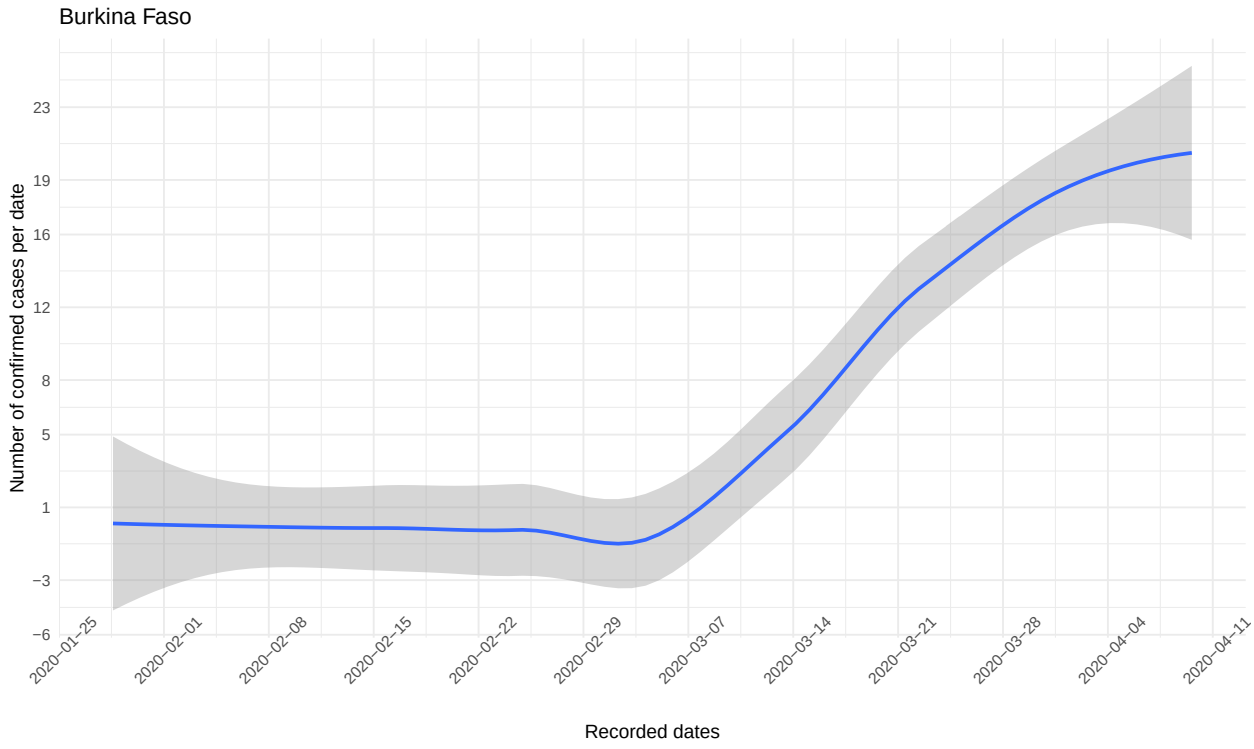


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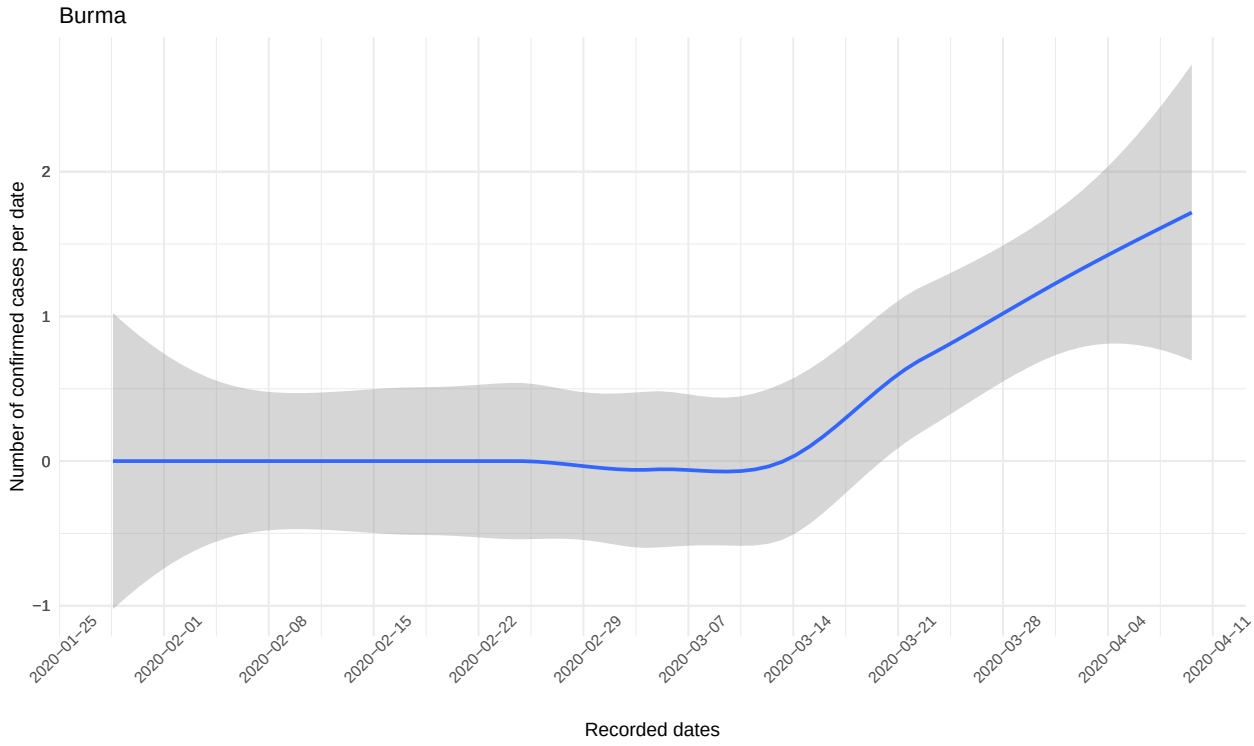


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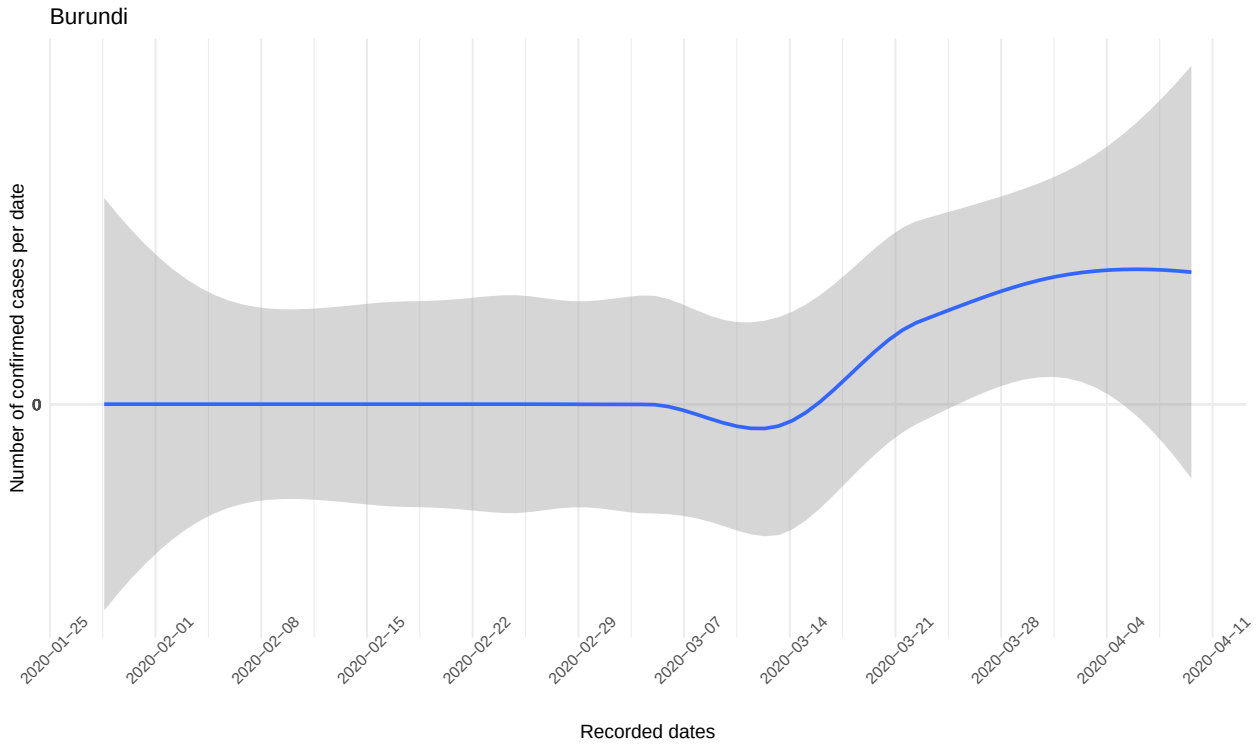


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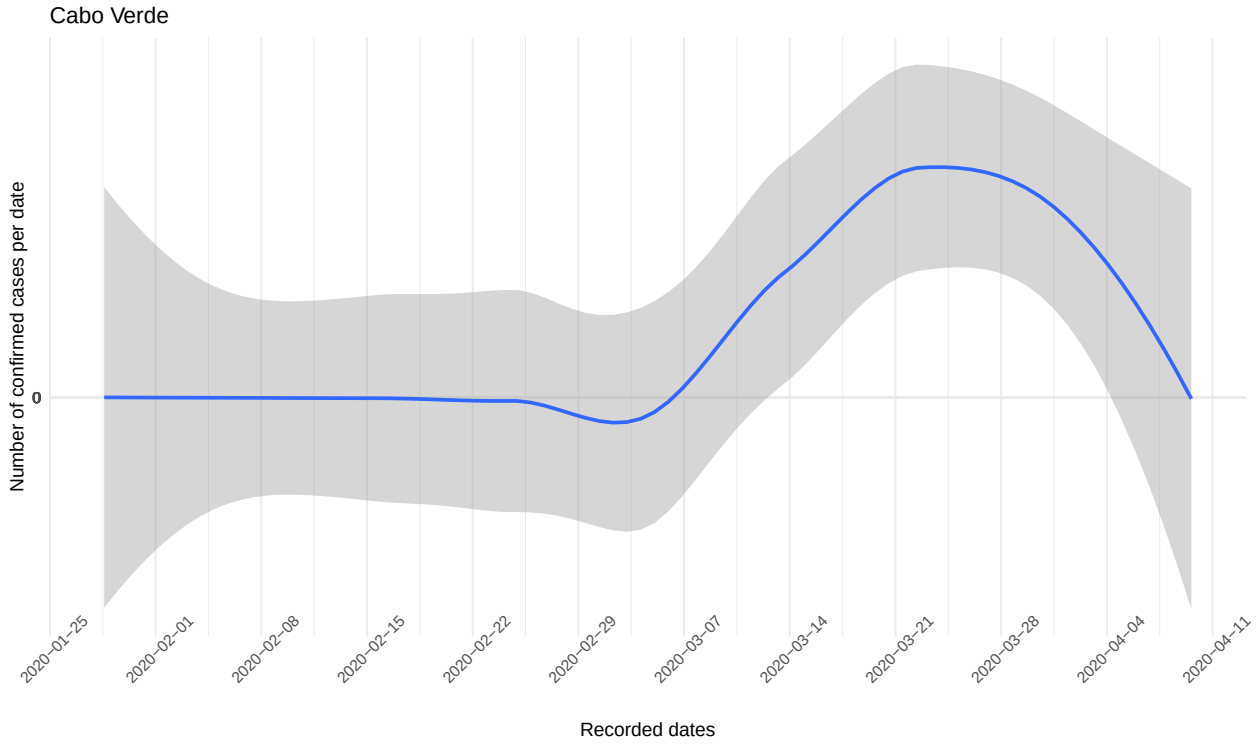


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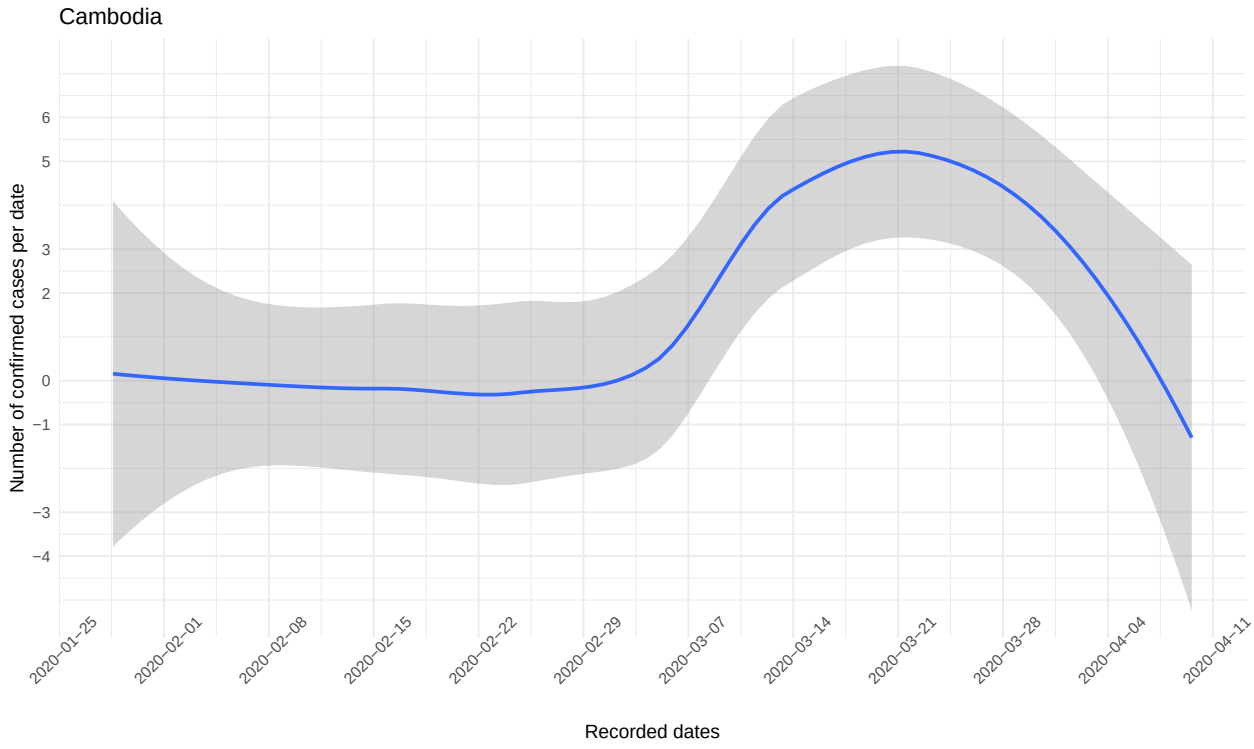


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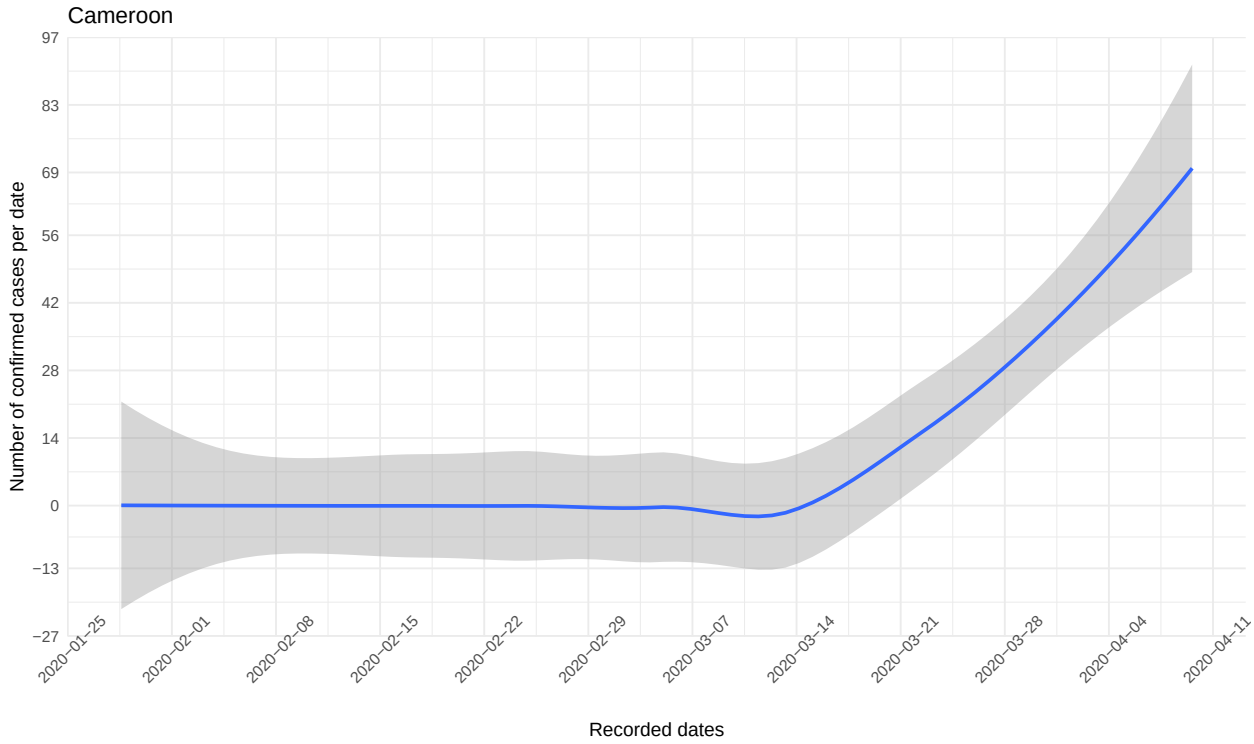


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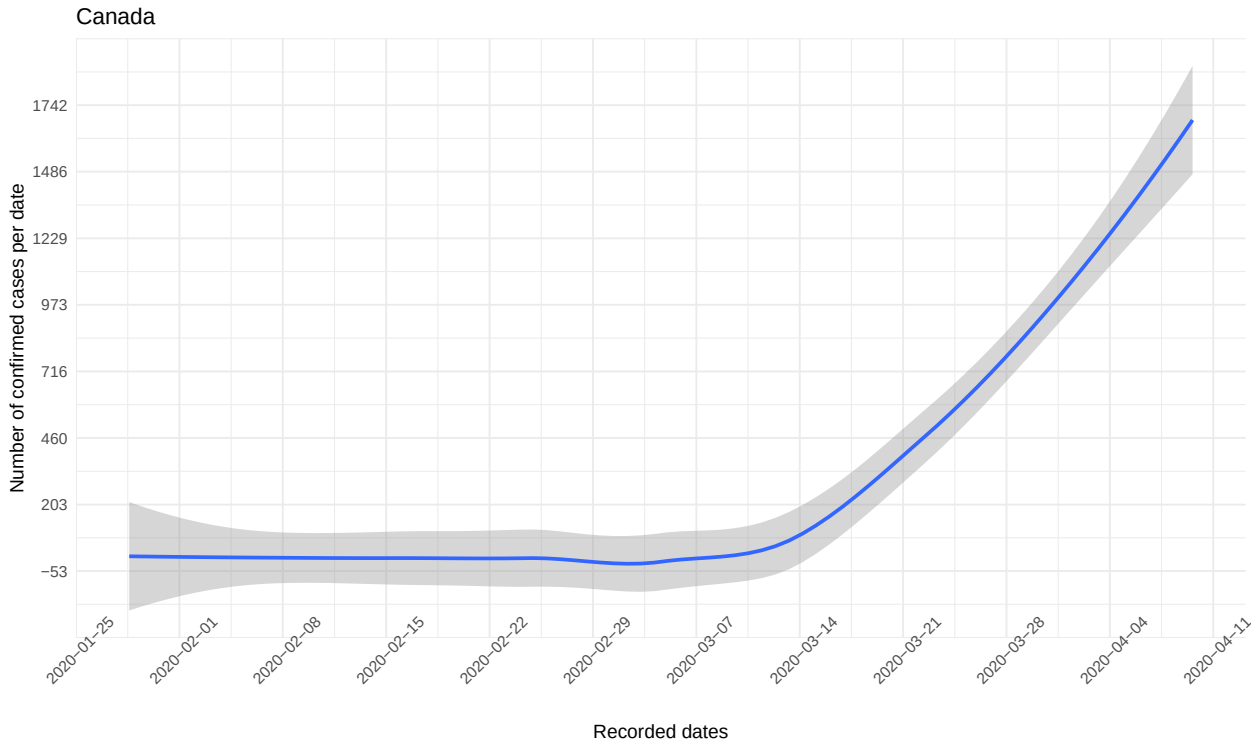


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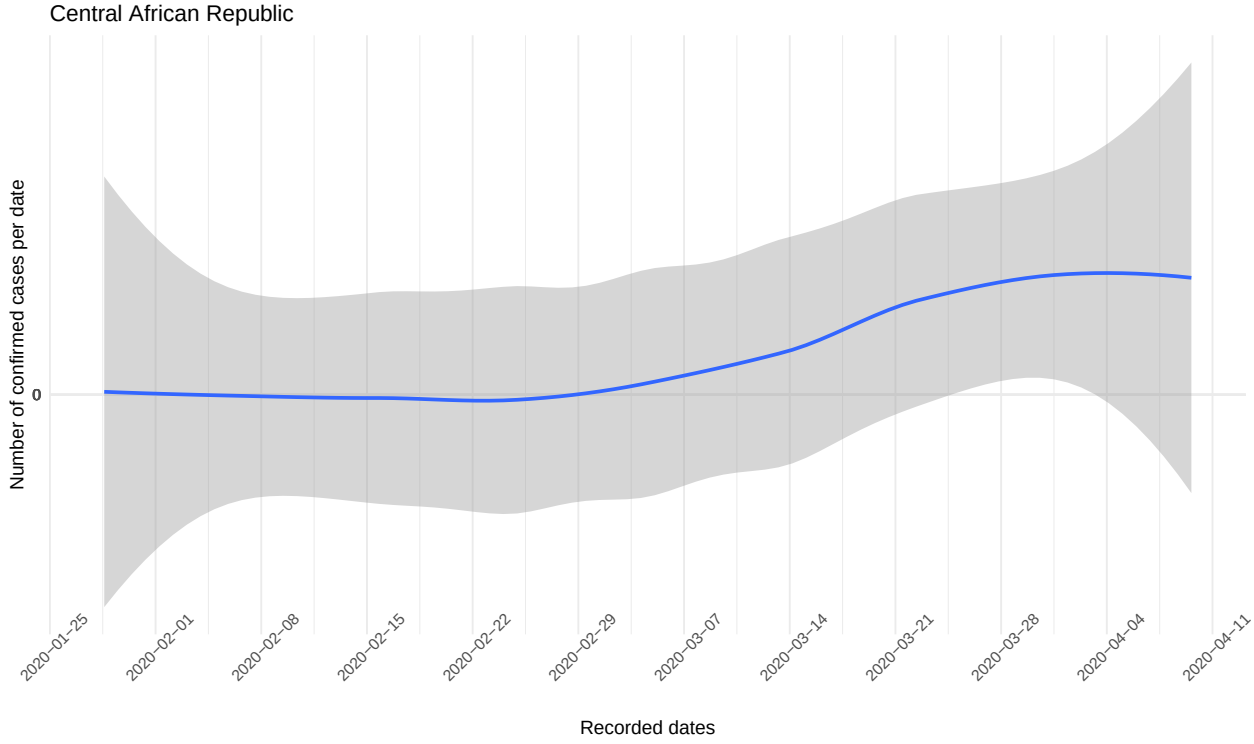


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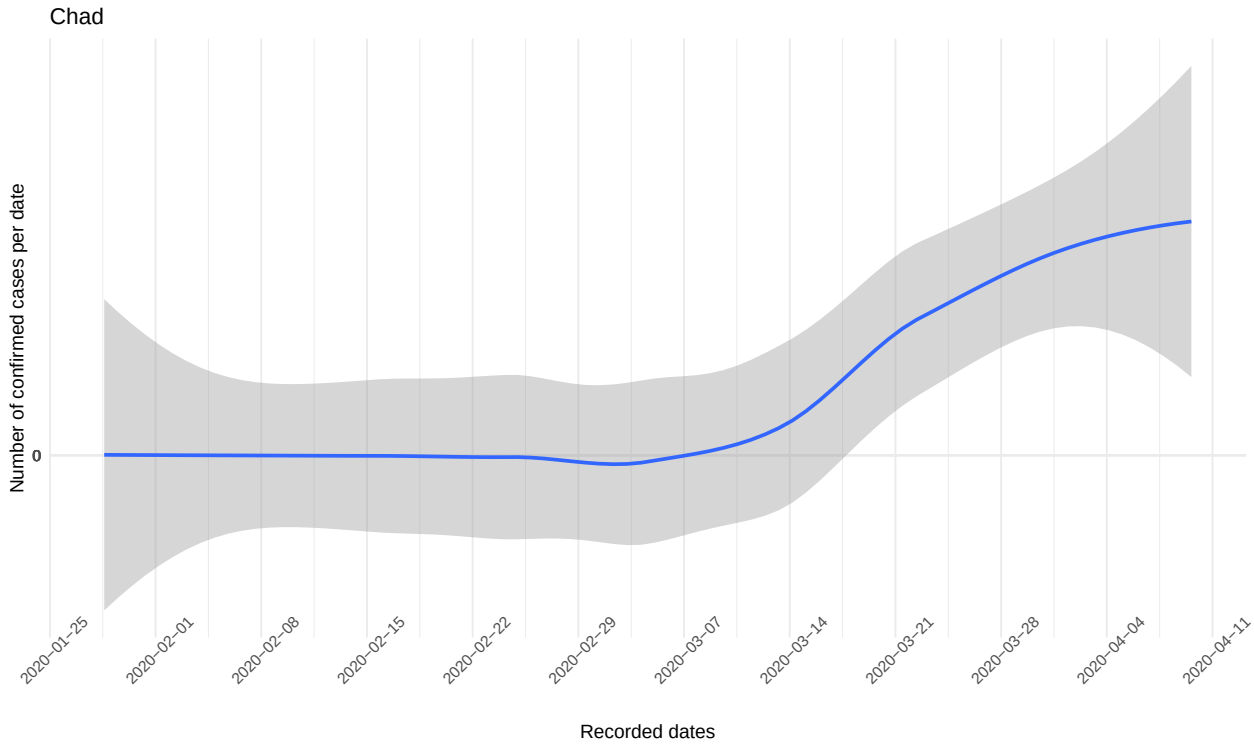


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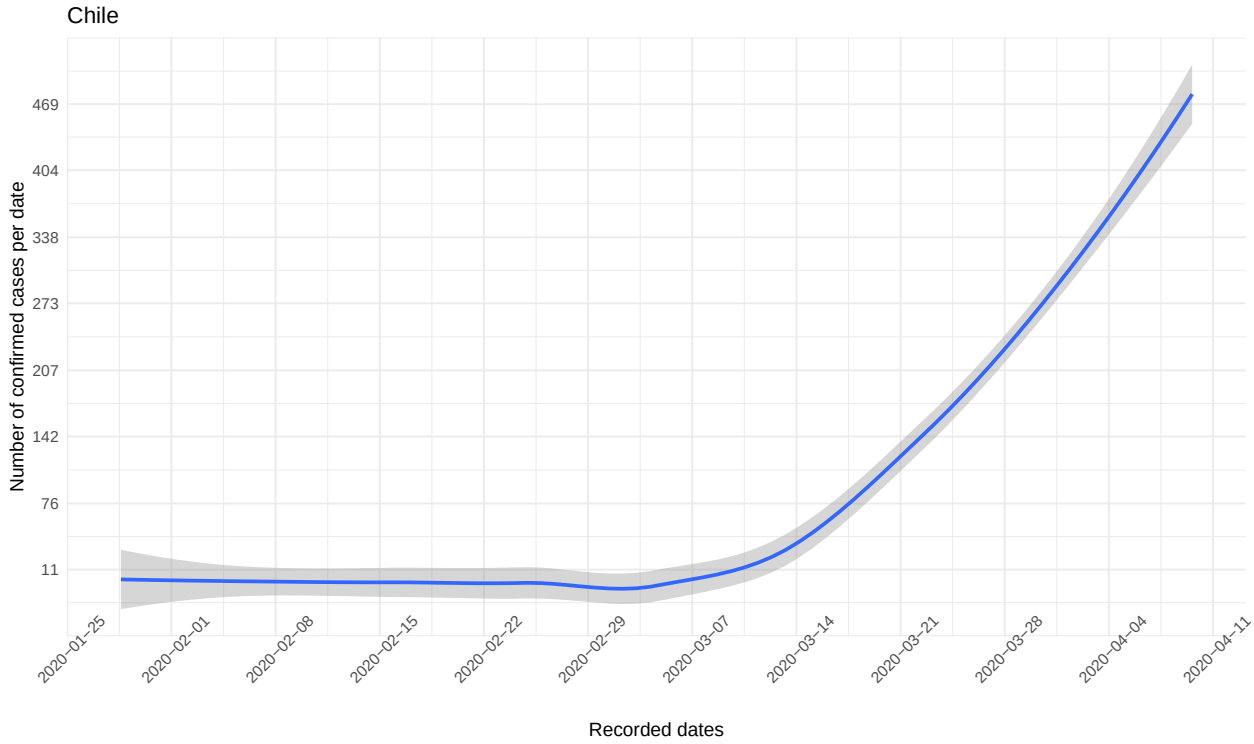


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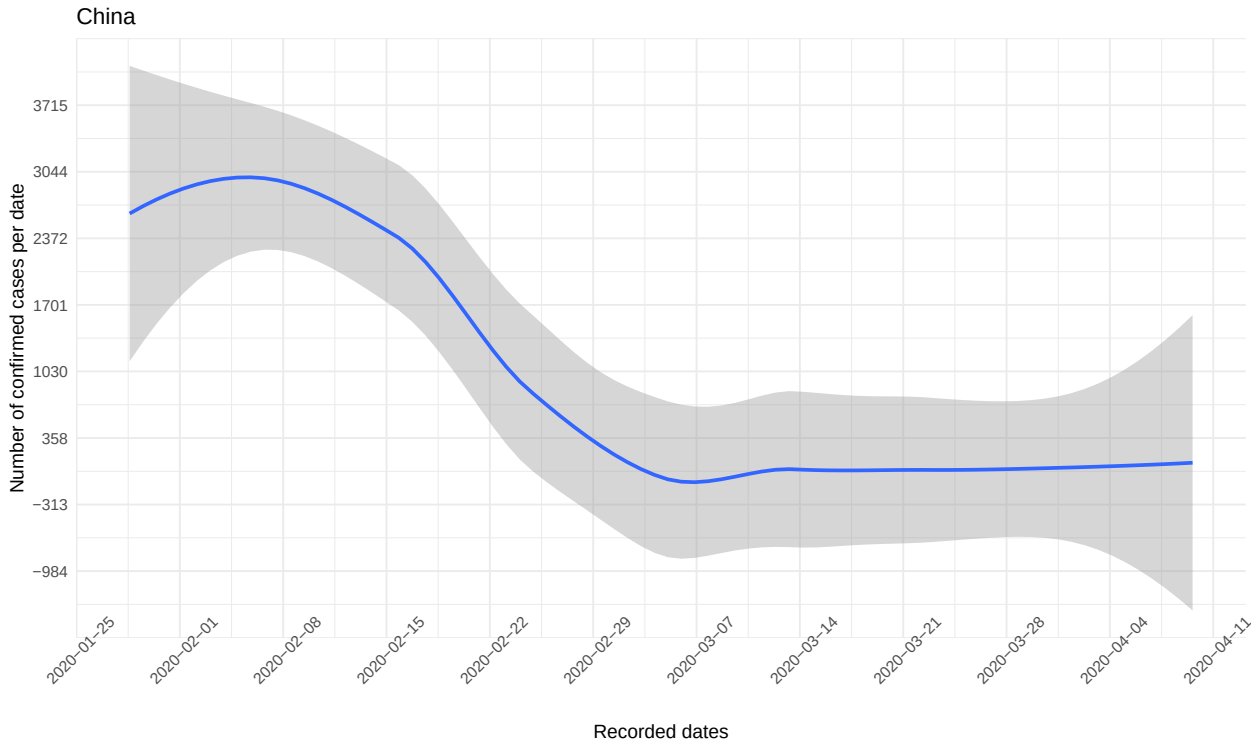


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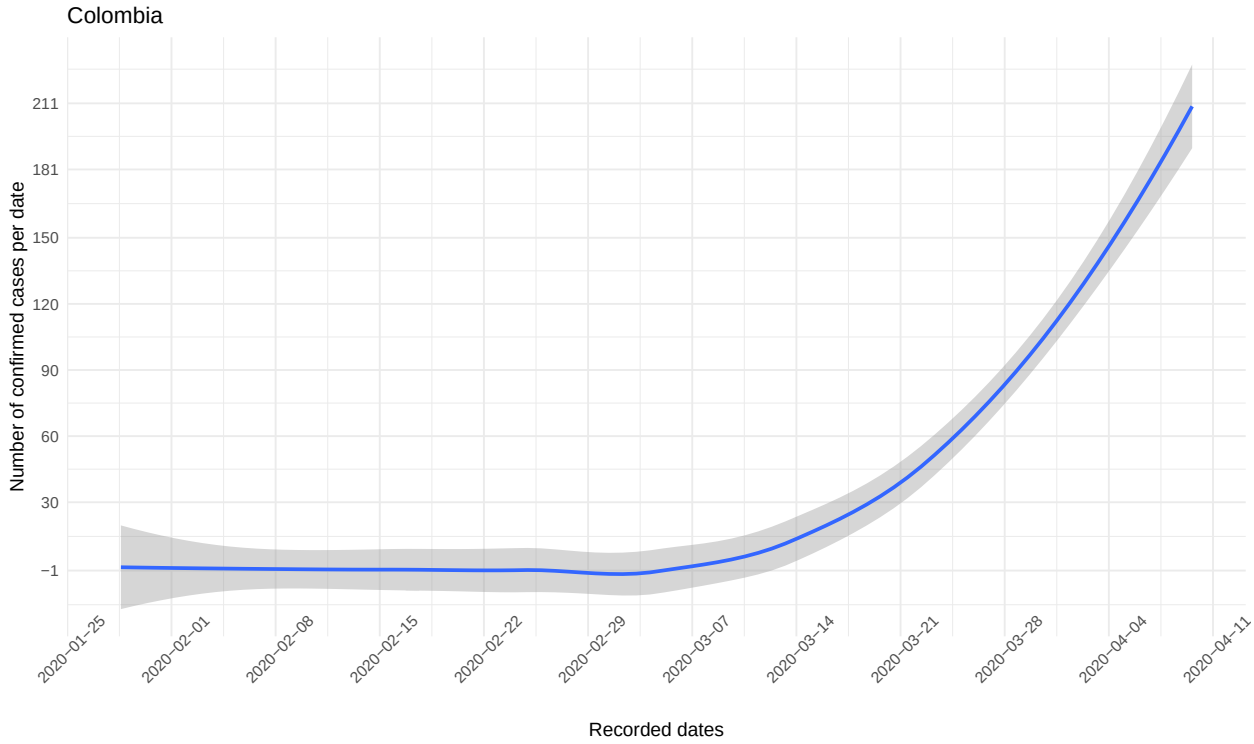


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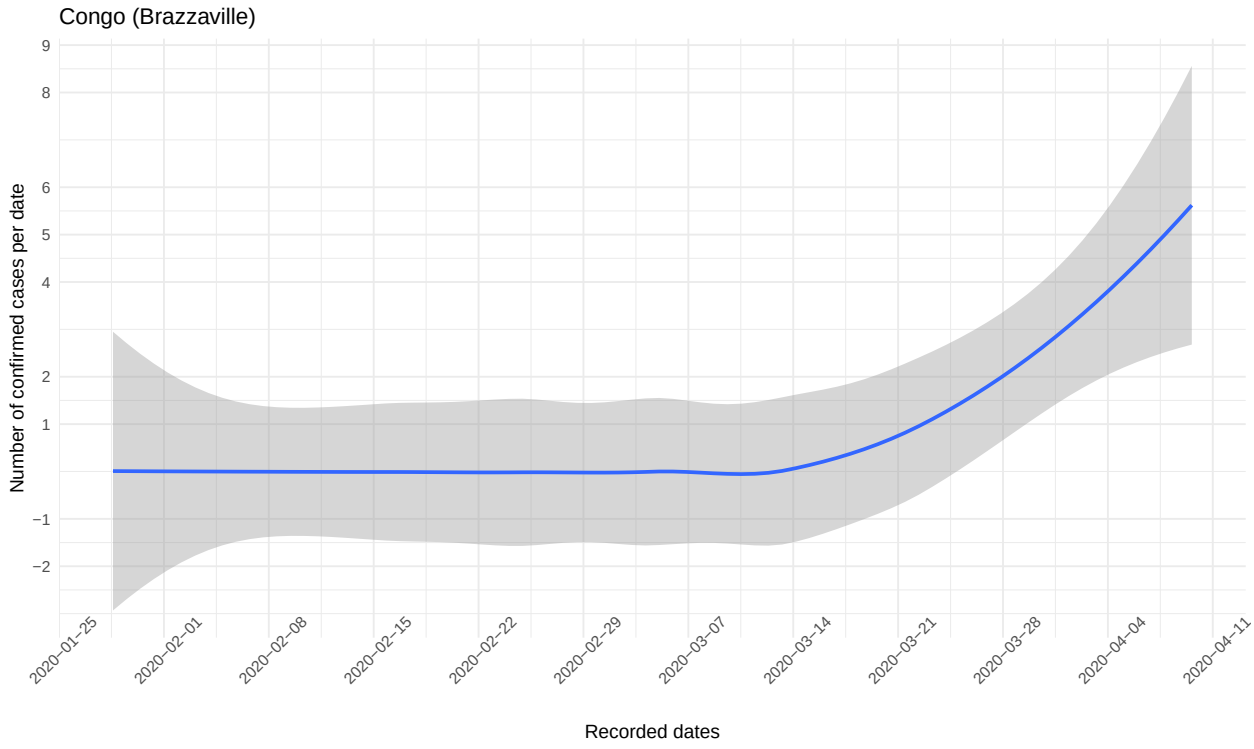


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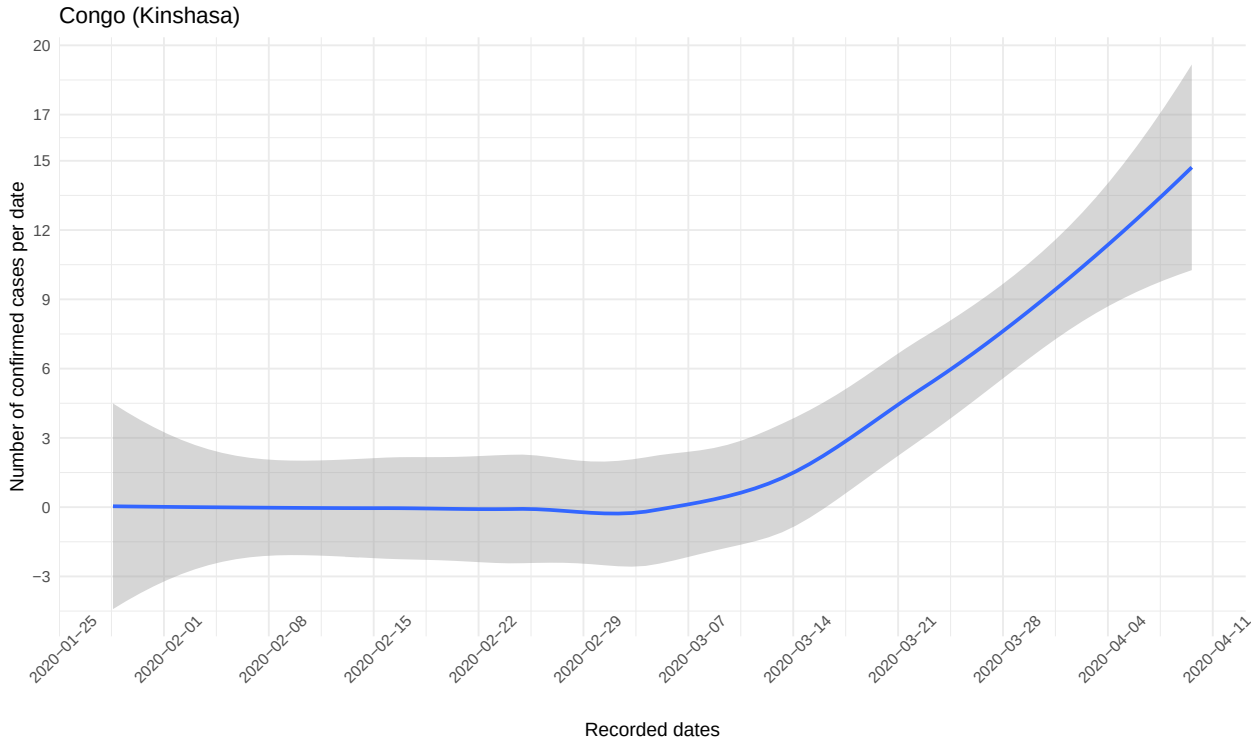


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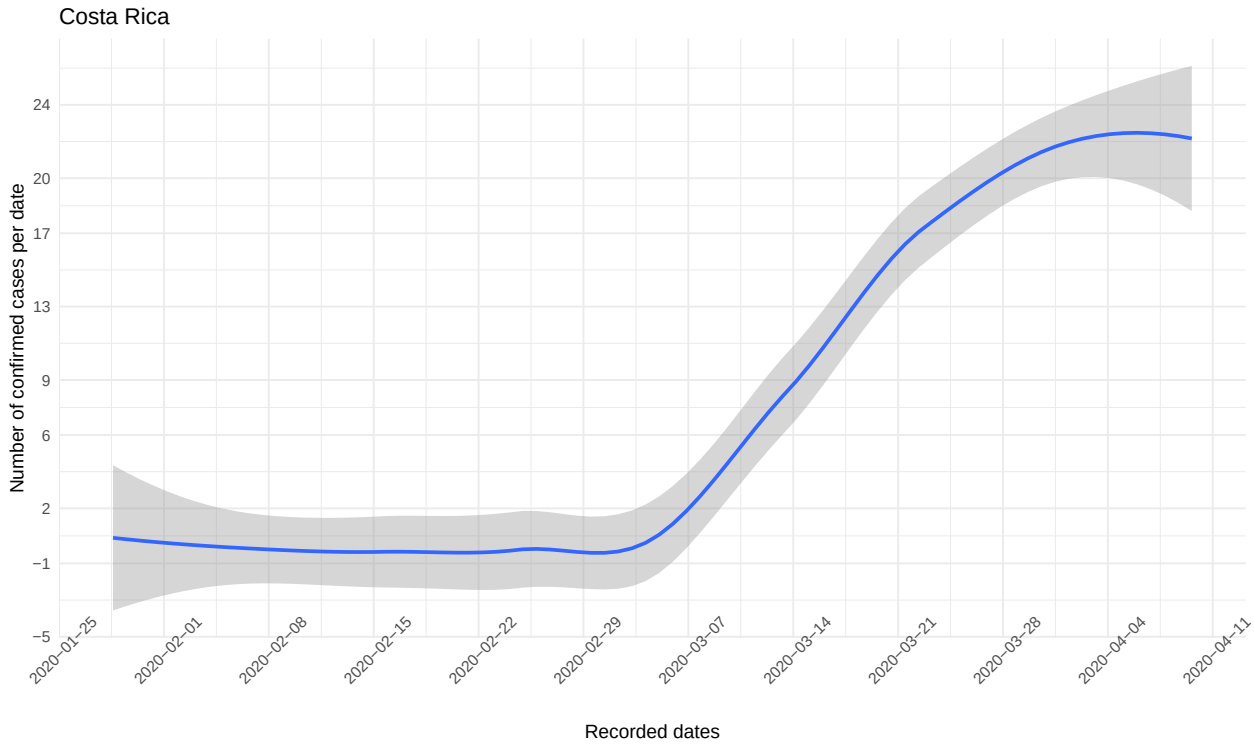


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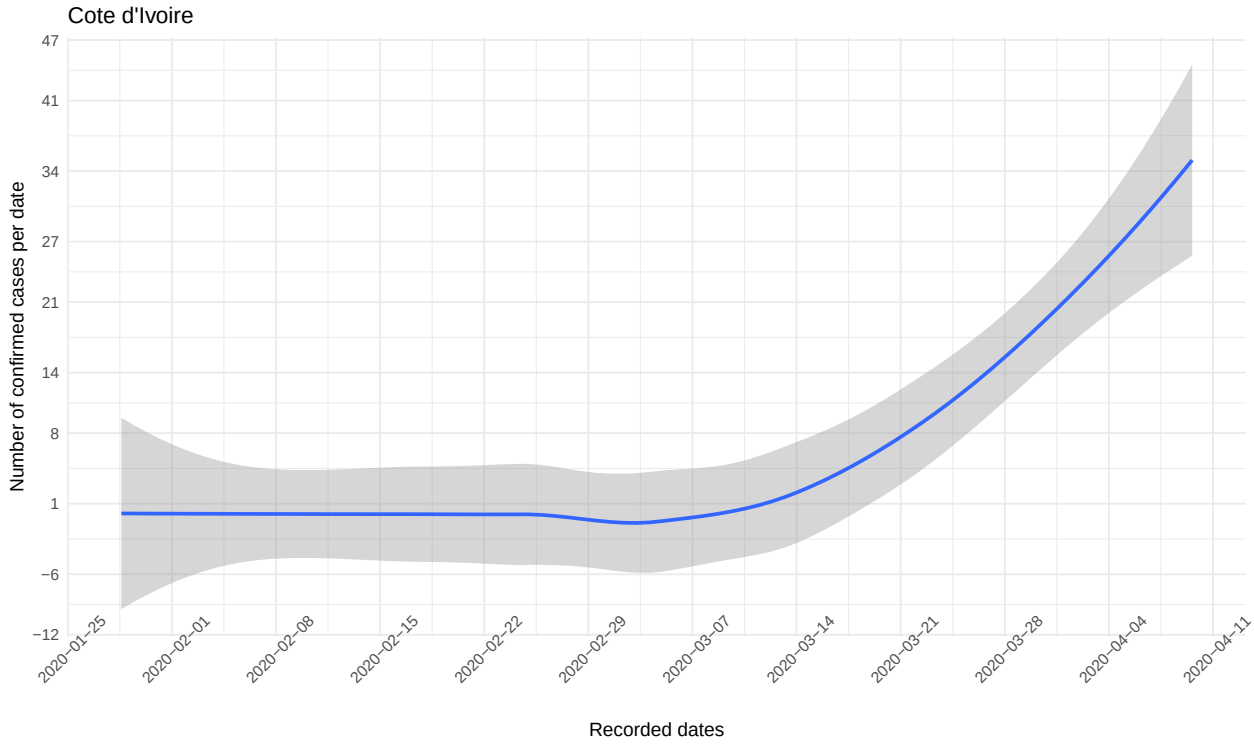


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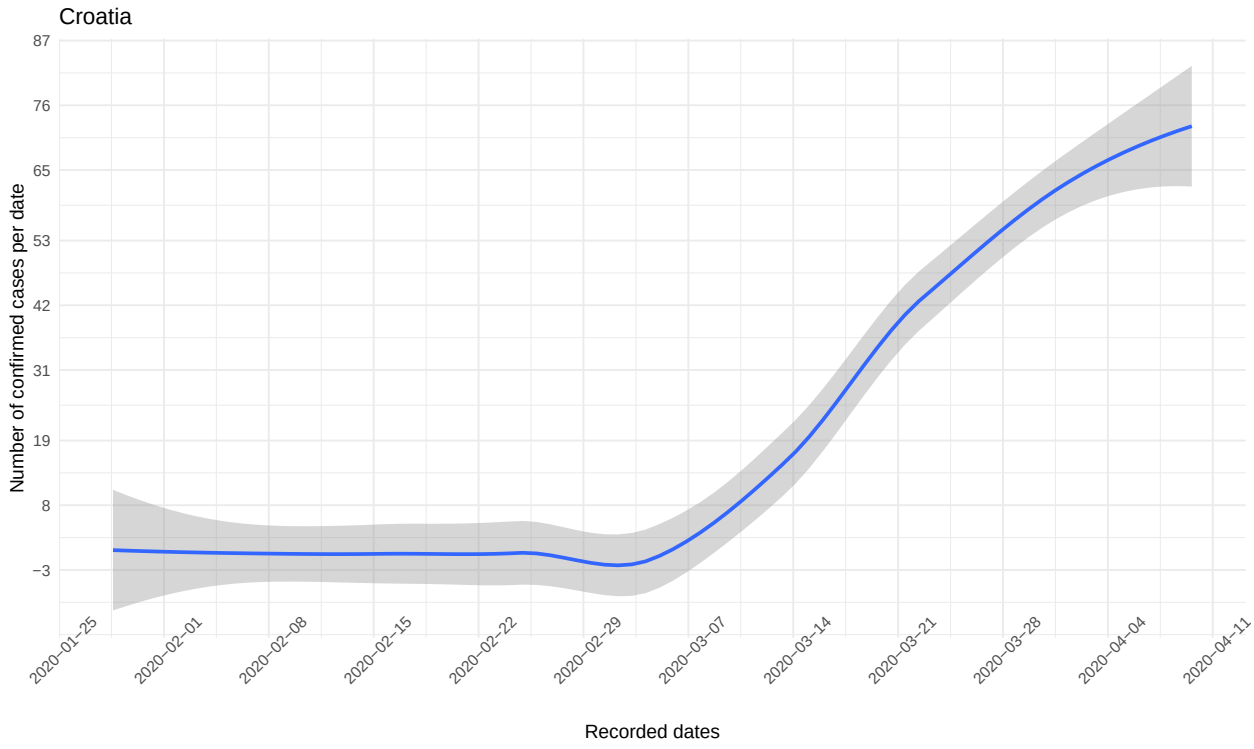


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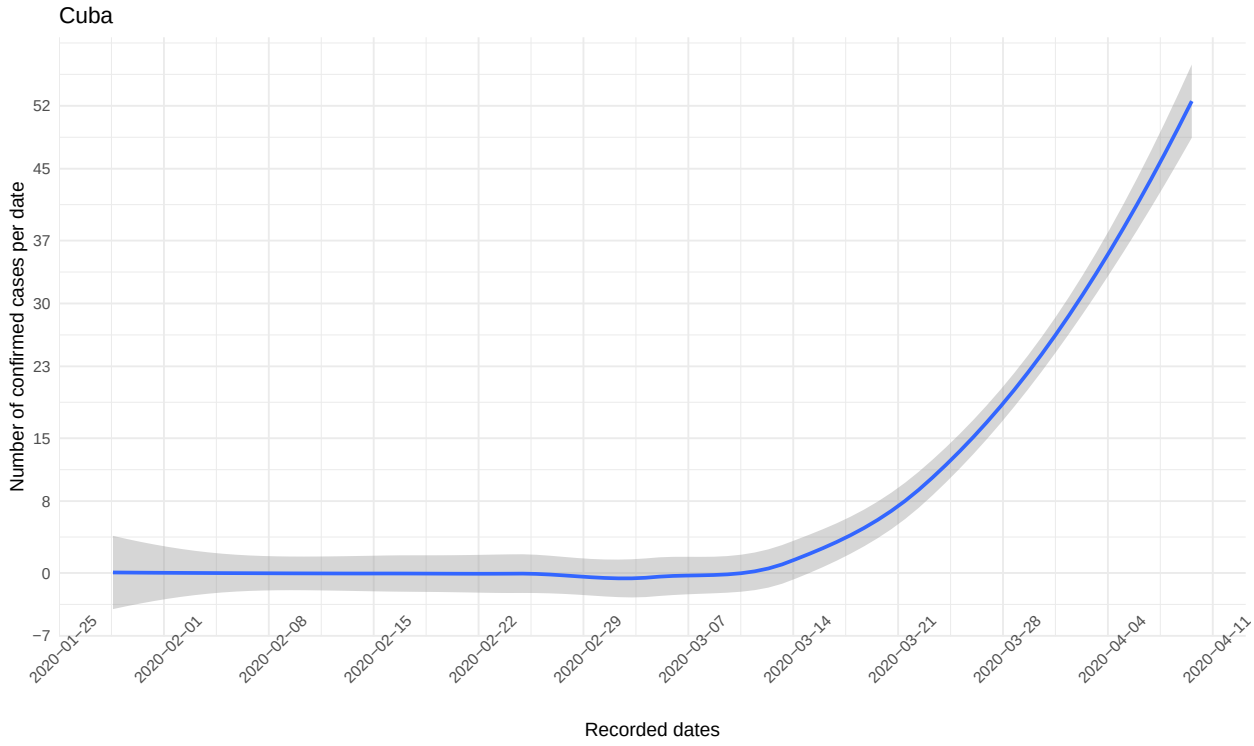


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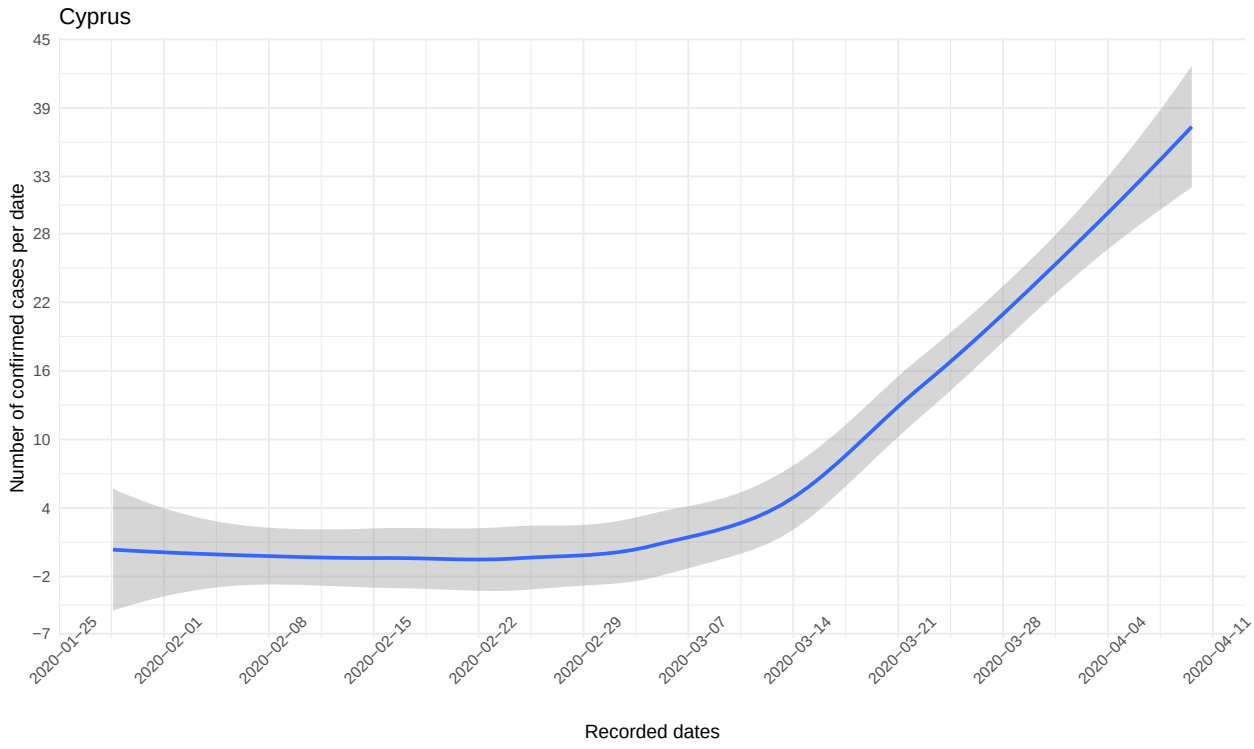


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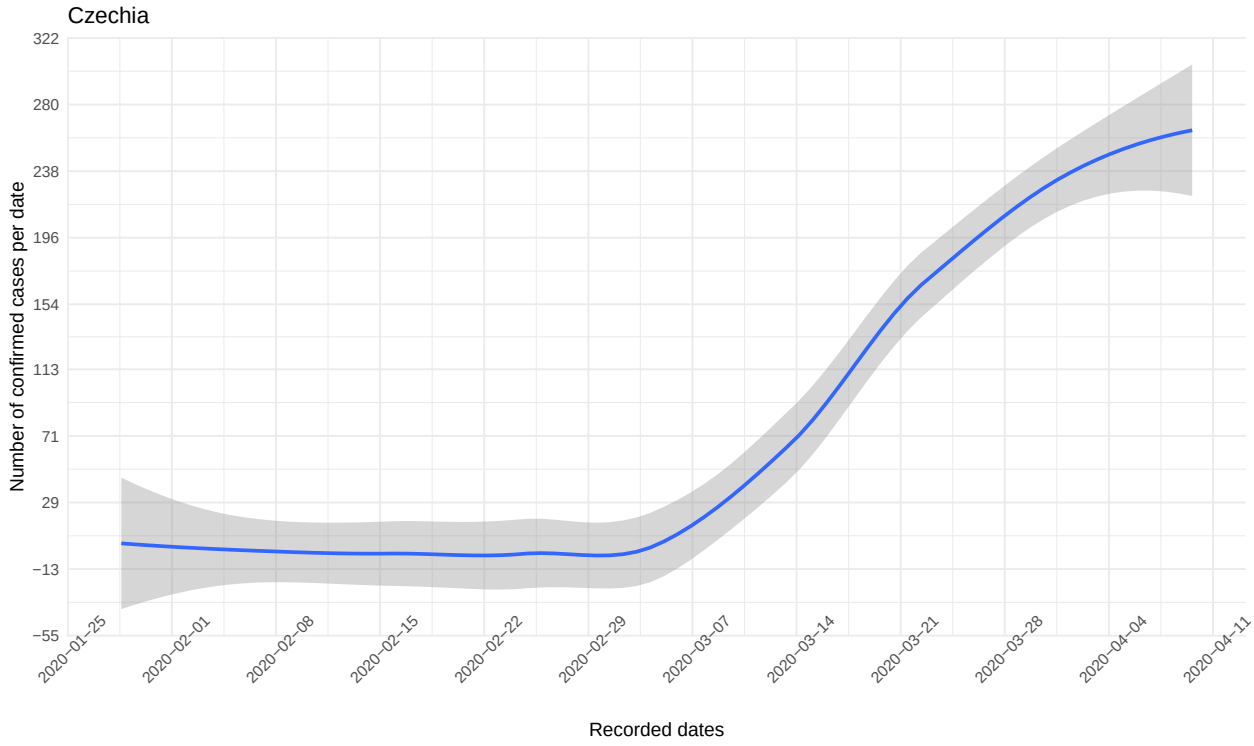


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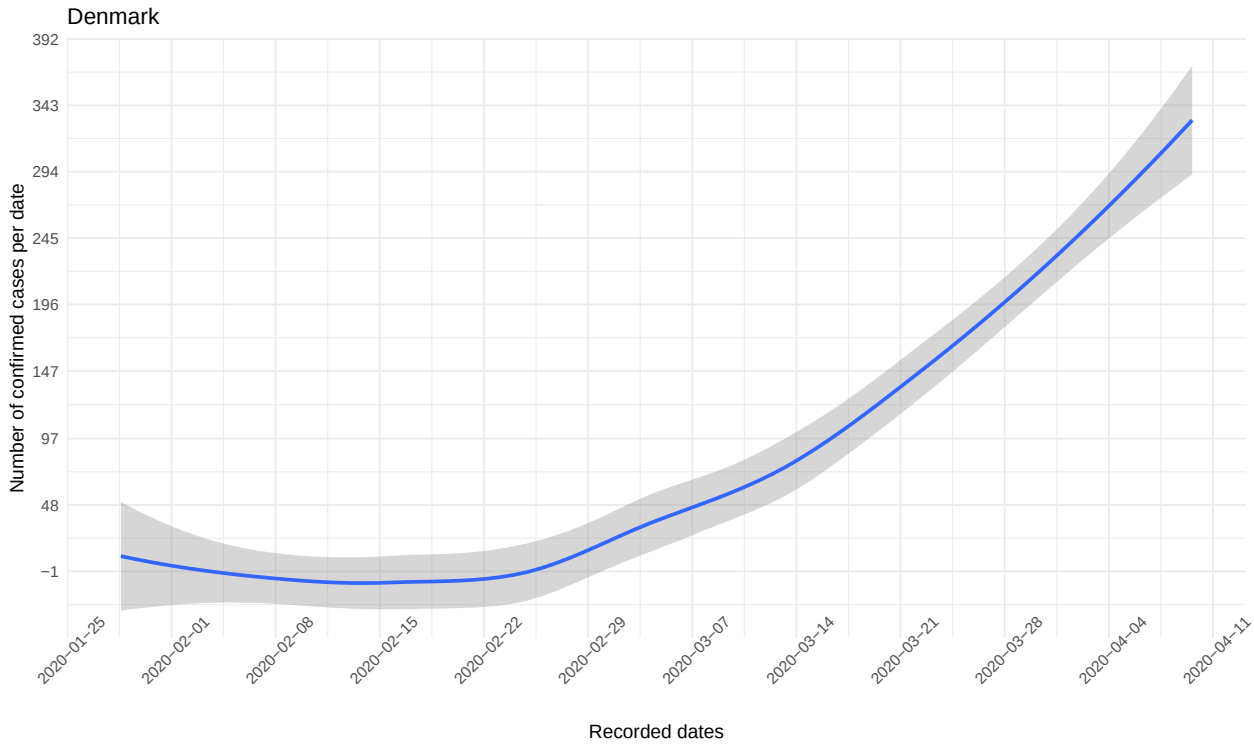


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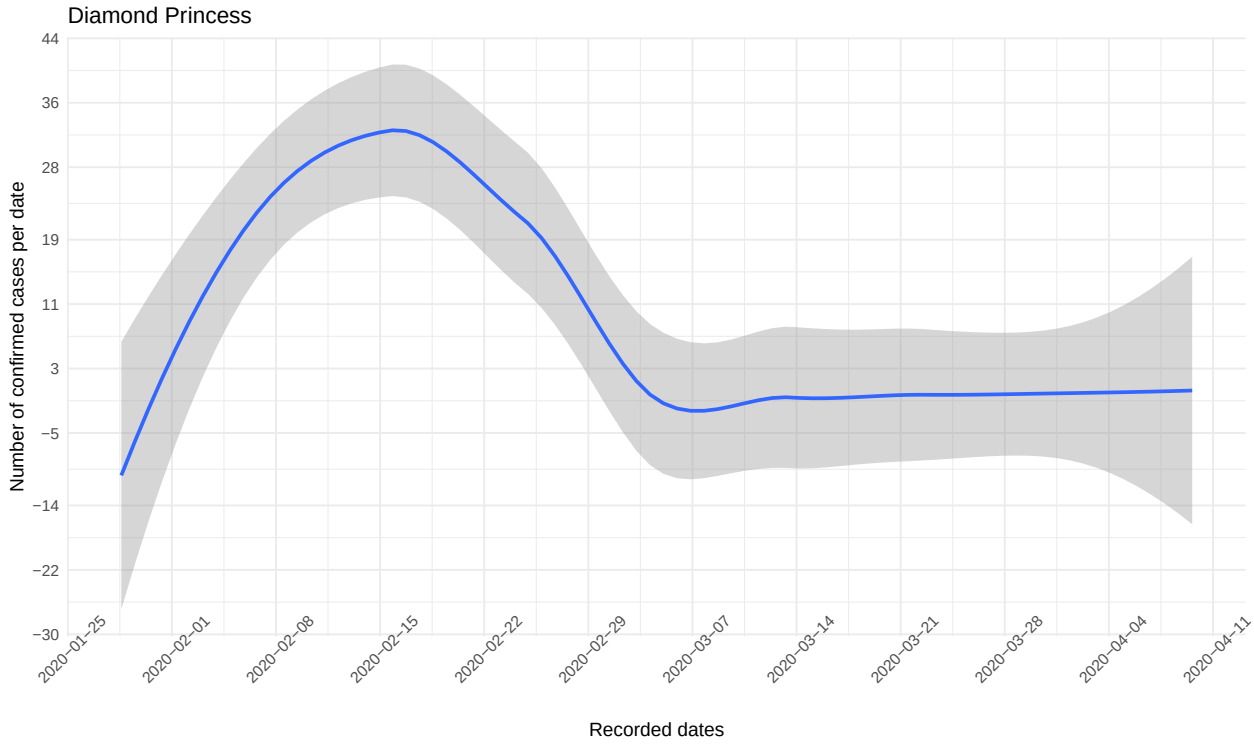


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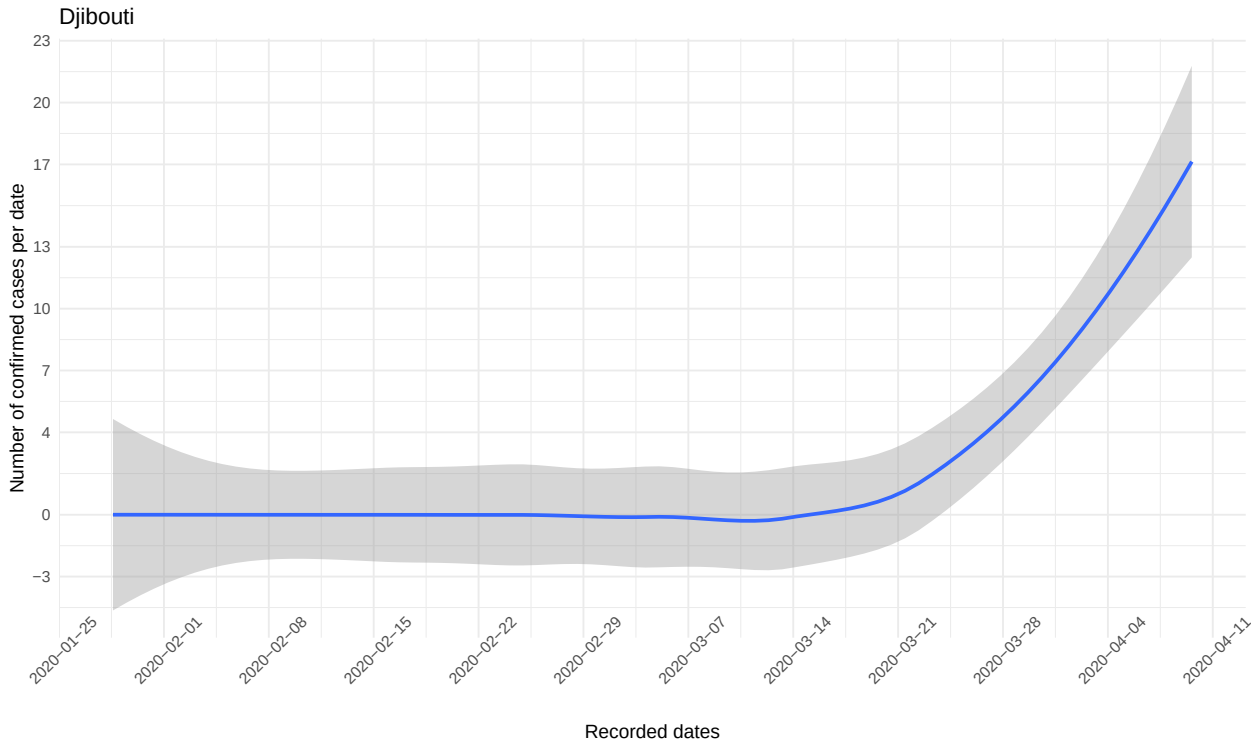


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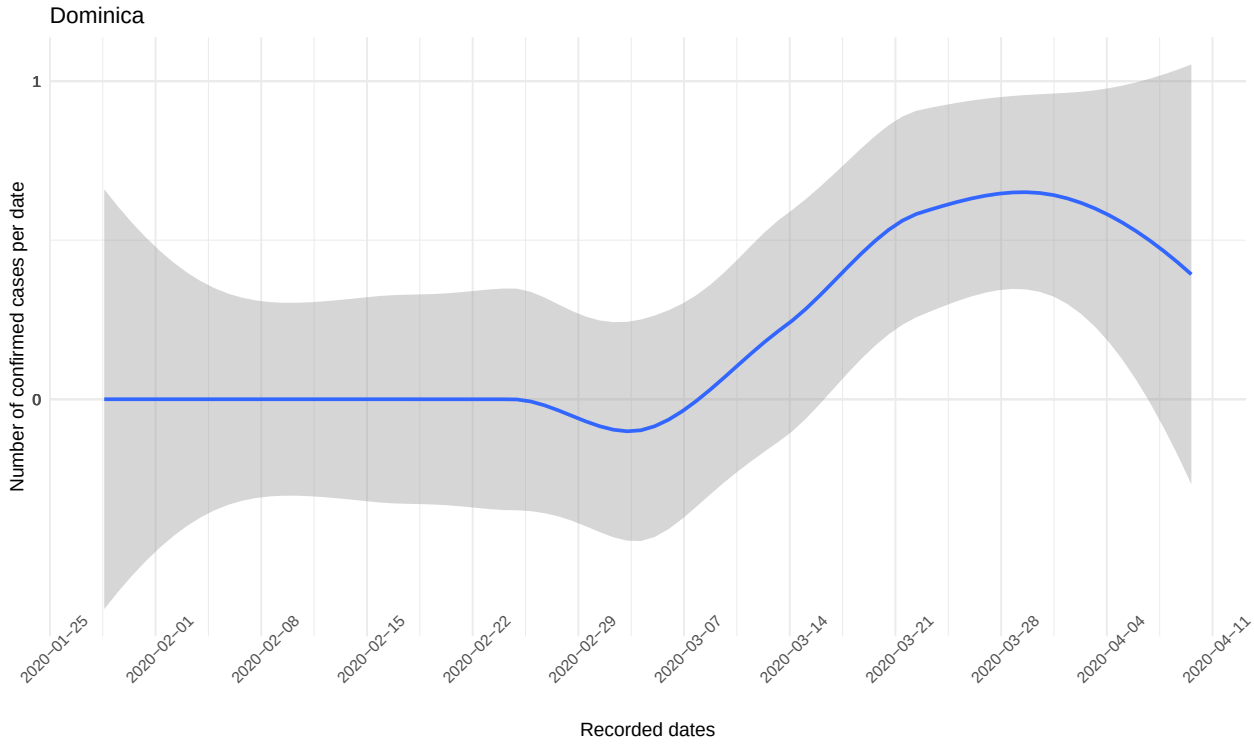


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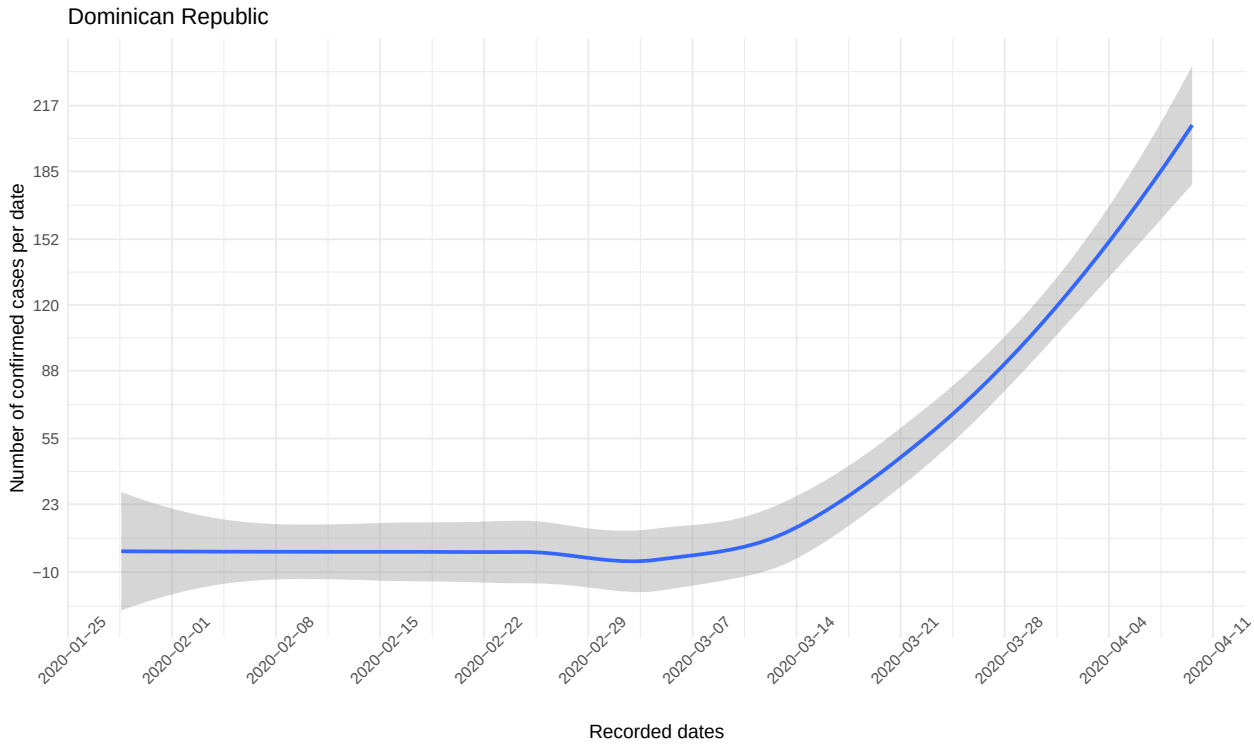


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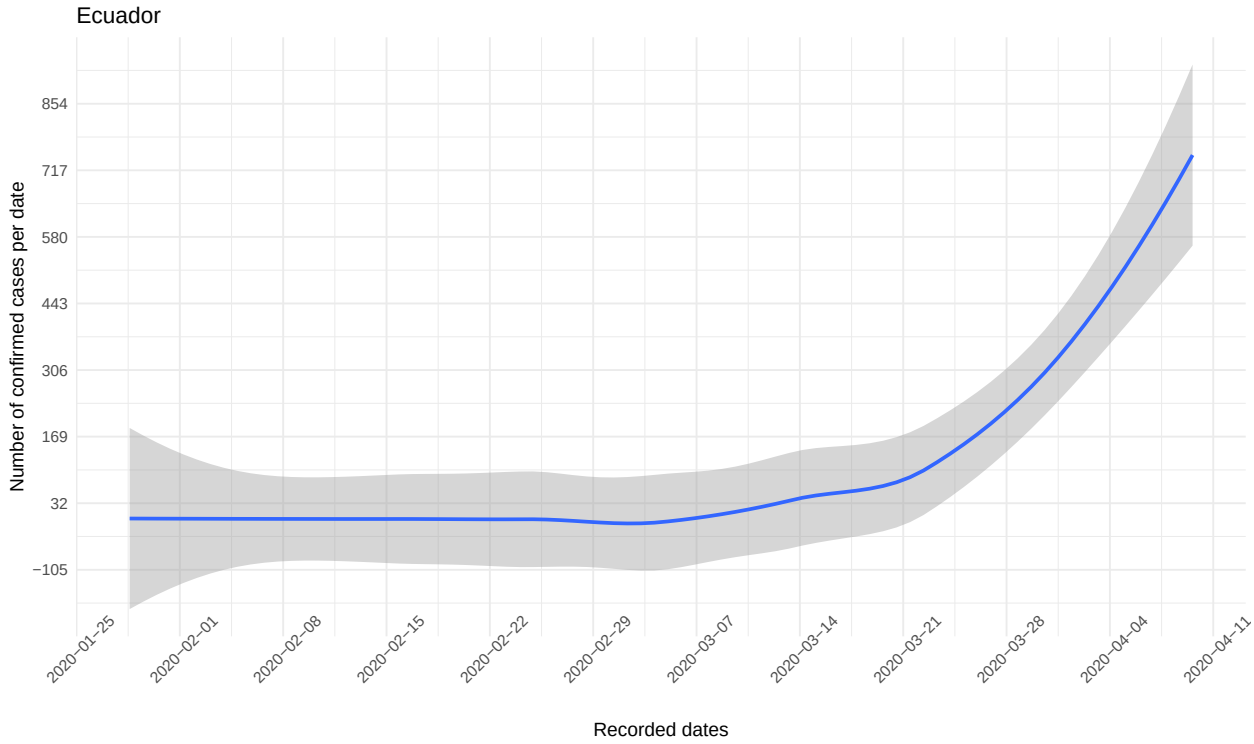


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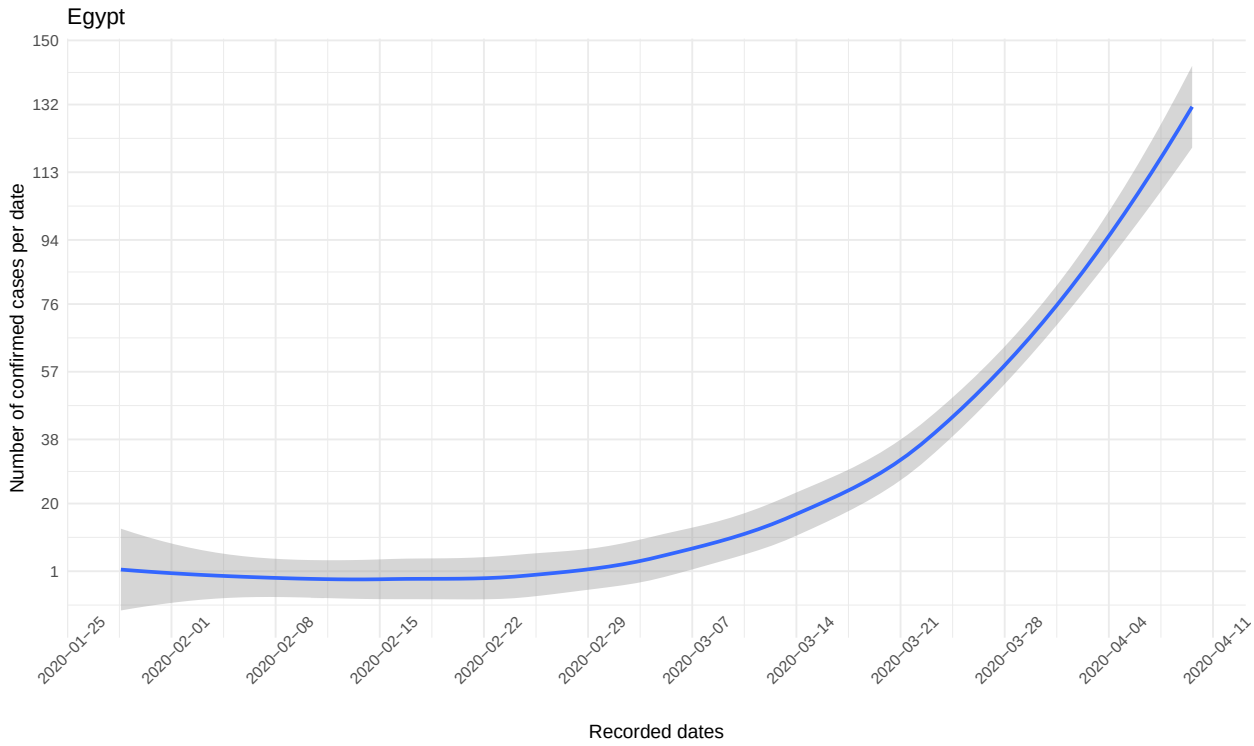


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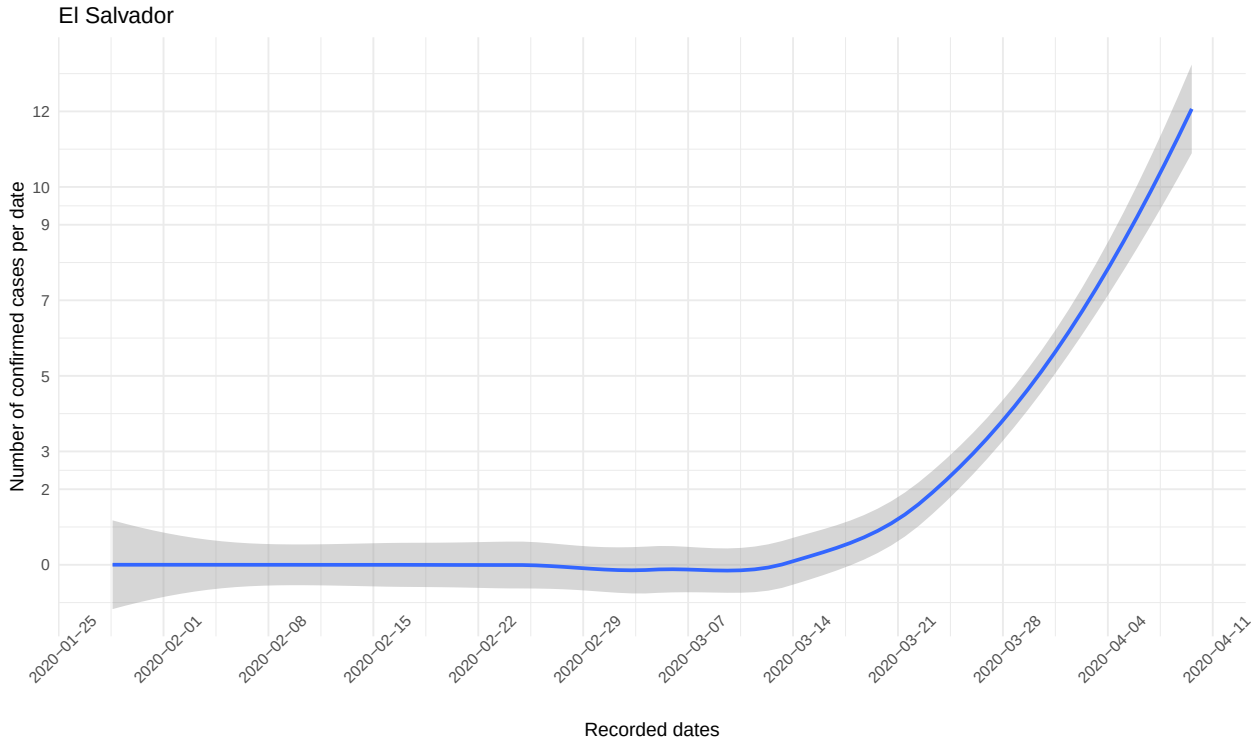


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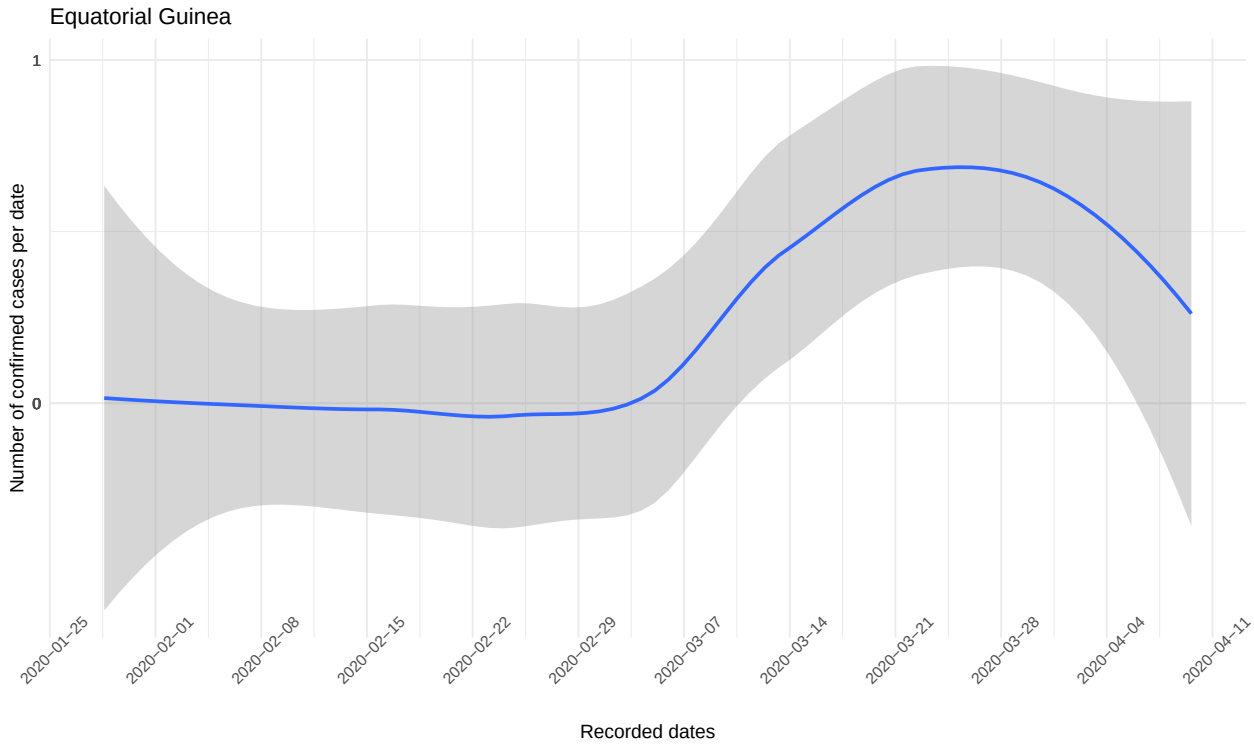


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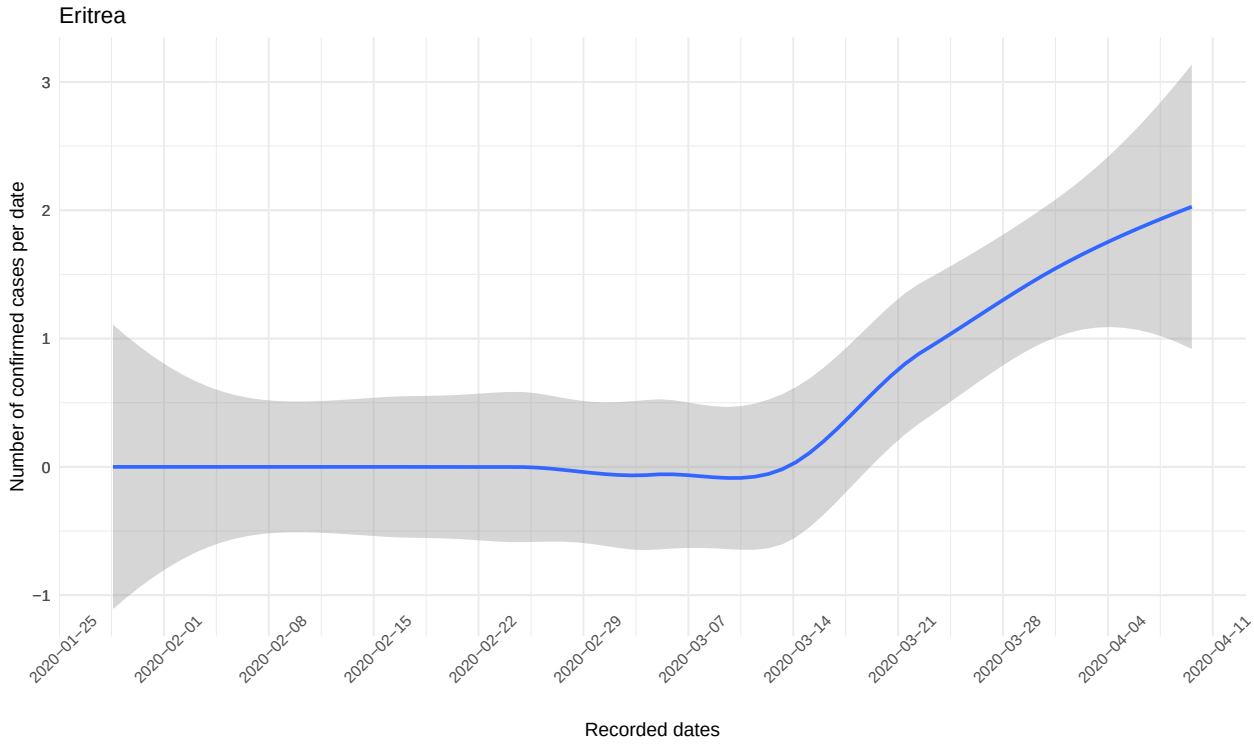


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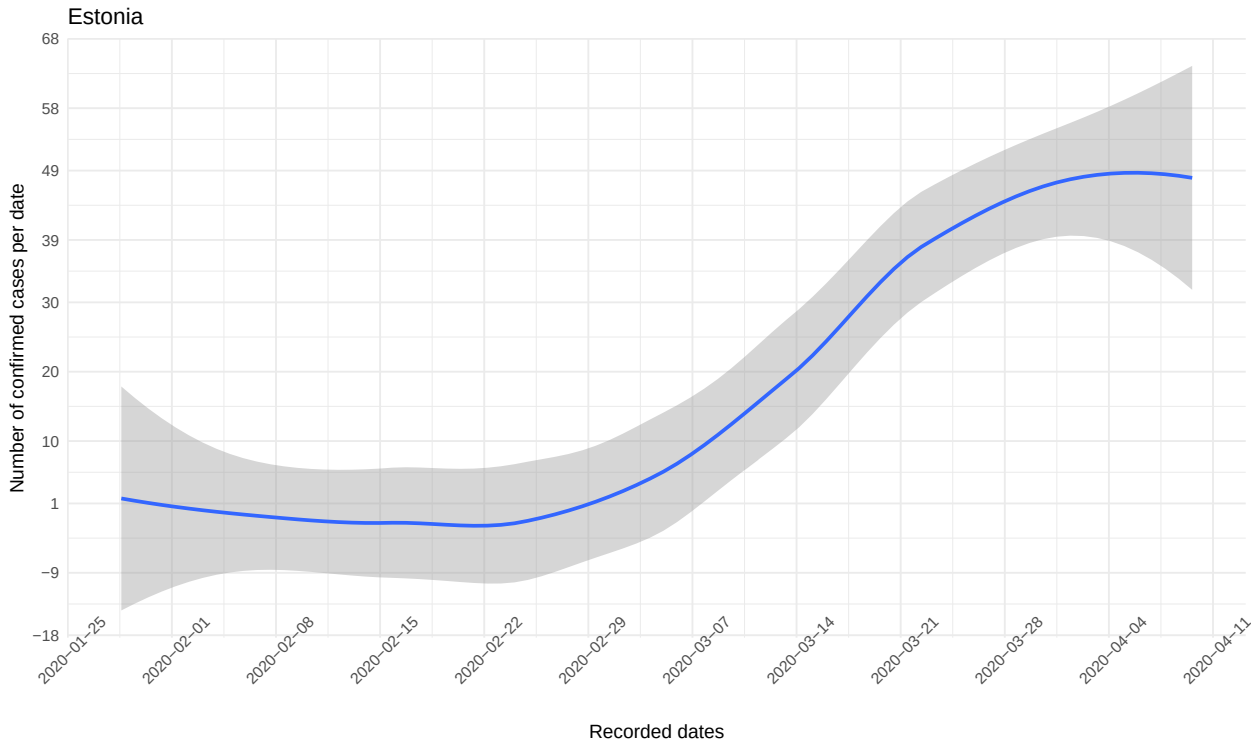


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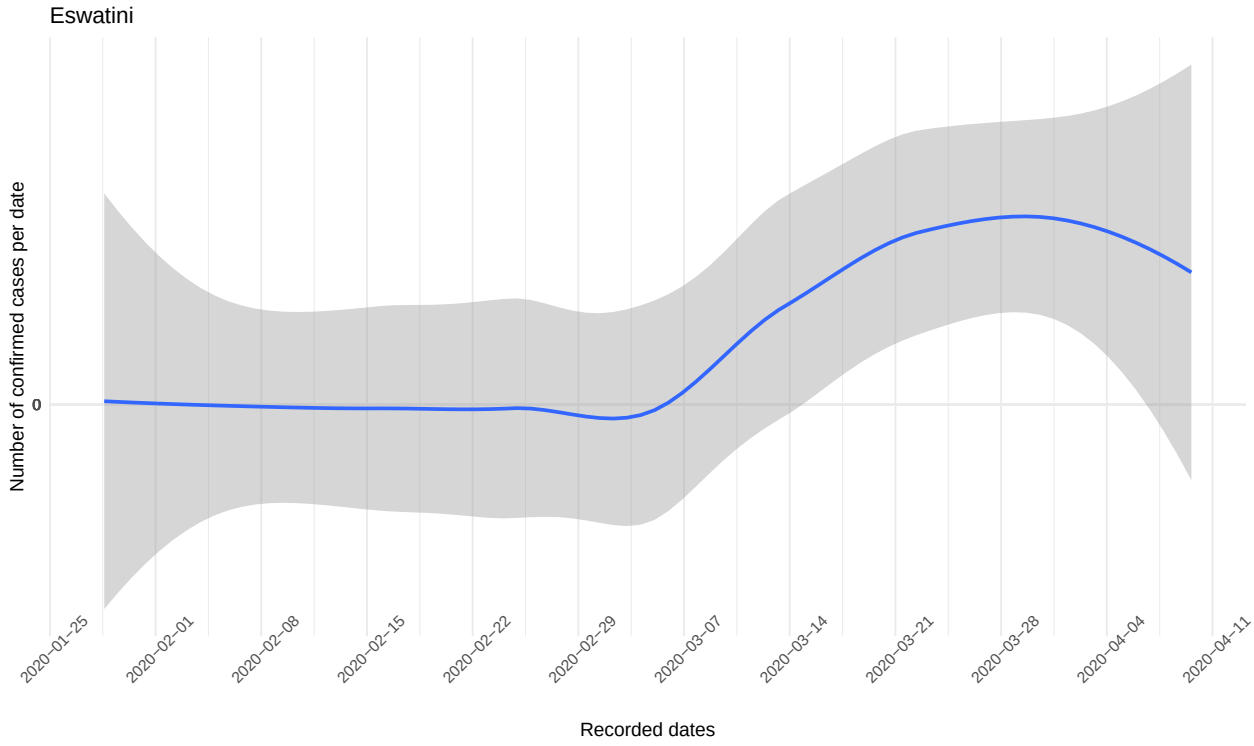


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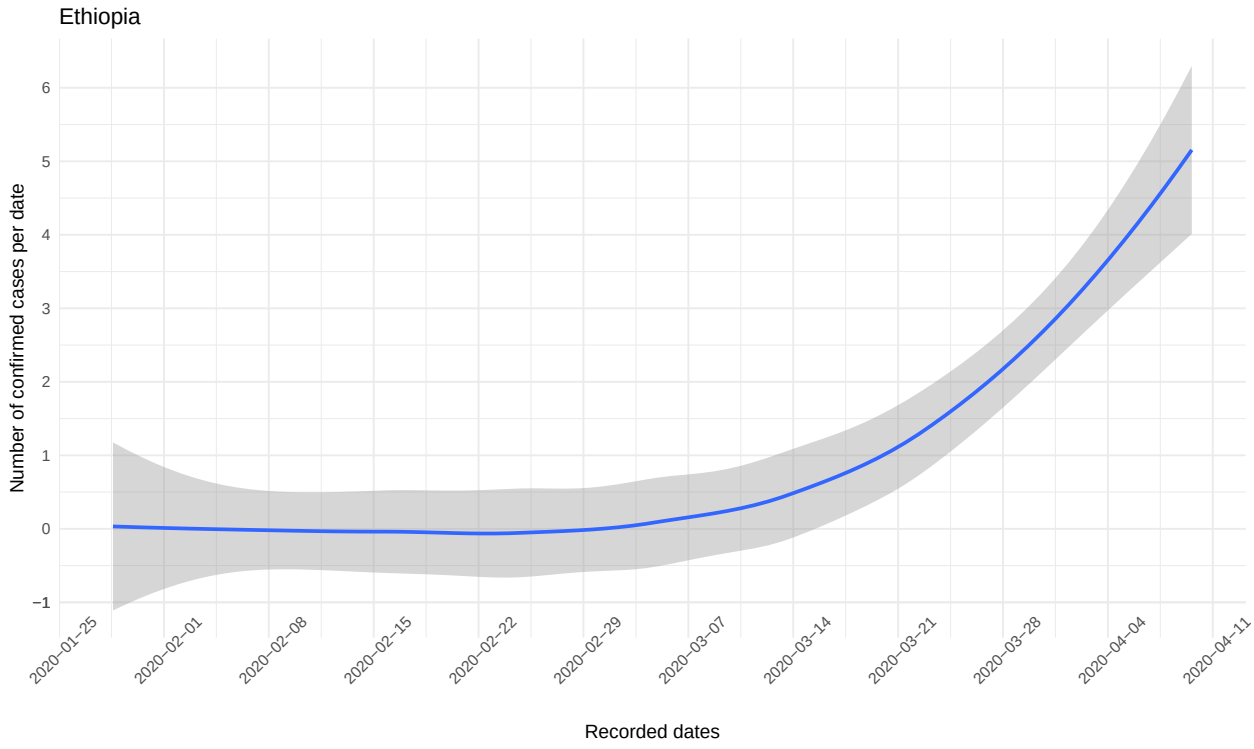


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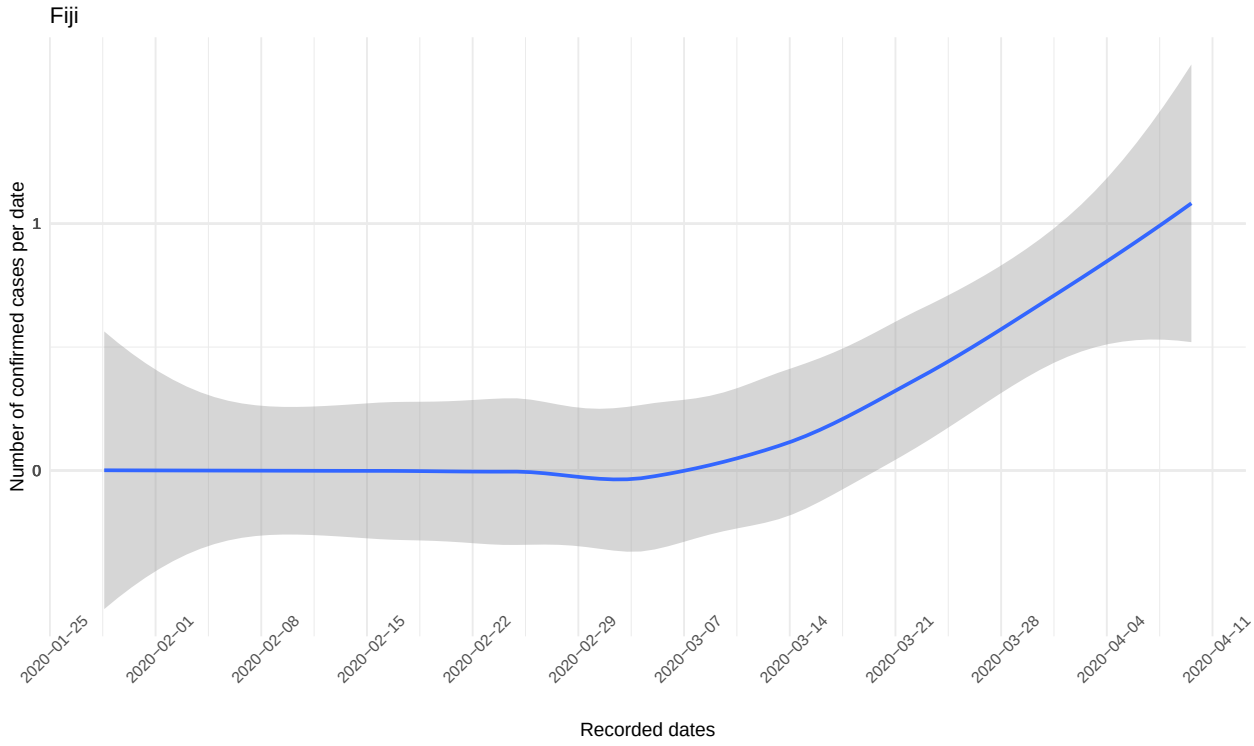


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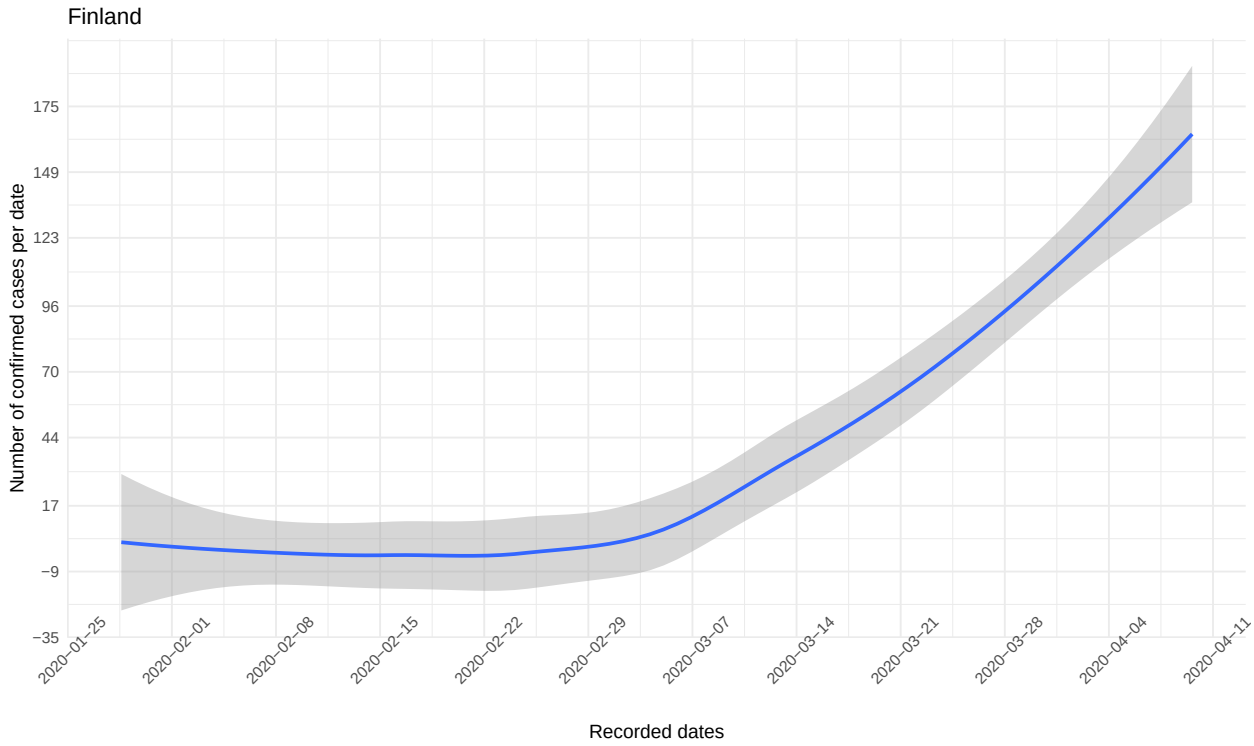


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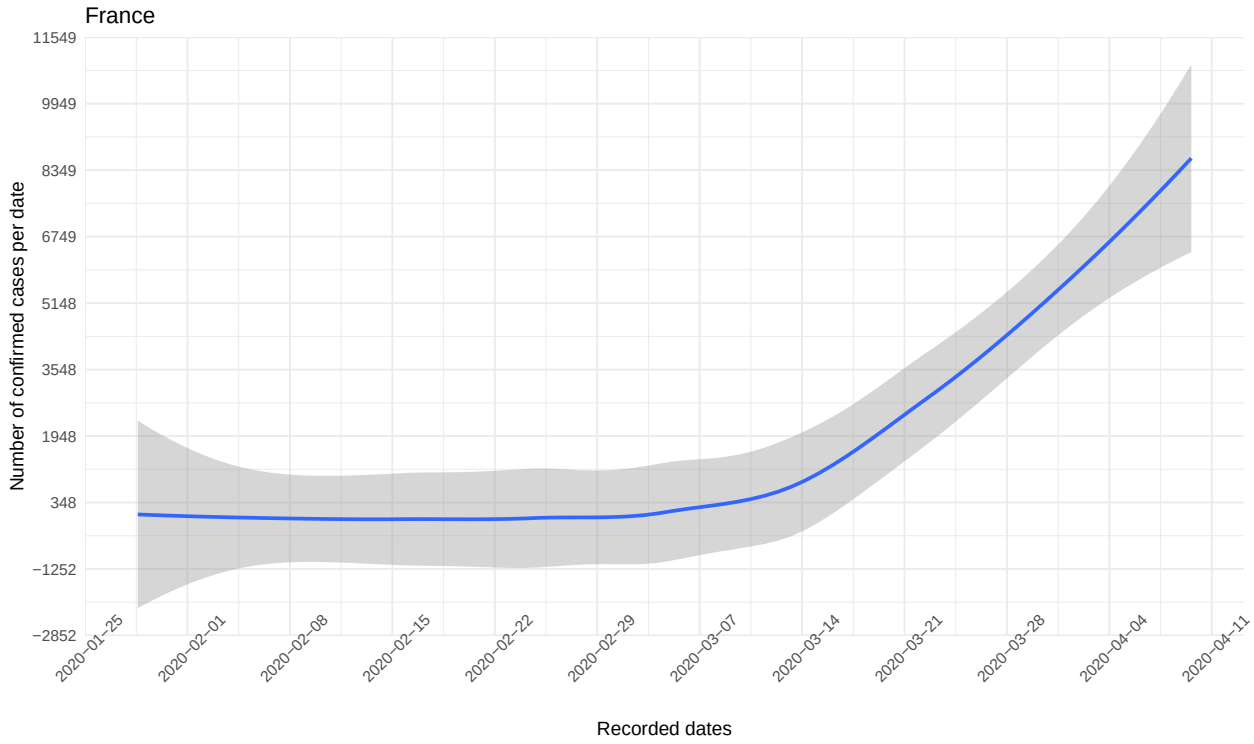


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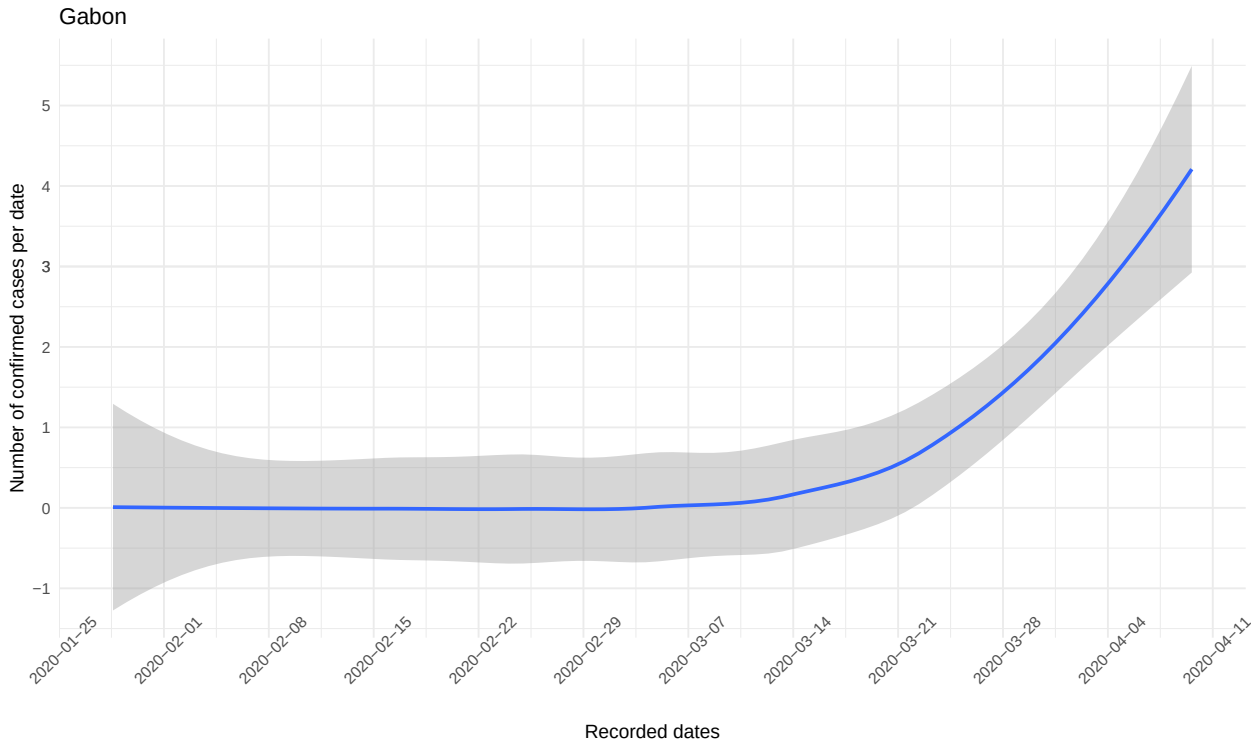


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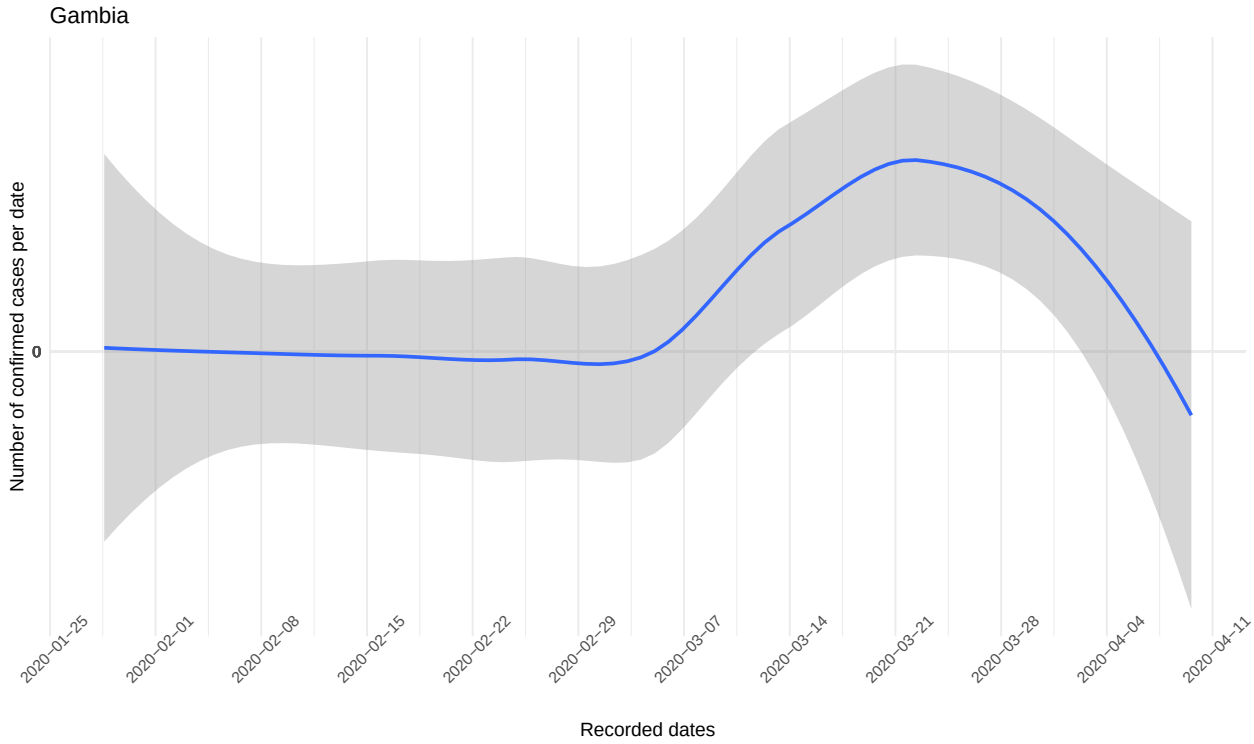


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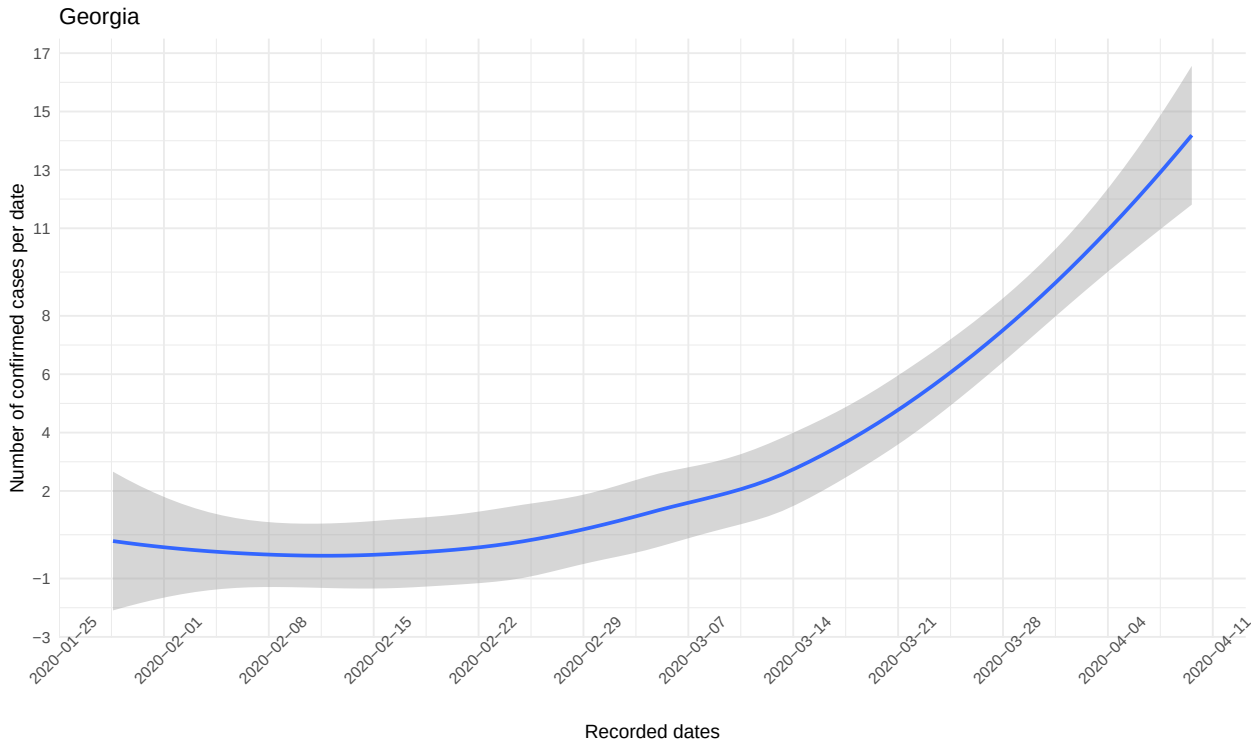


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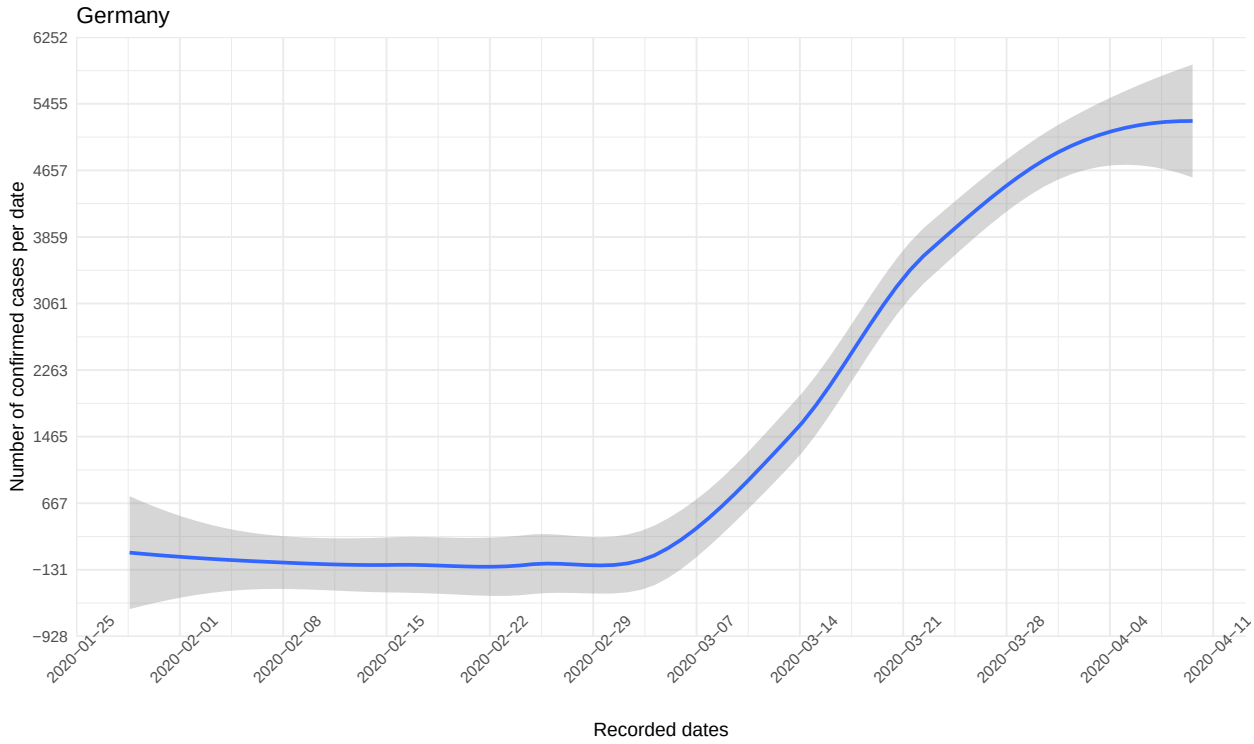


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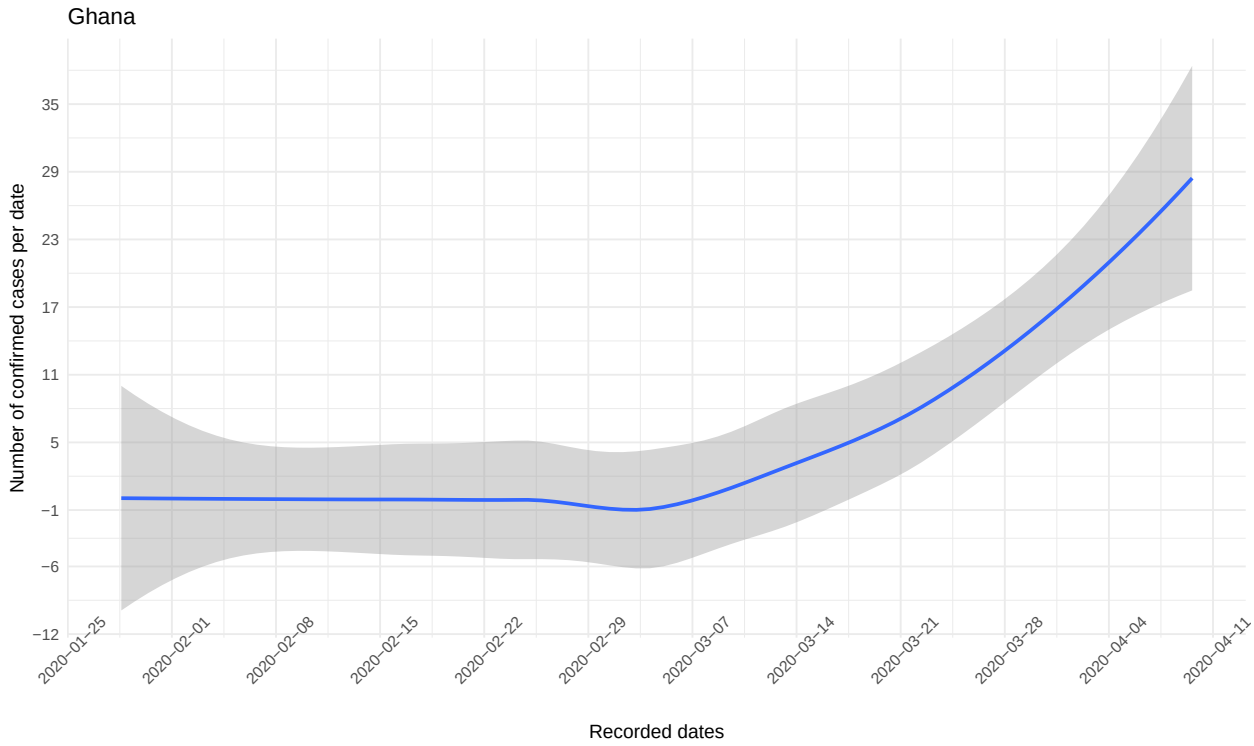


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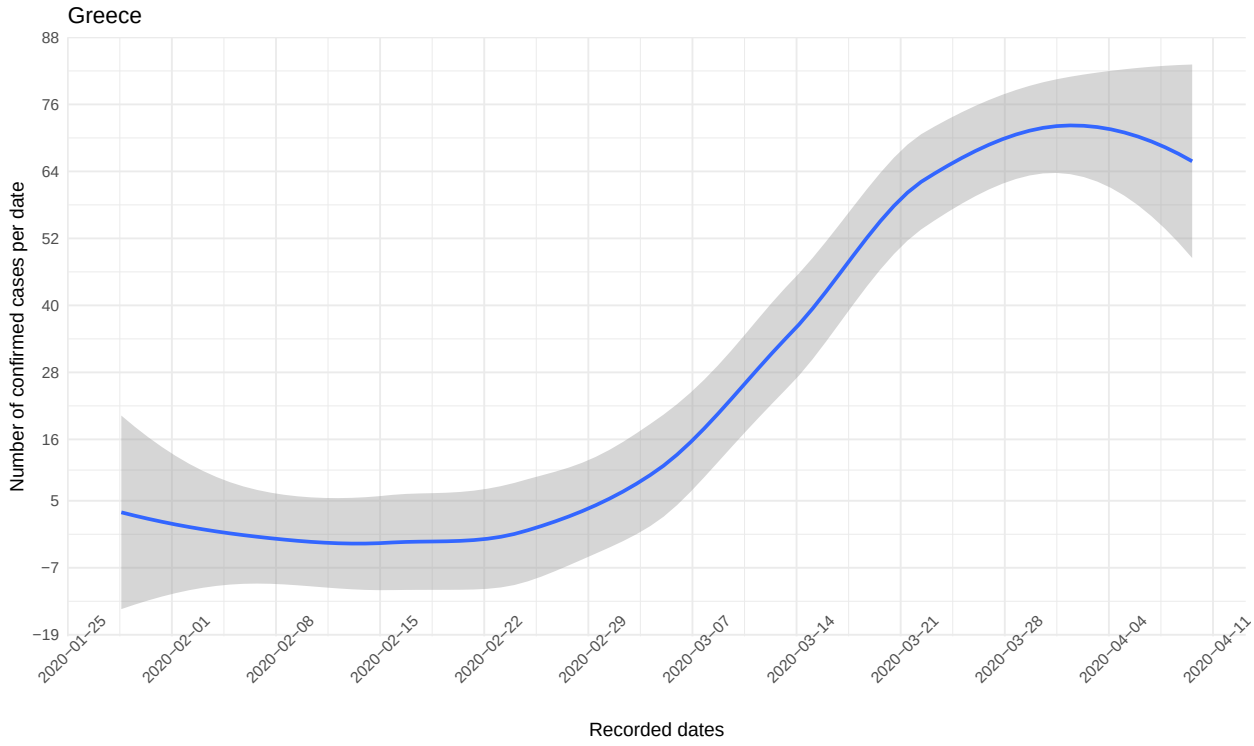


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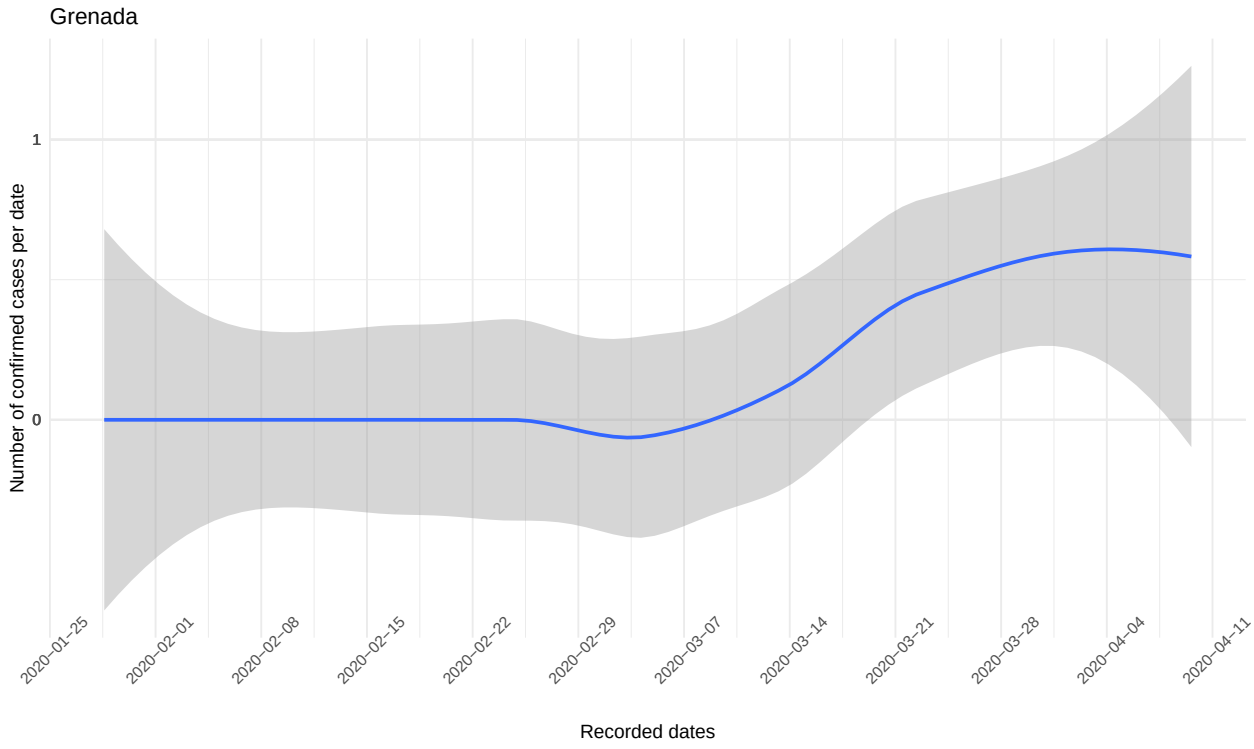


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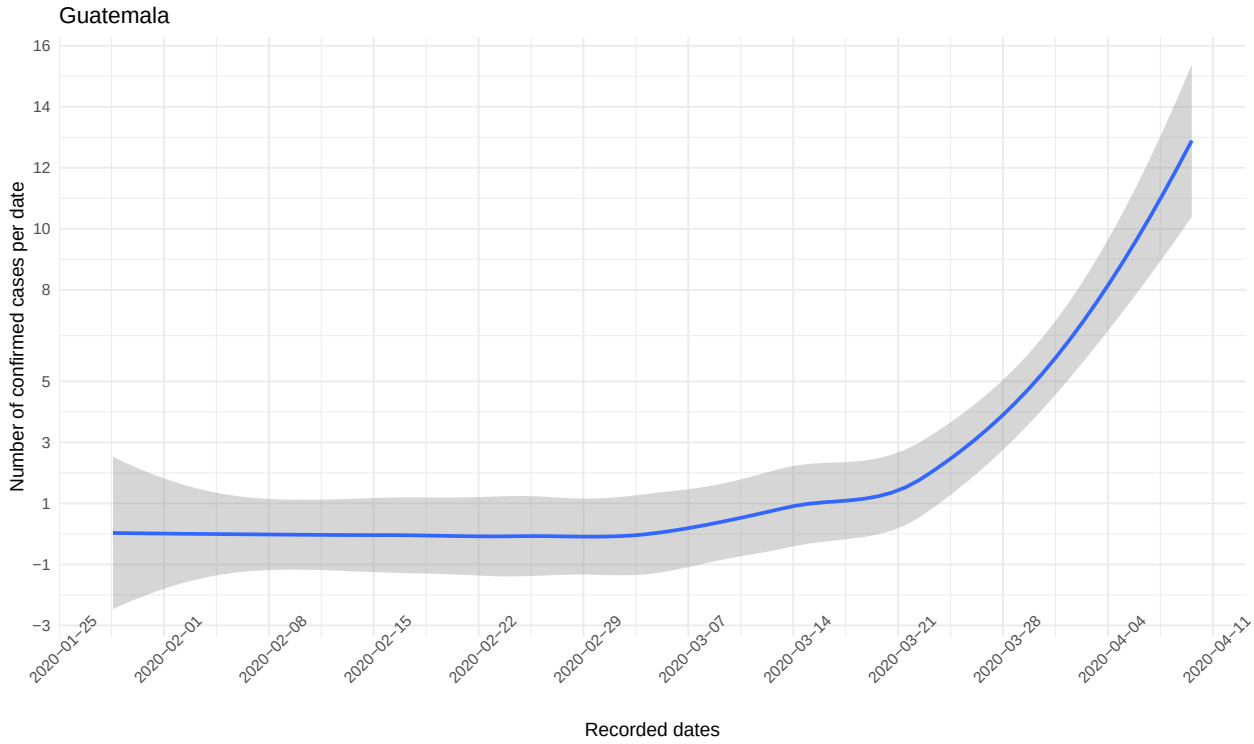


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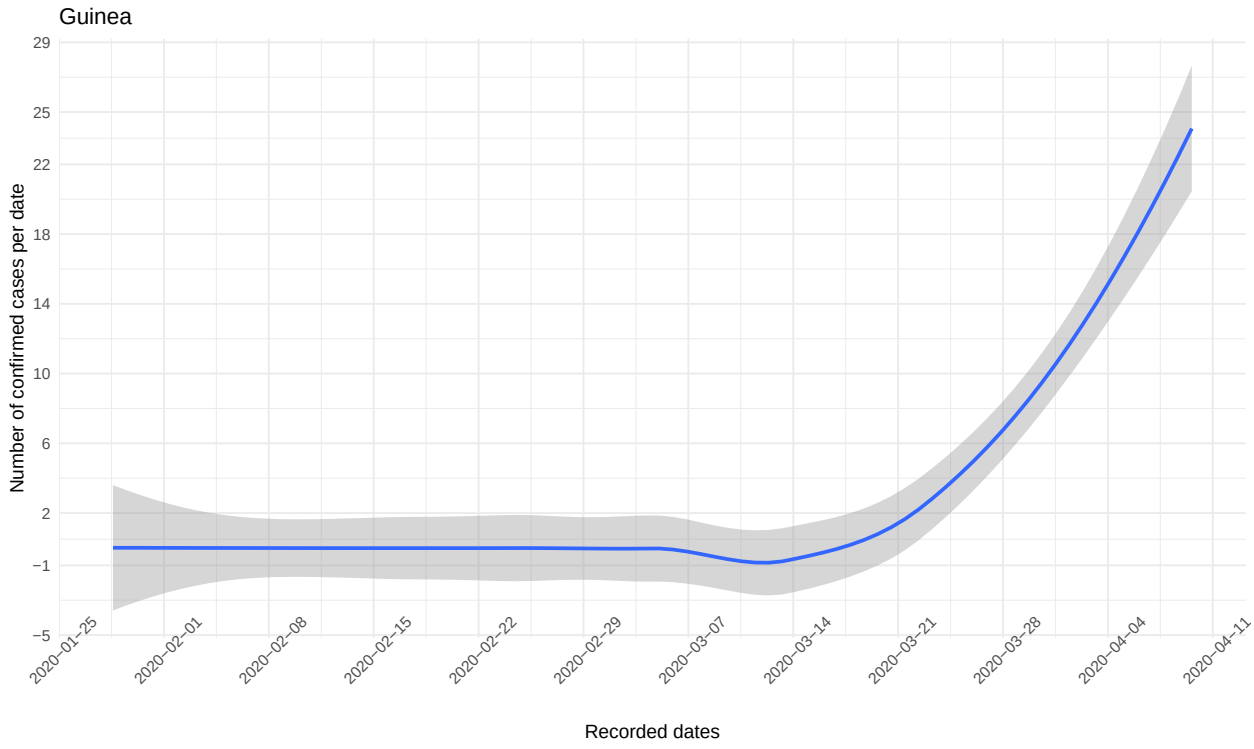


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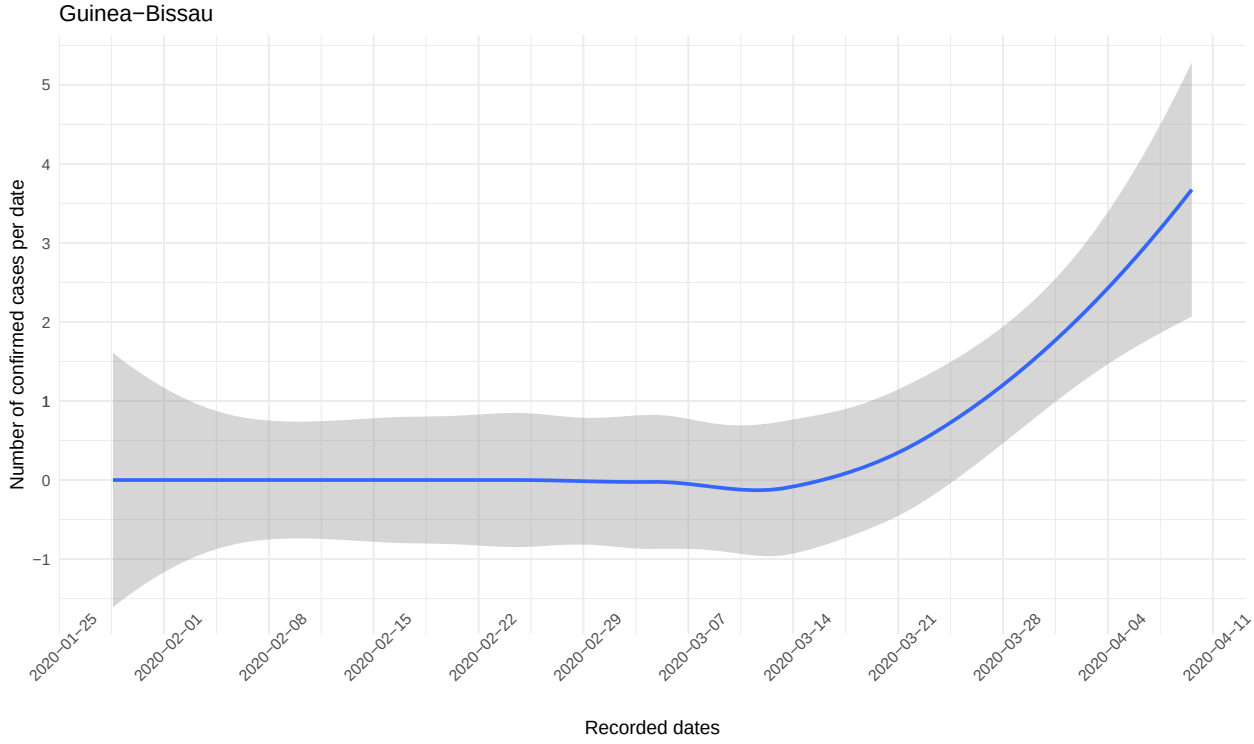


```
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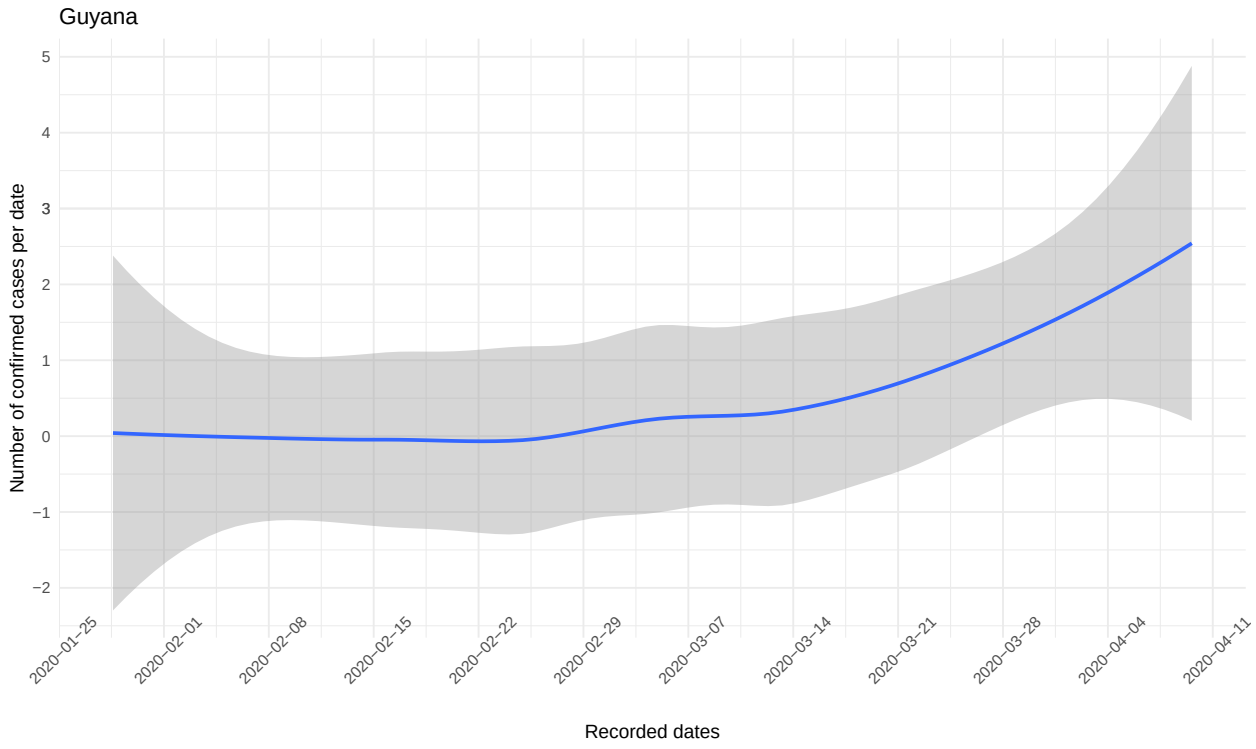


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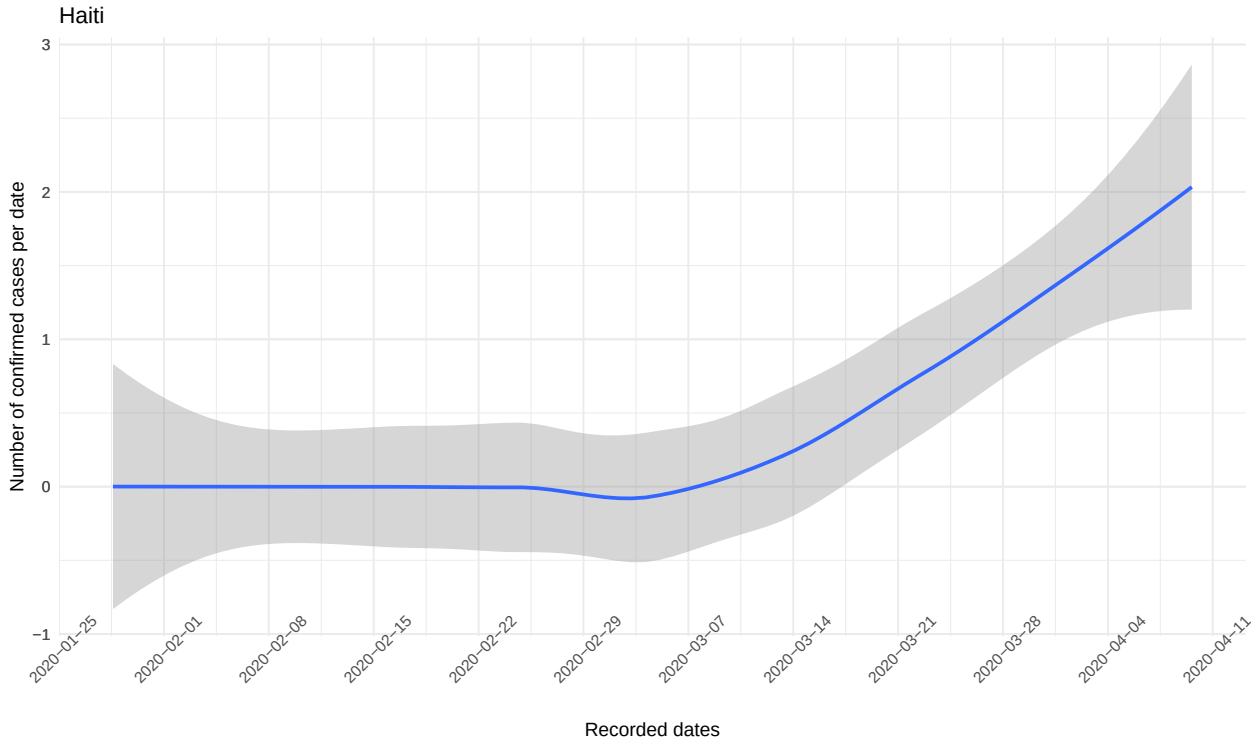


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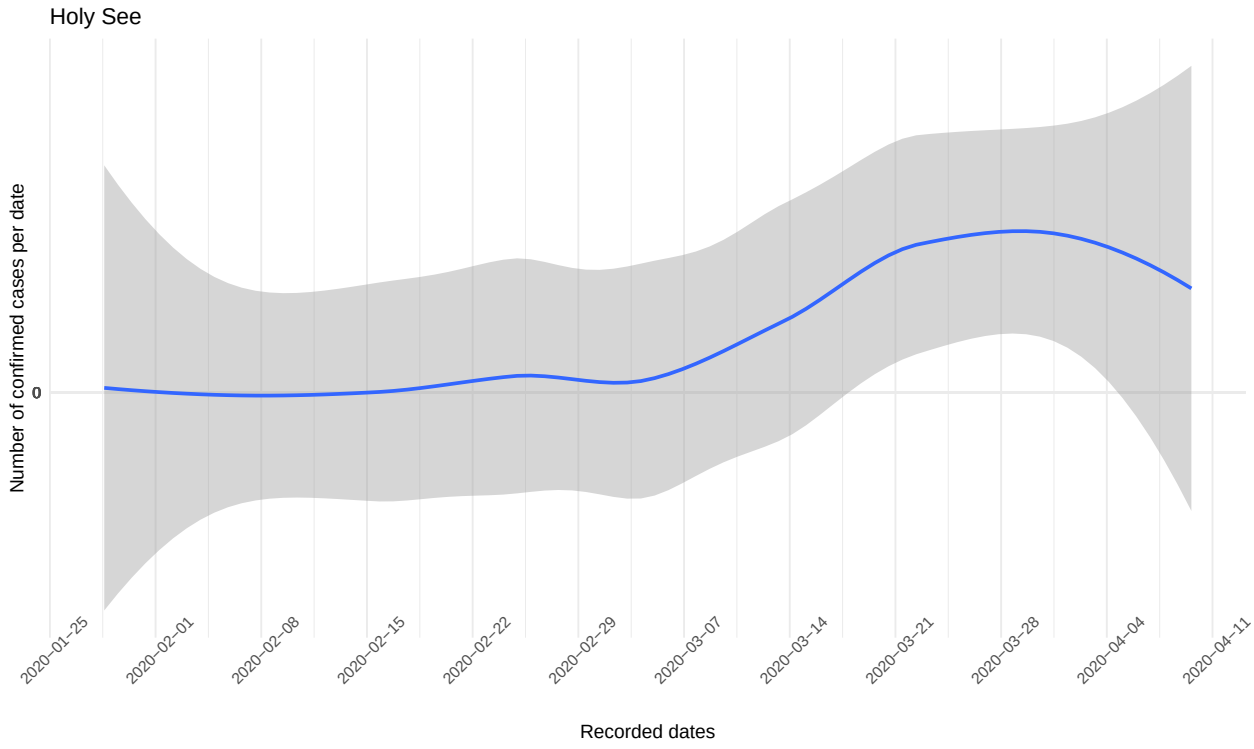


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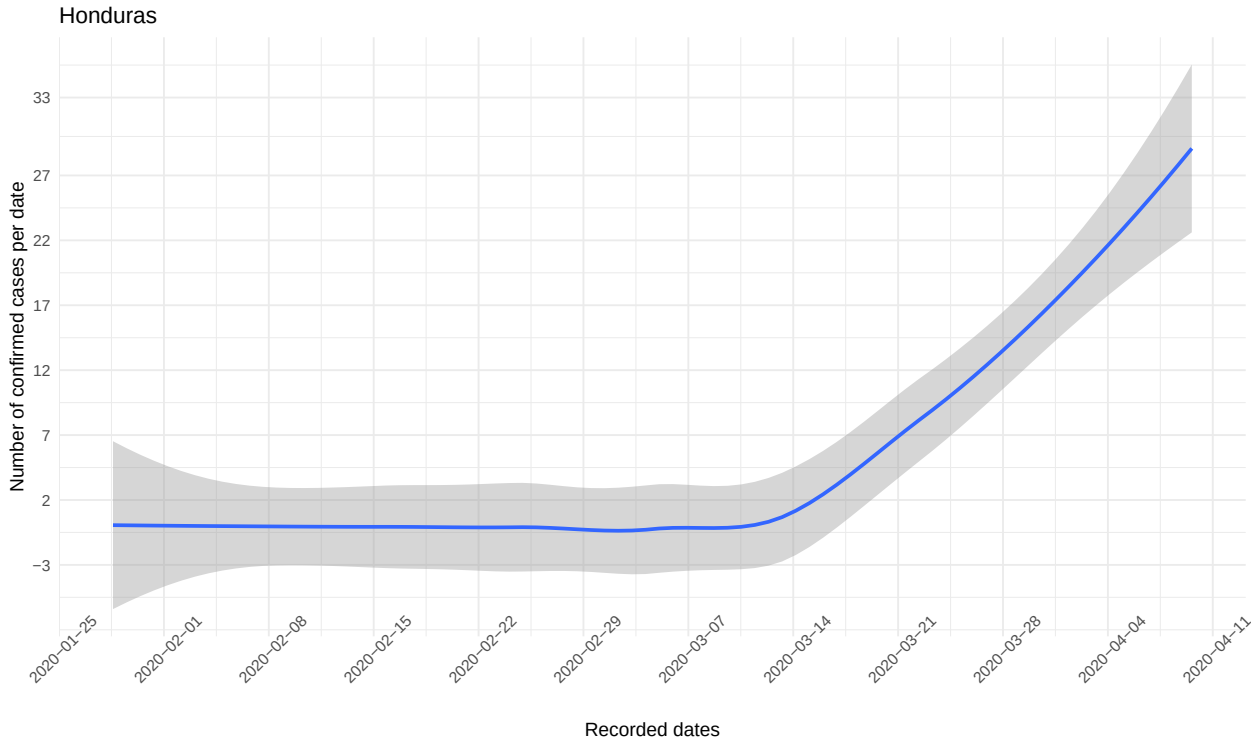


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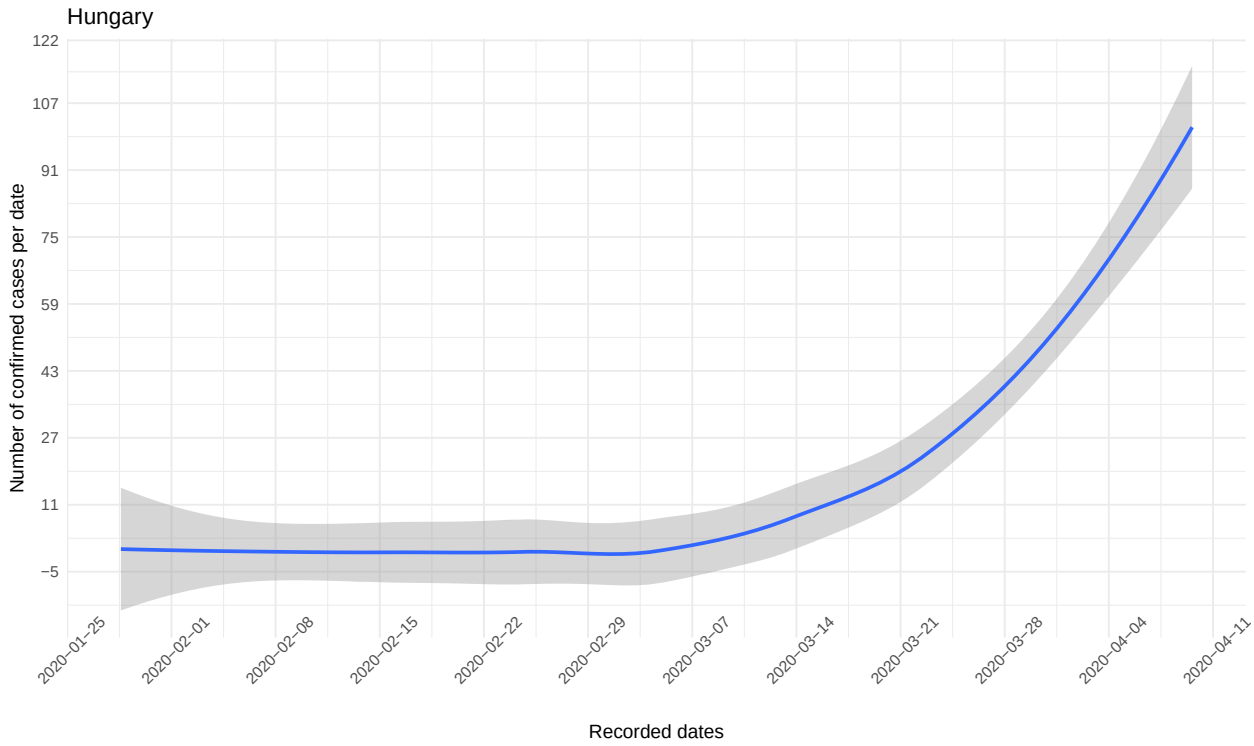


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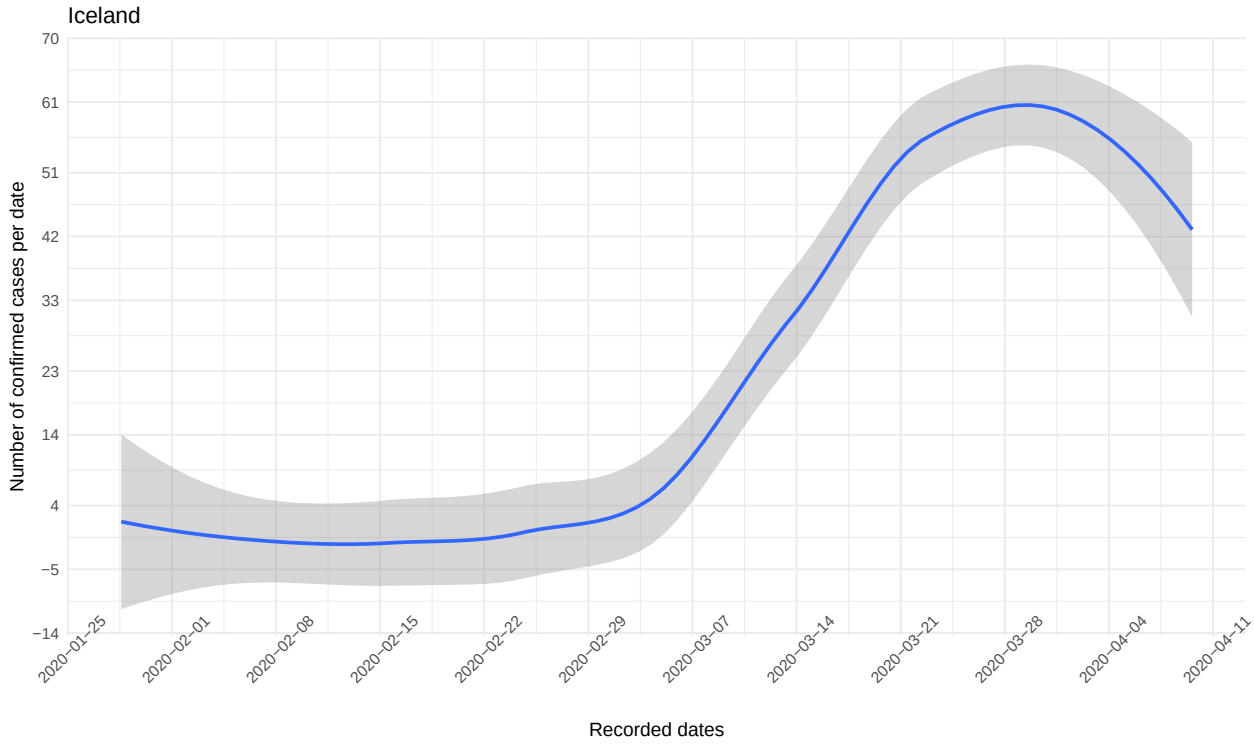


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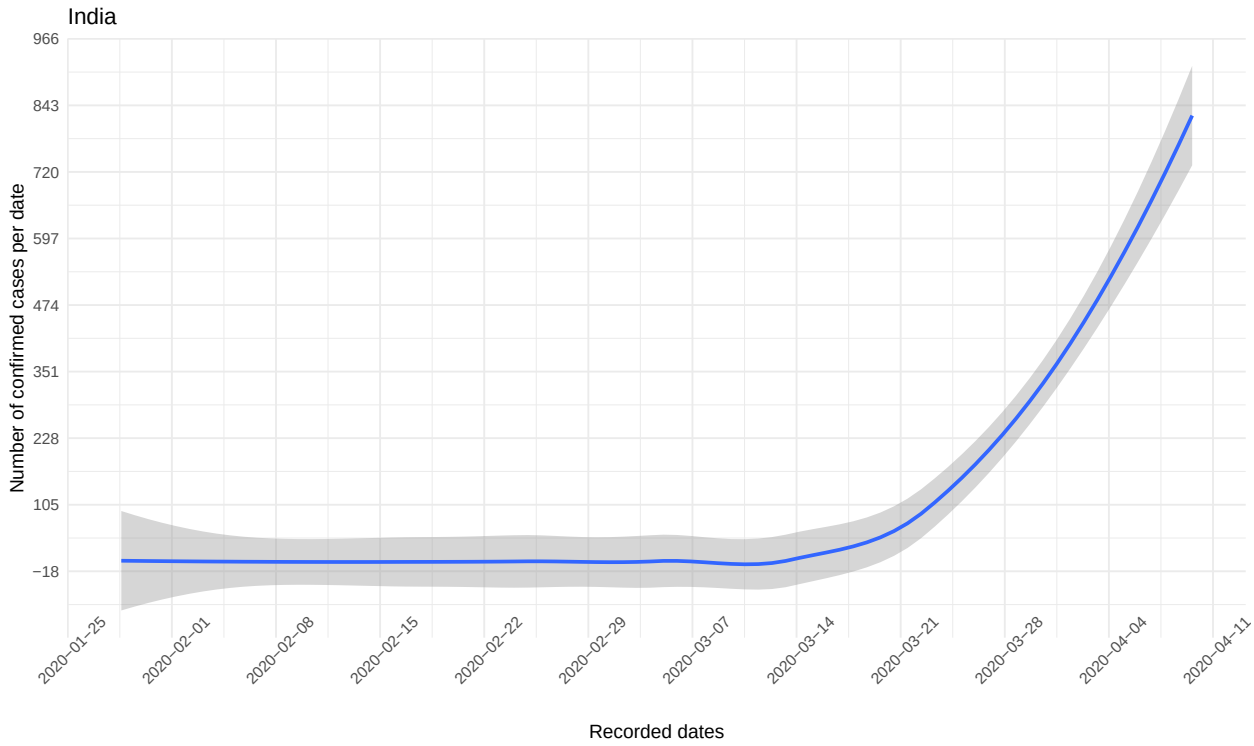


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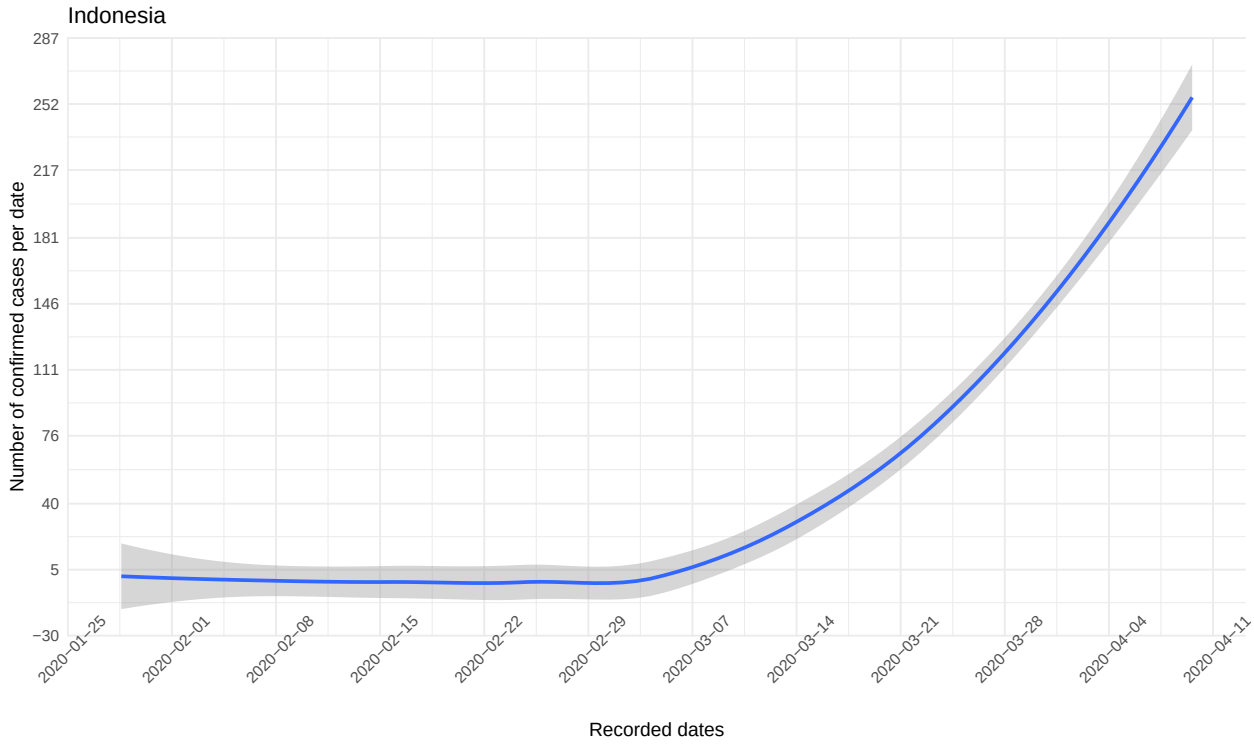


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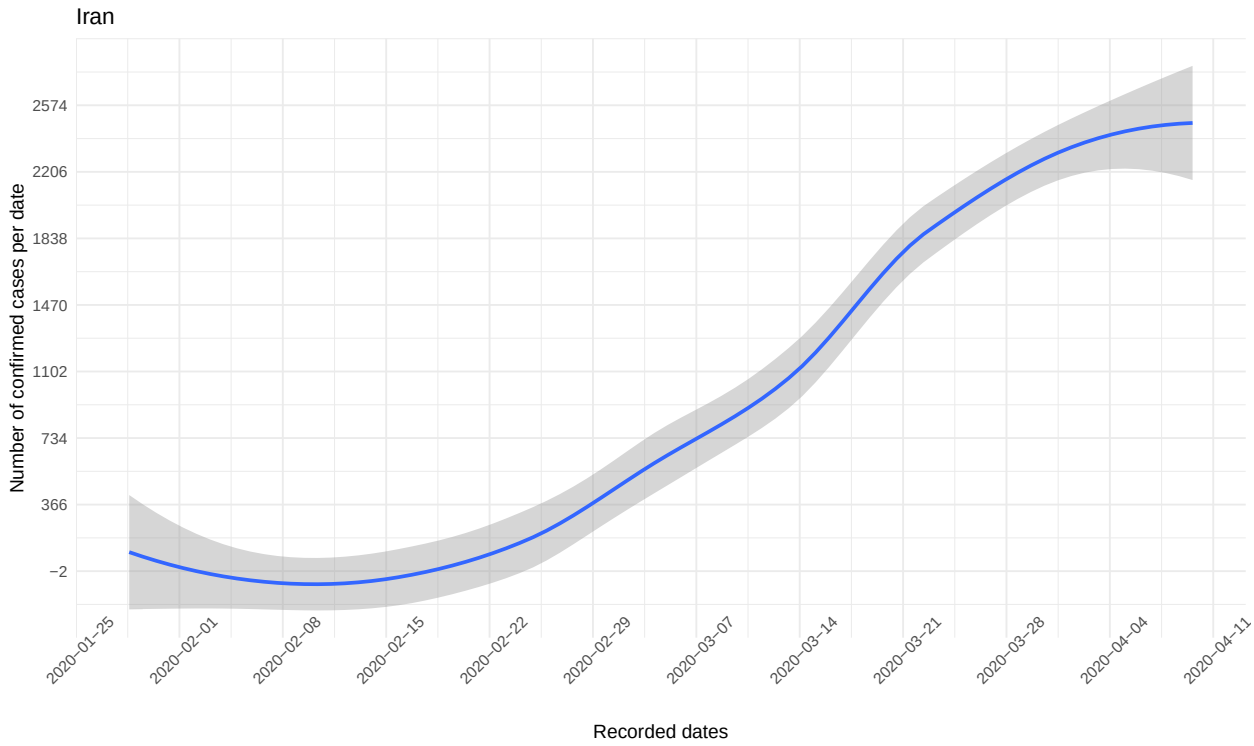


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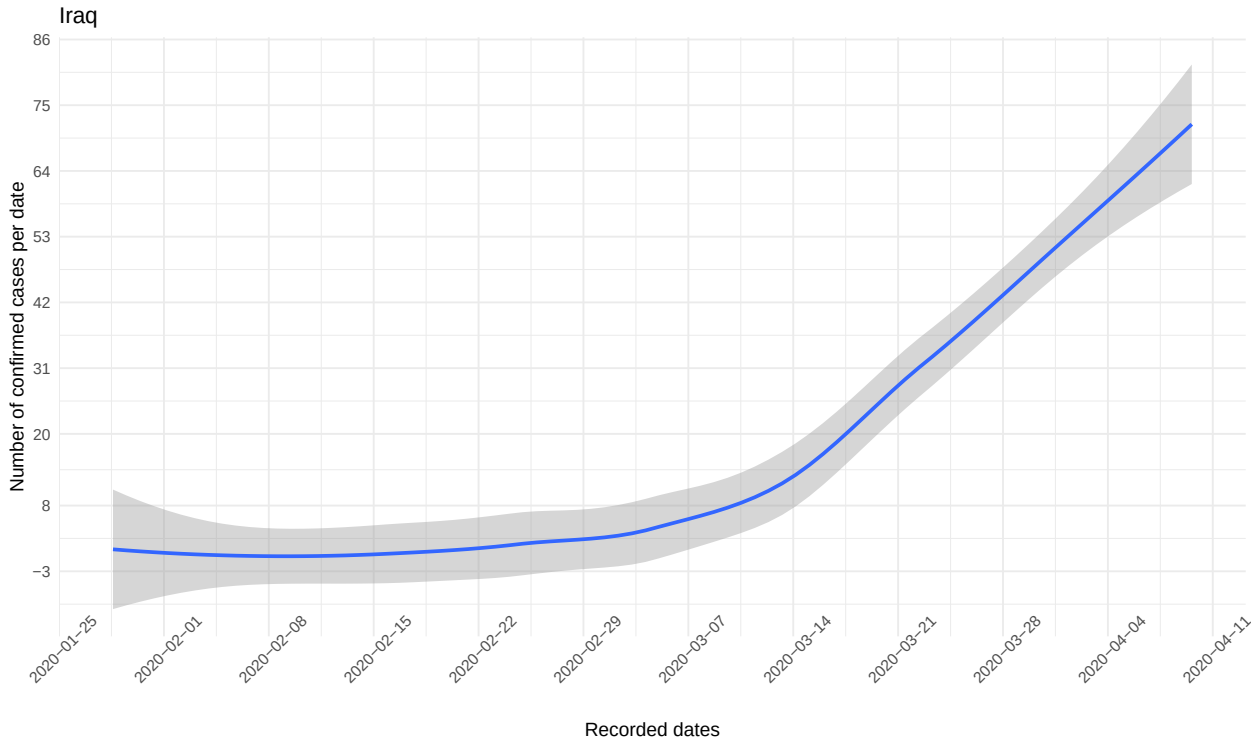


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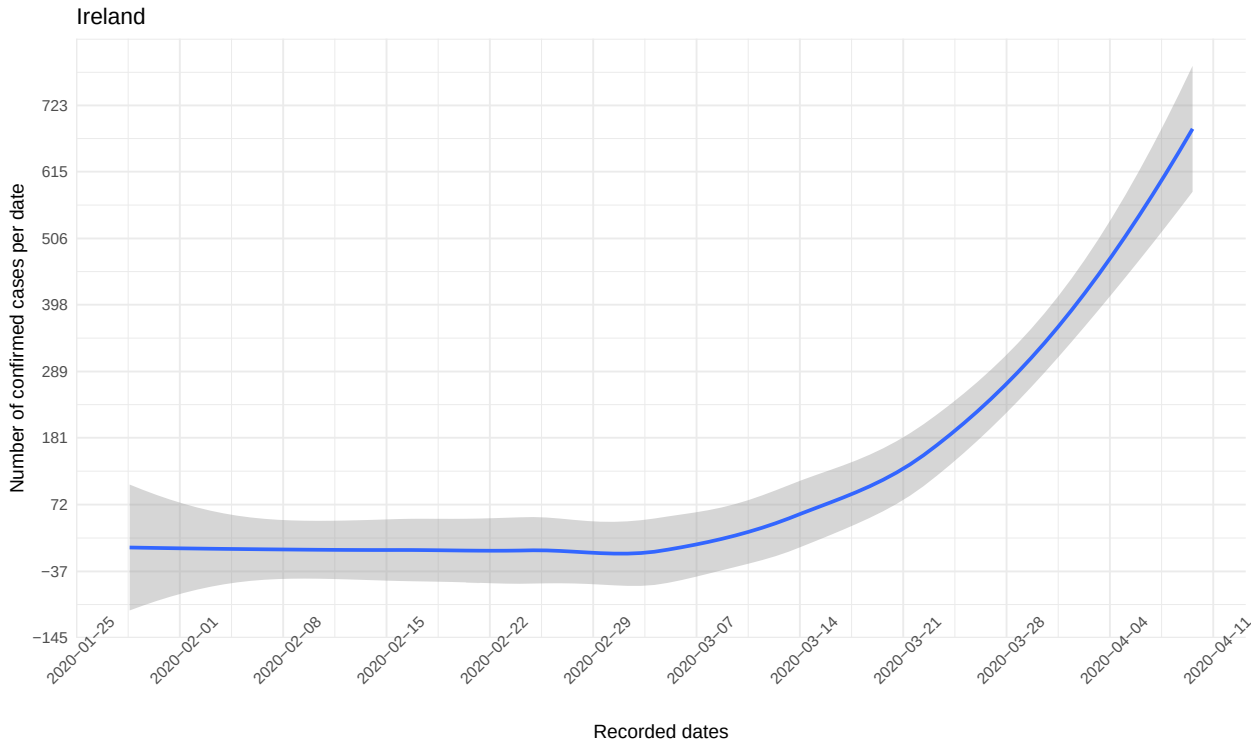


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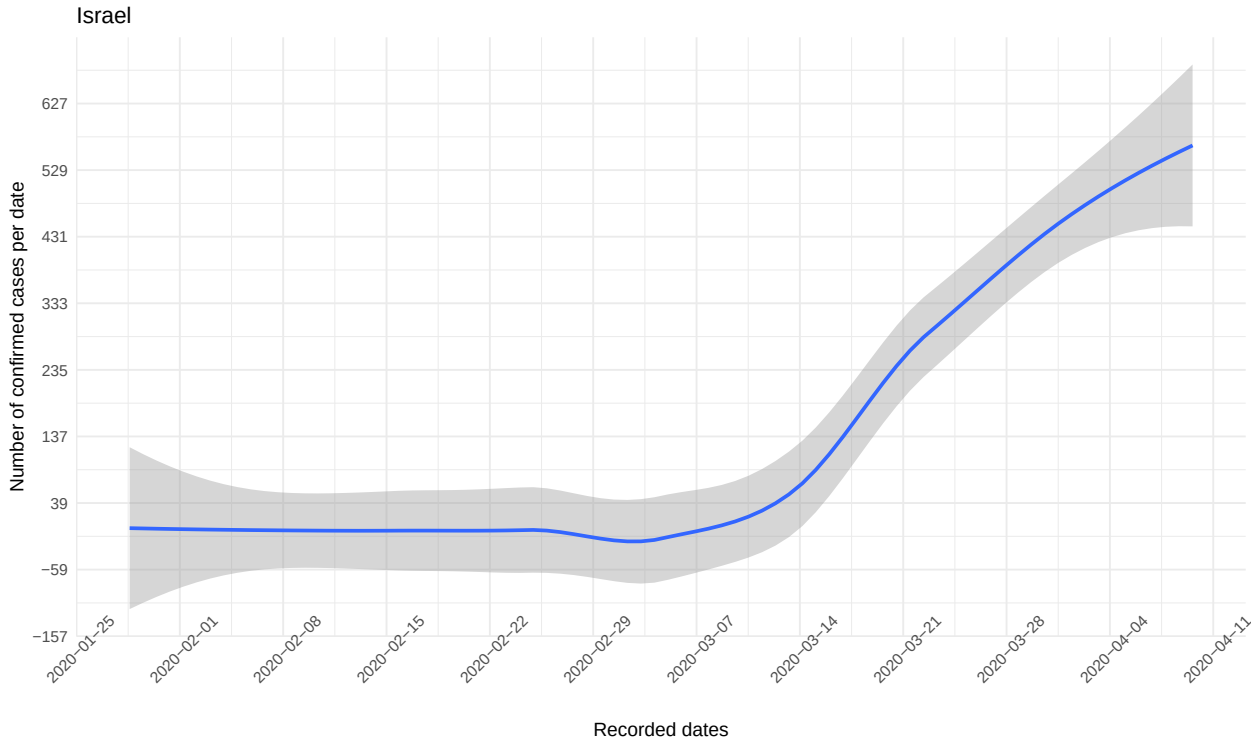


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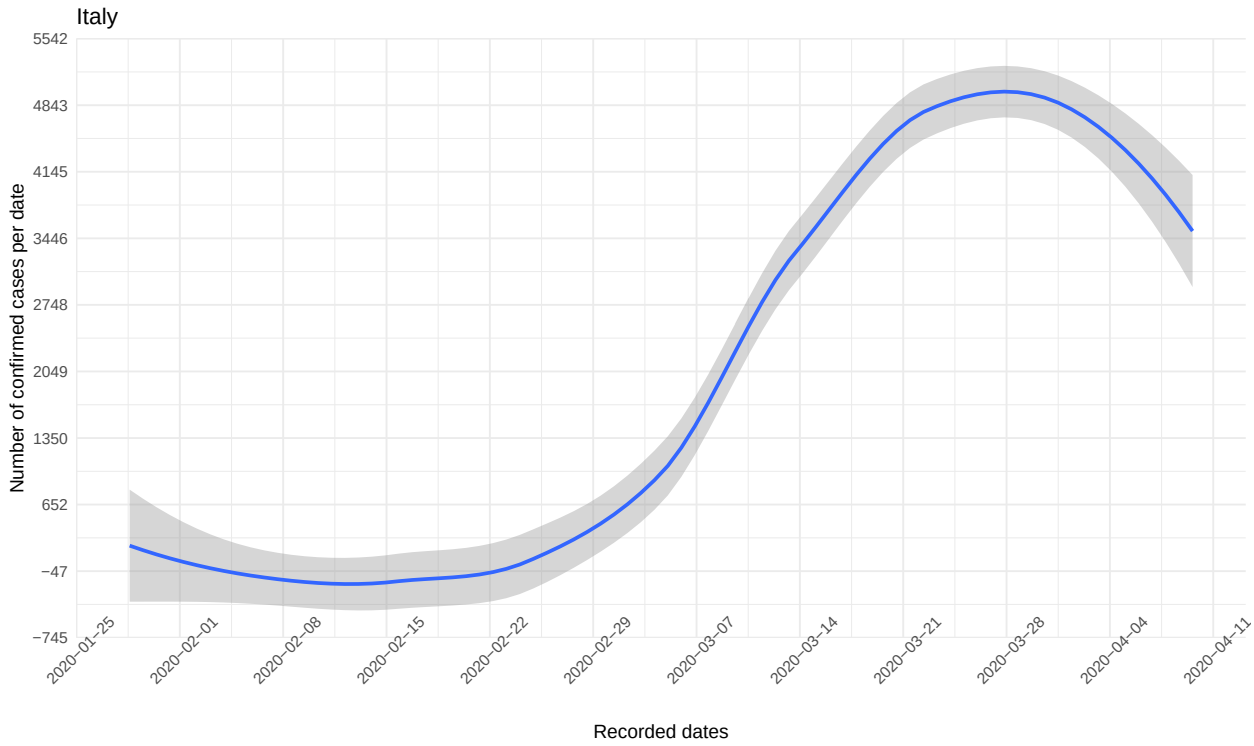


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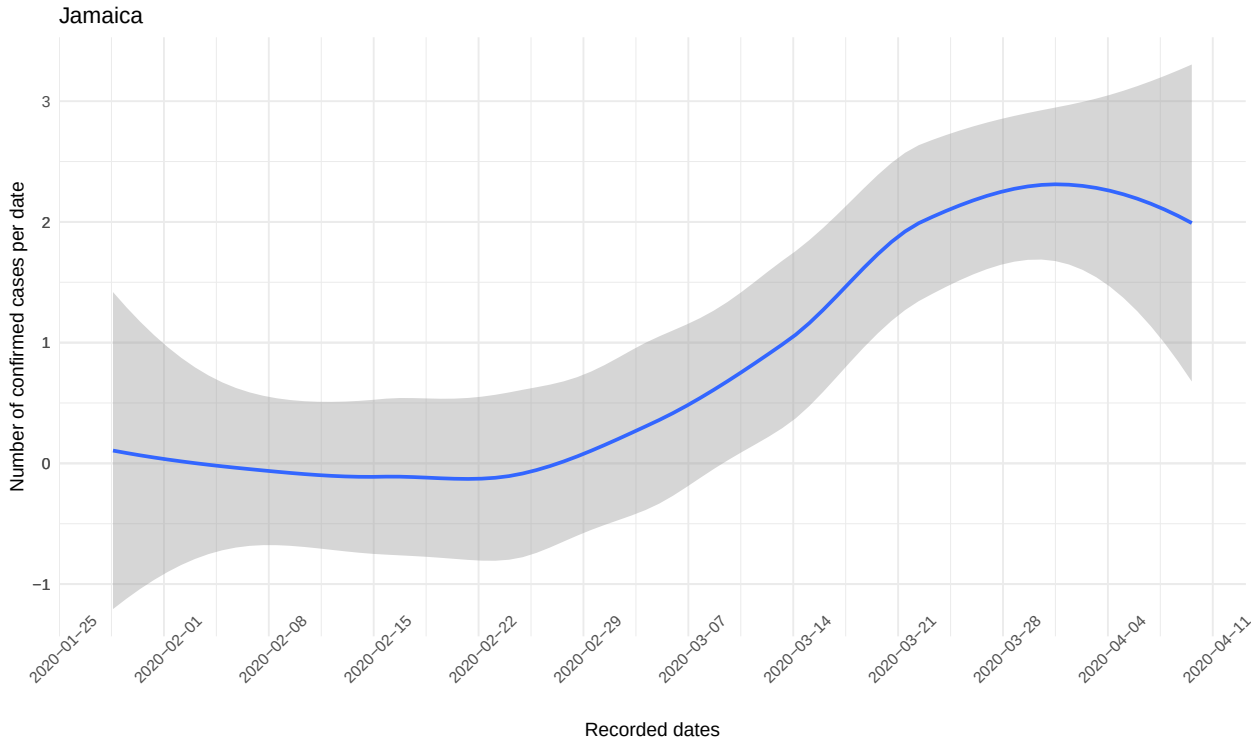


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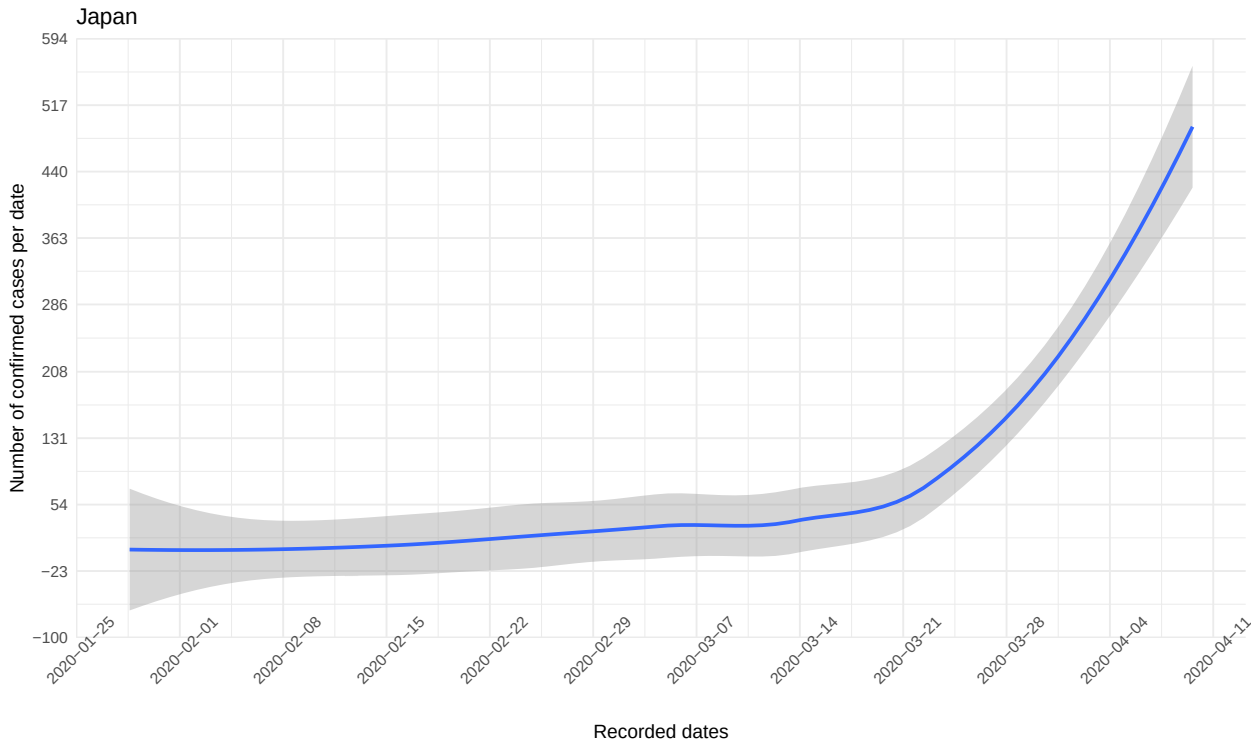


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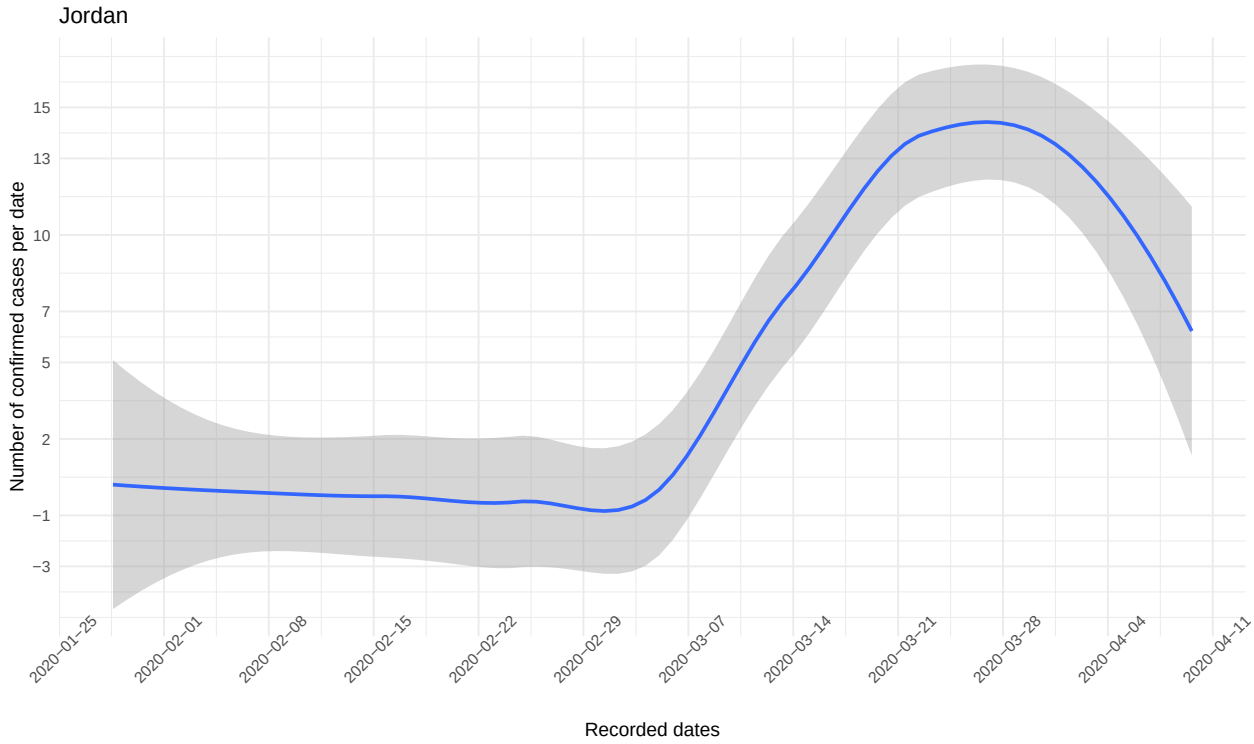


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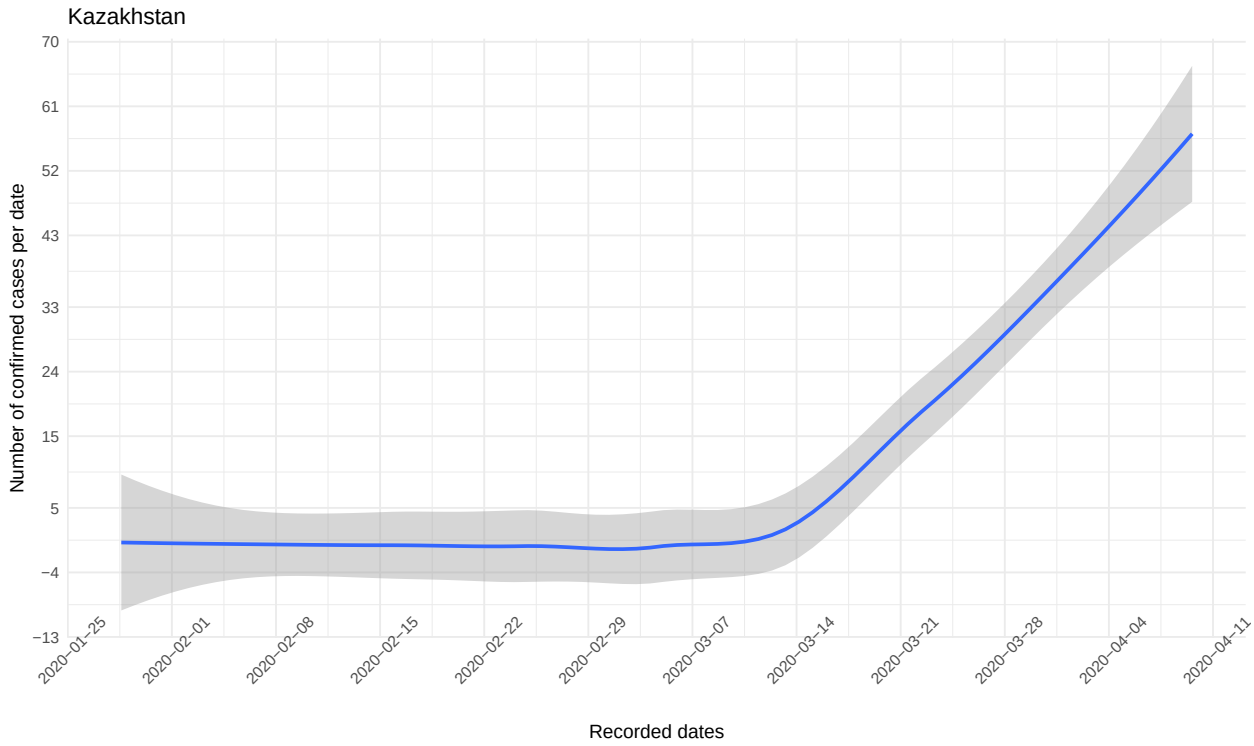


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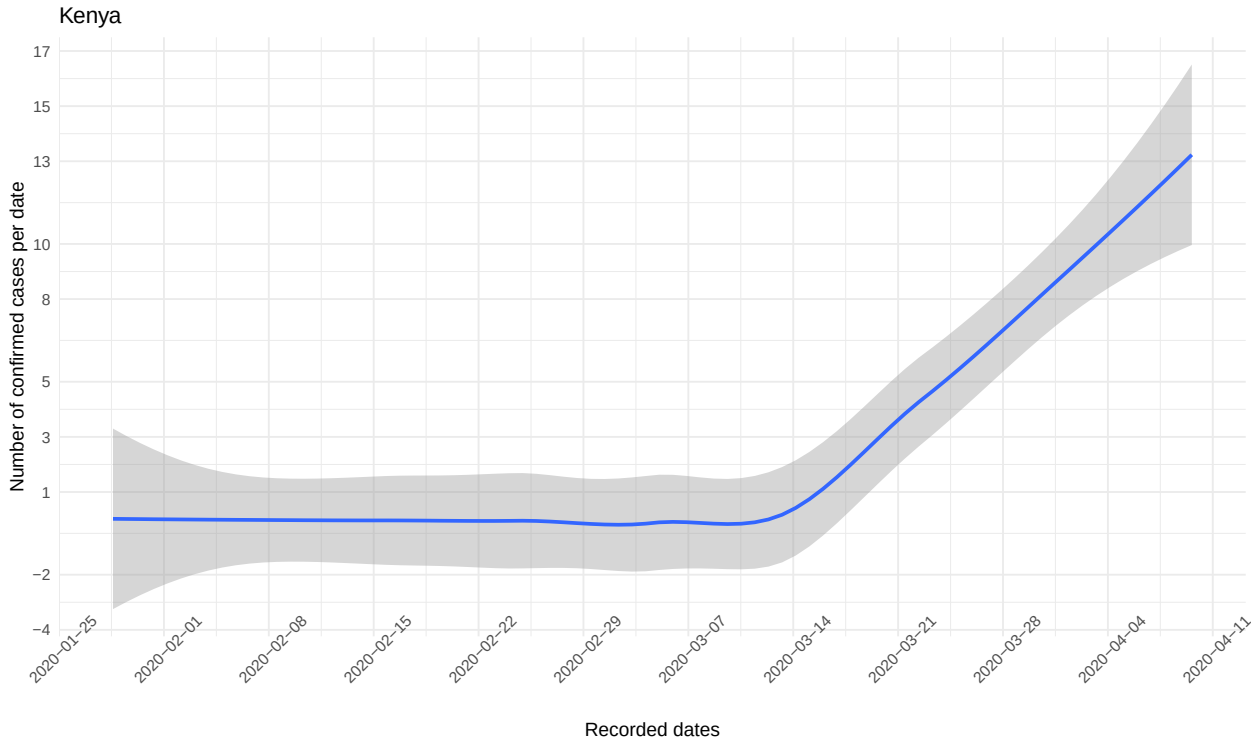


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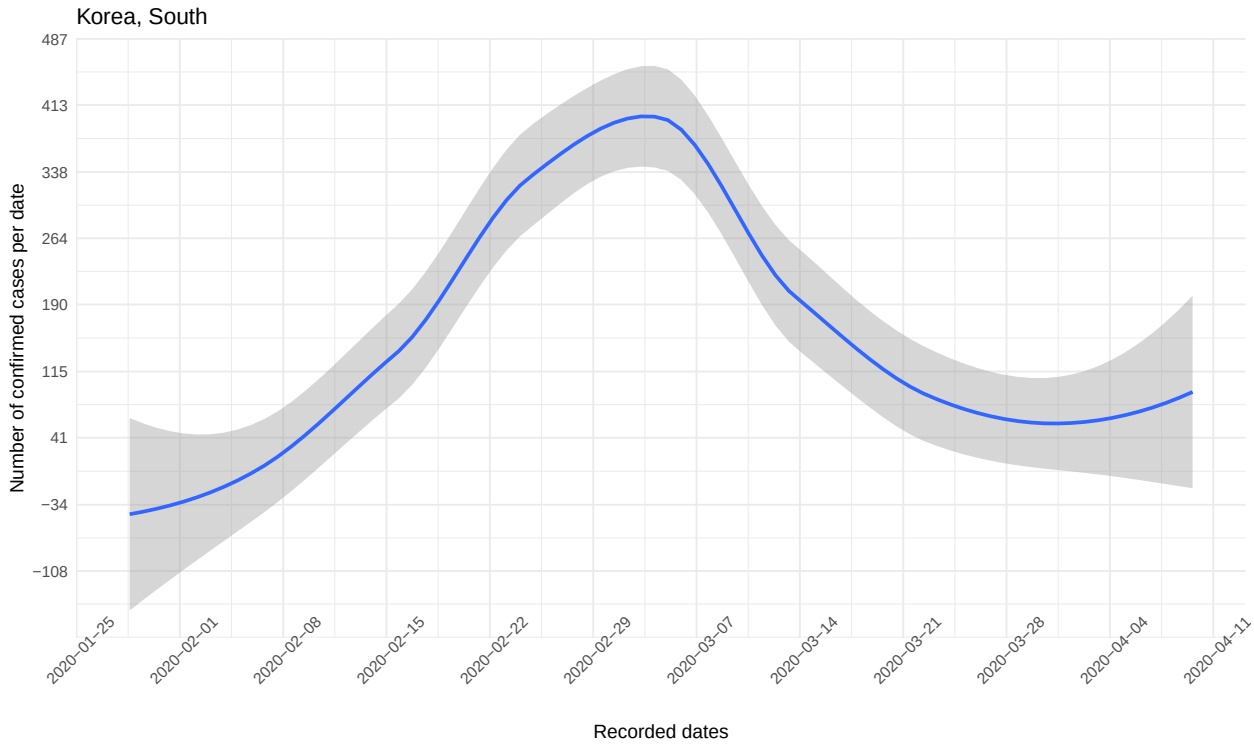


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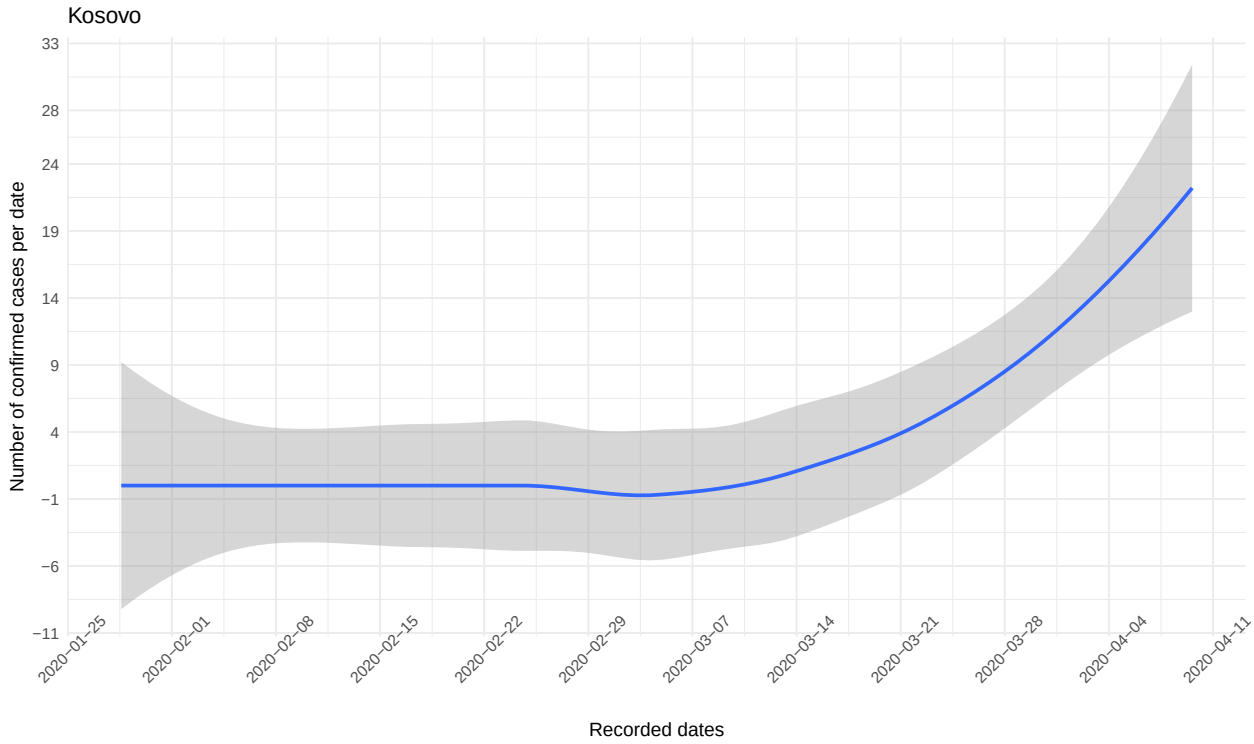


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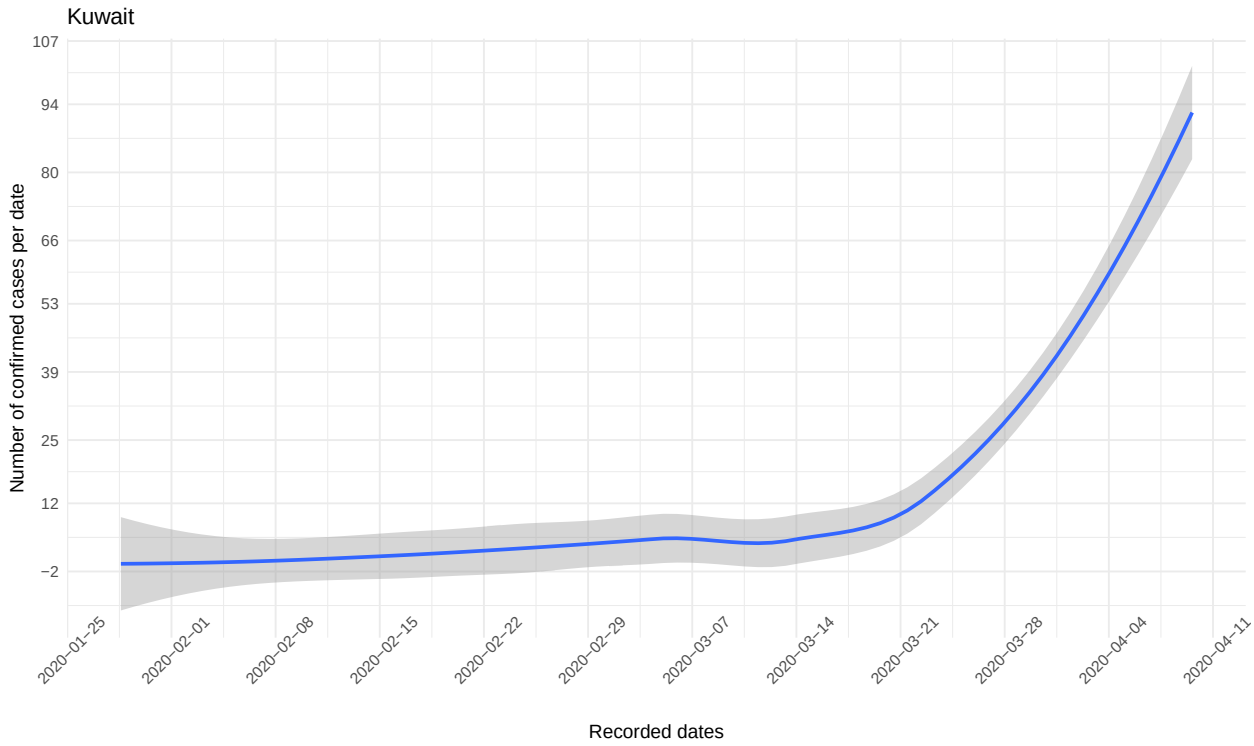


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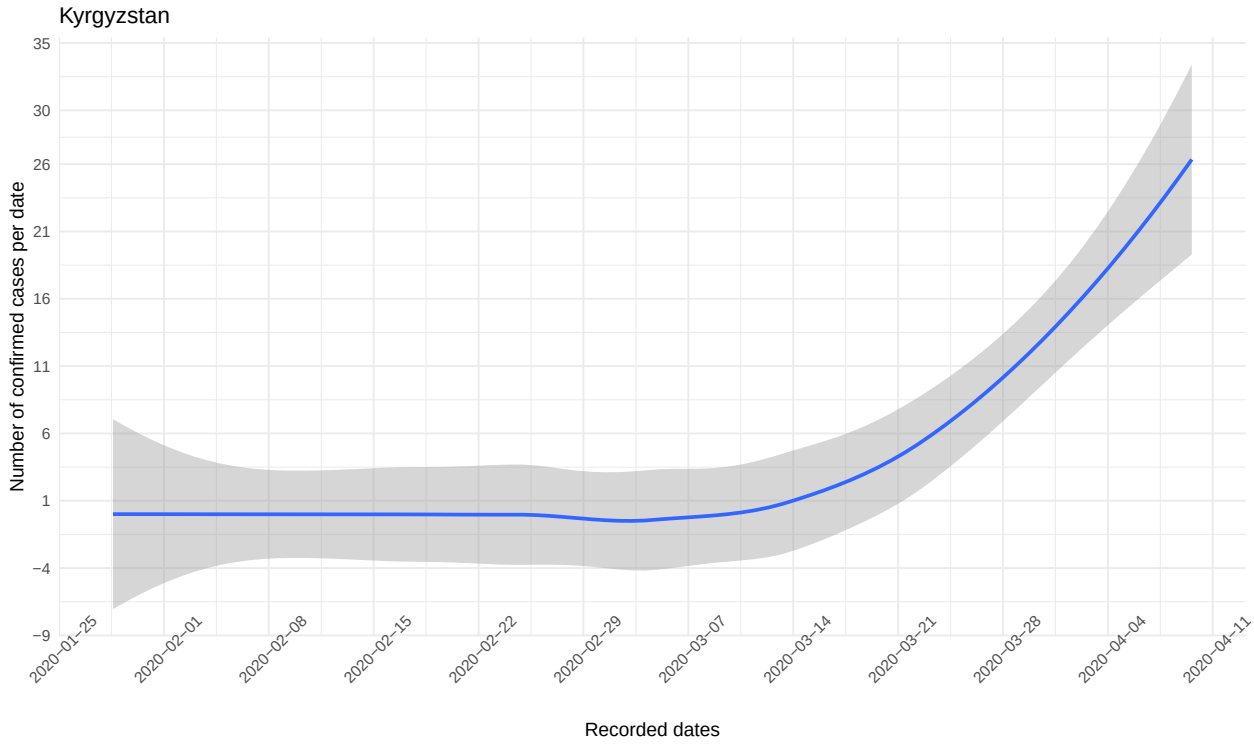


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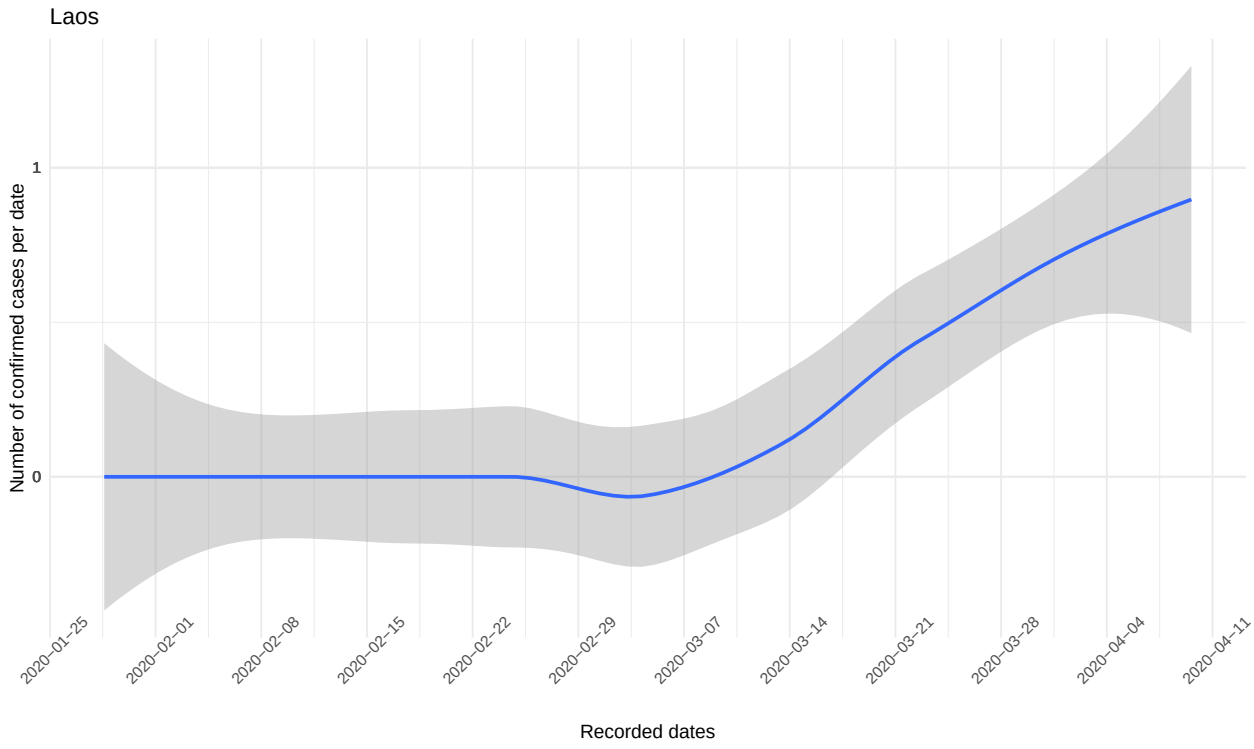


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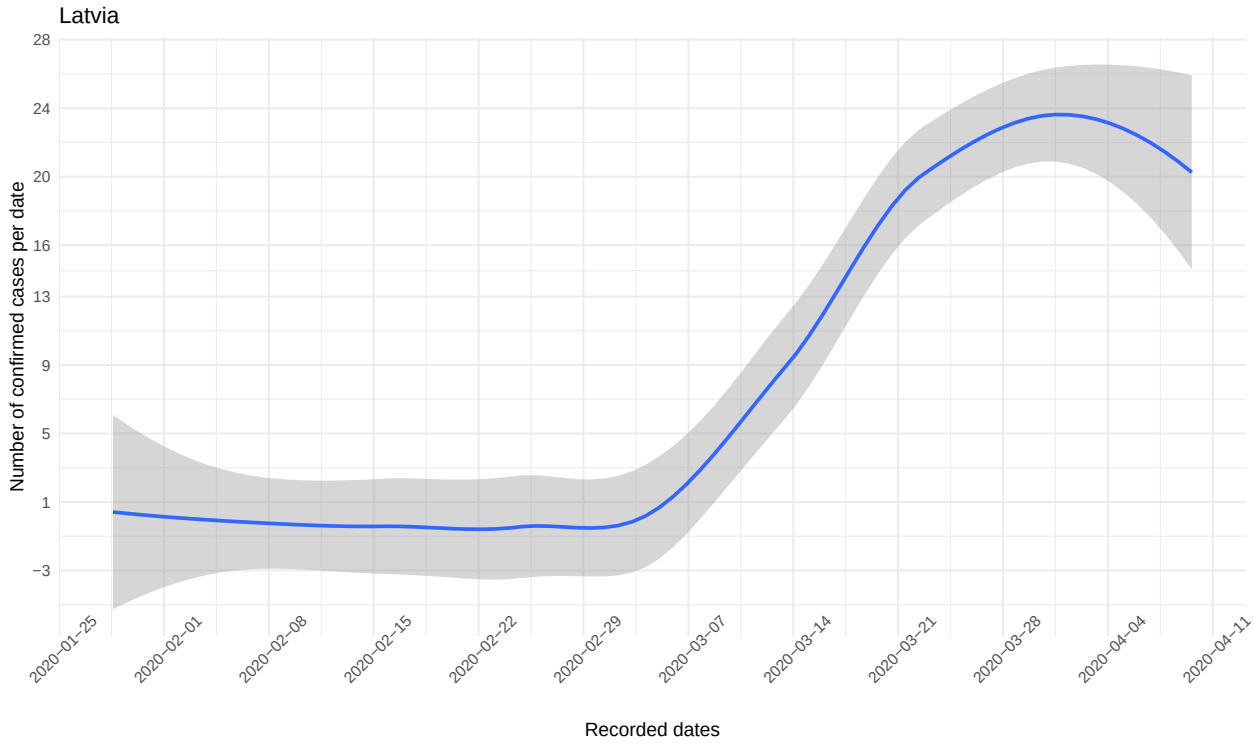


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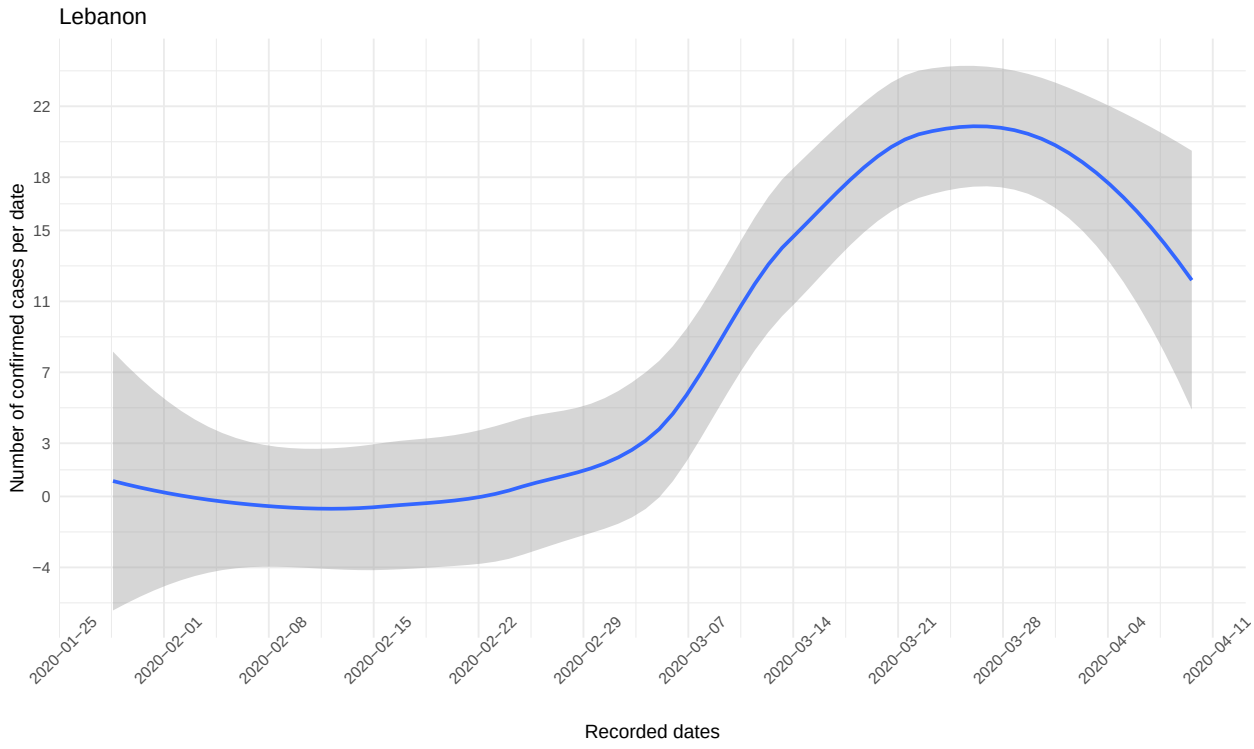


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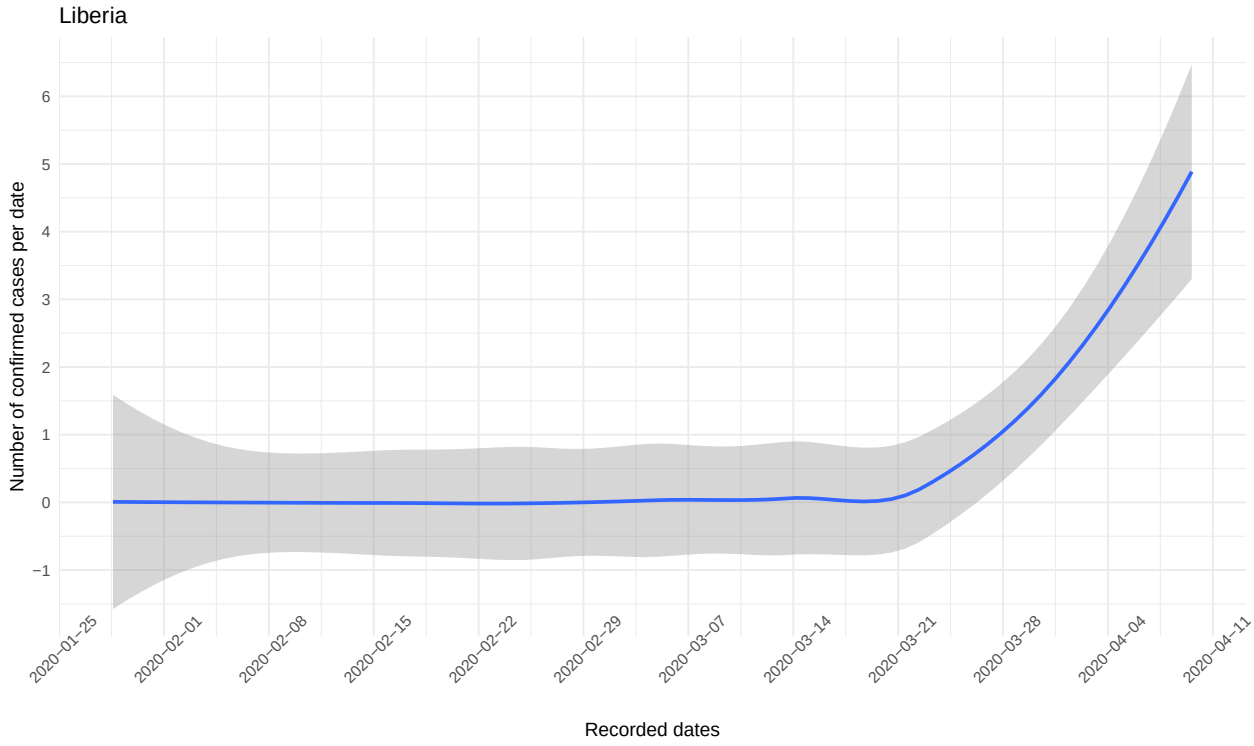


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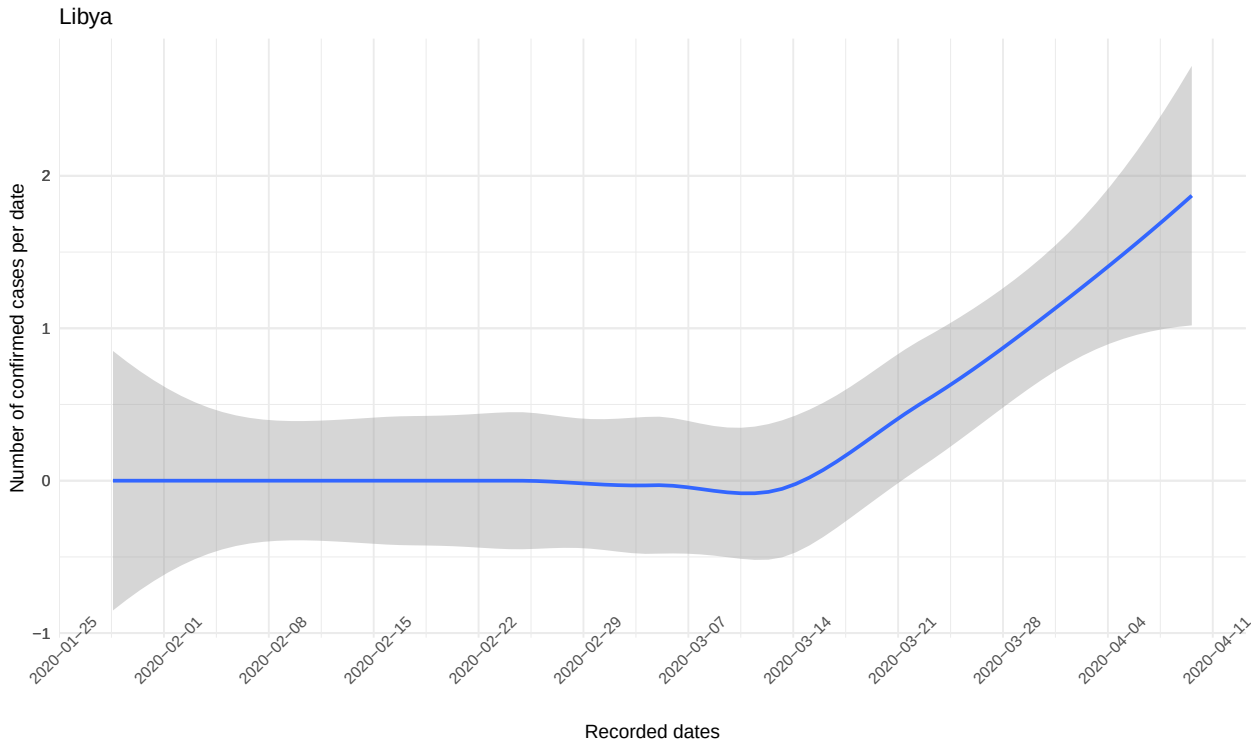


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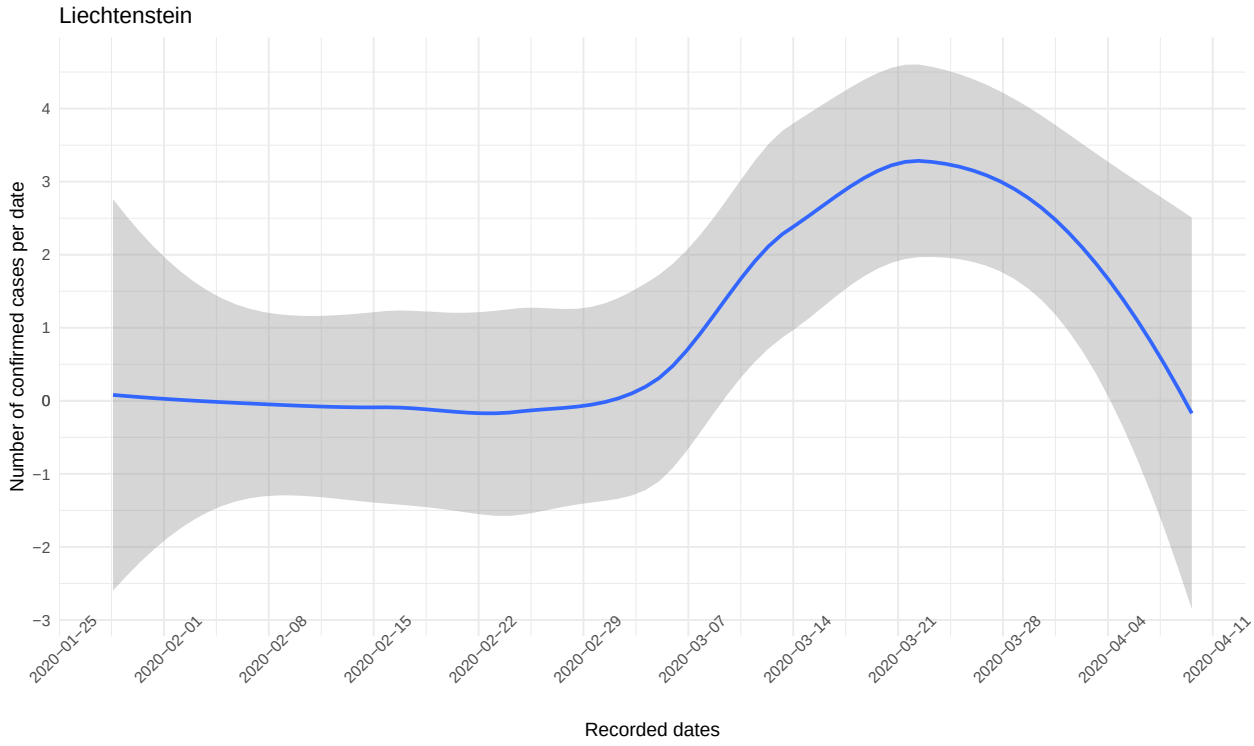


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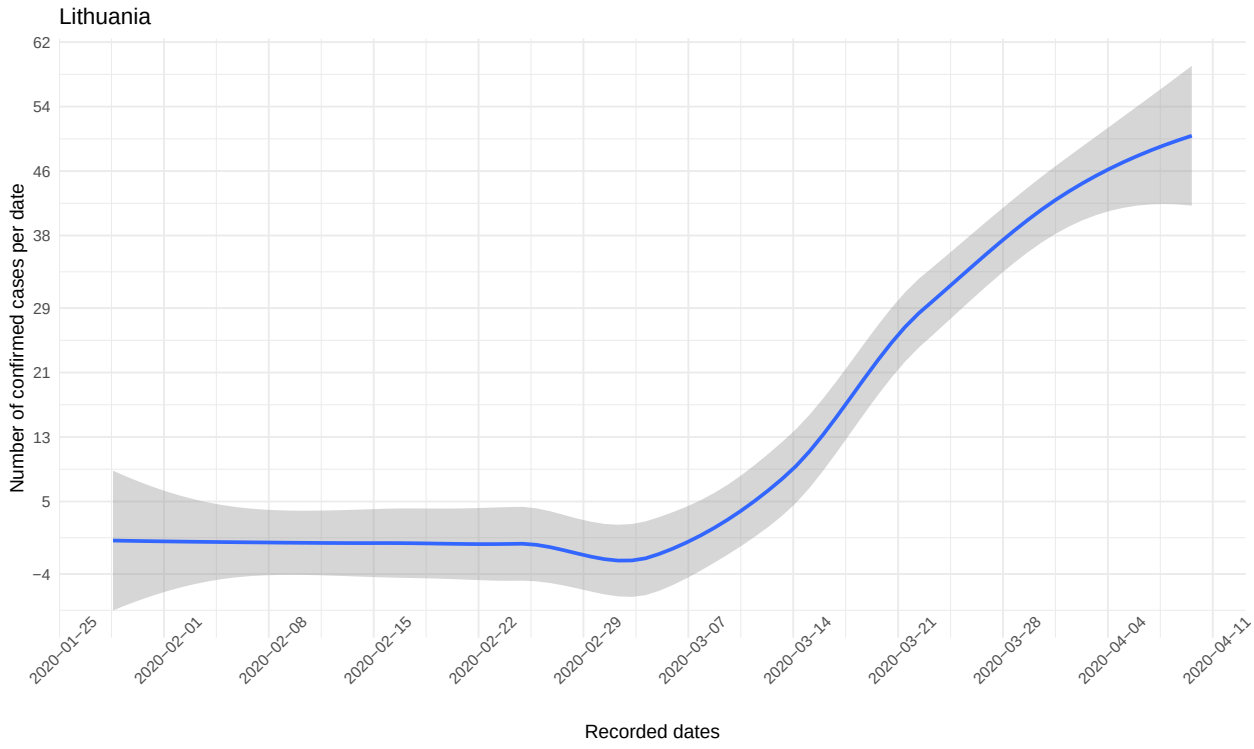


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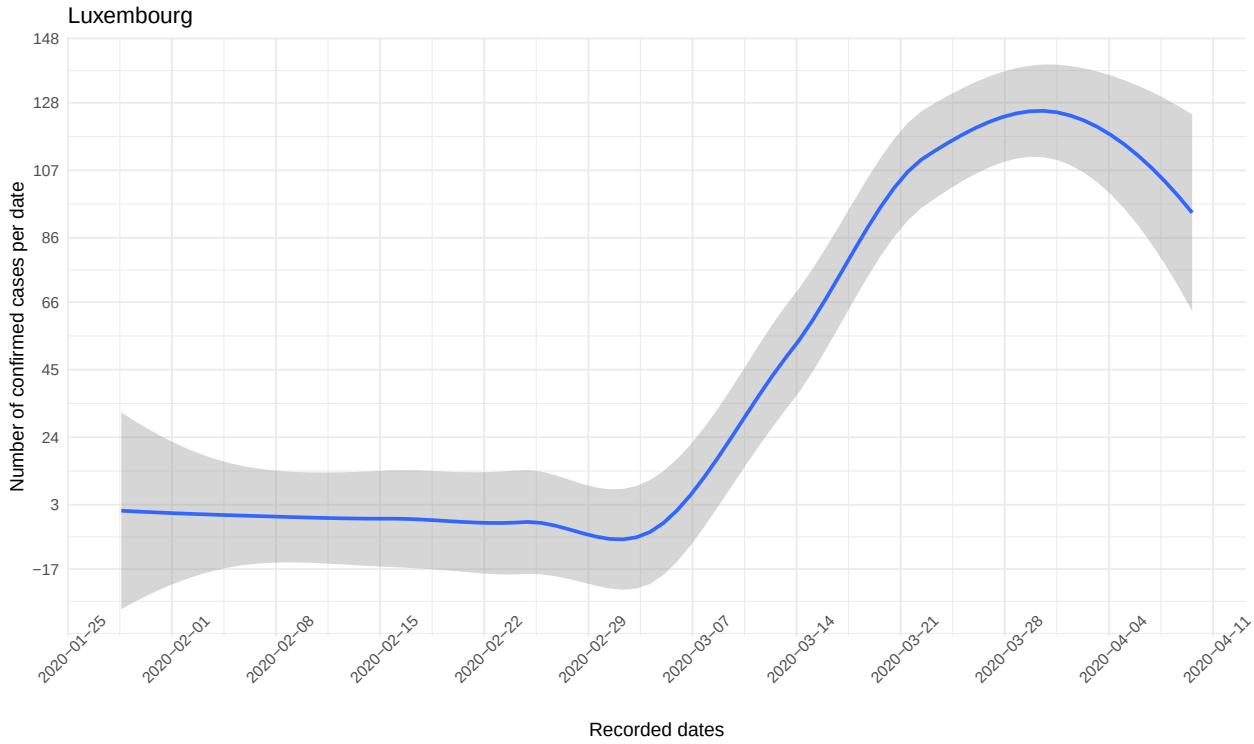


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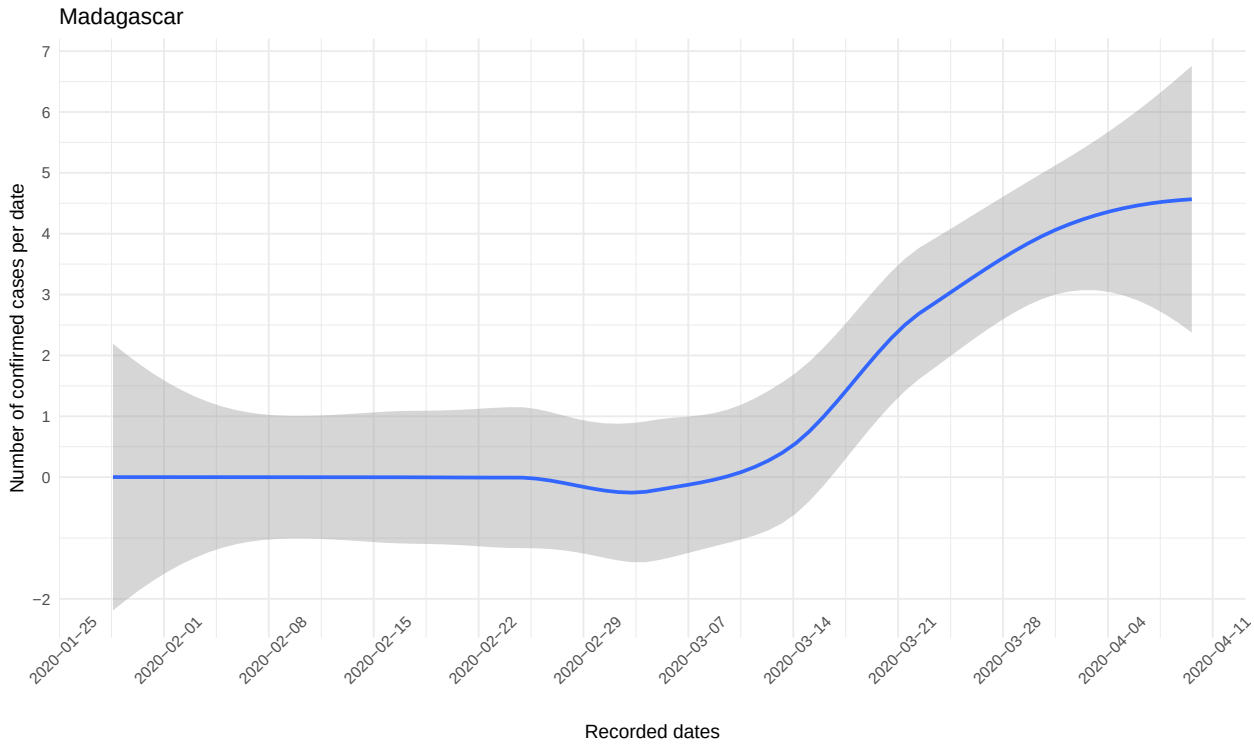


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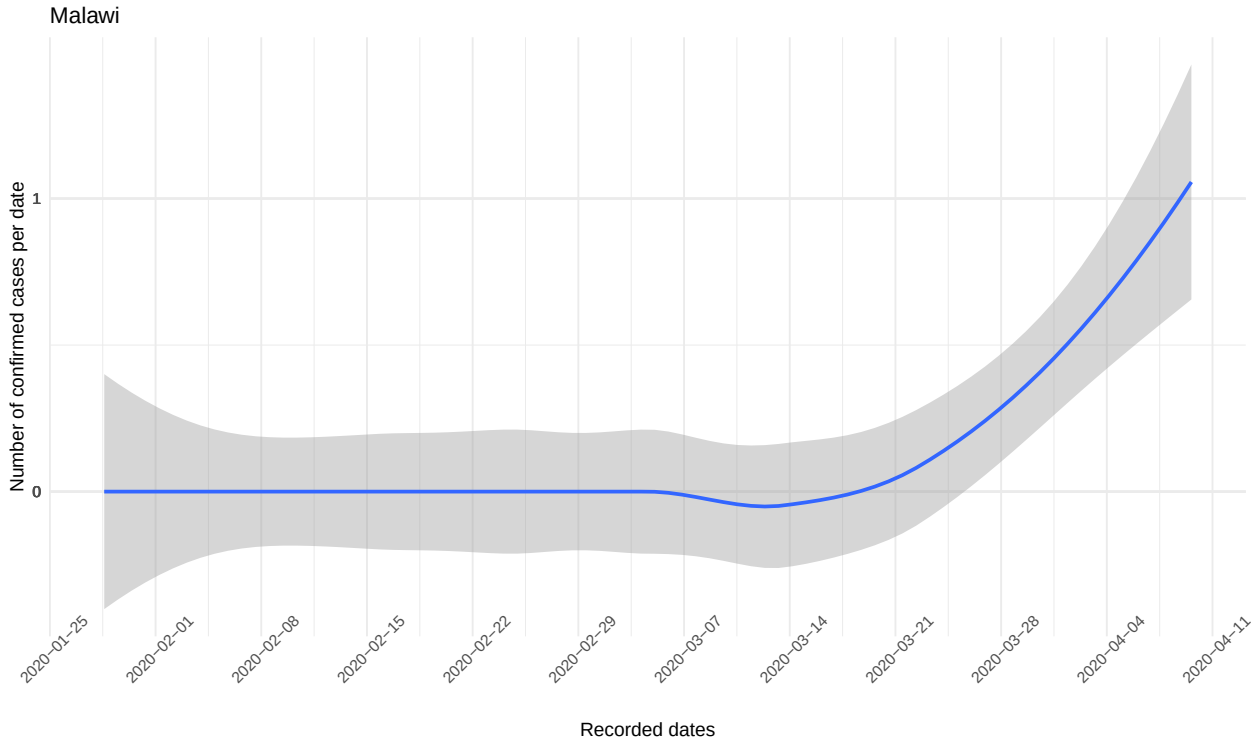


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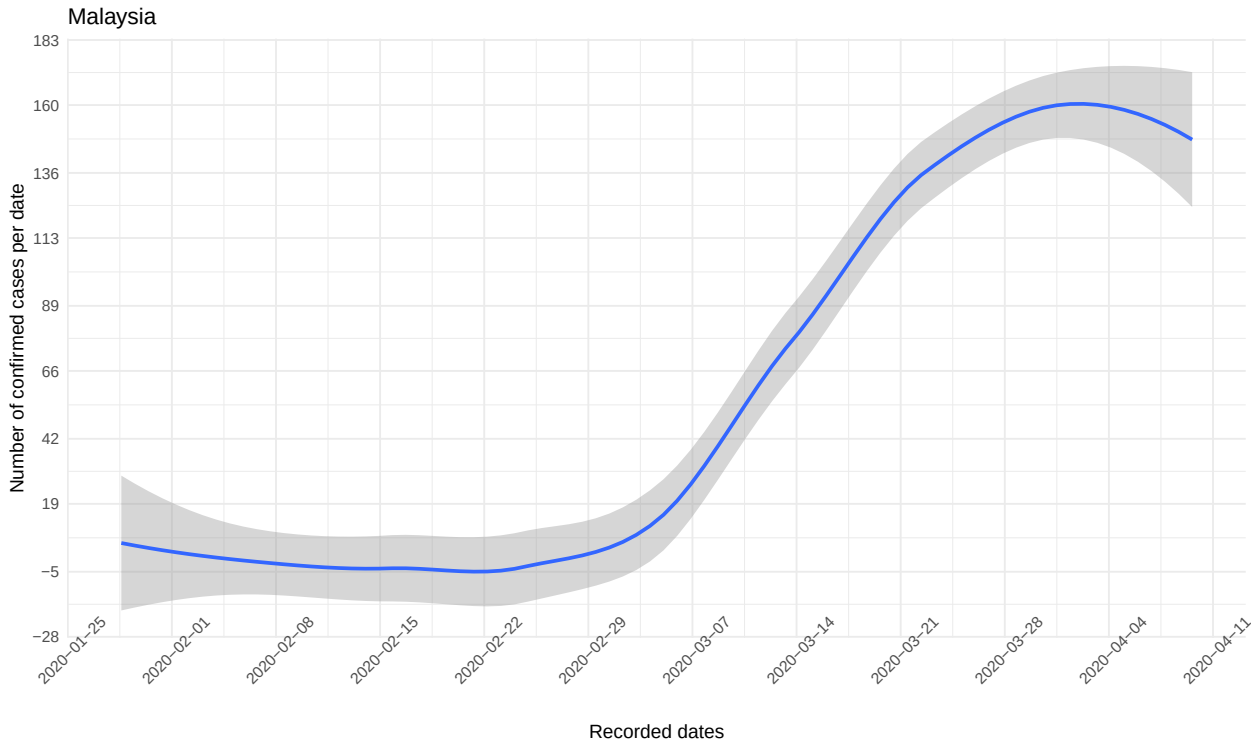


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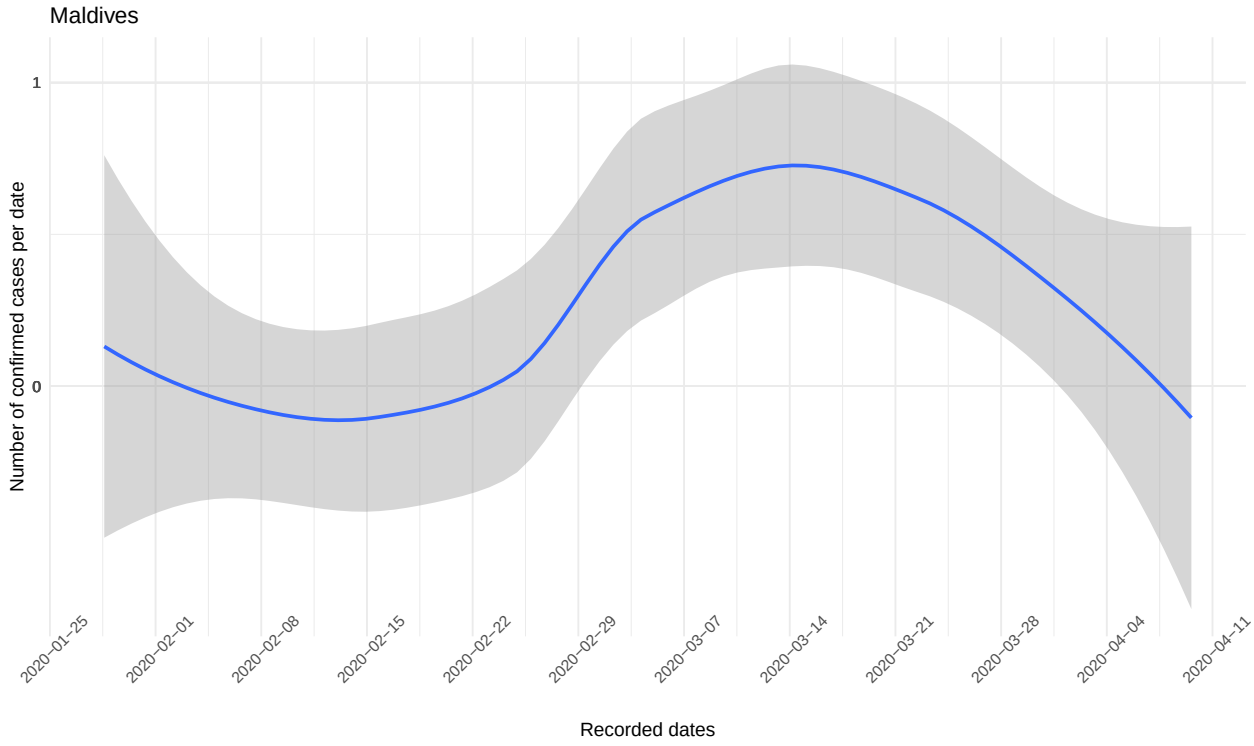


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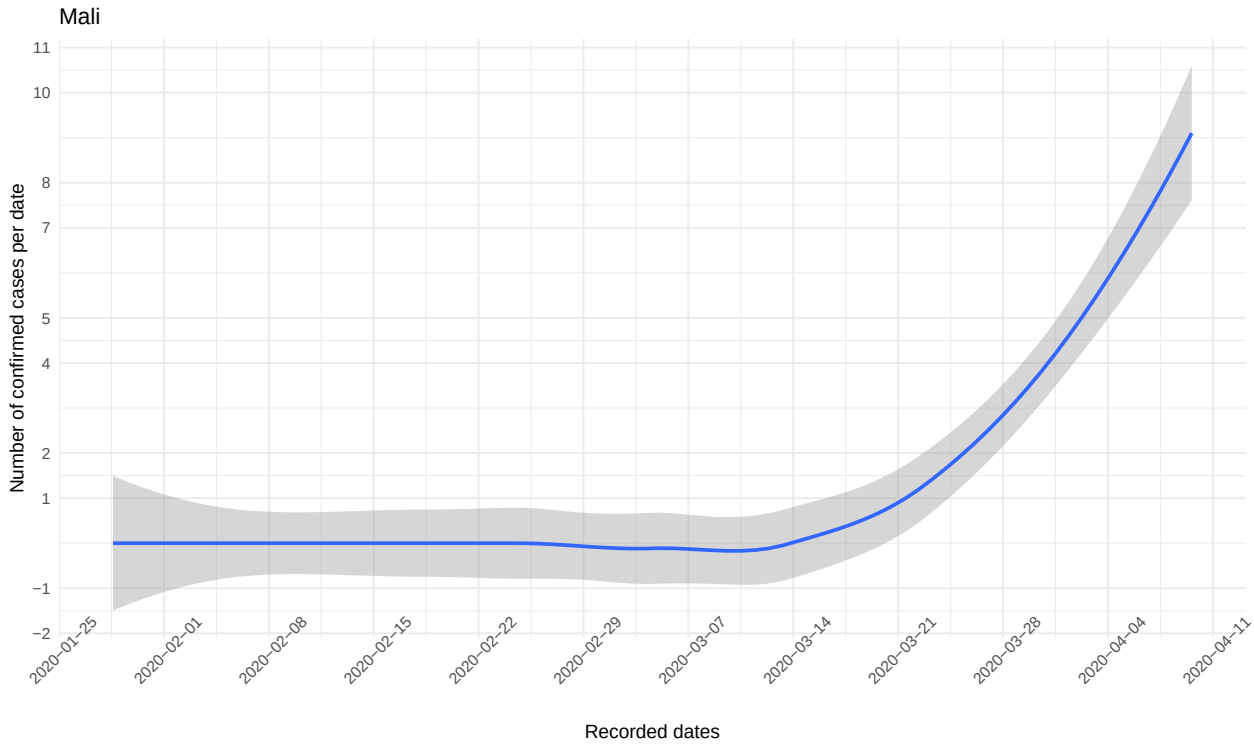


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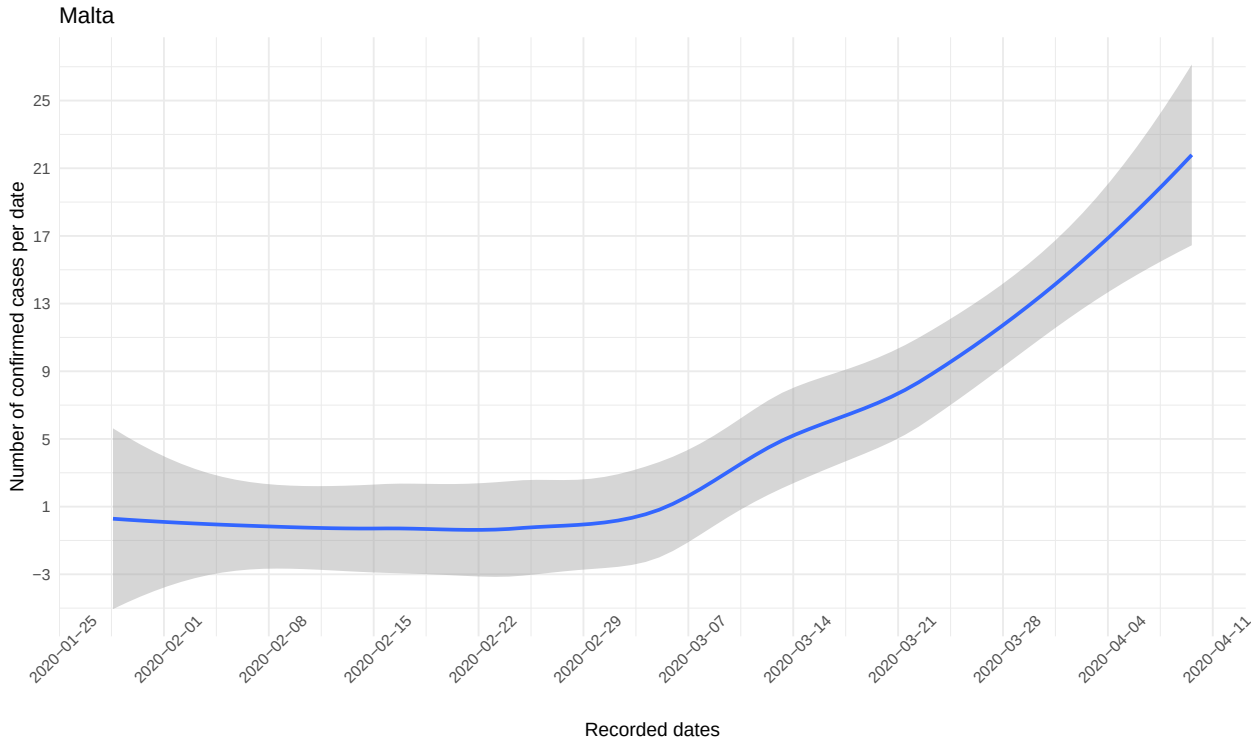


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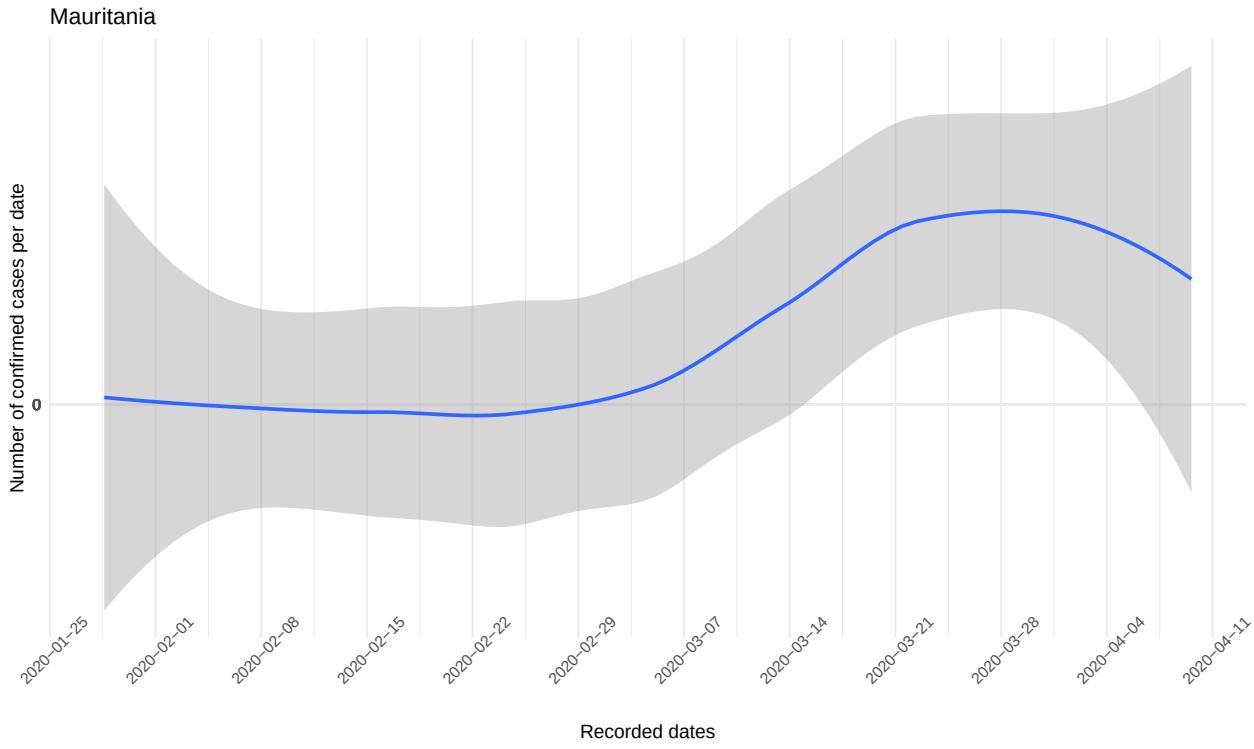


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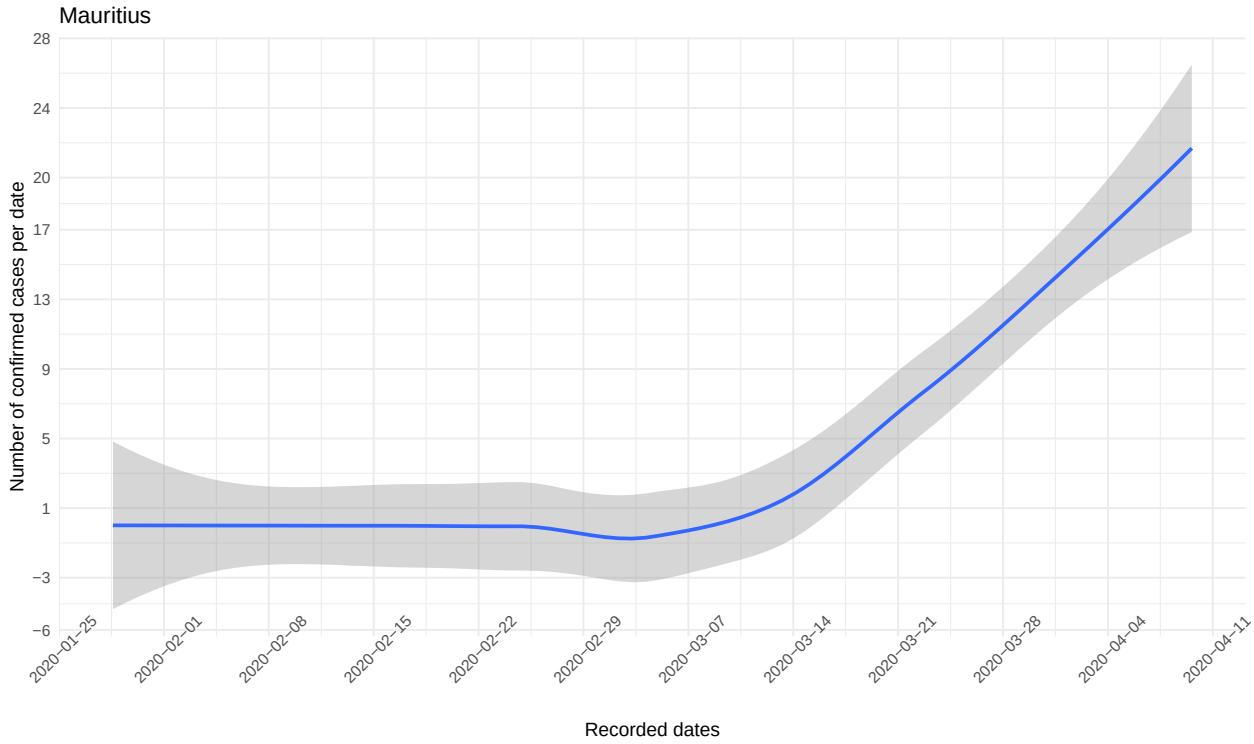


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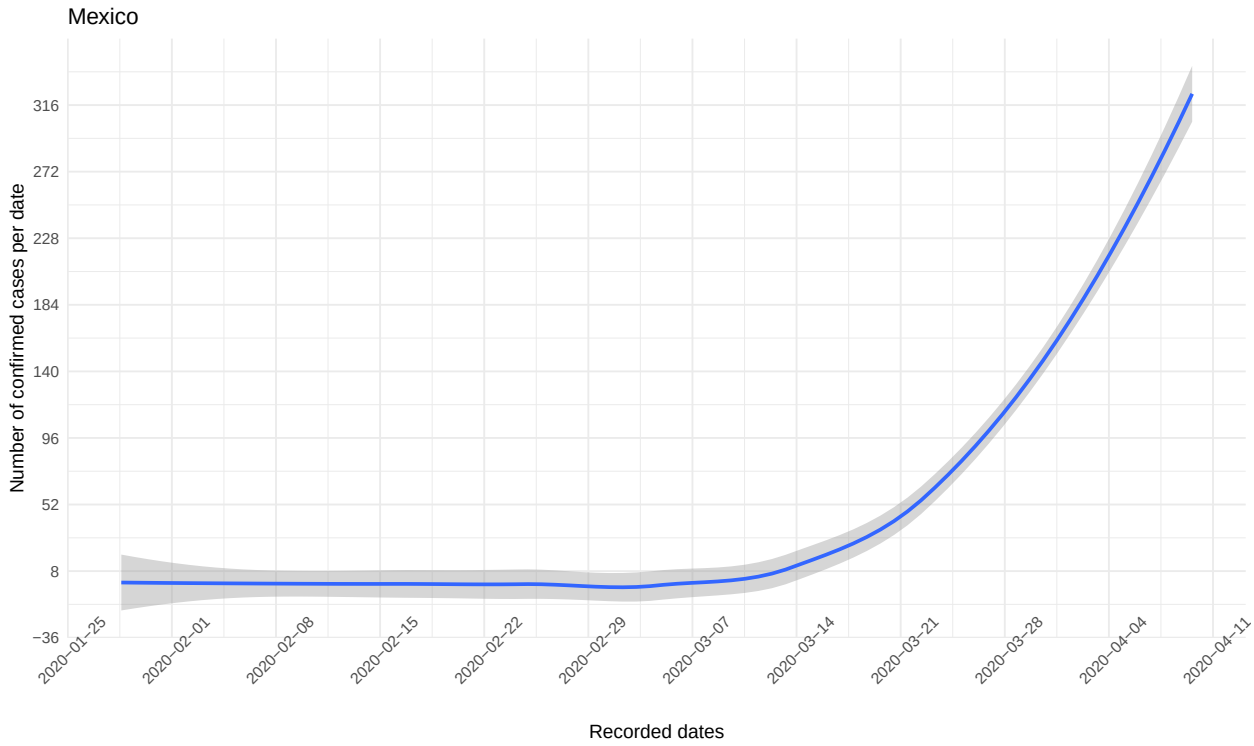


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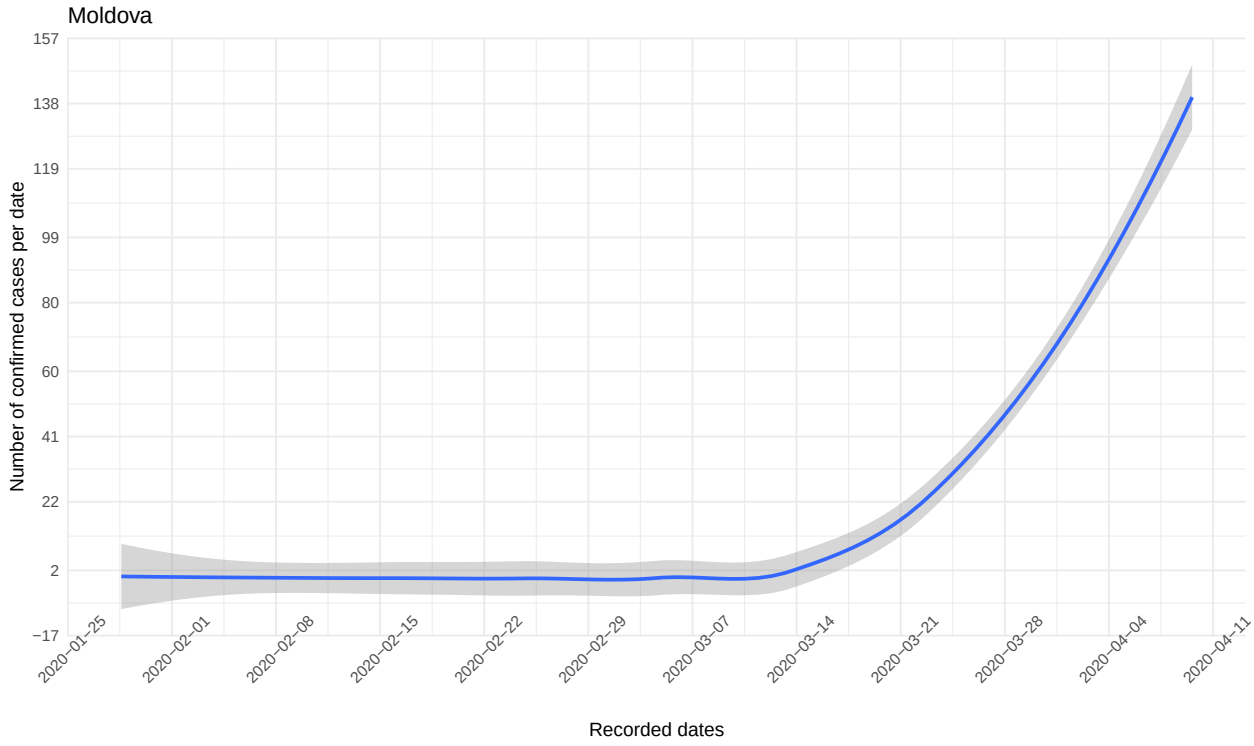


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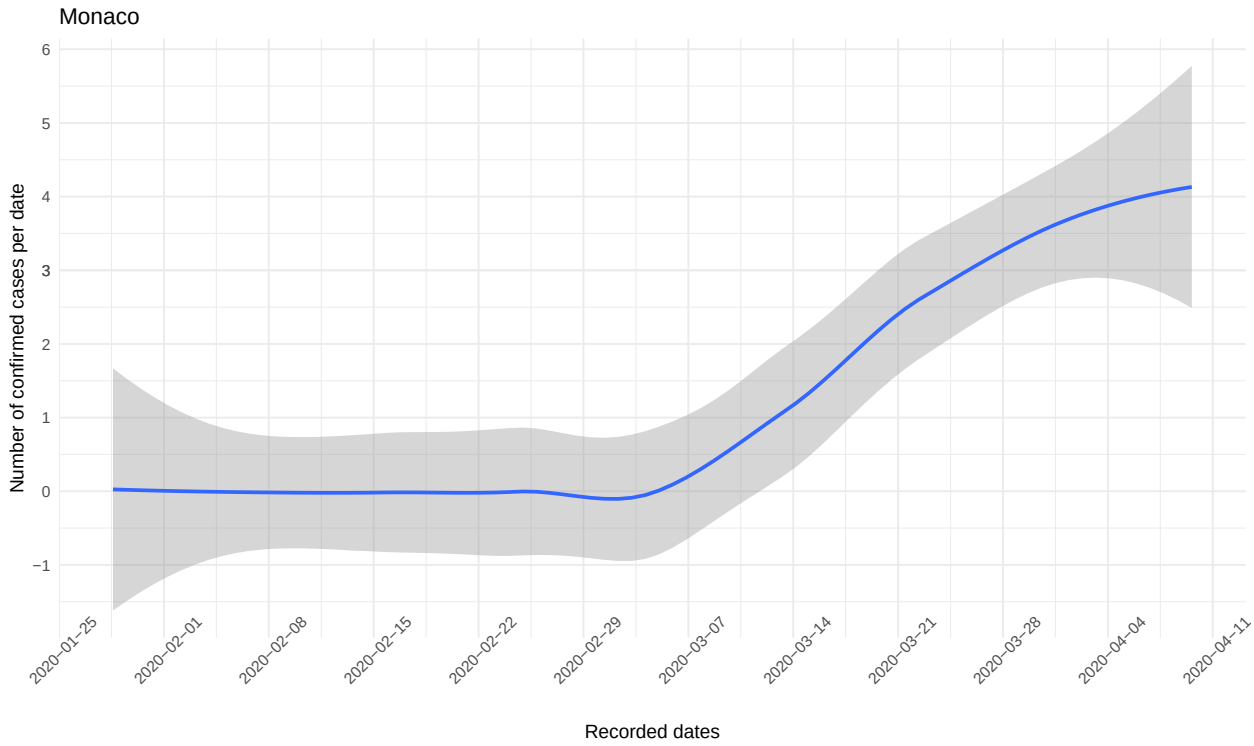


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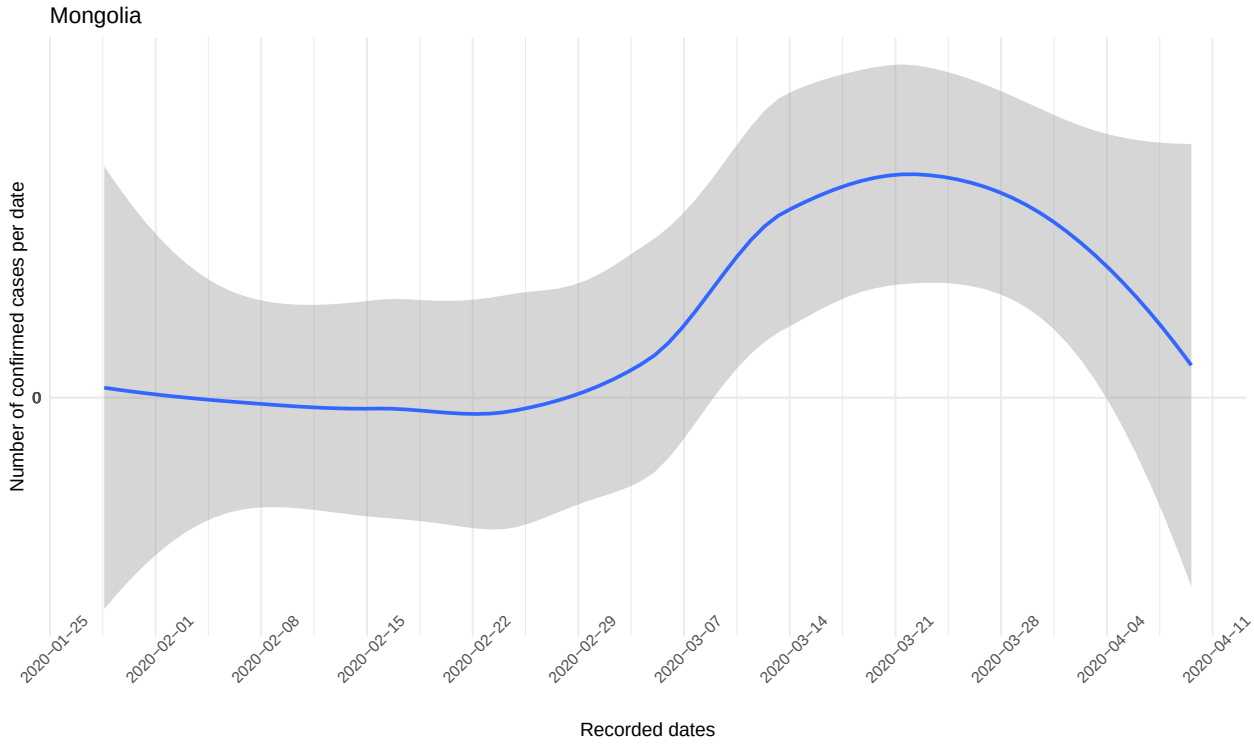


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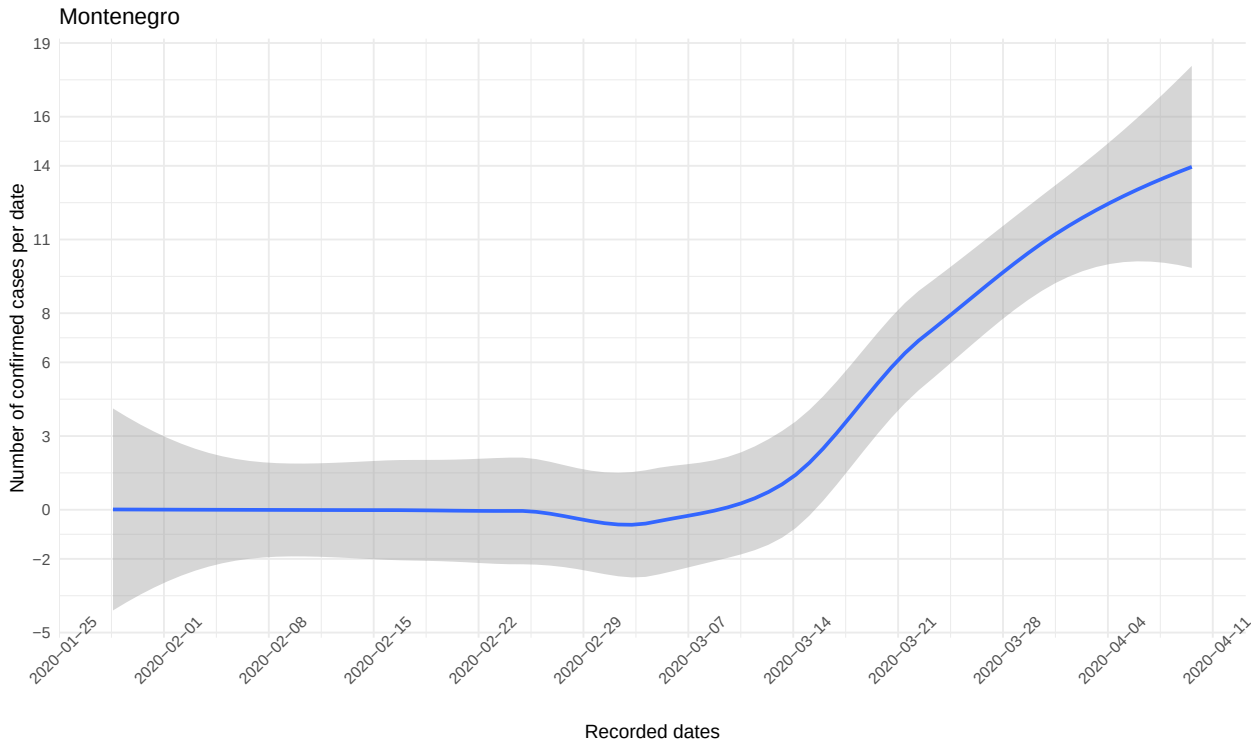


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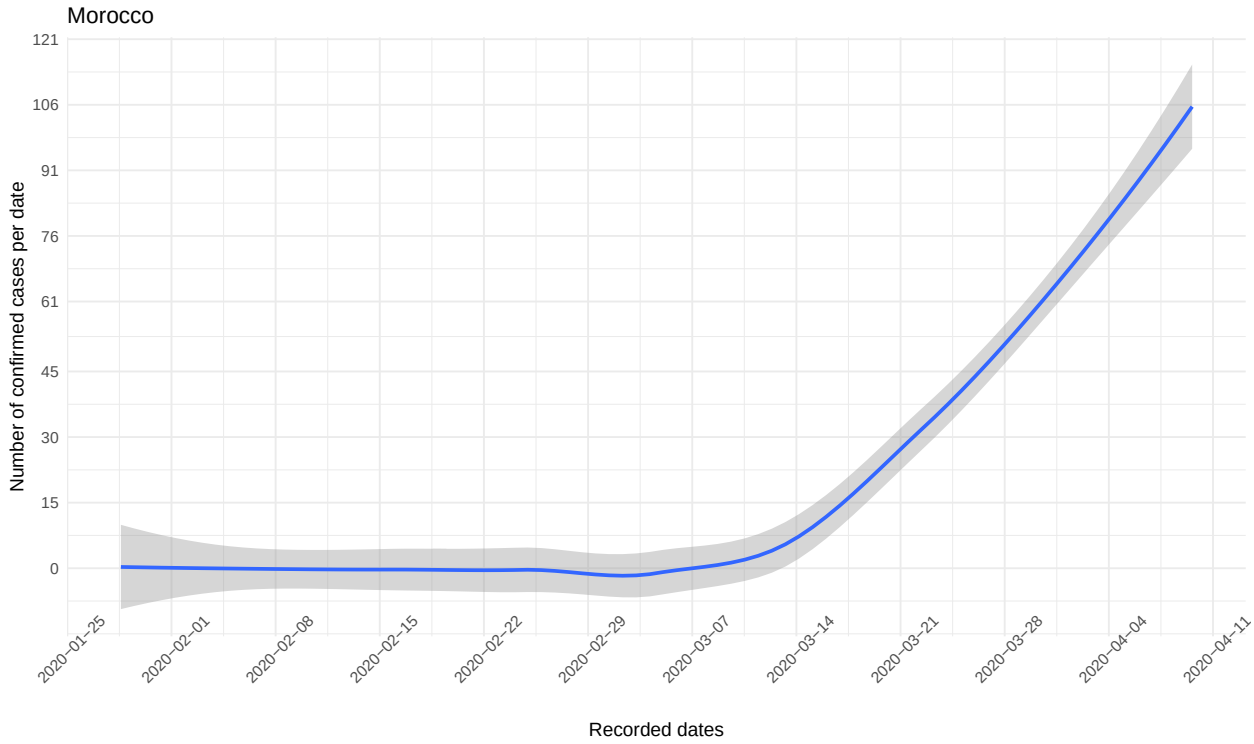


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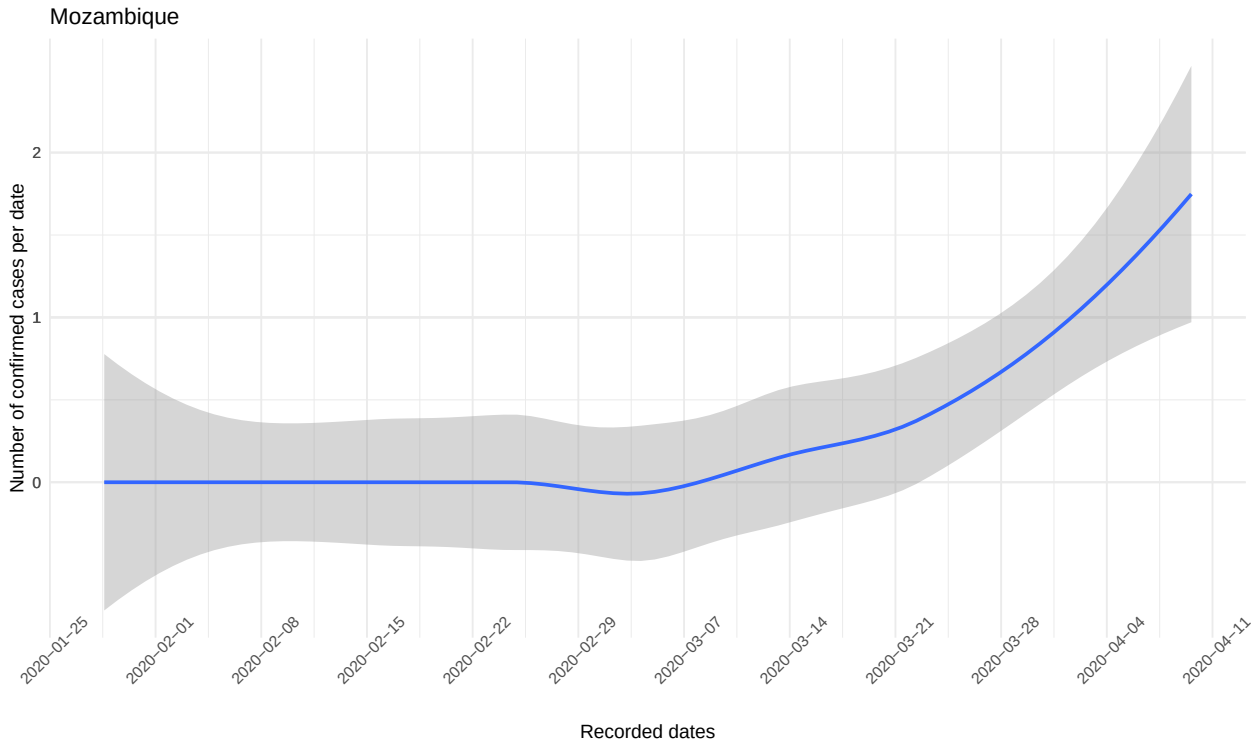


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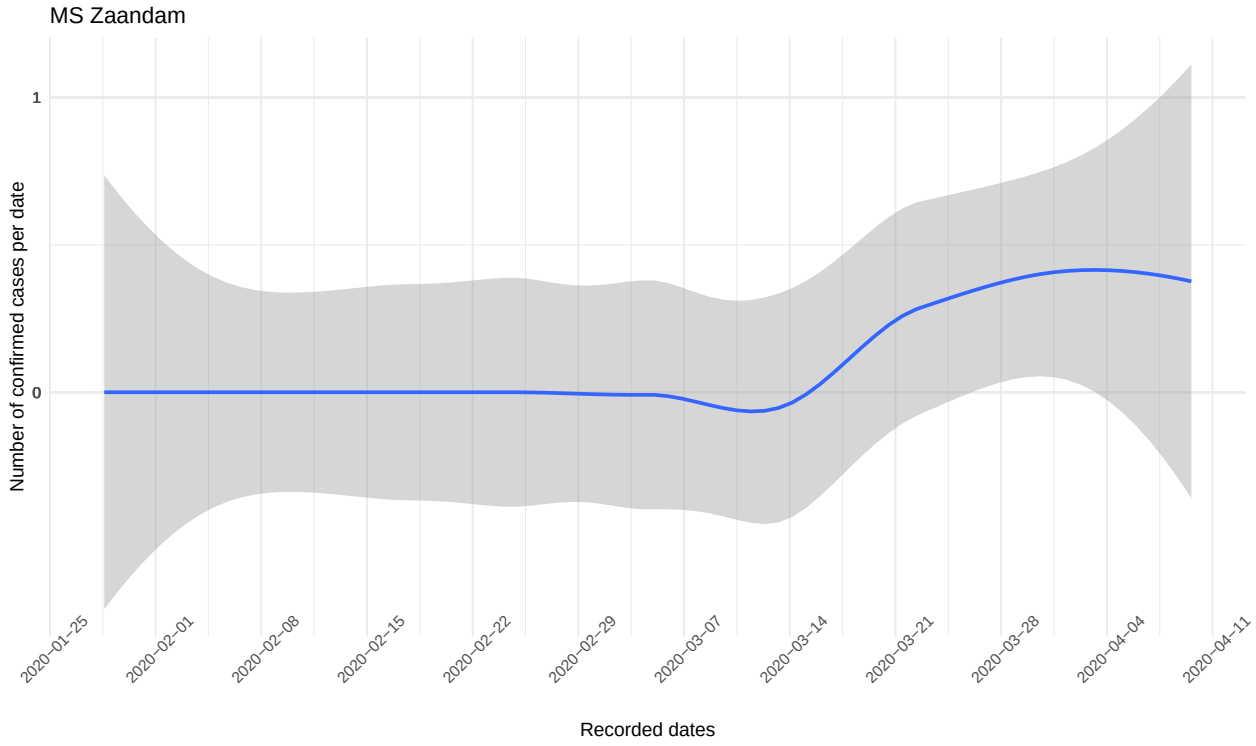


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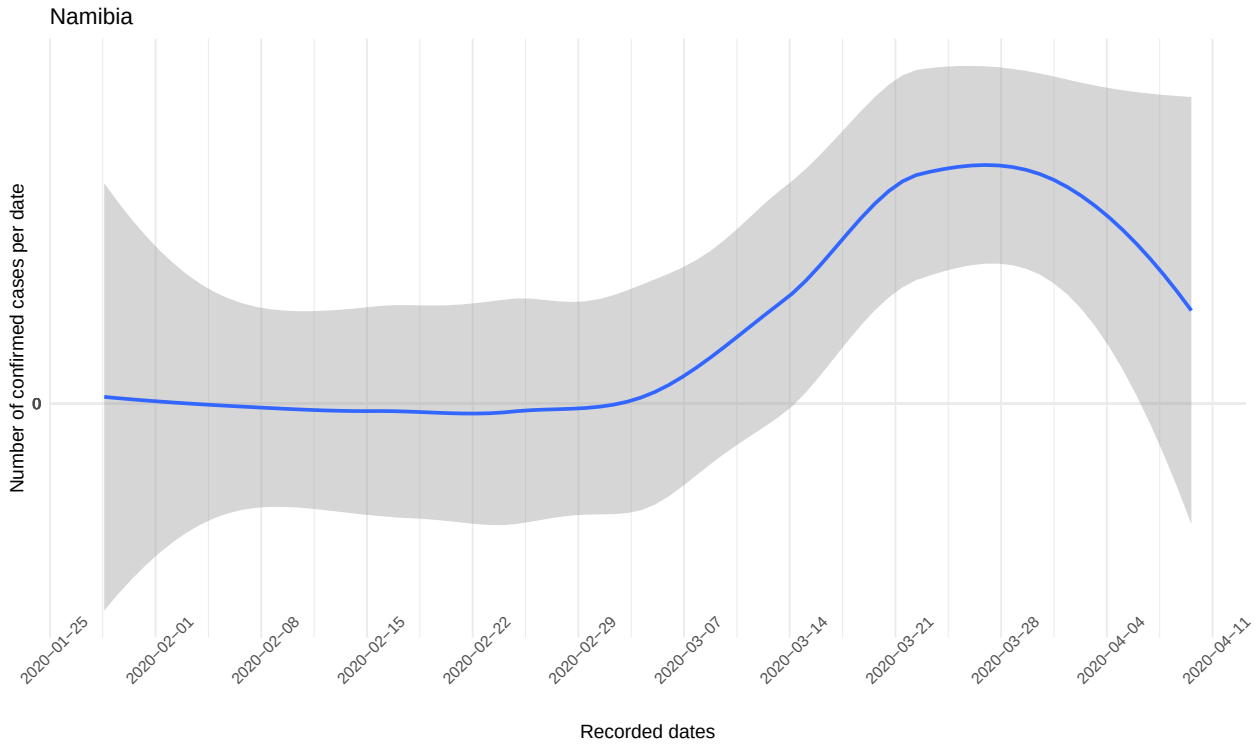


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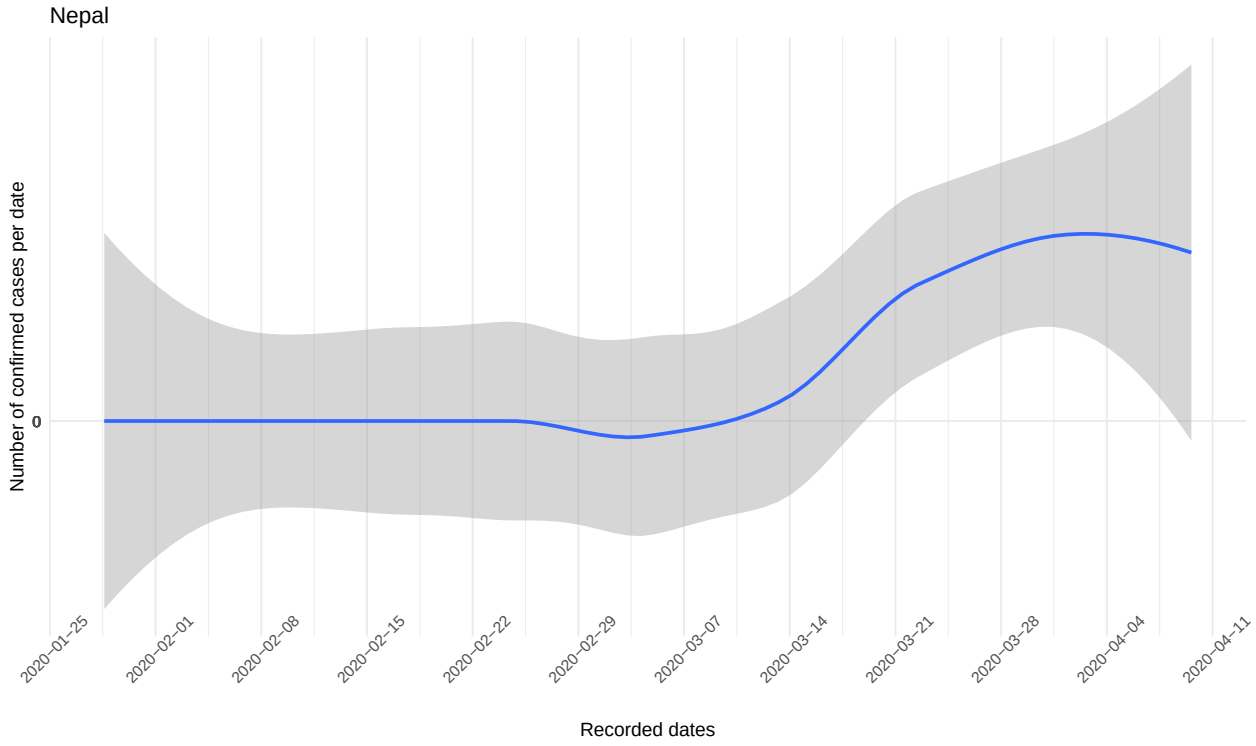


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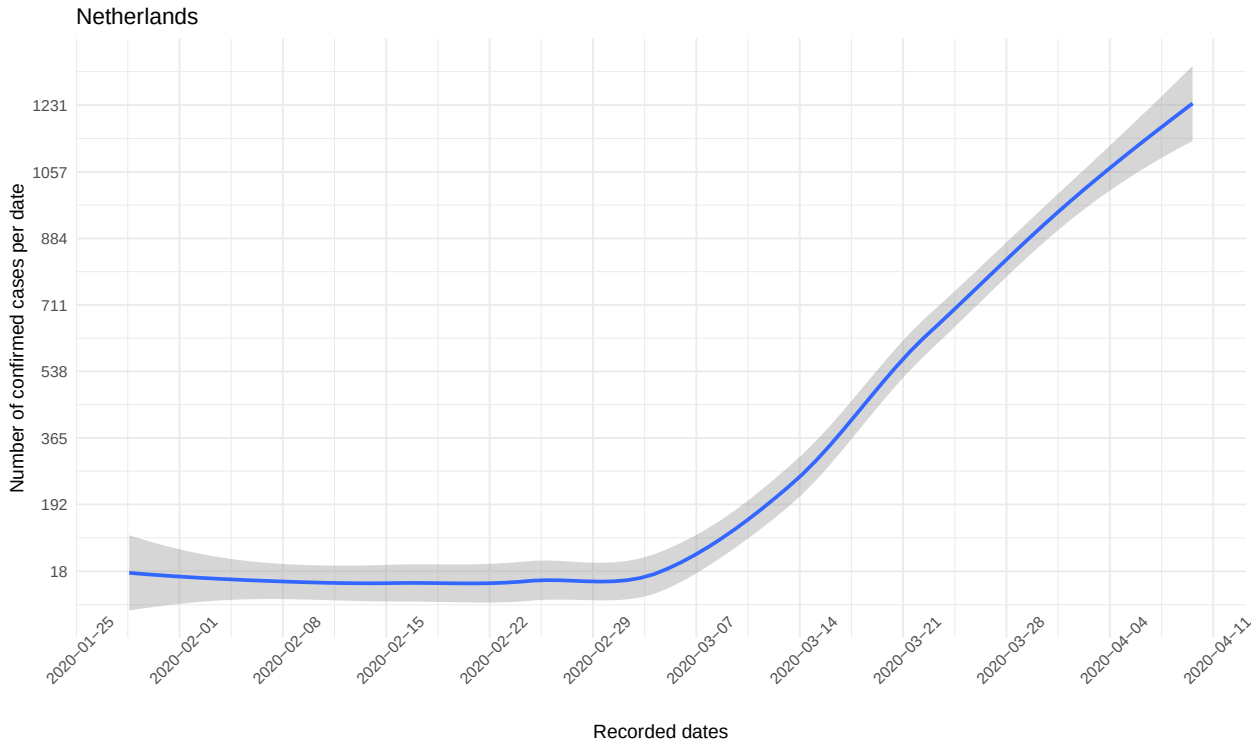


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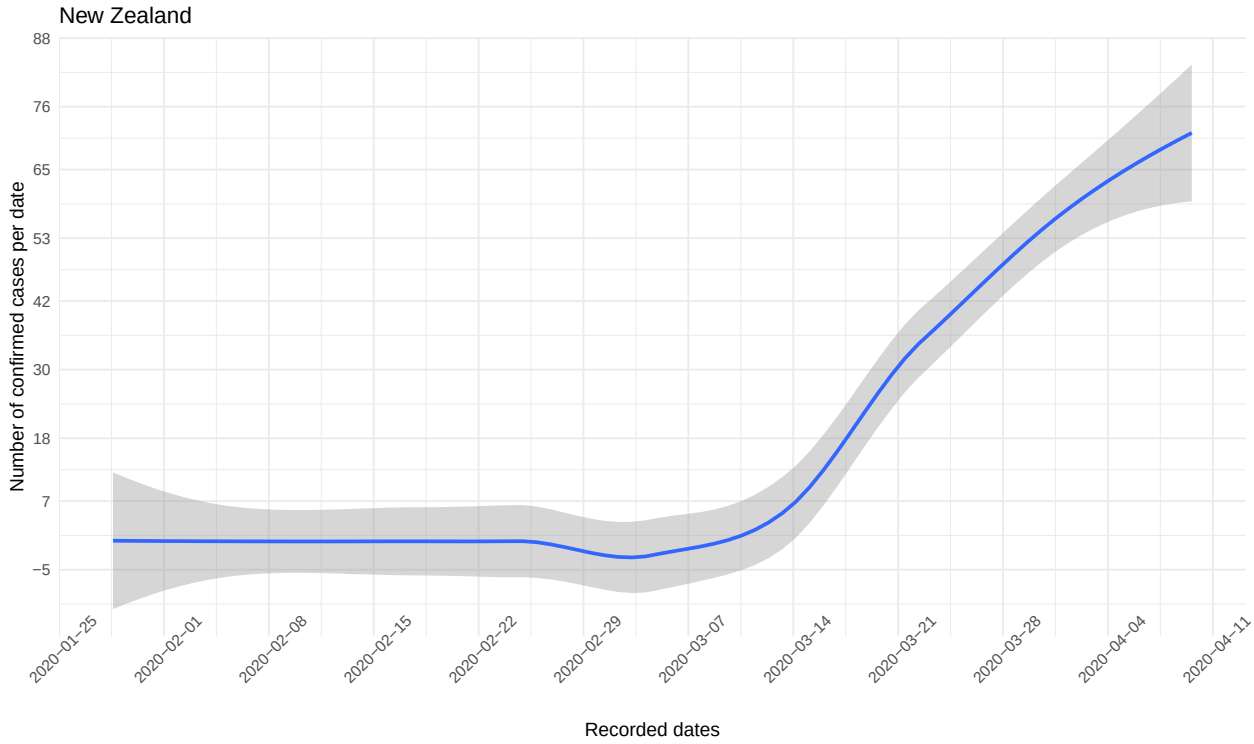


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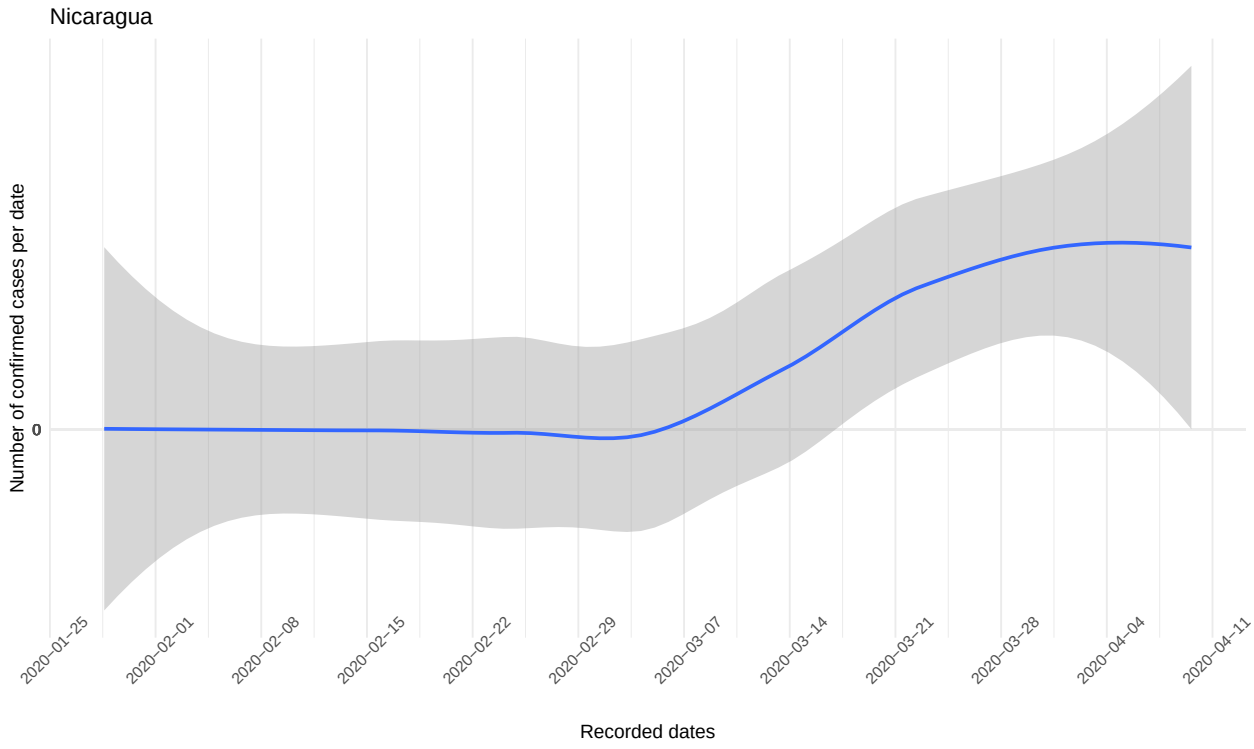


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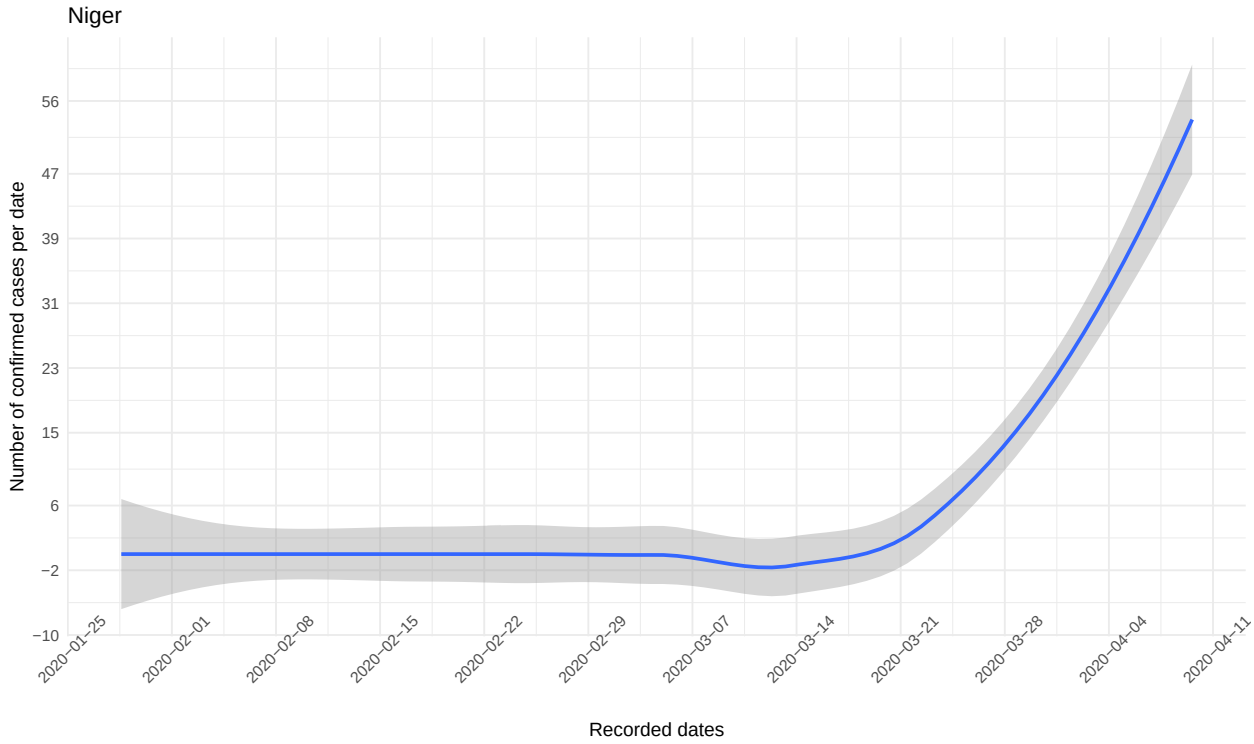


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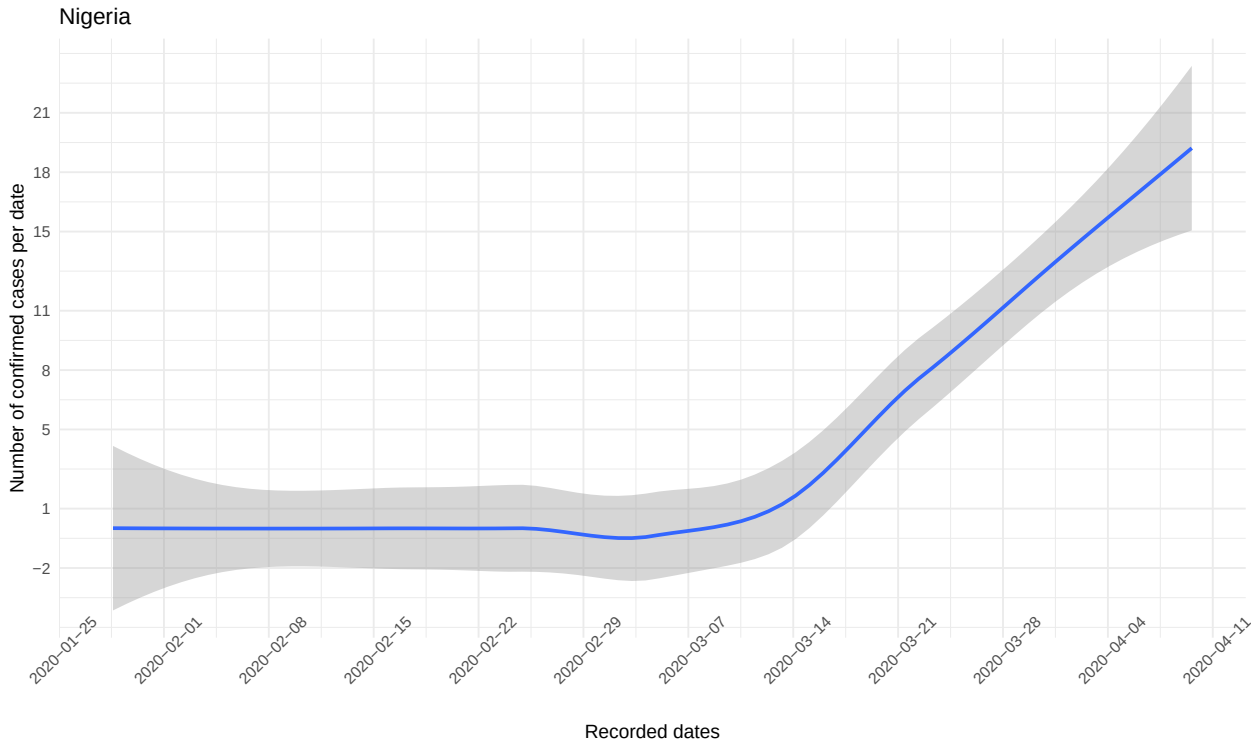


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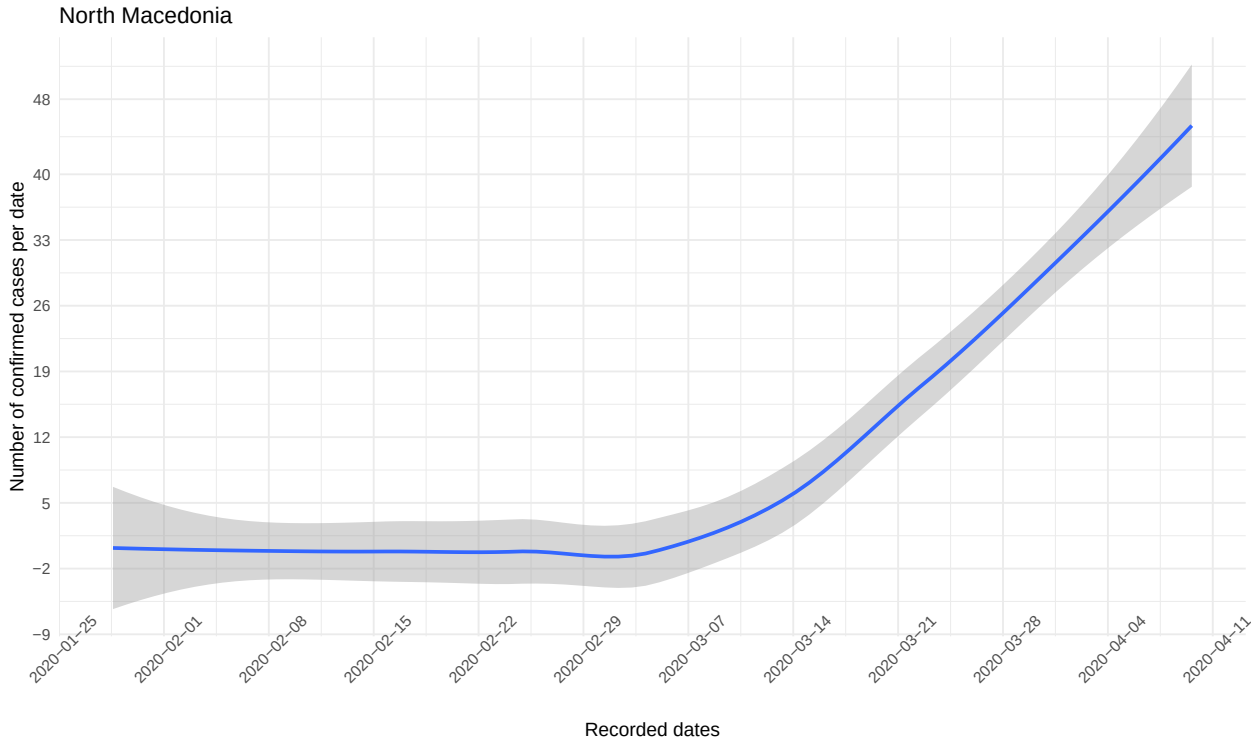


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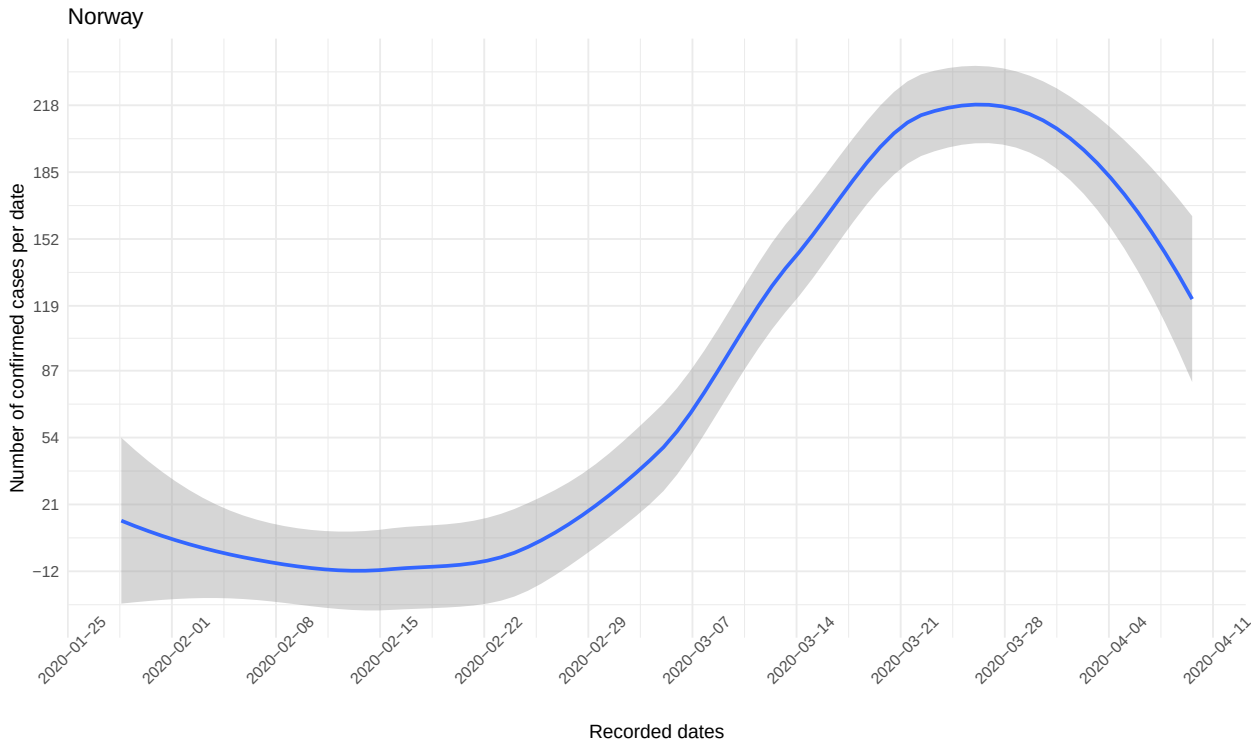


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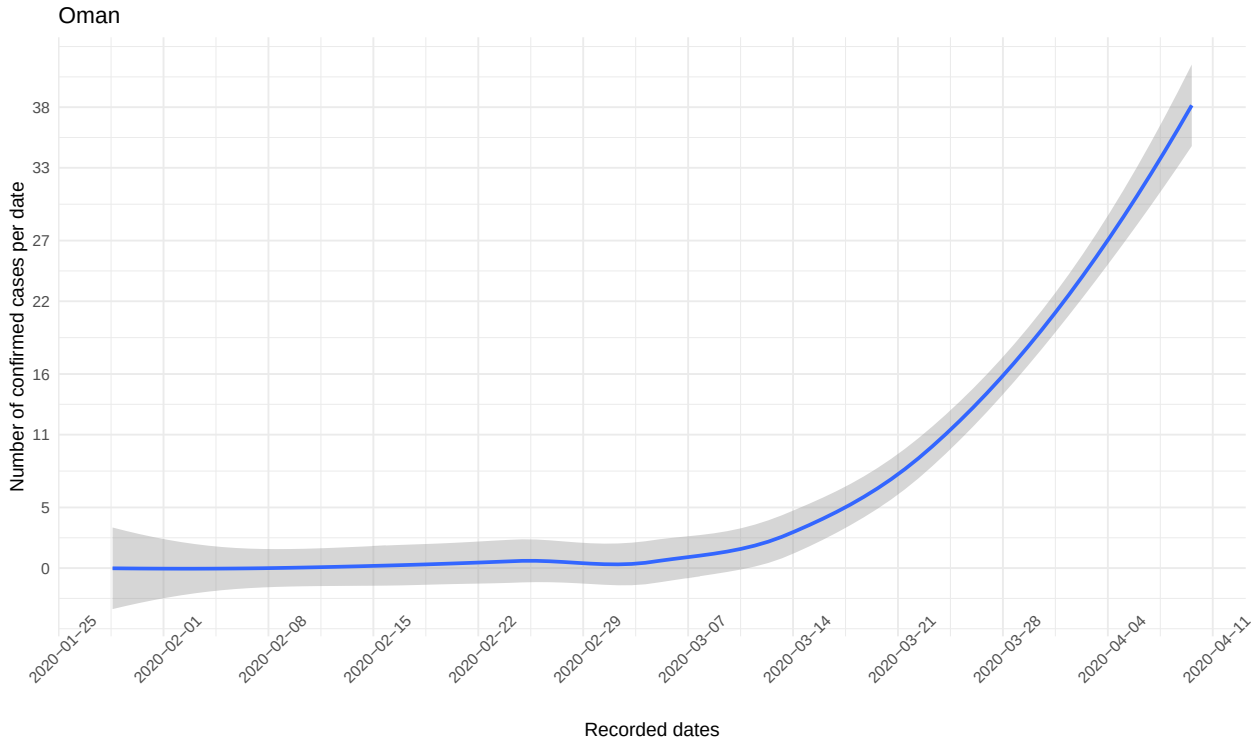


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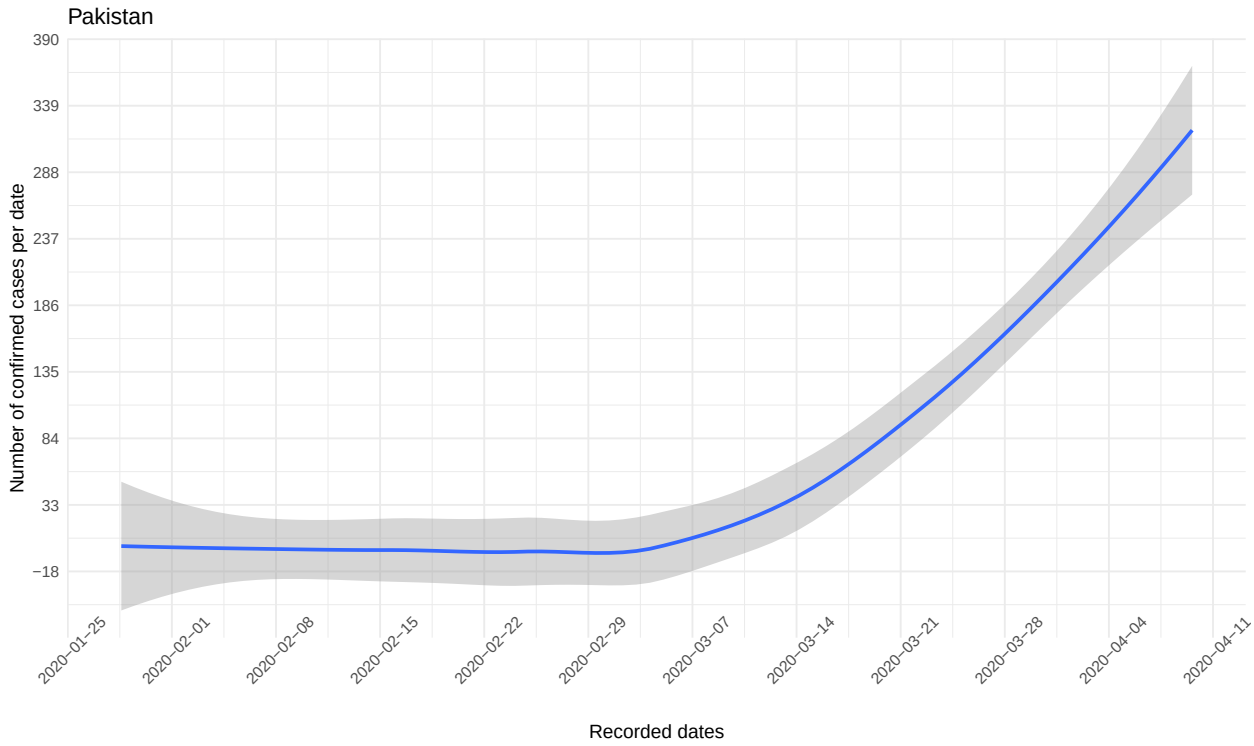


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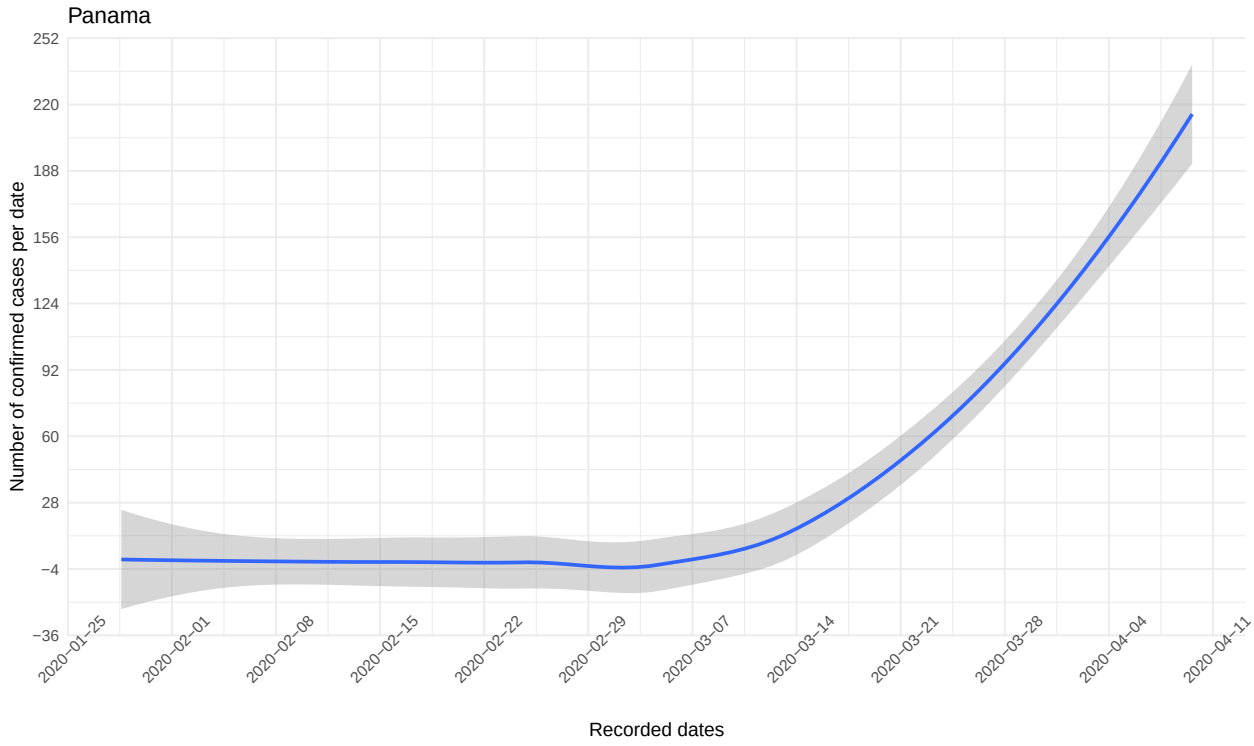


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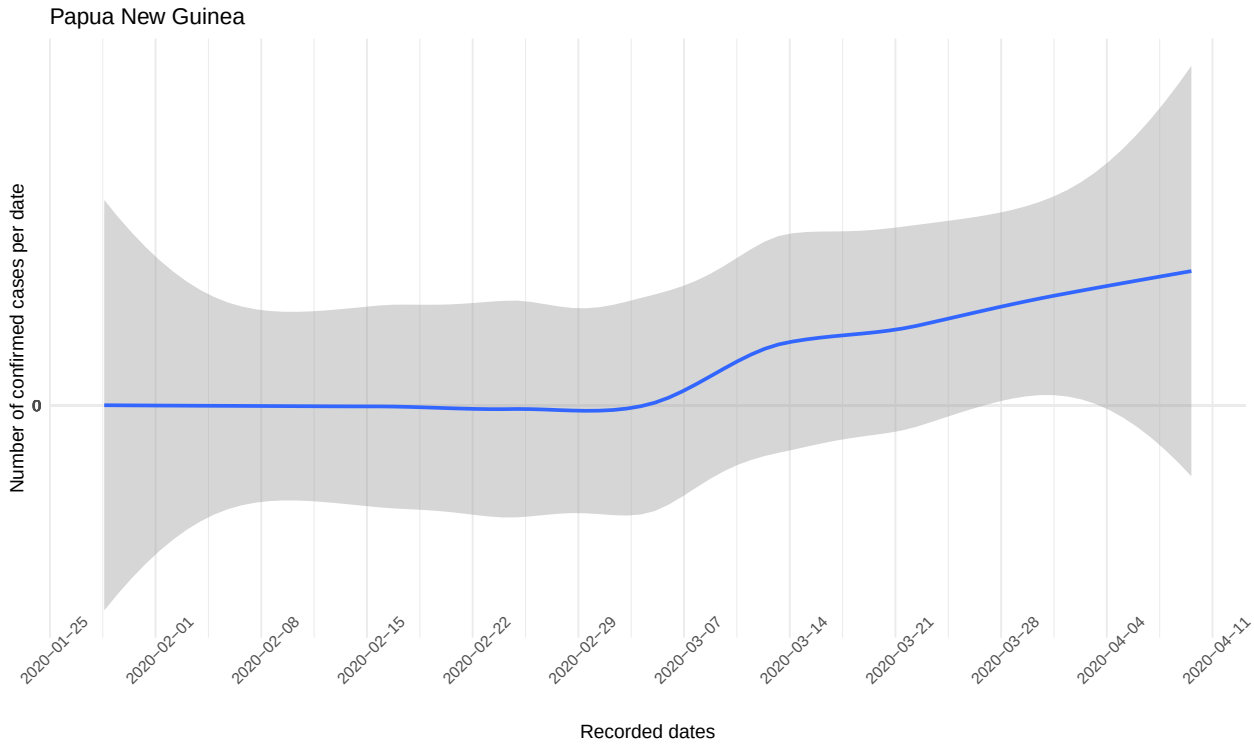


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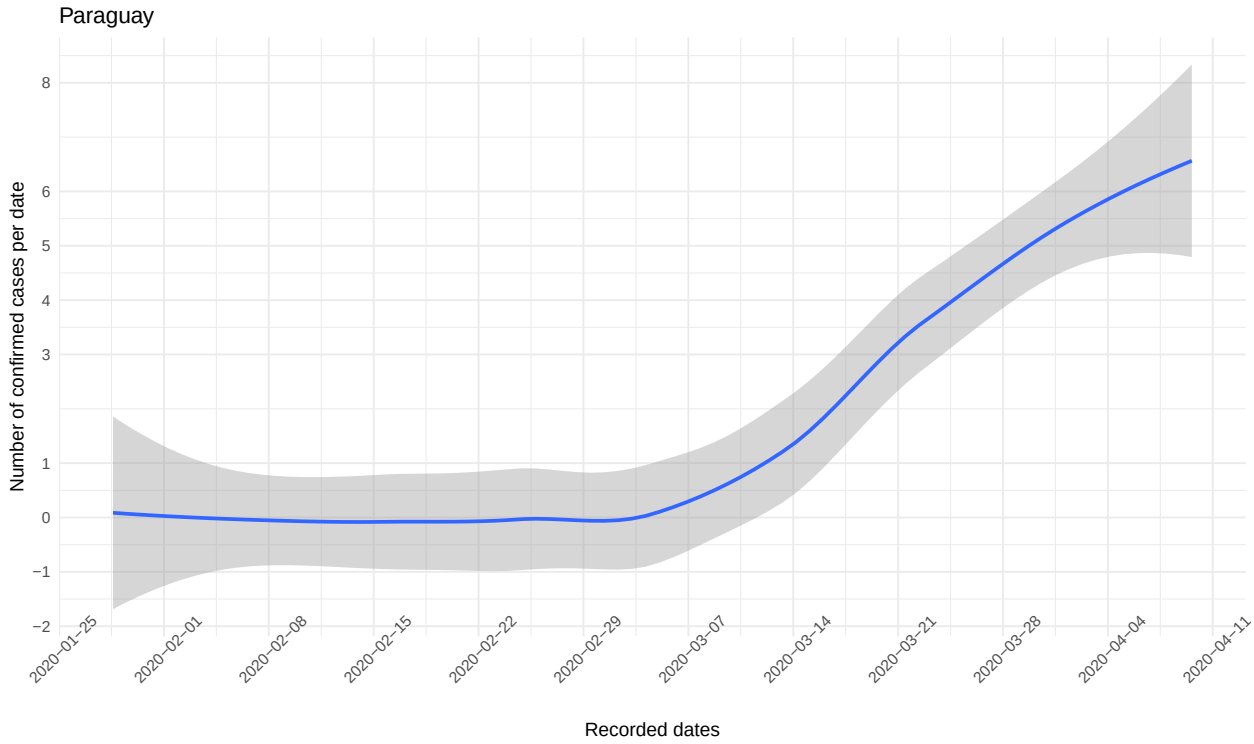


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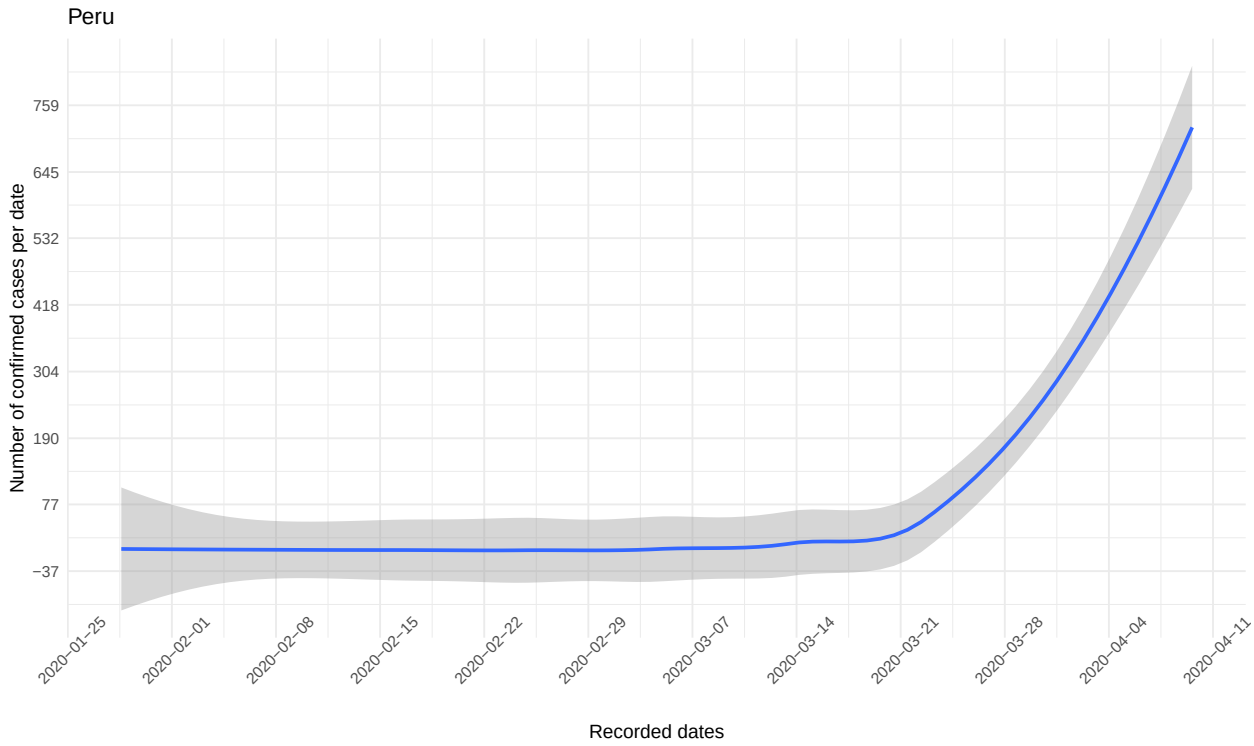


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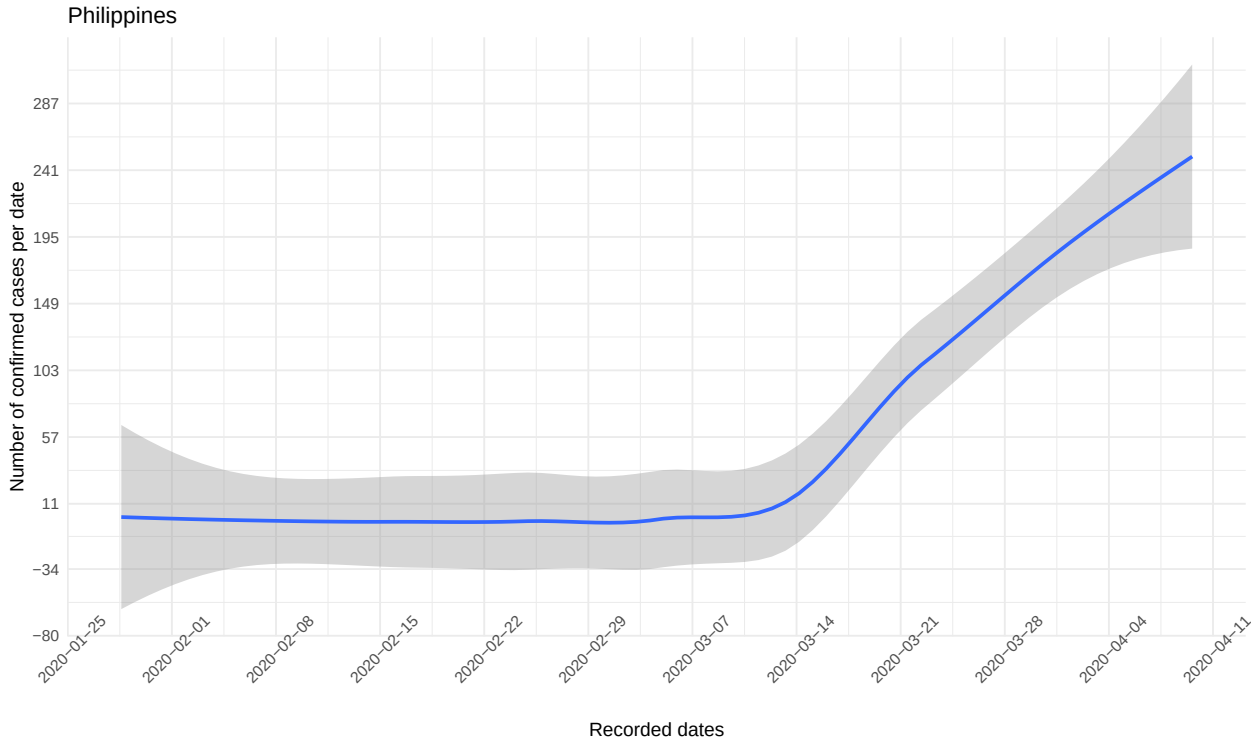


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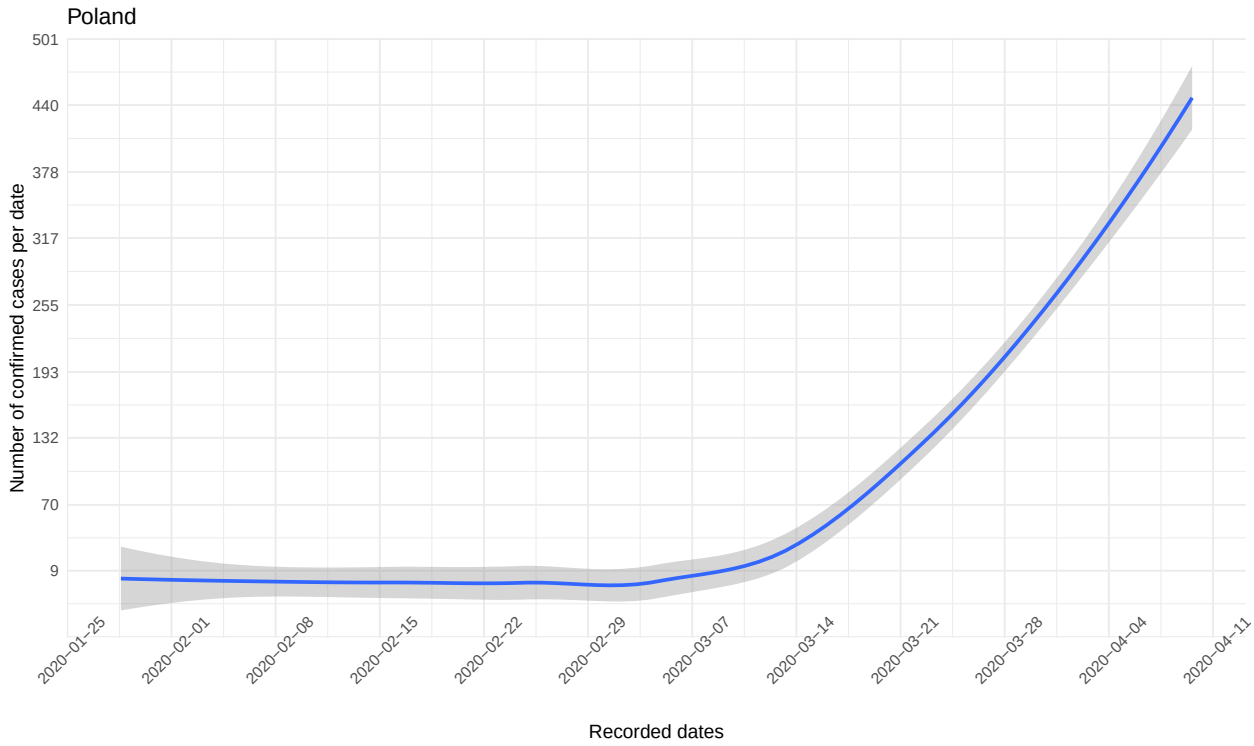


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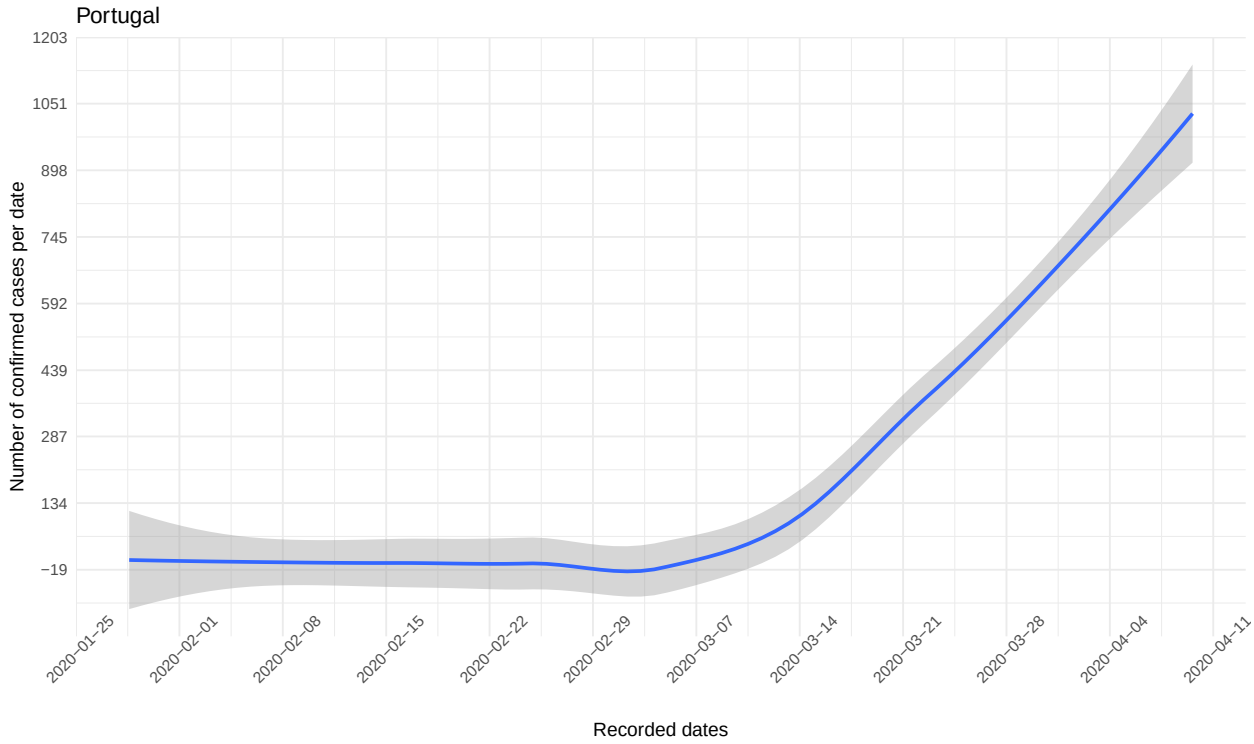


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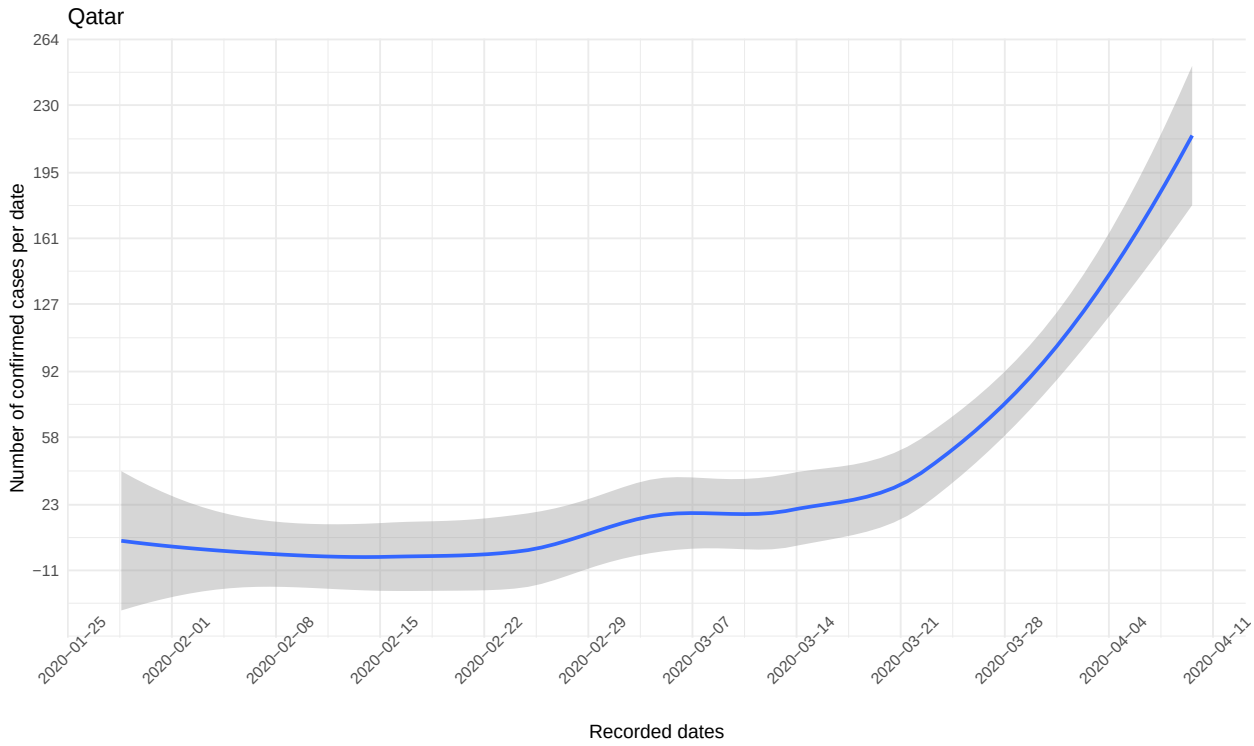


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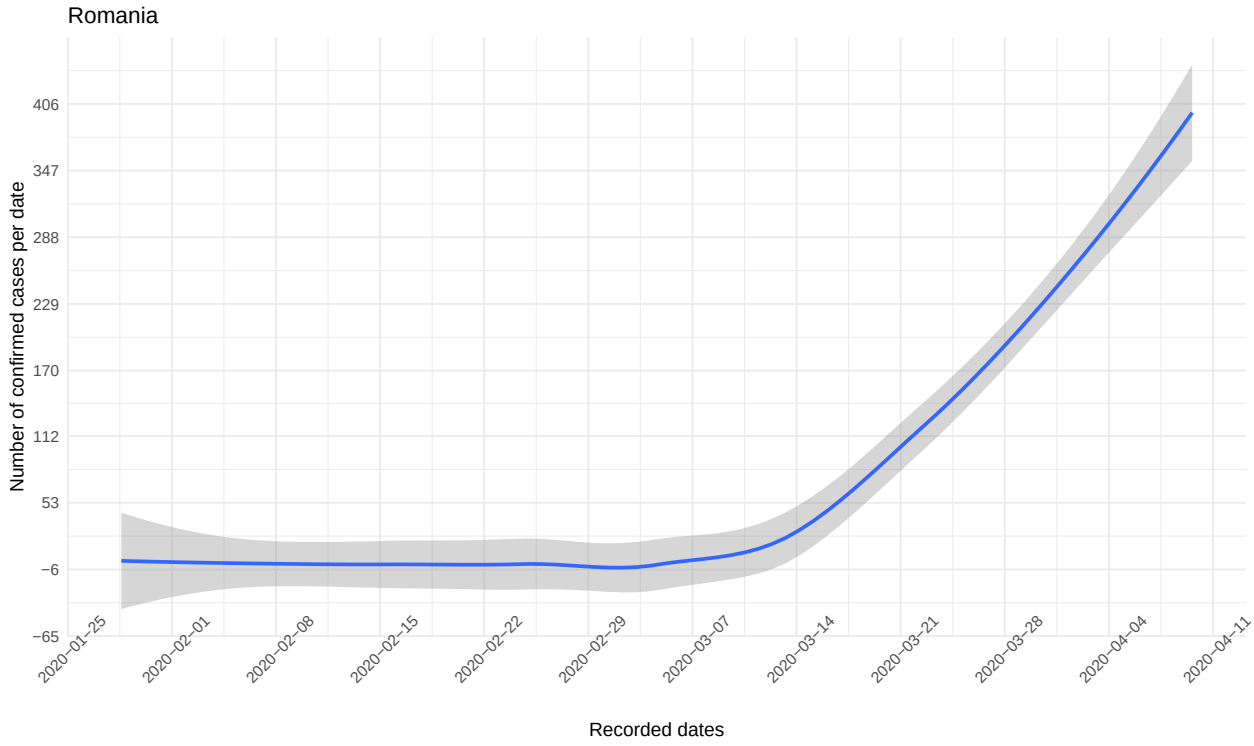


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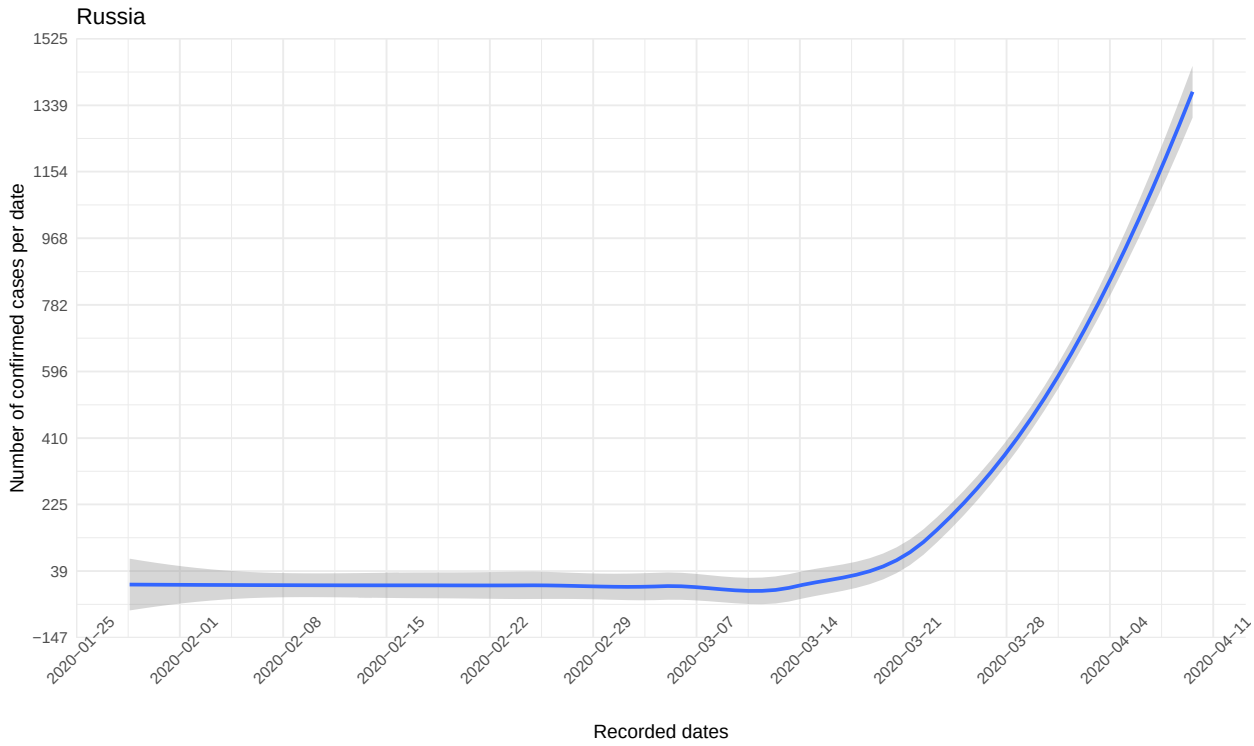


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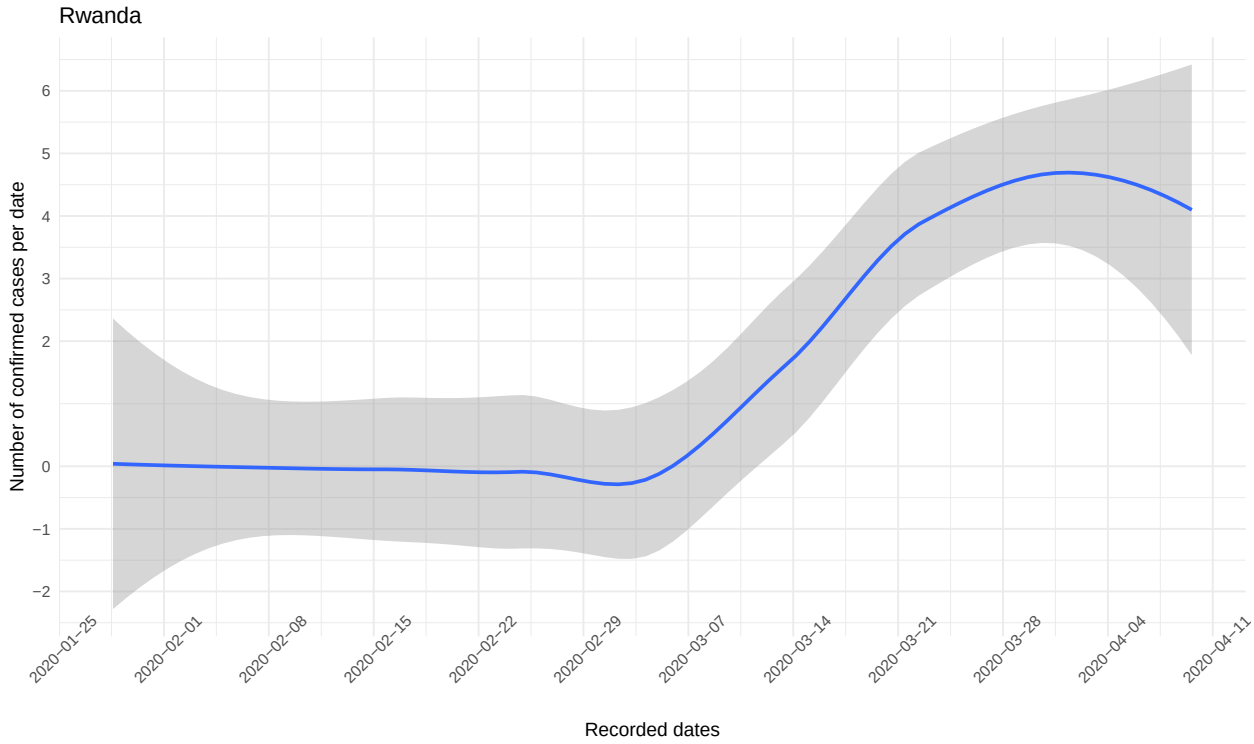


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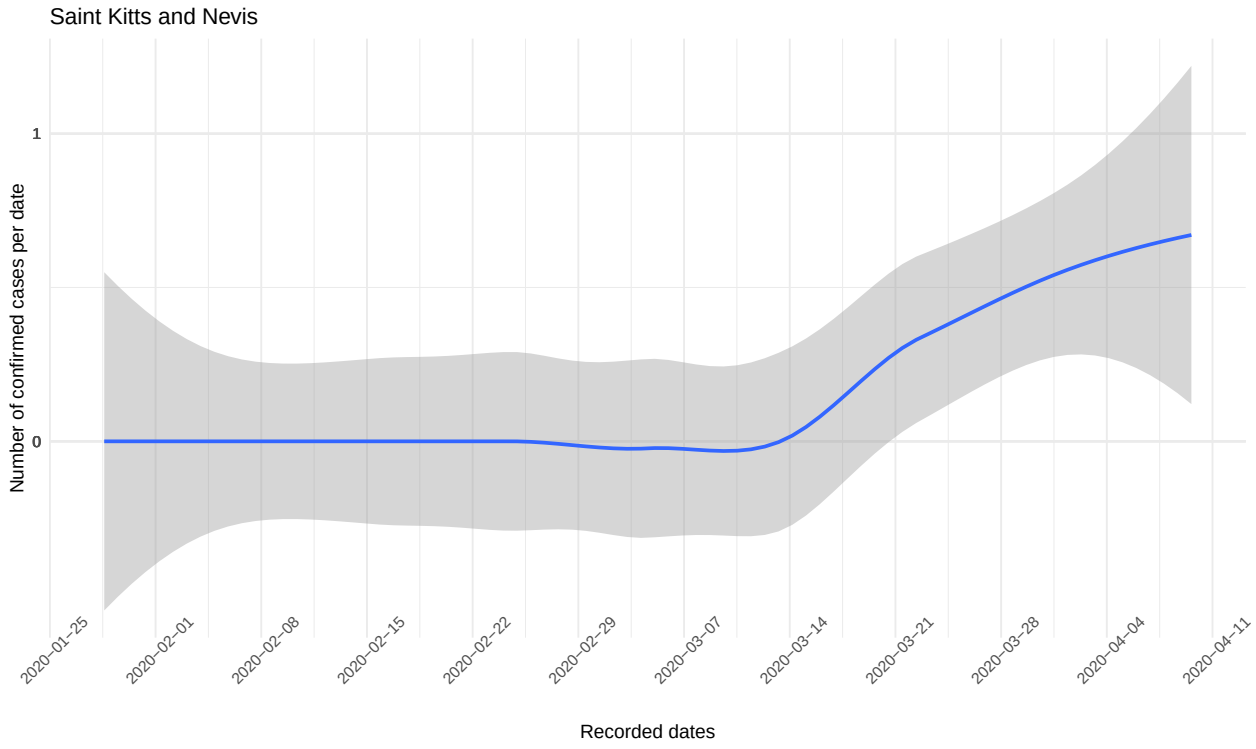


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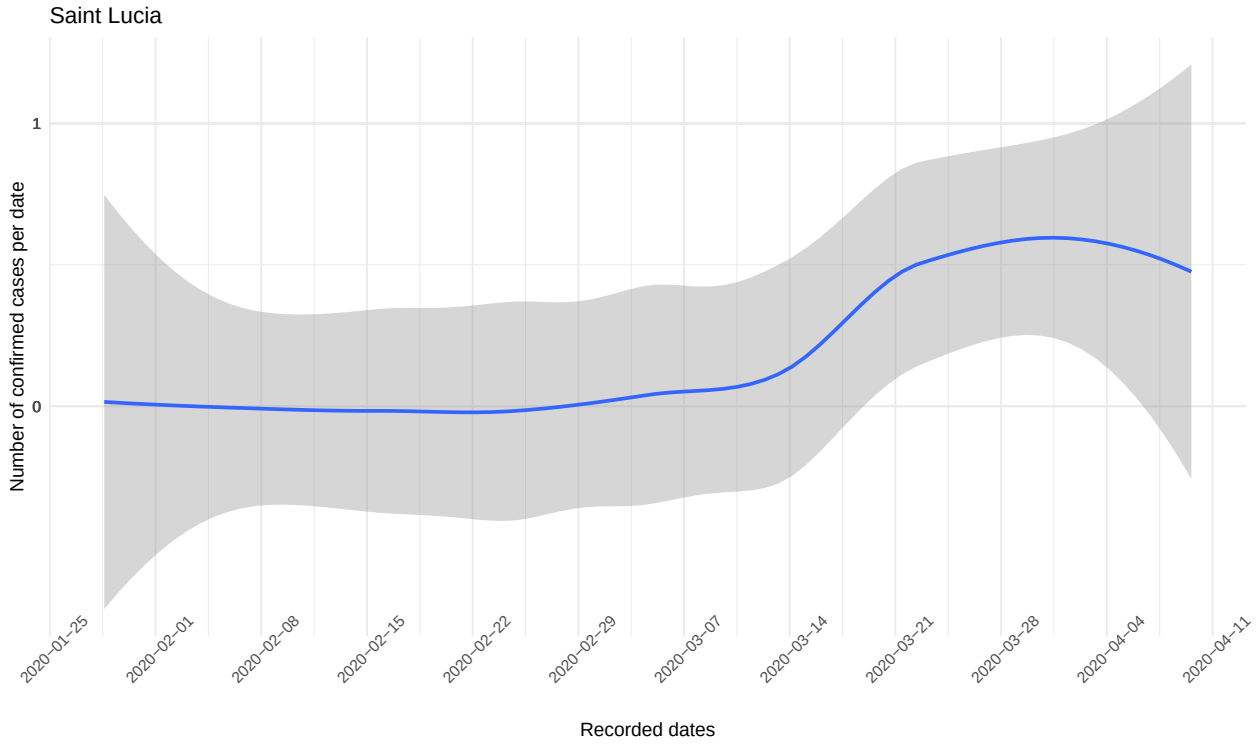


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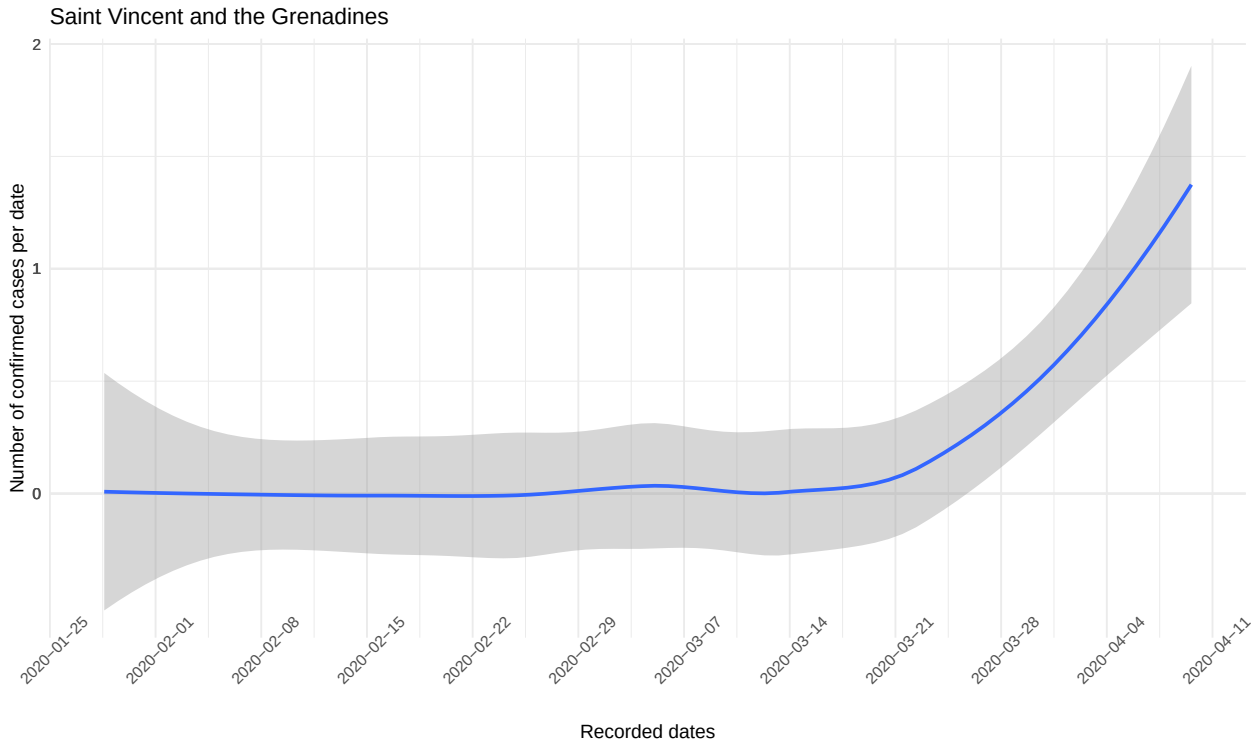


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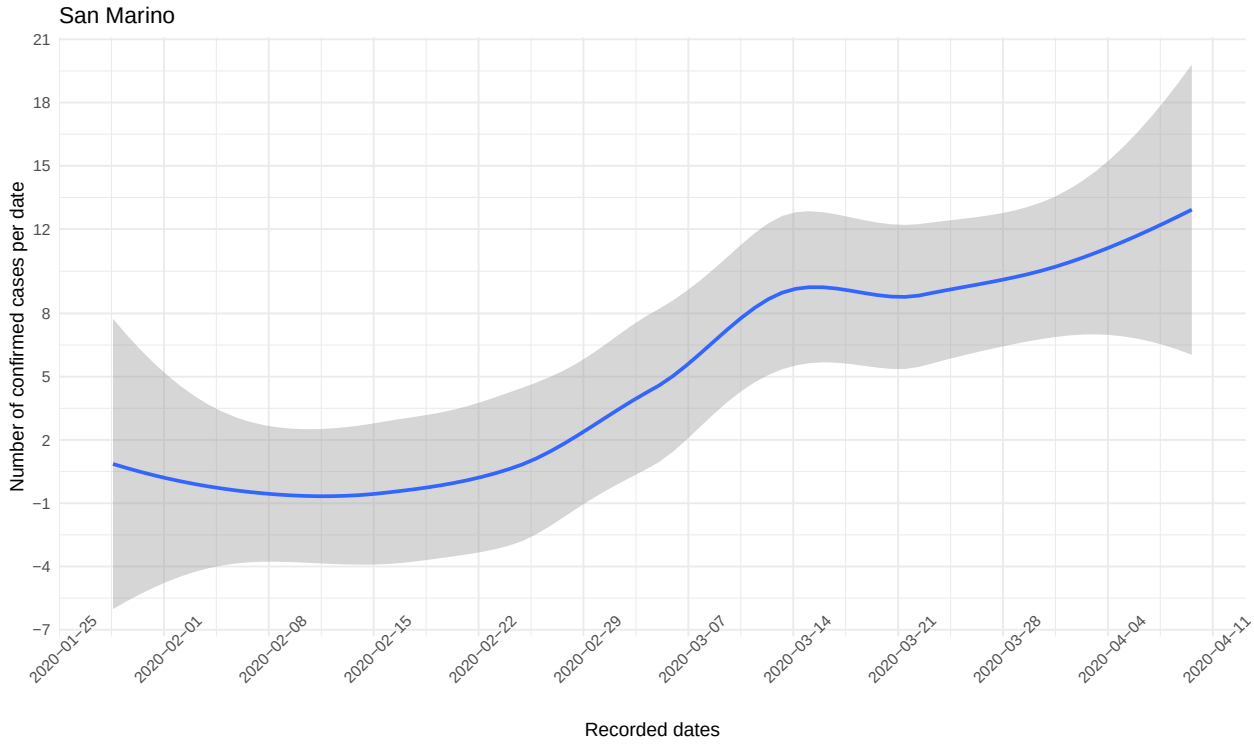


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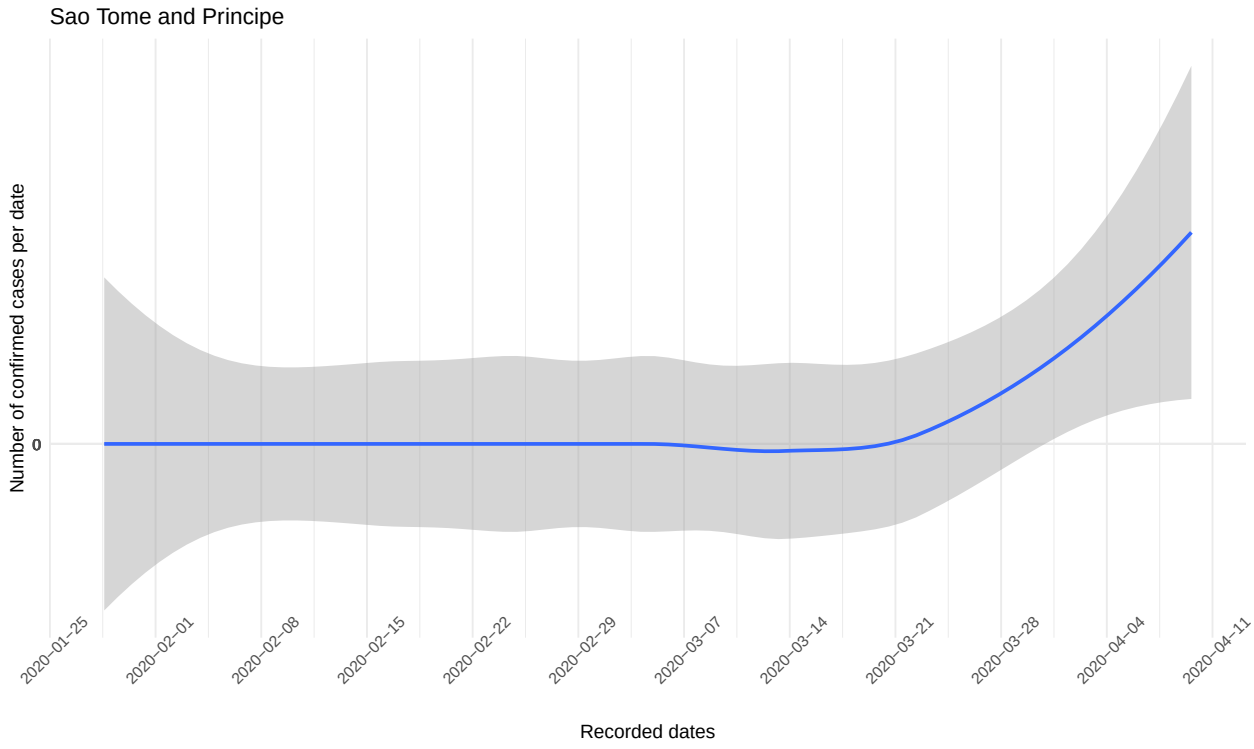


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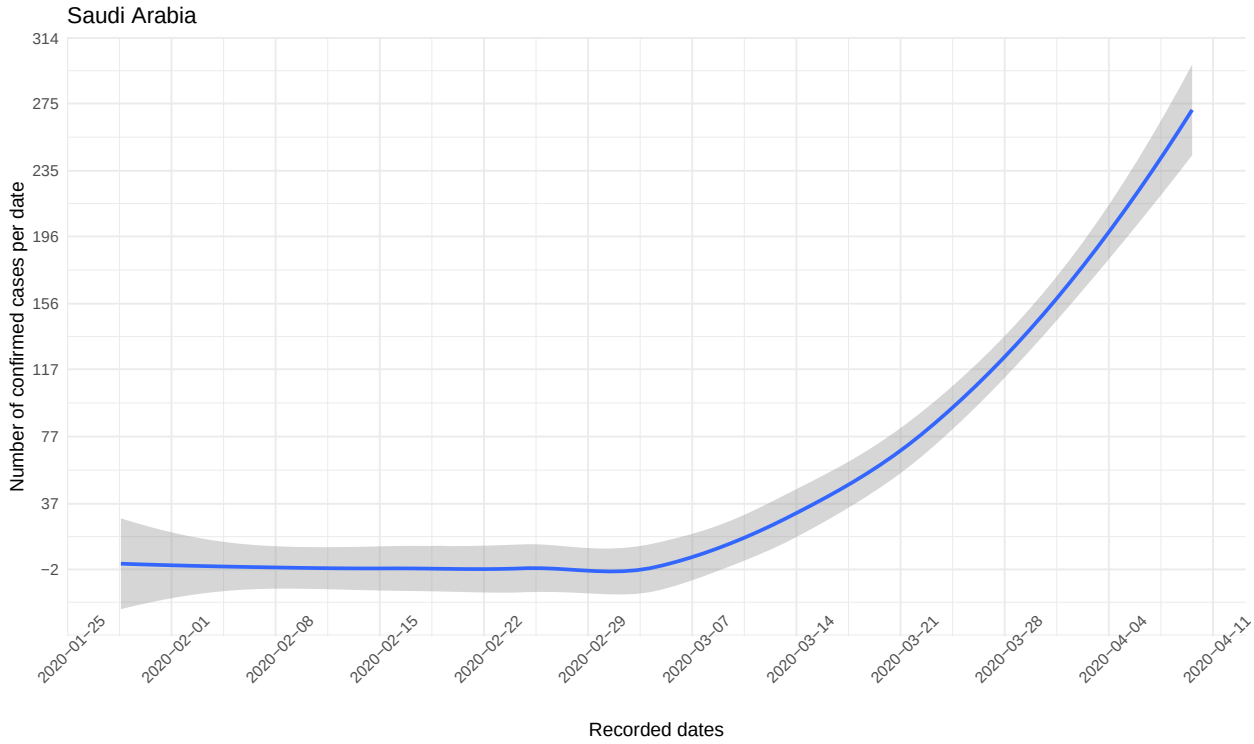


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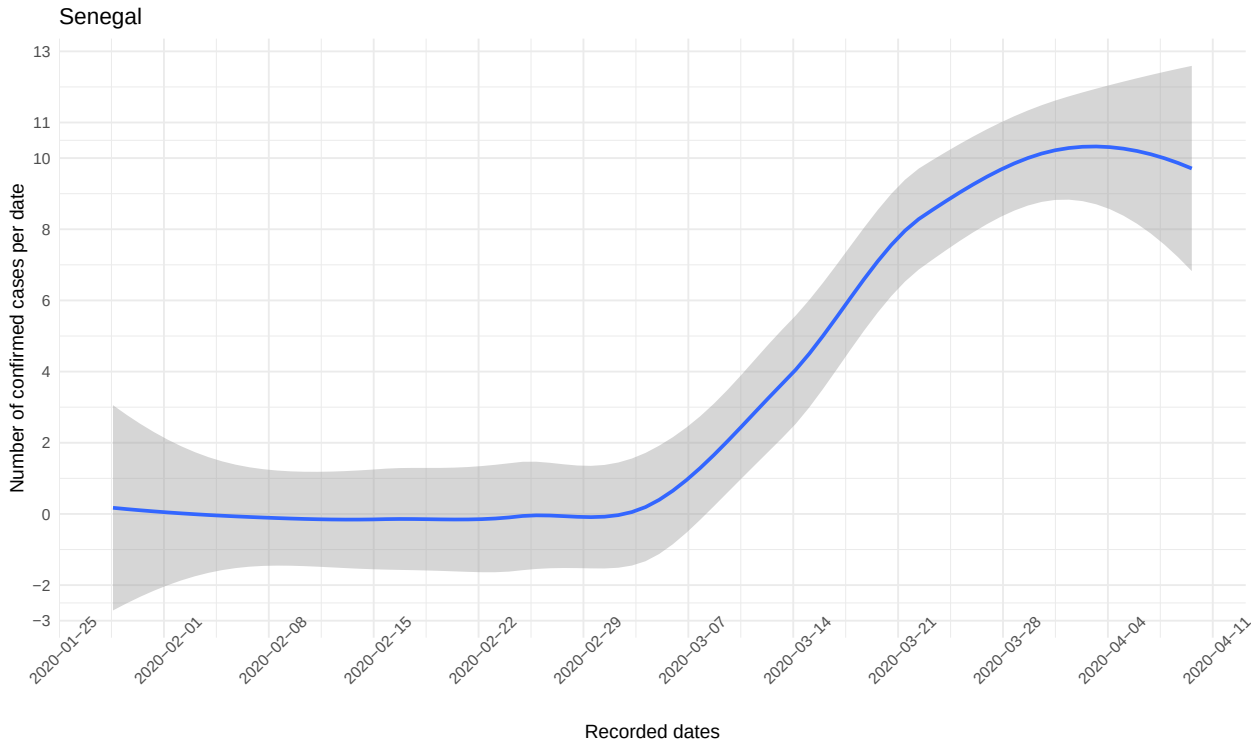


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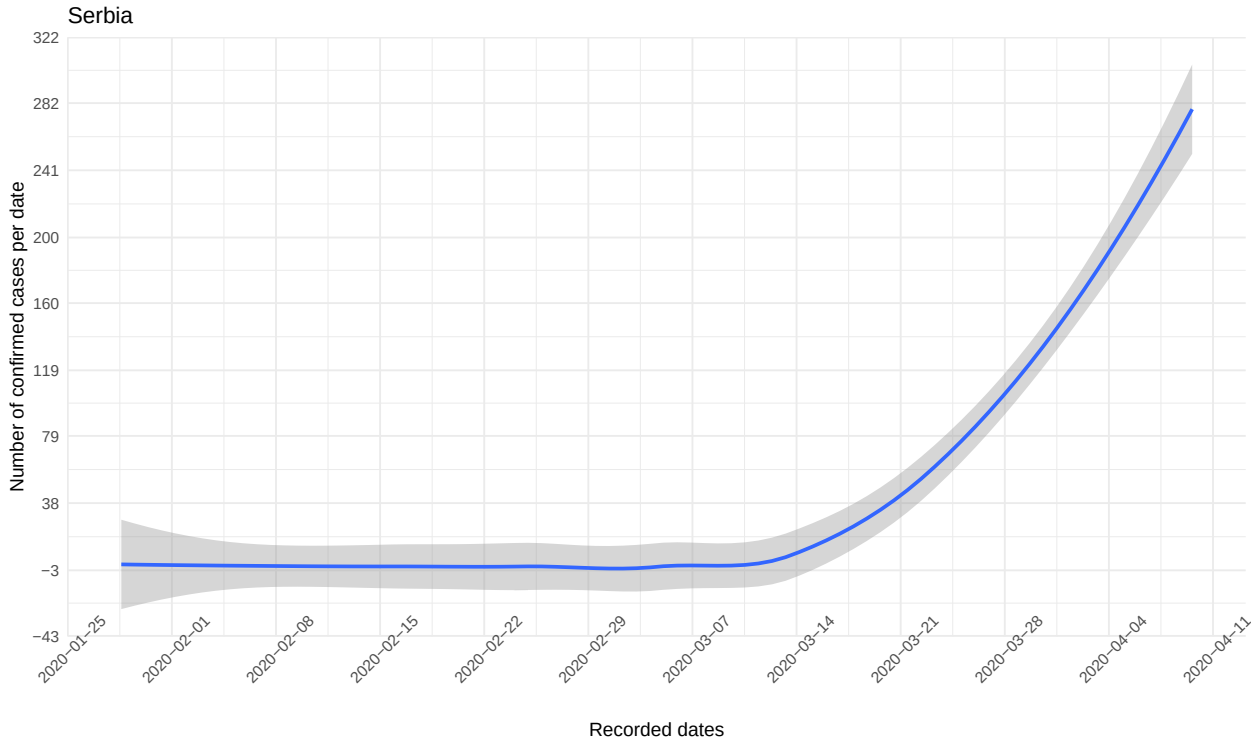


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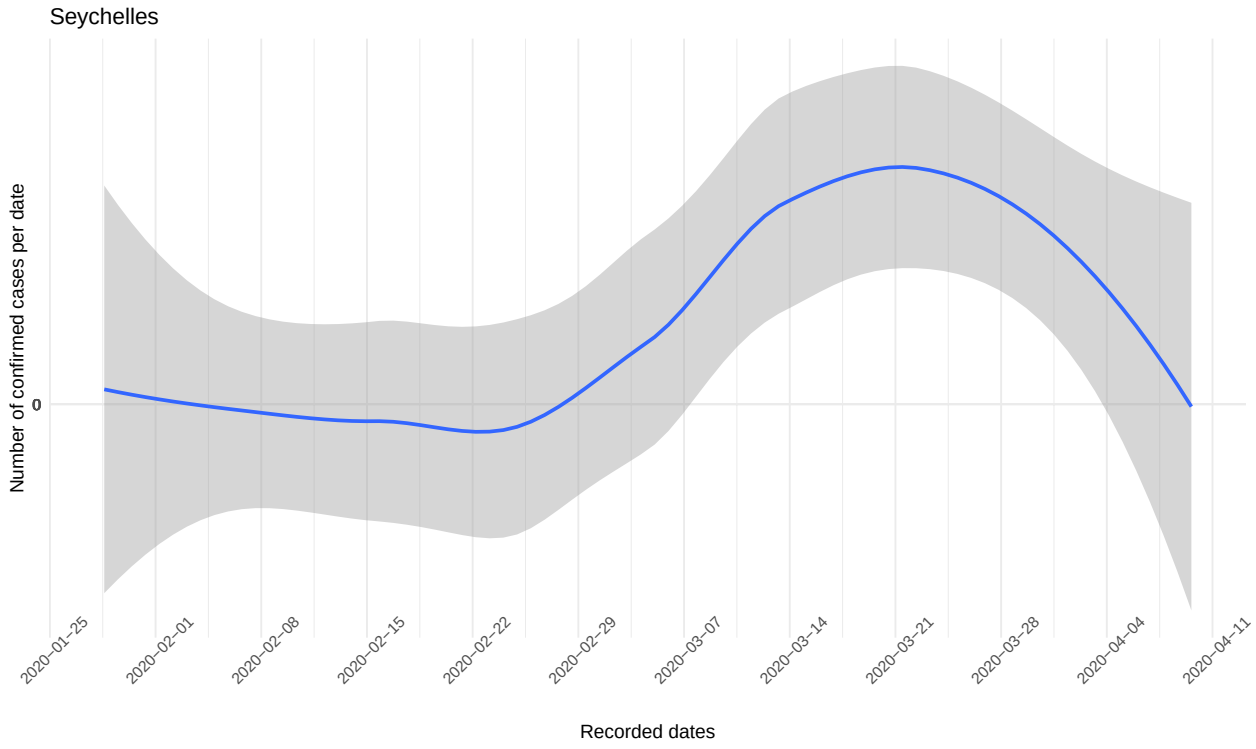


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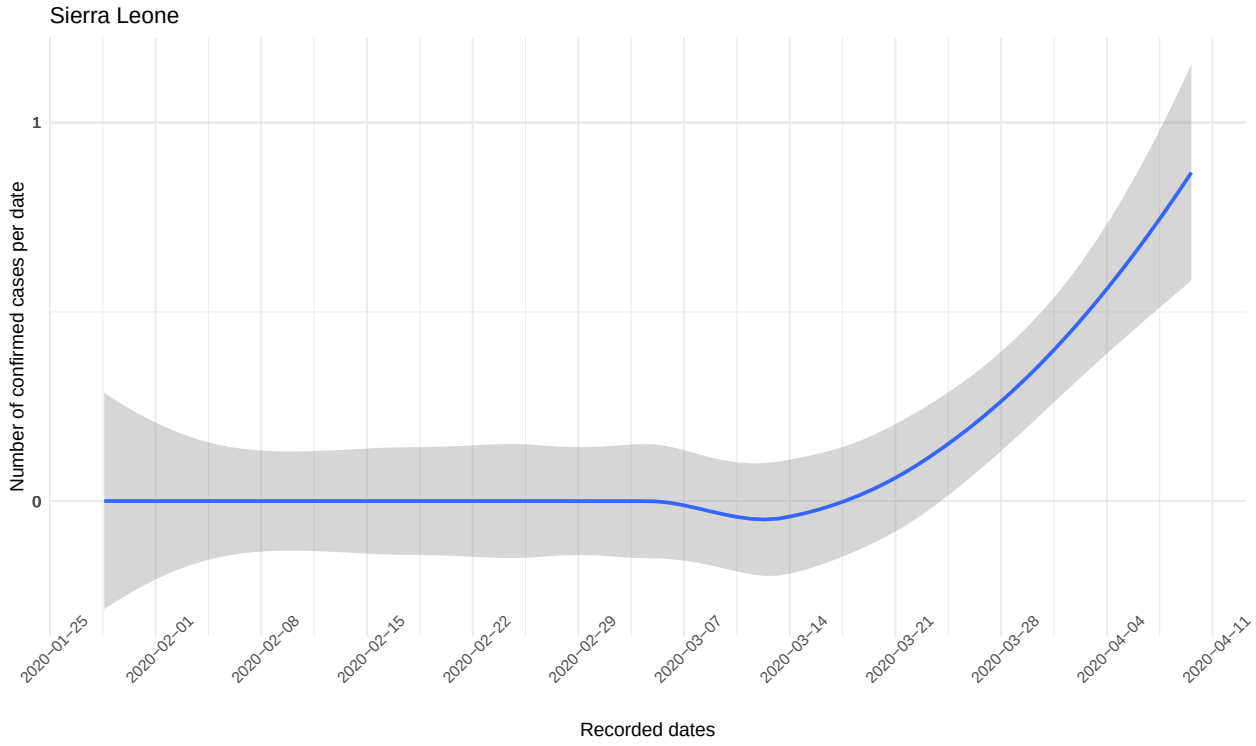


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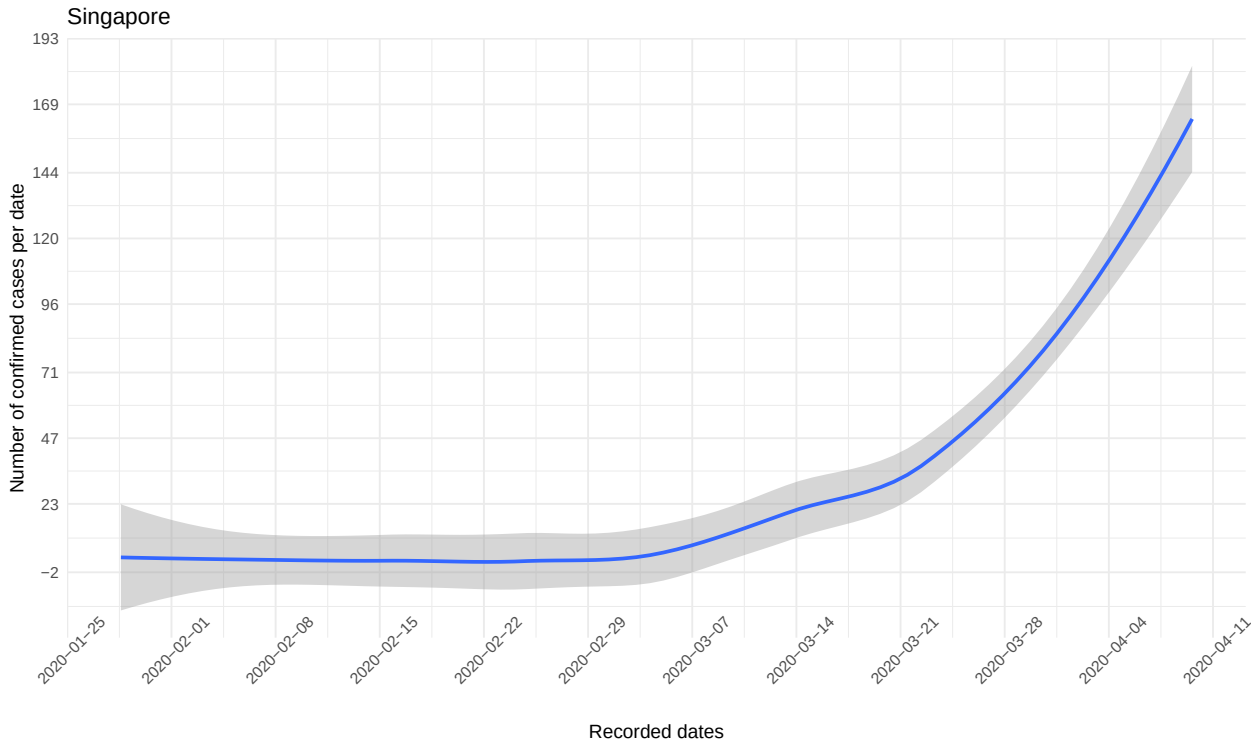


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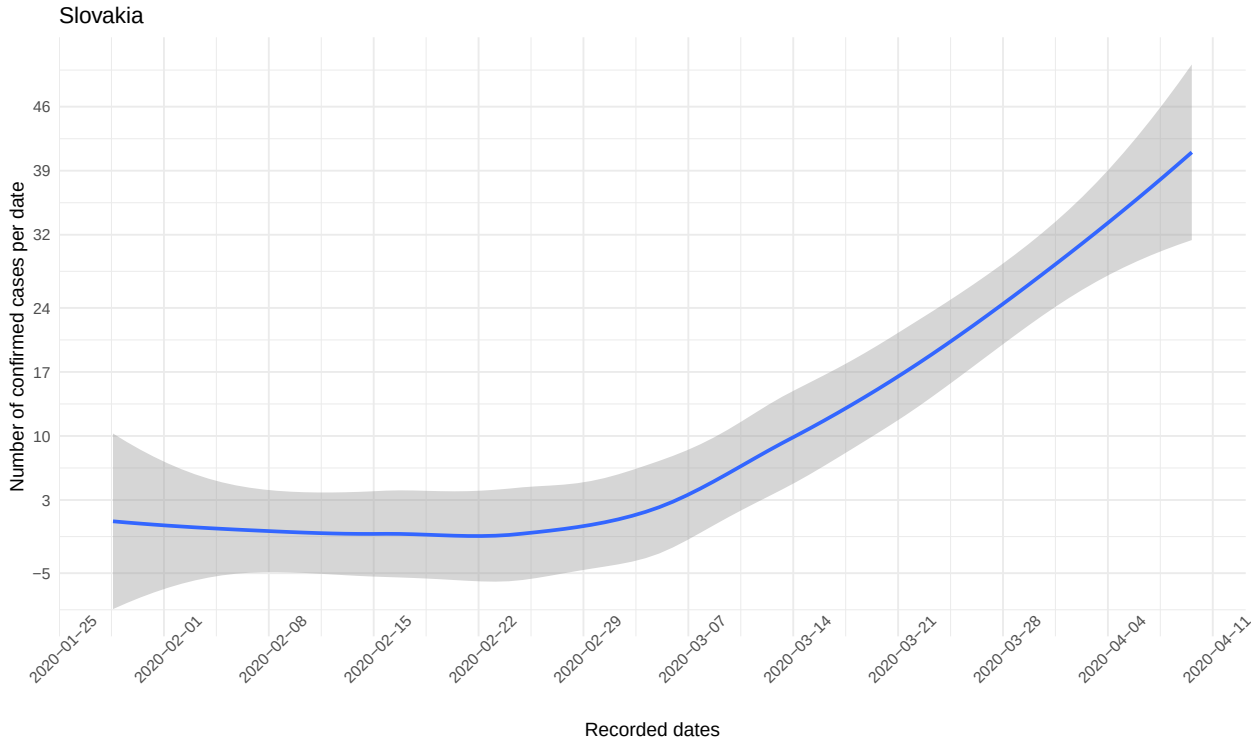


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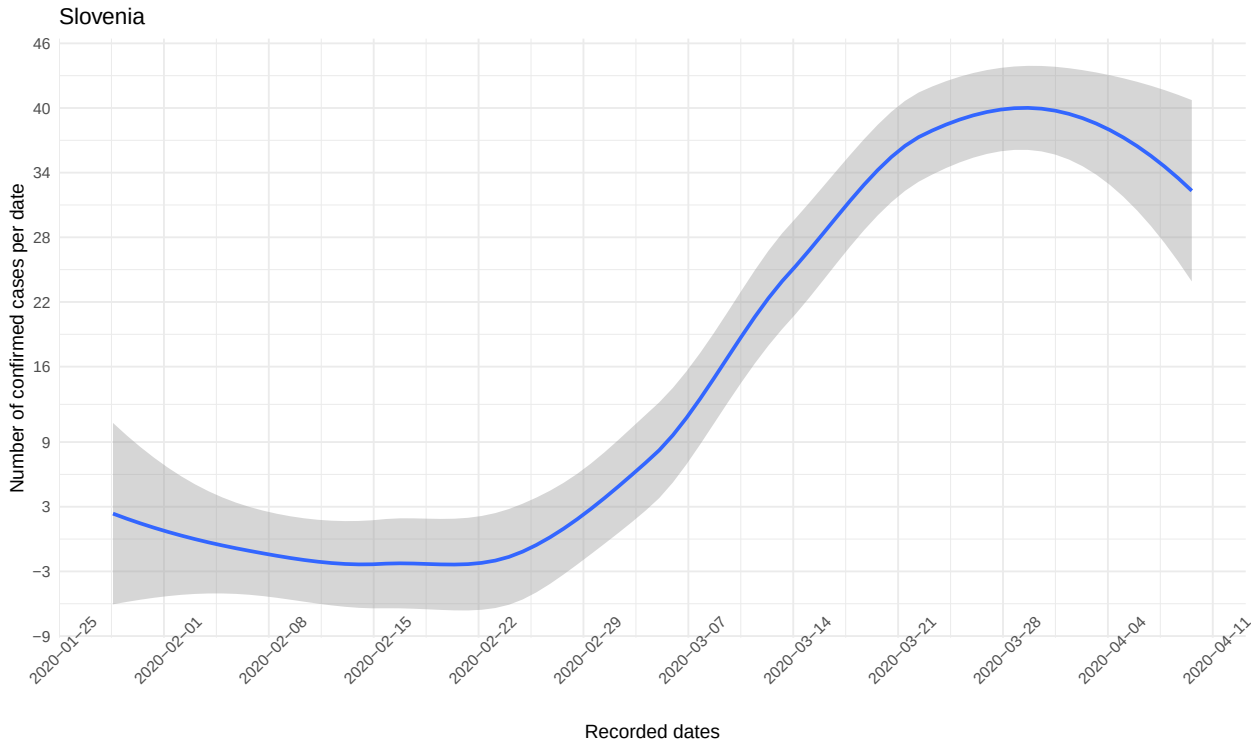


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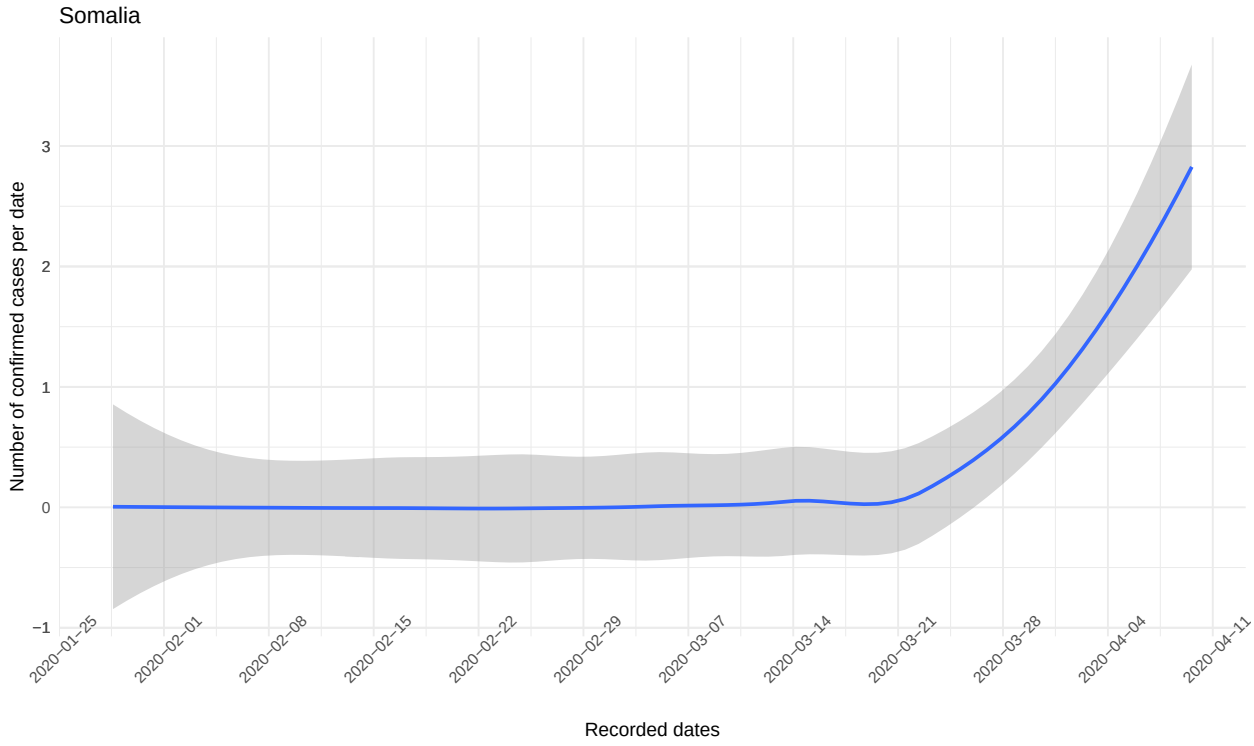


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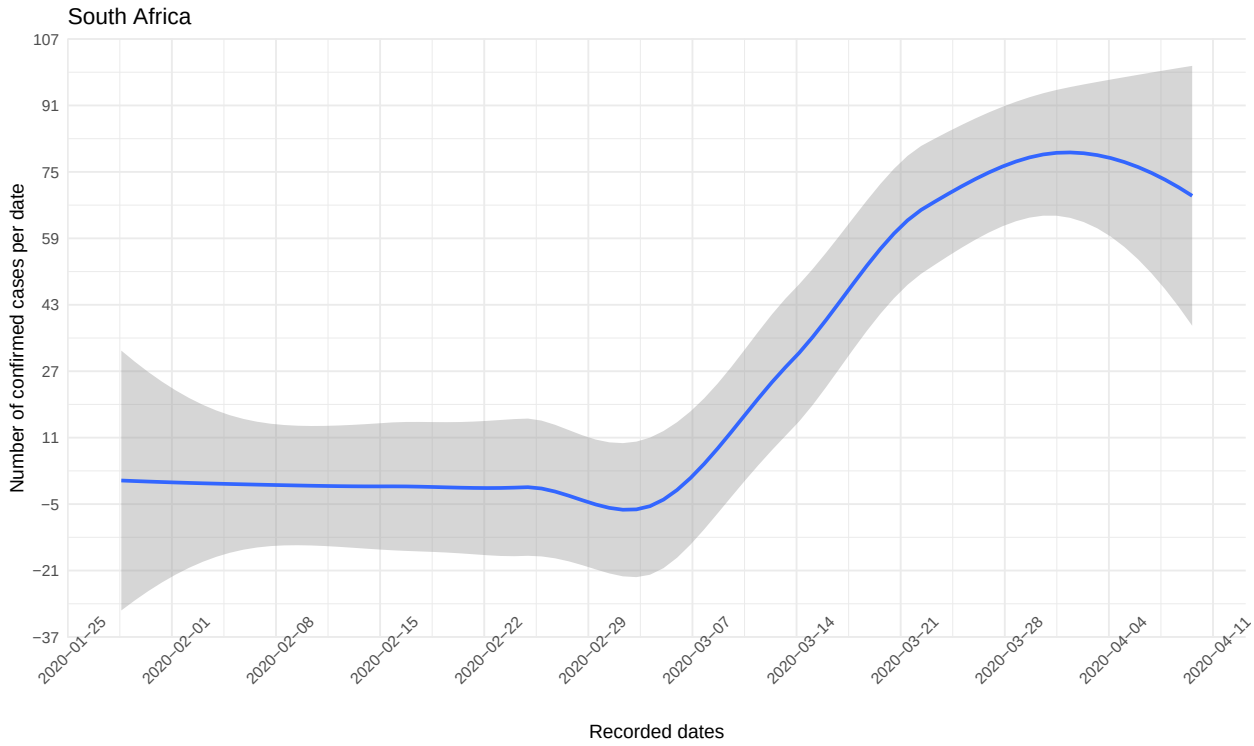


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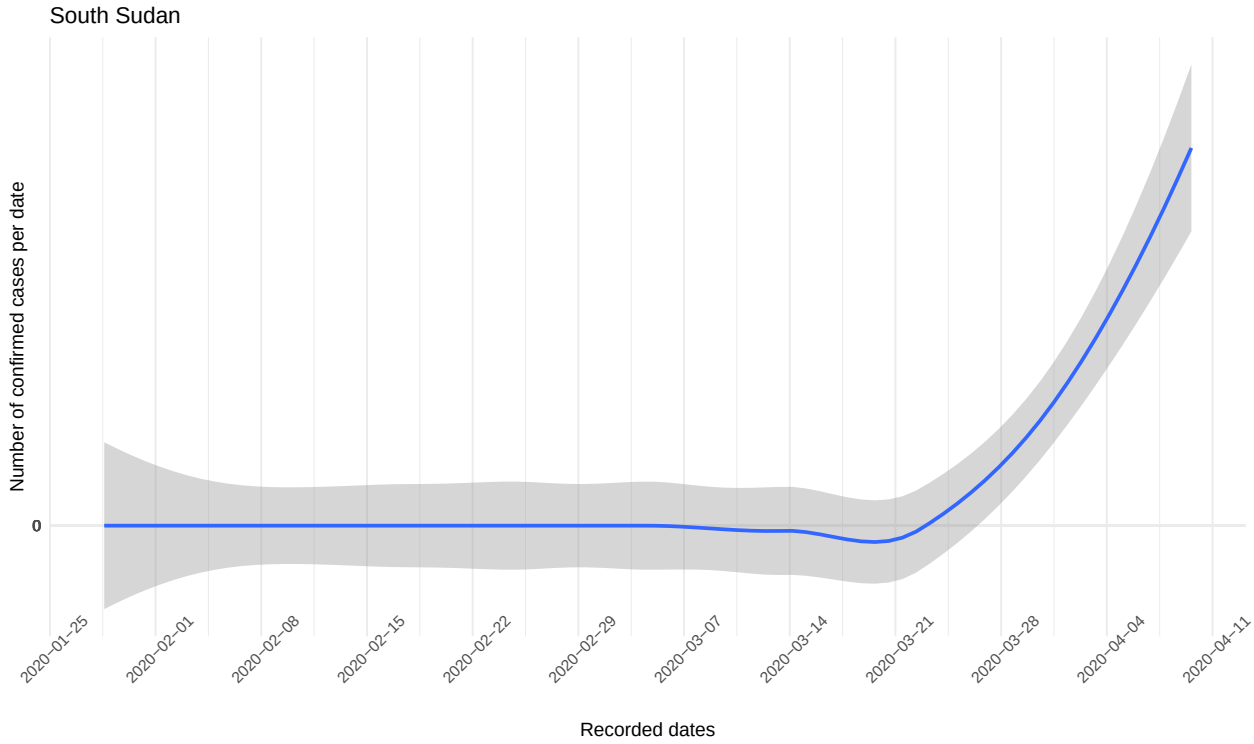


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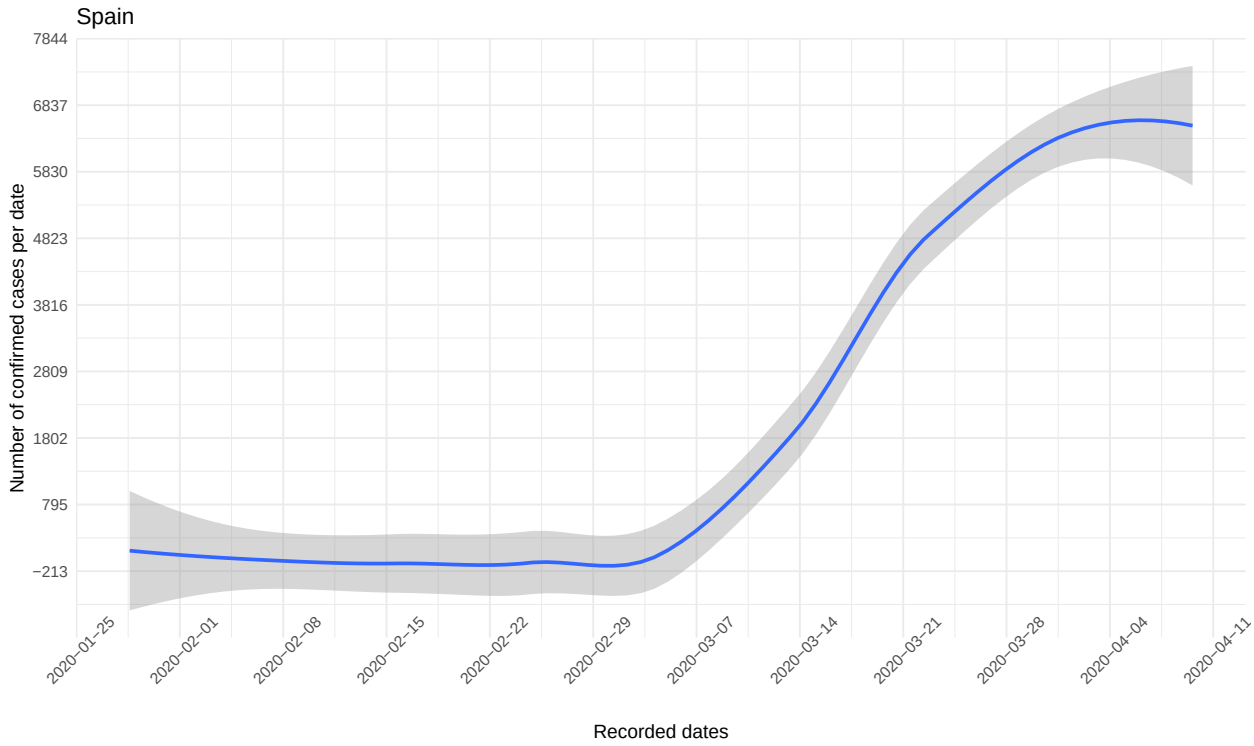


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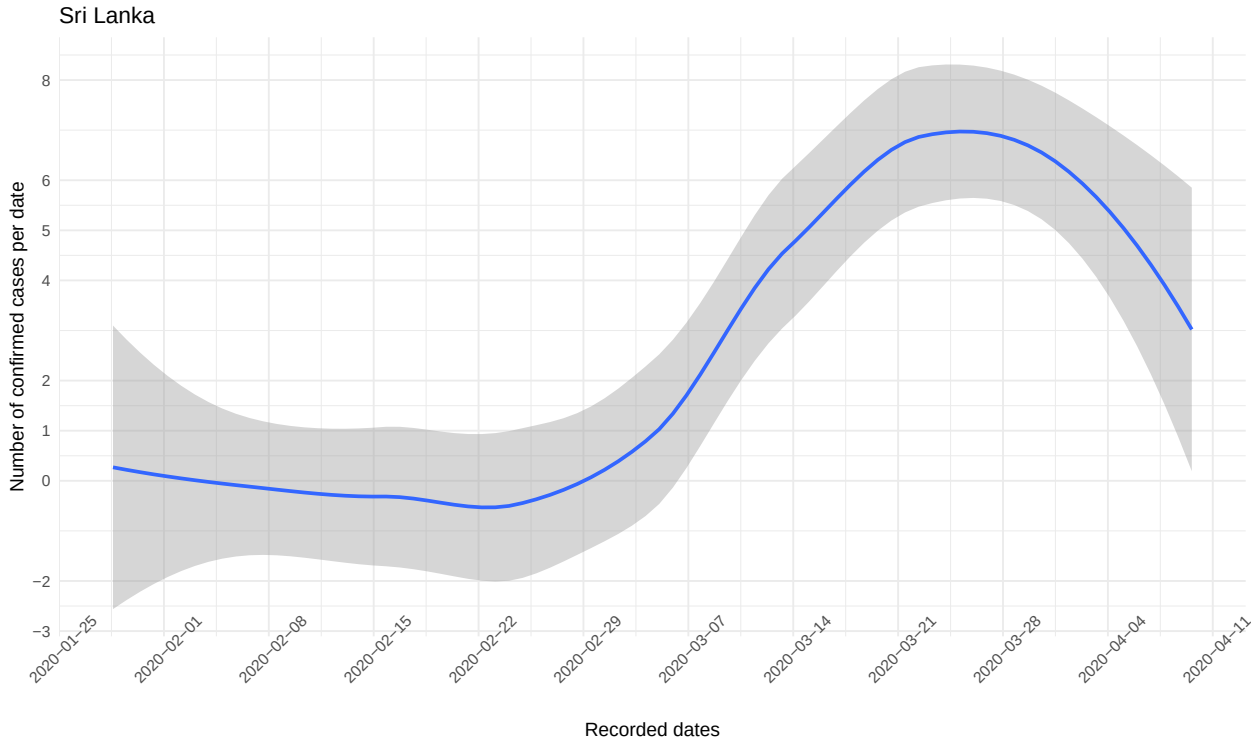


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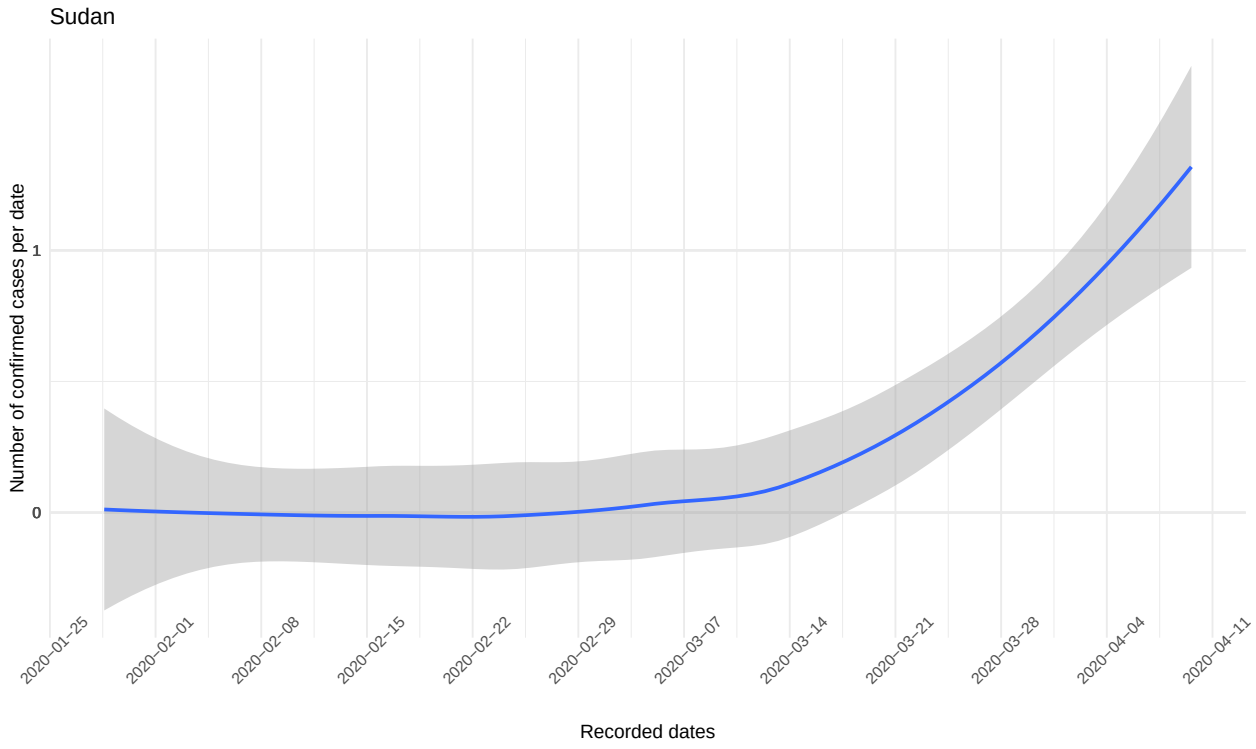


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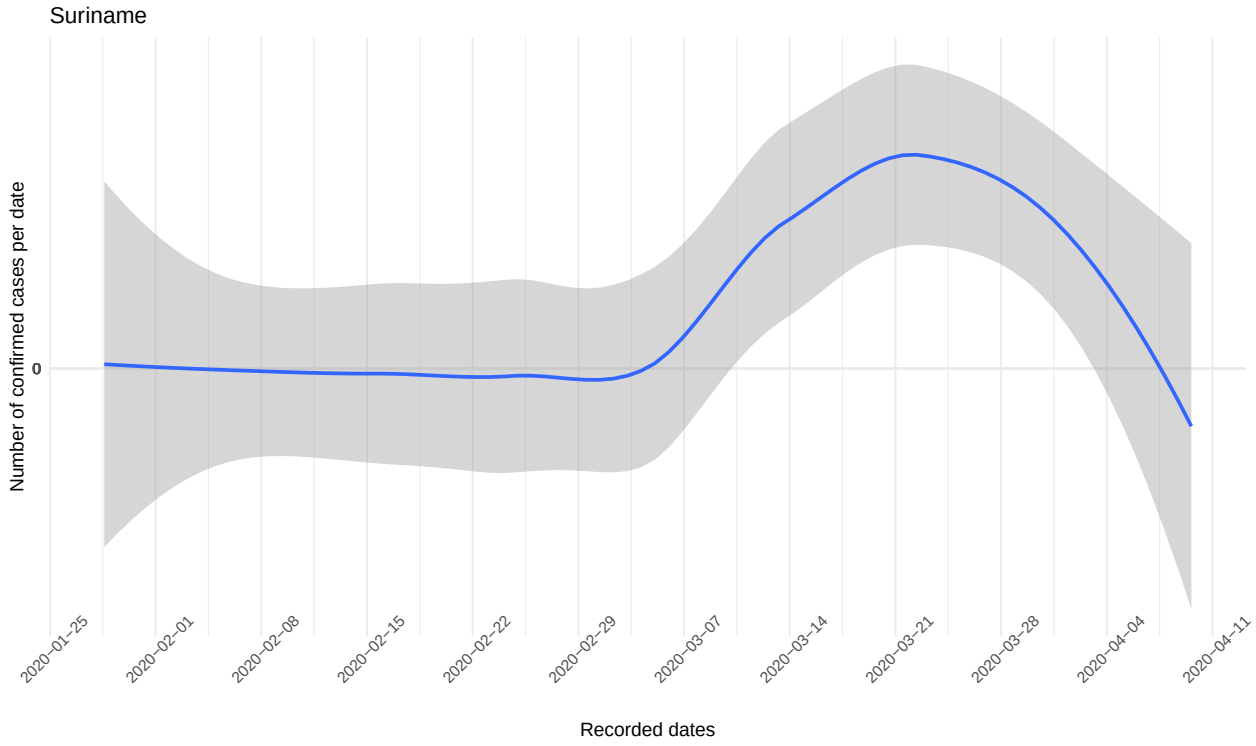


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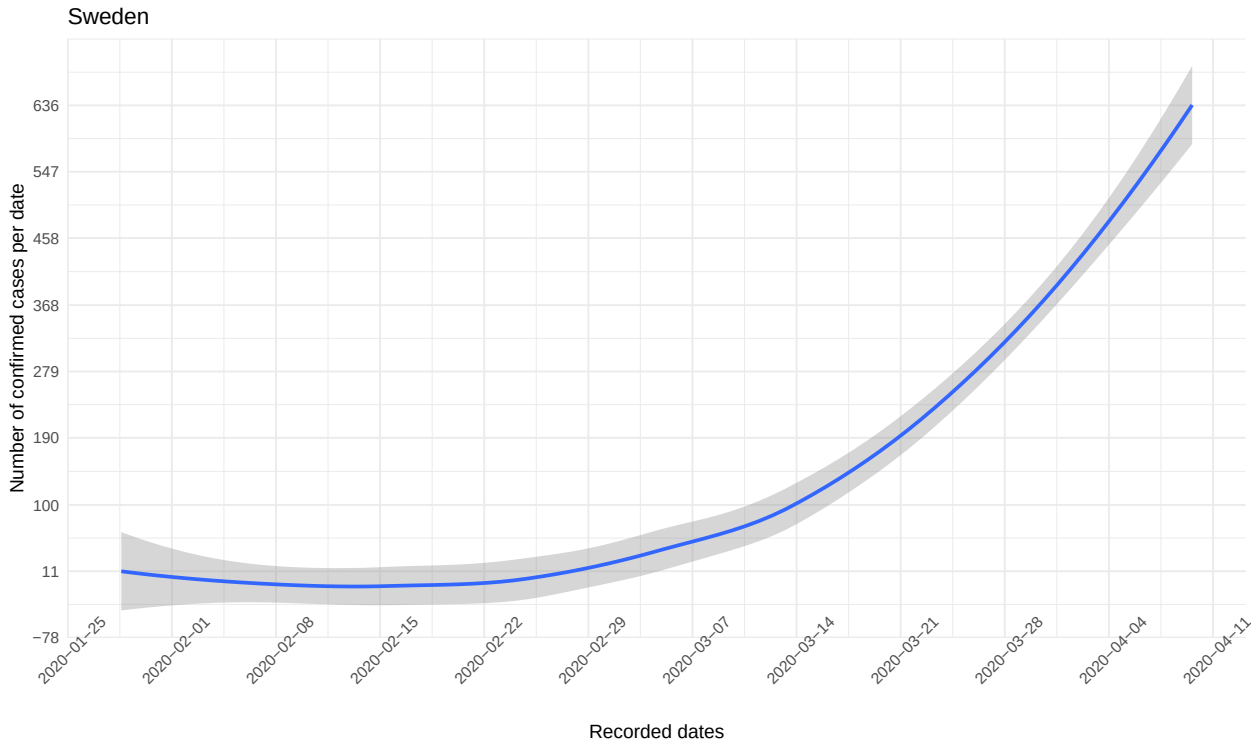


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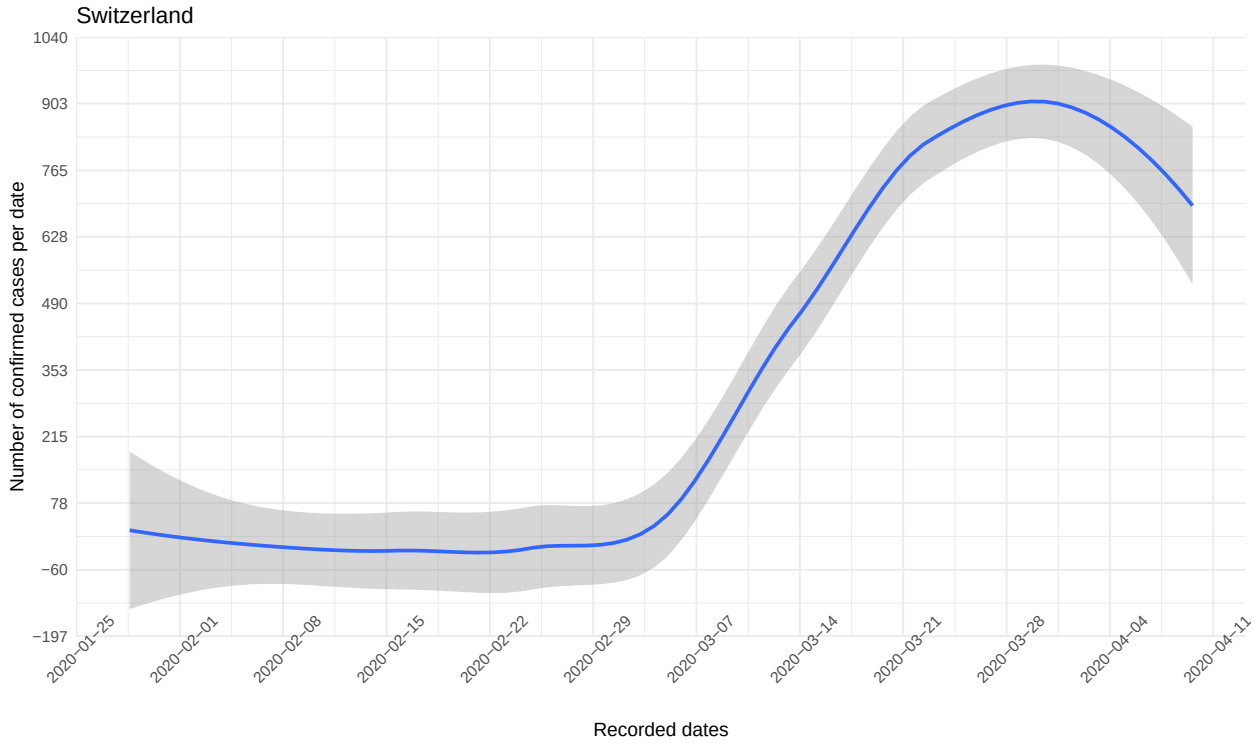


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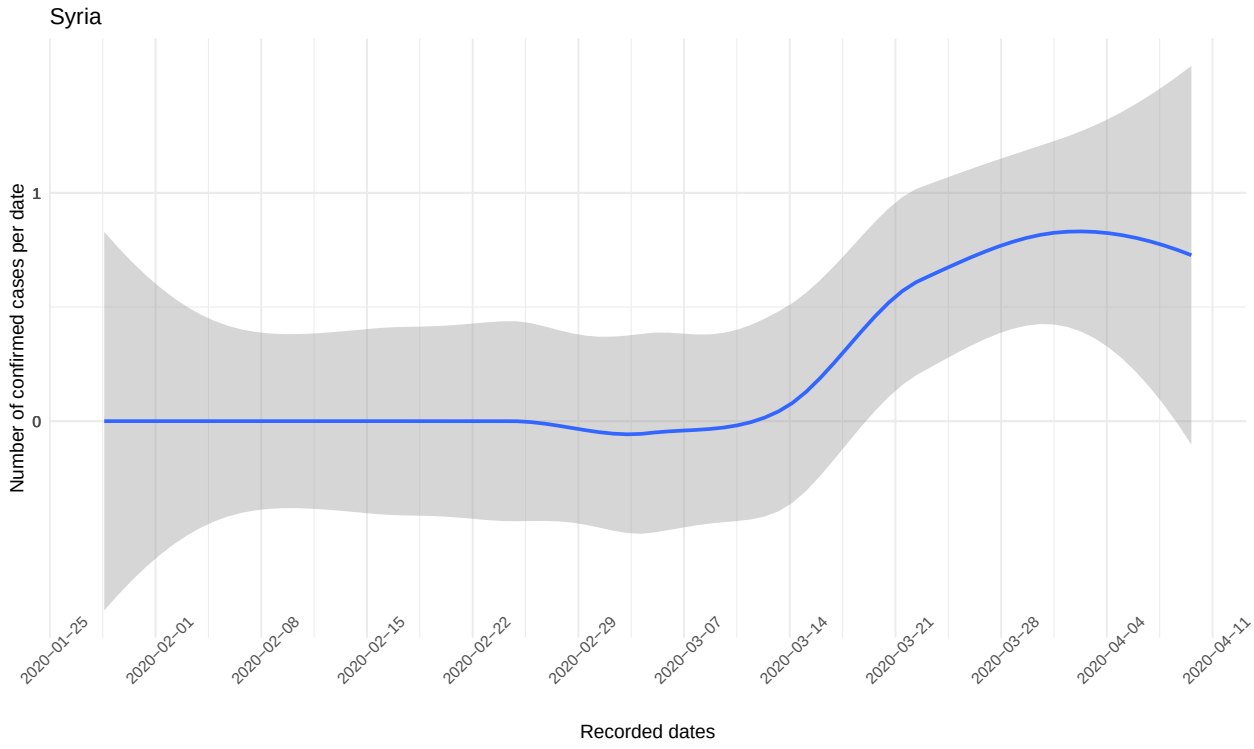


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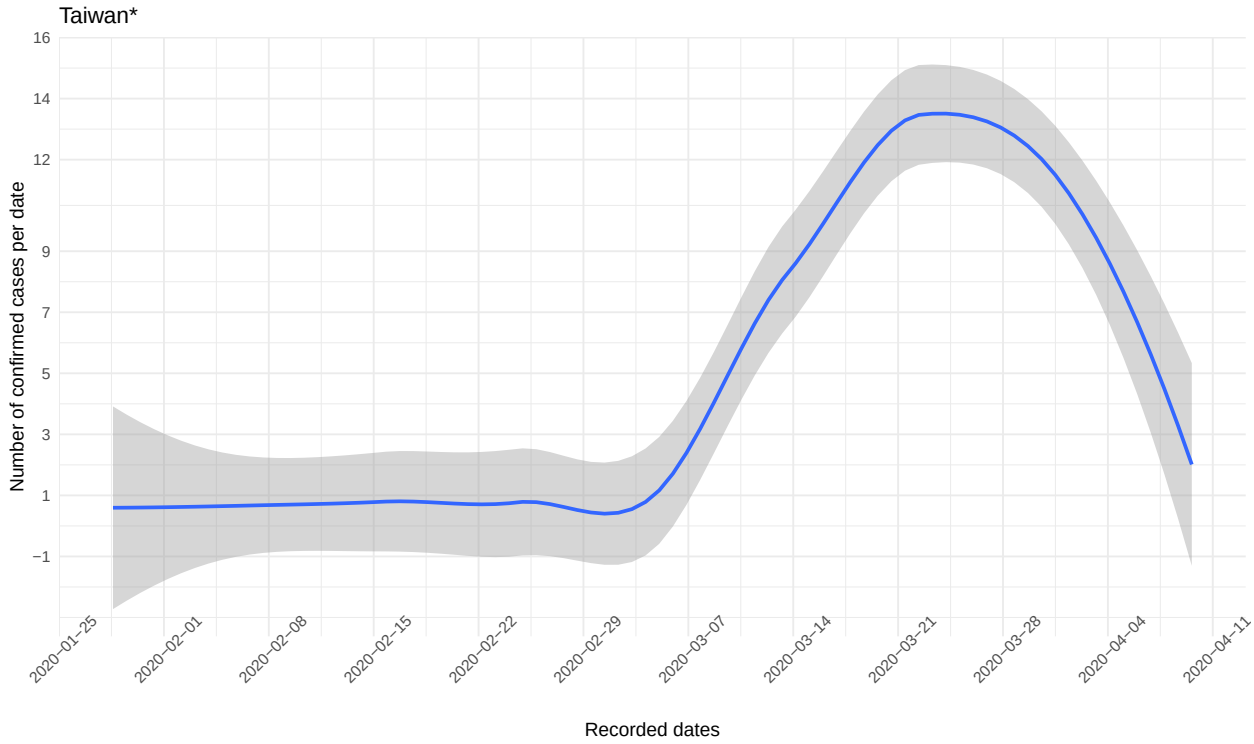


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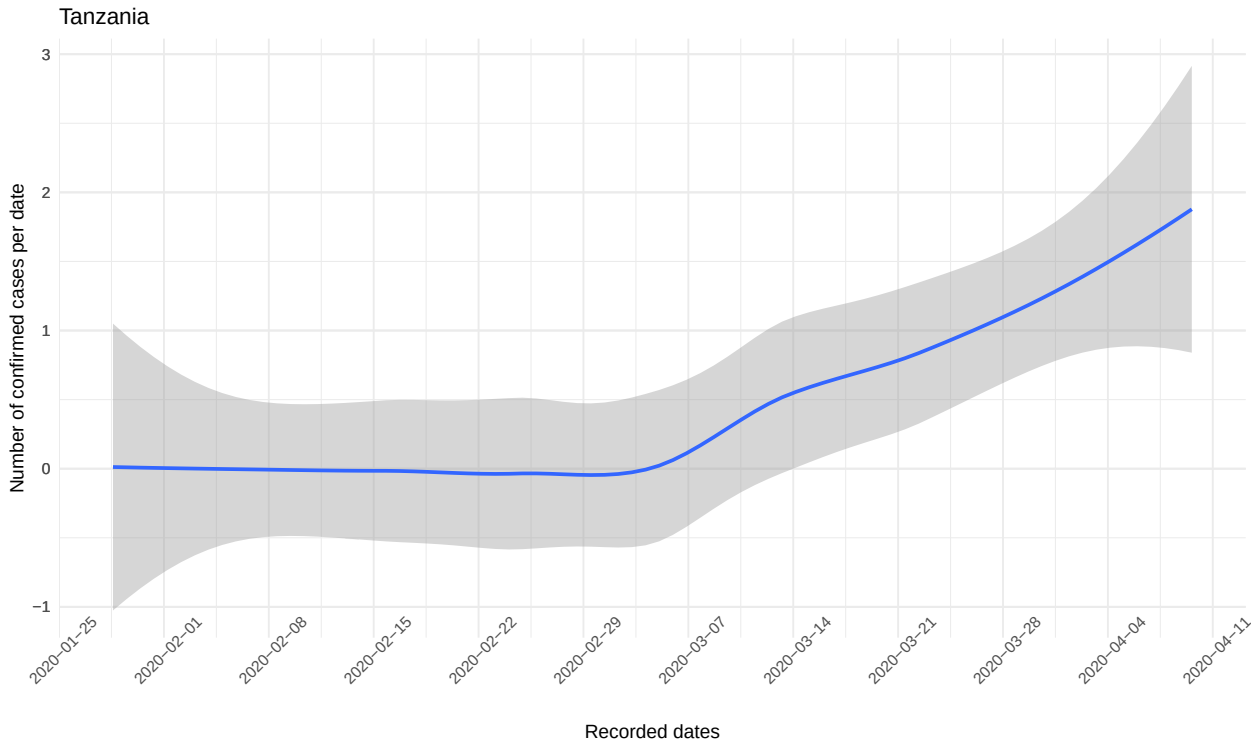


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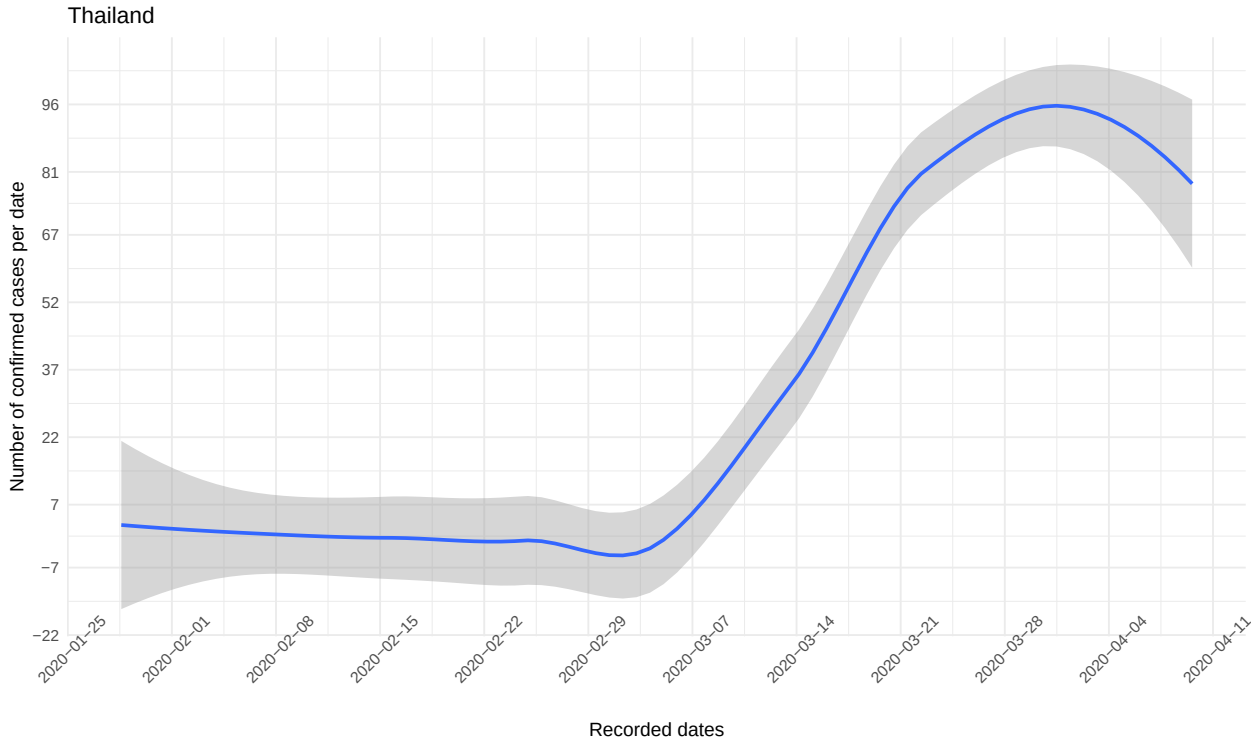


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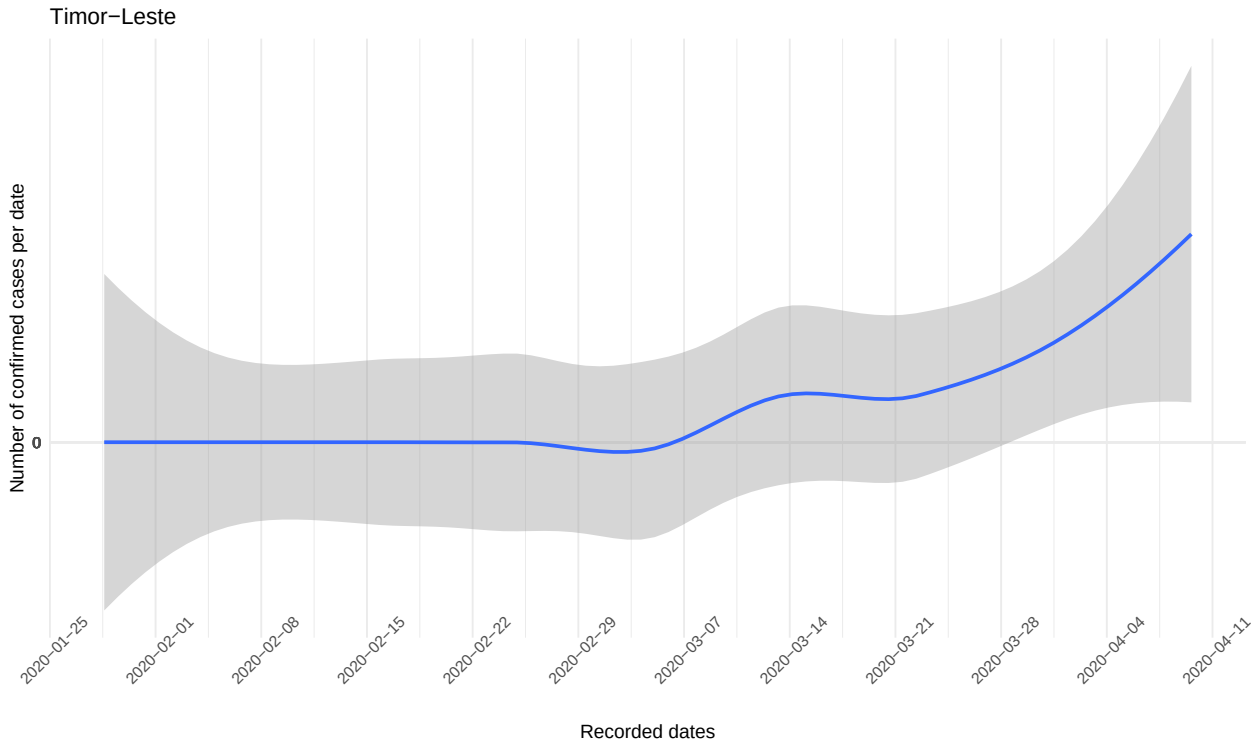


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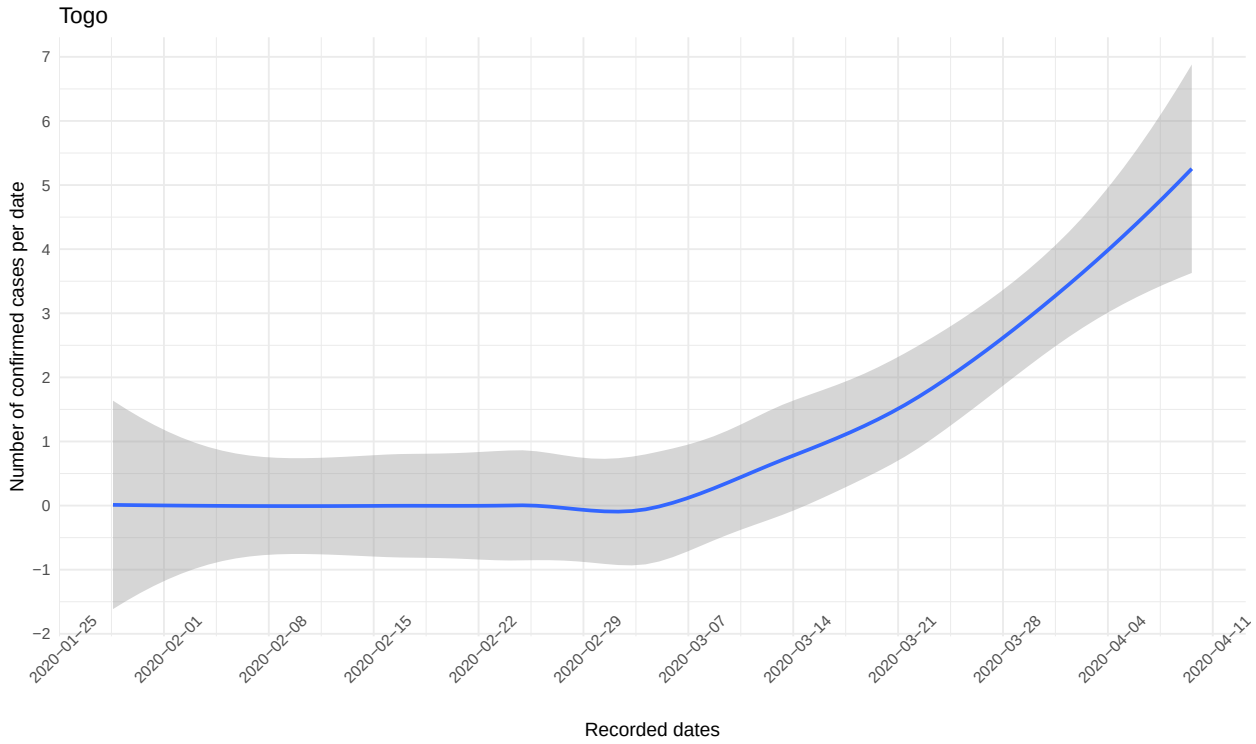


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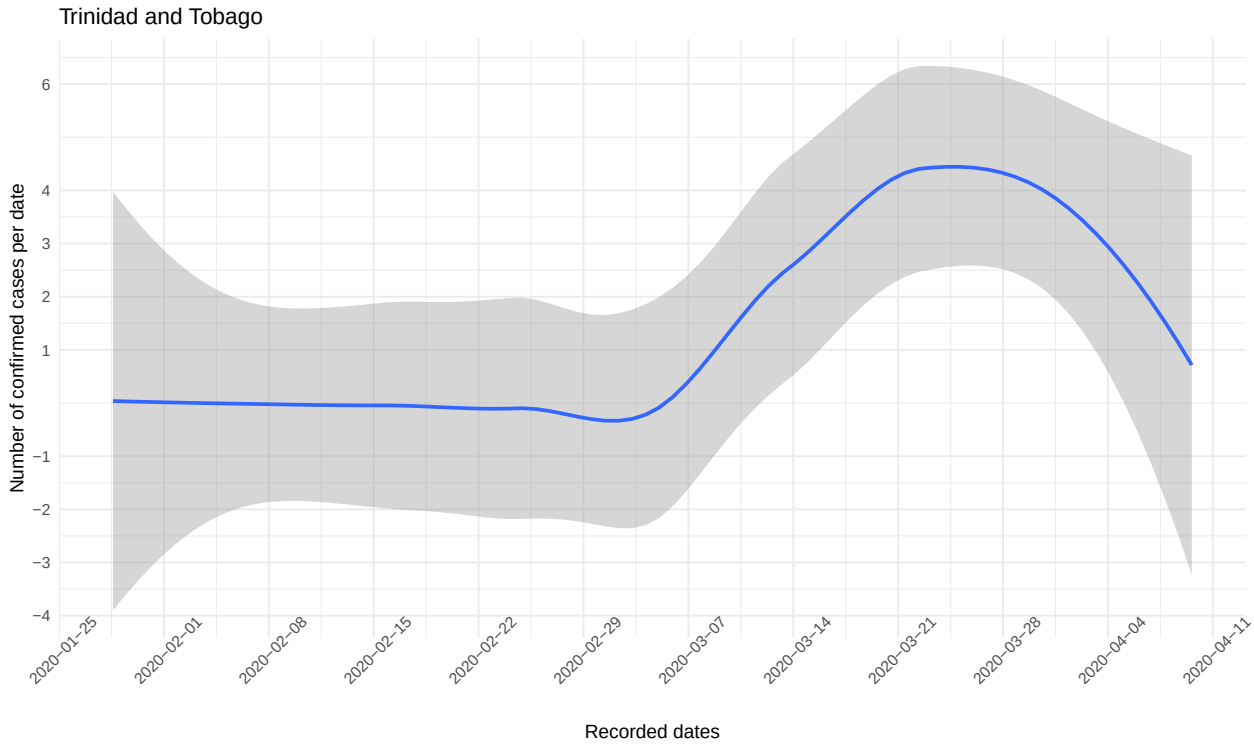


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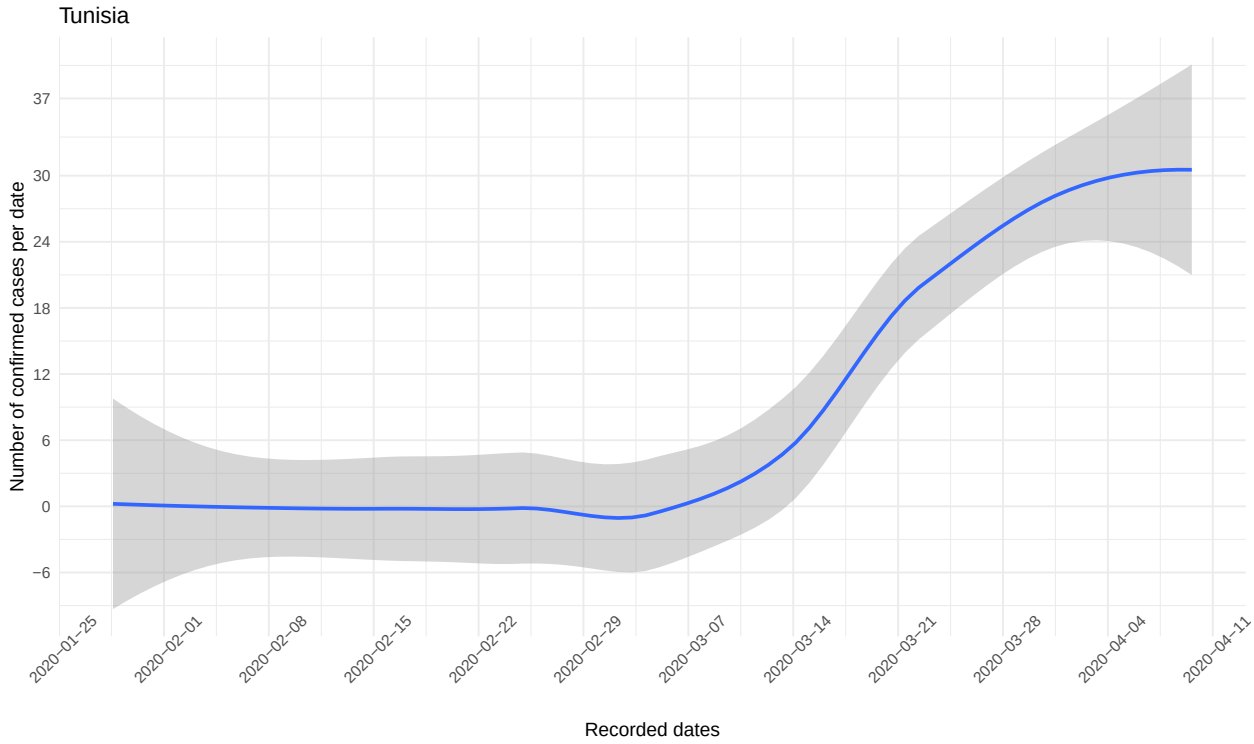


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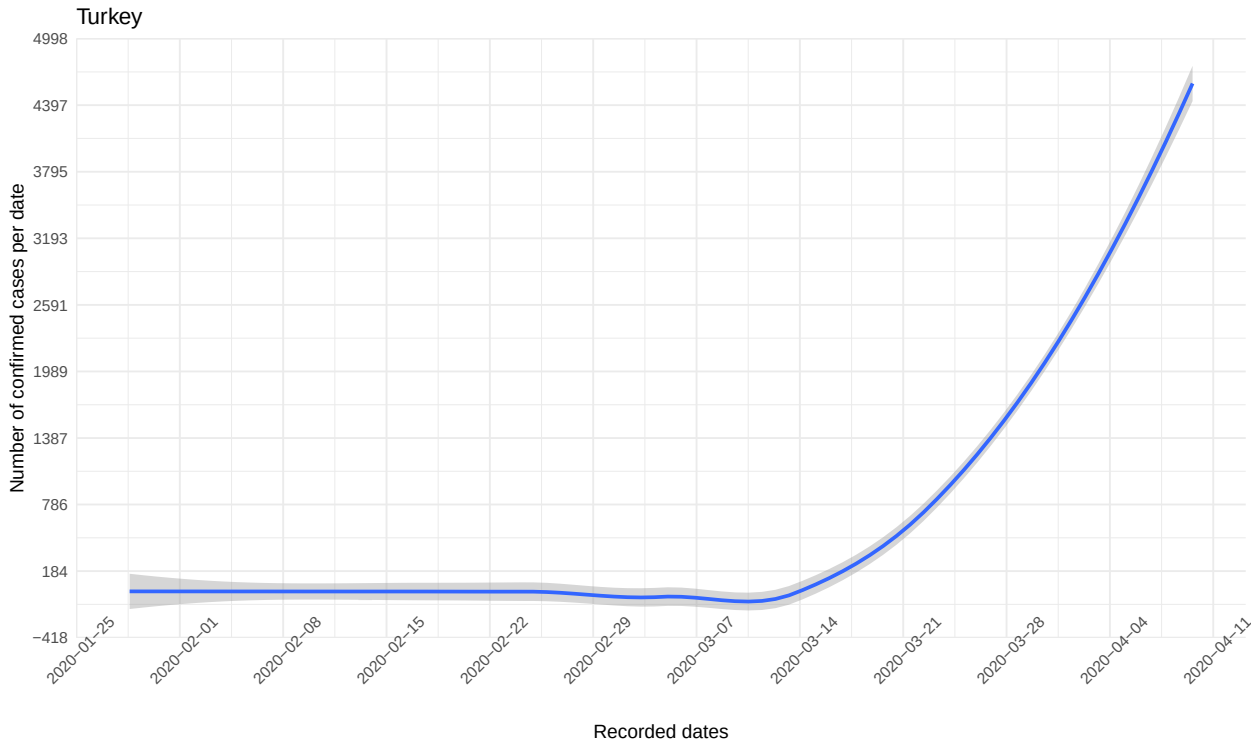


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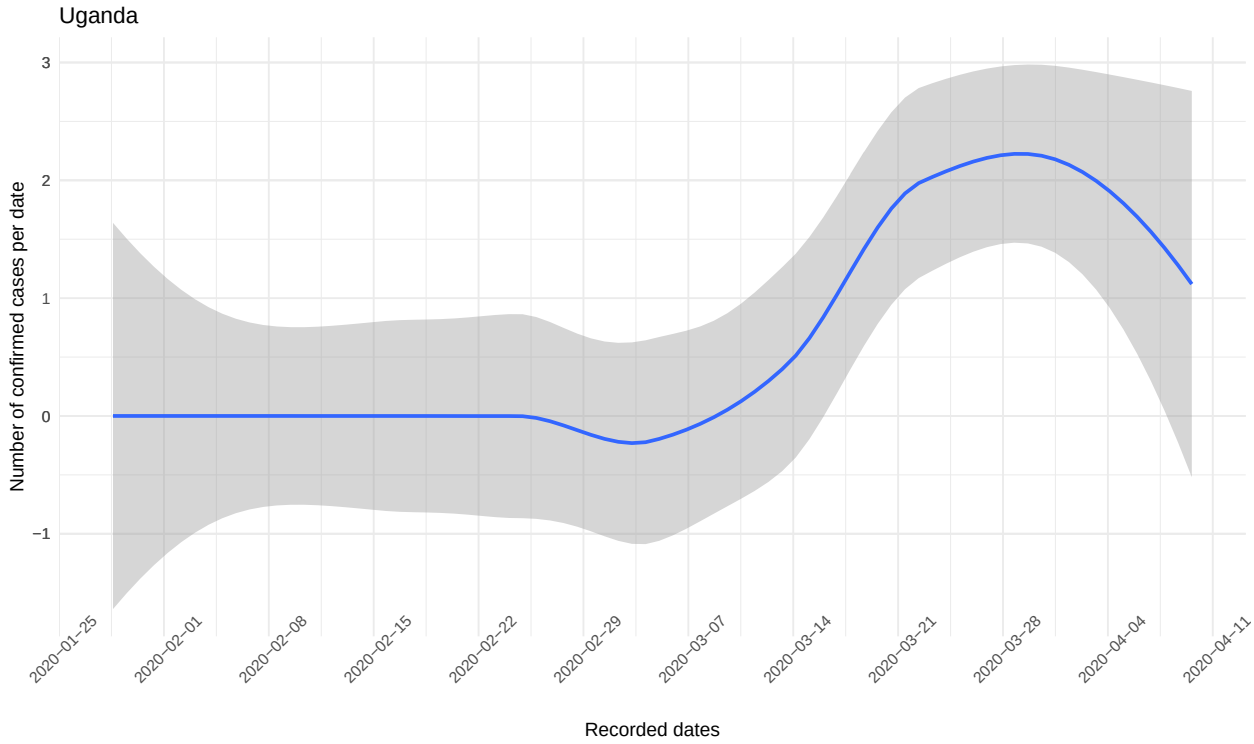


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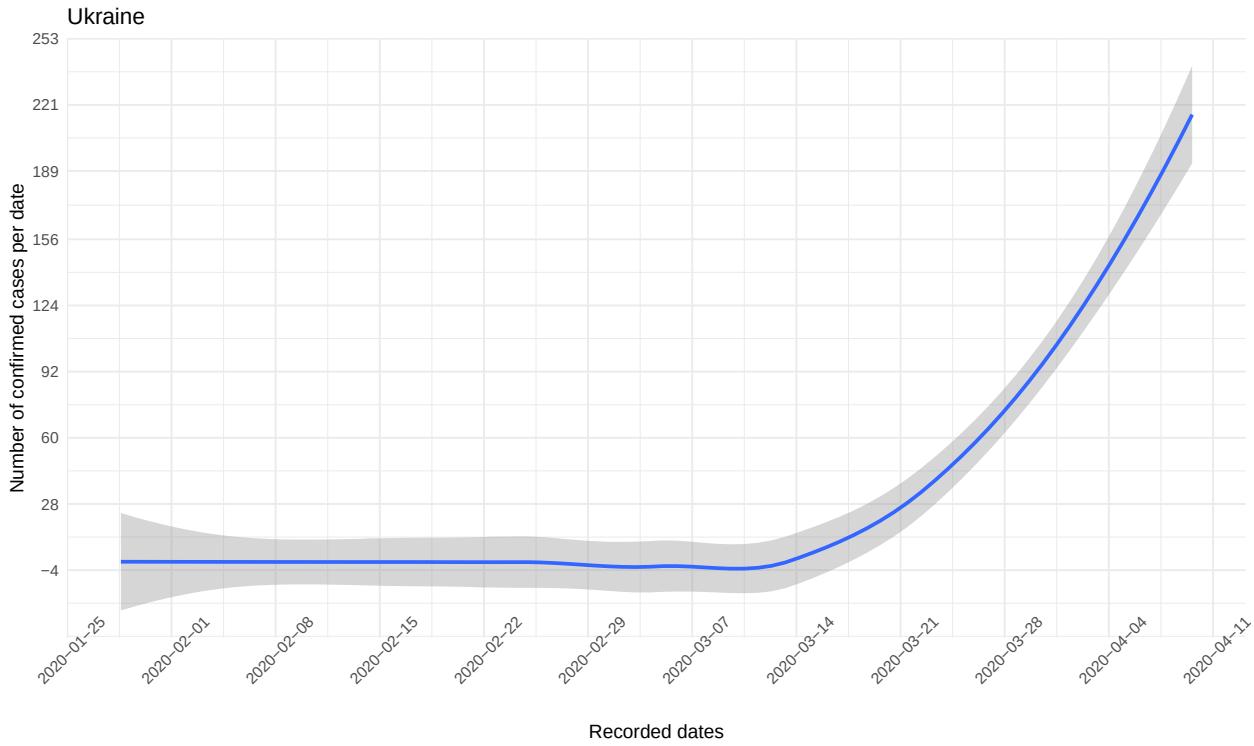


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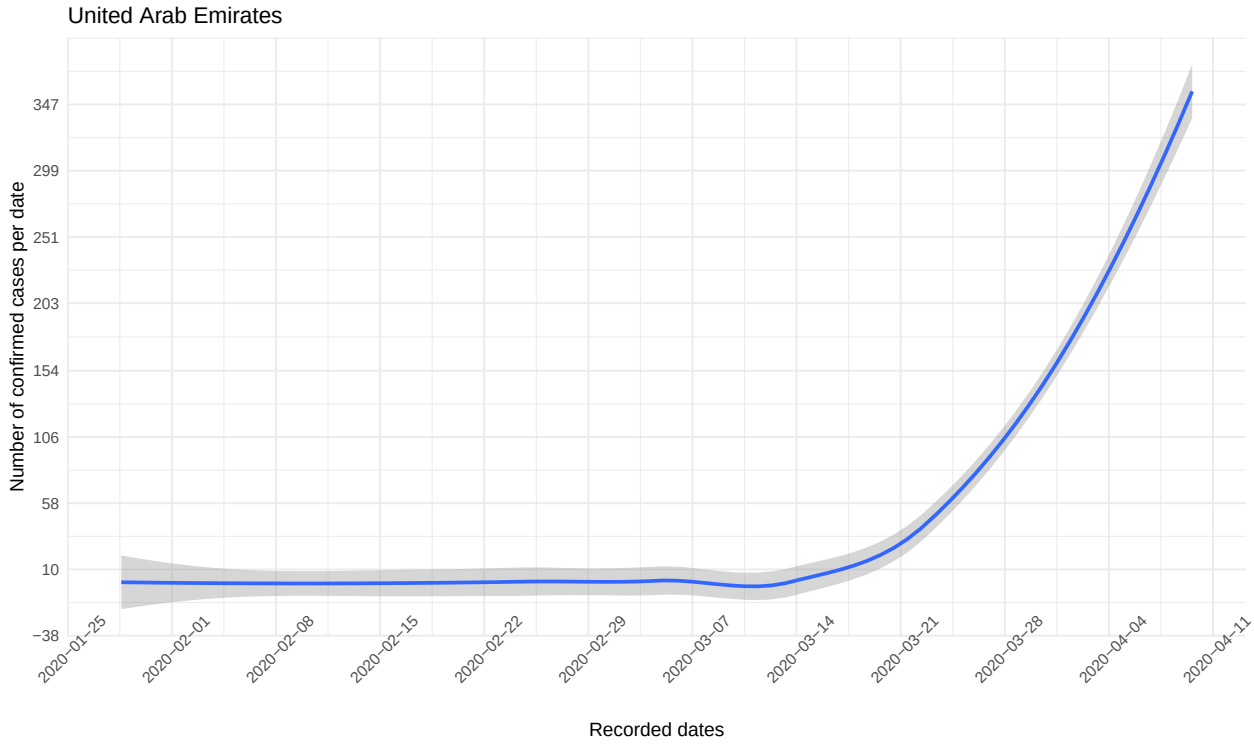


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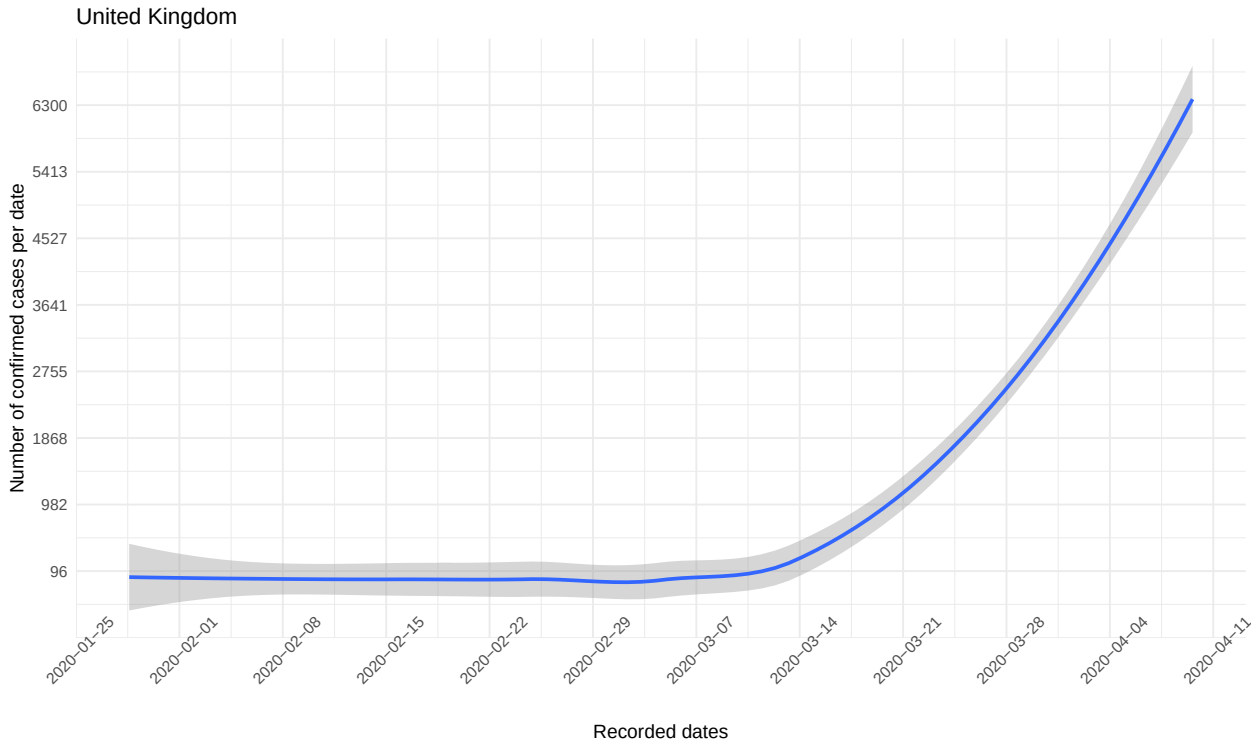


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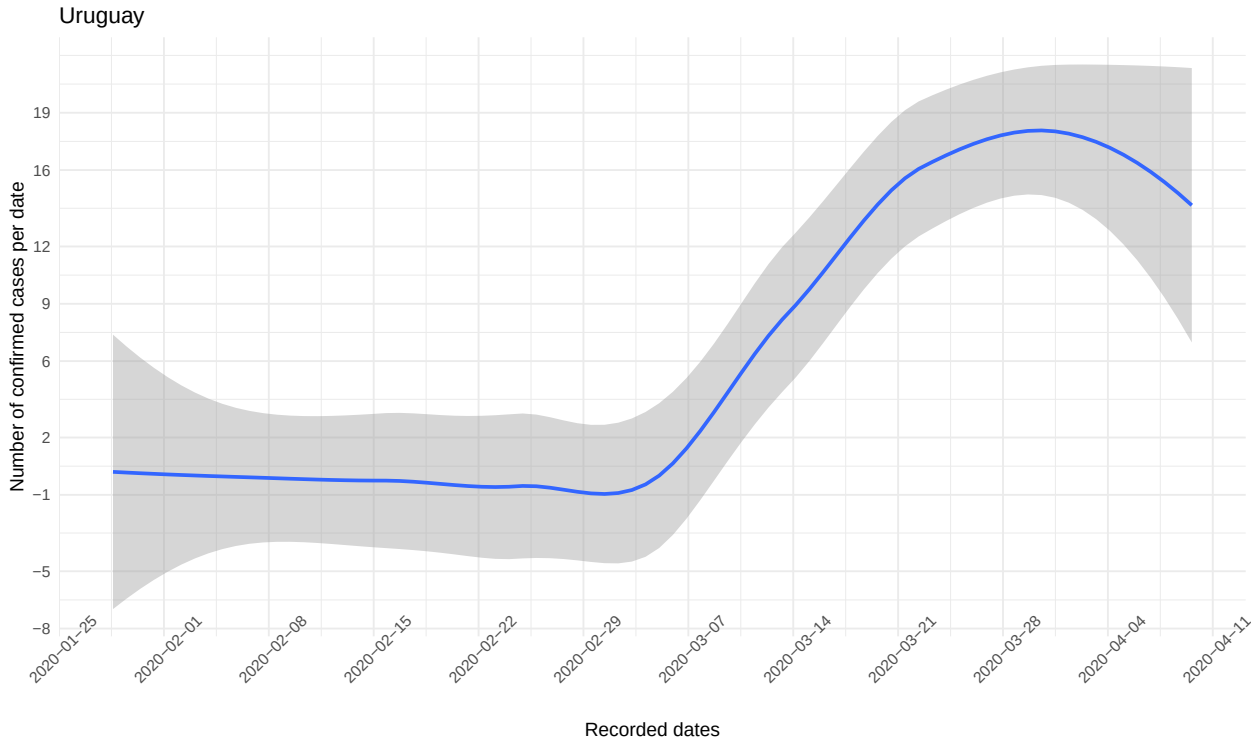


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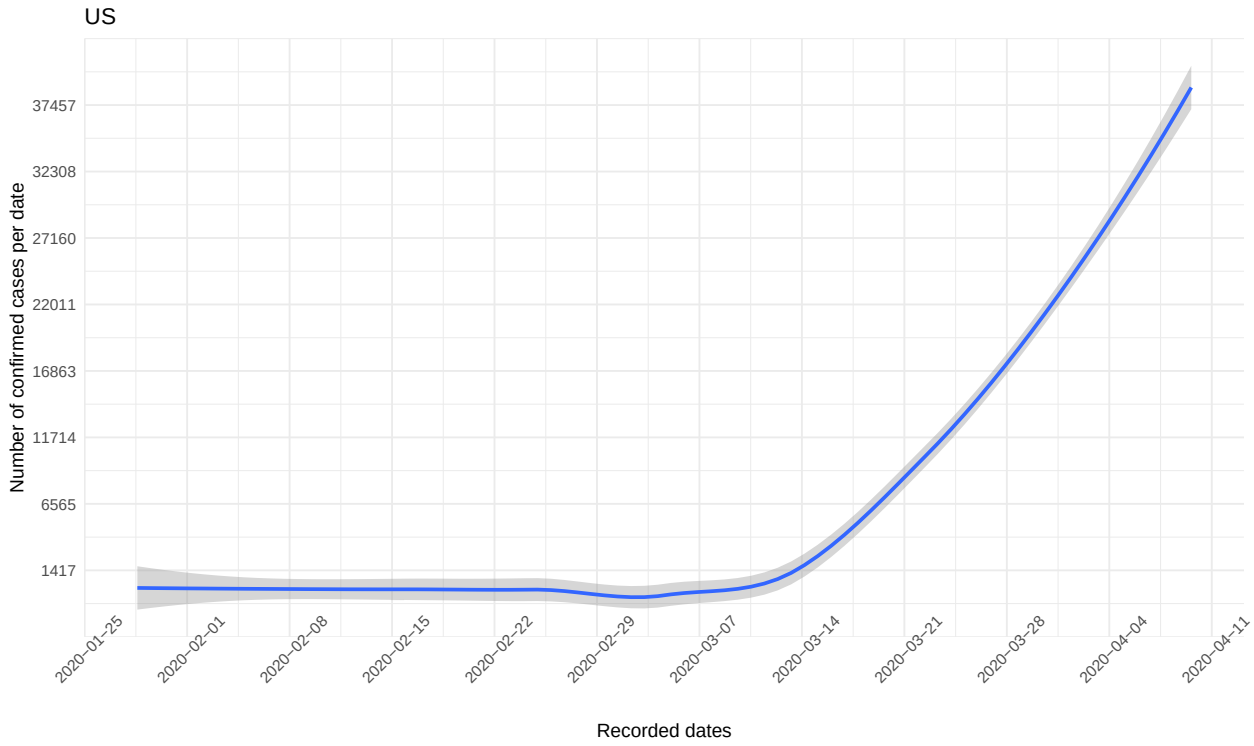


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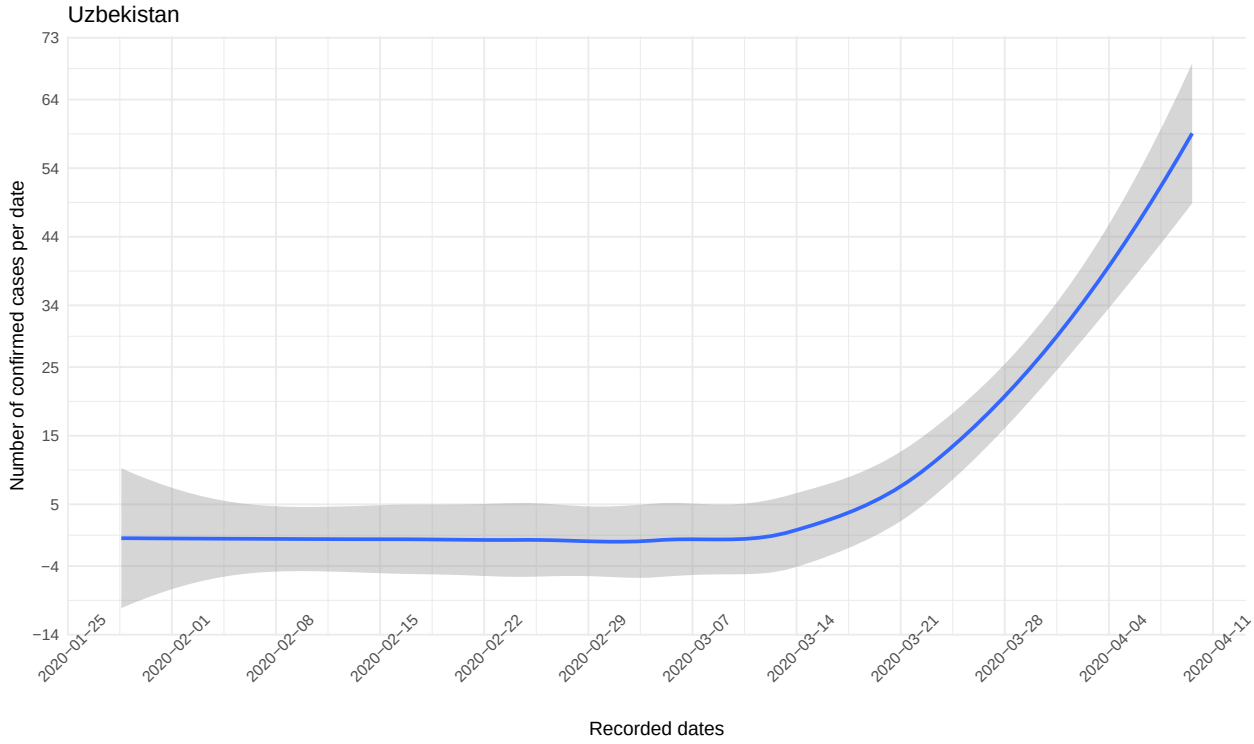


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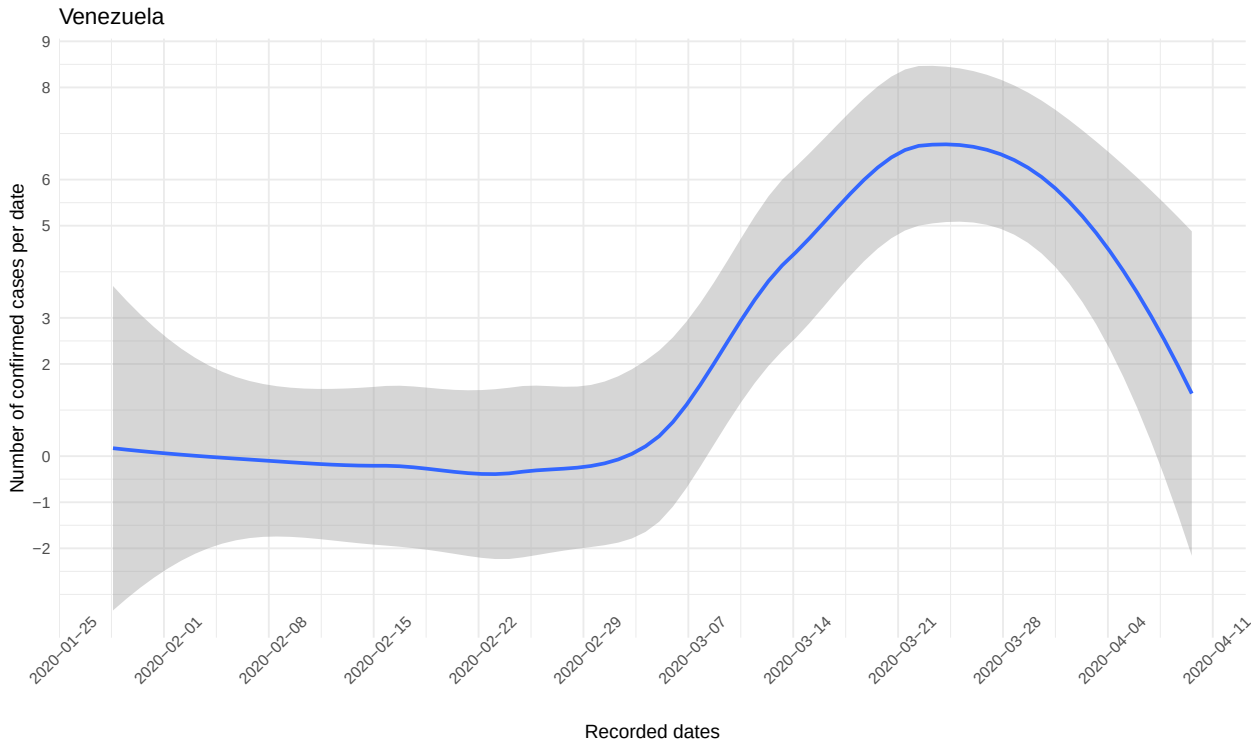


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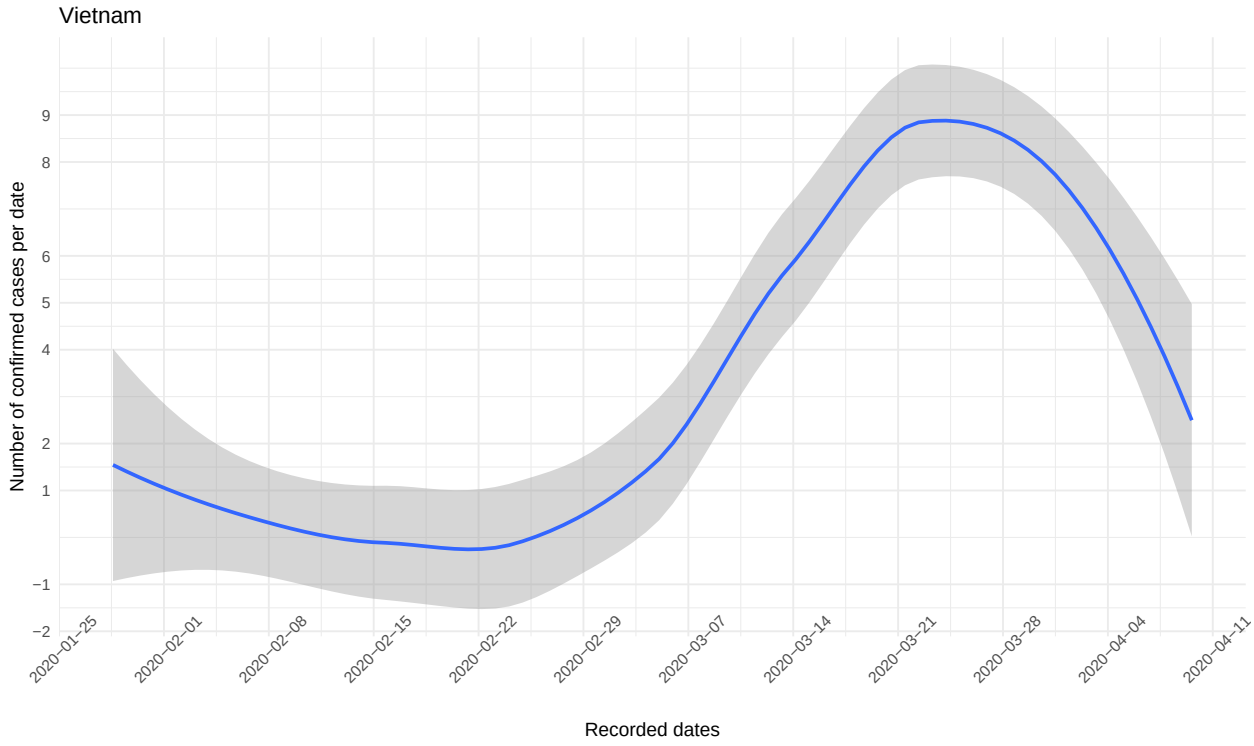


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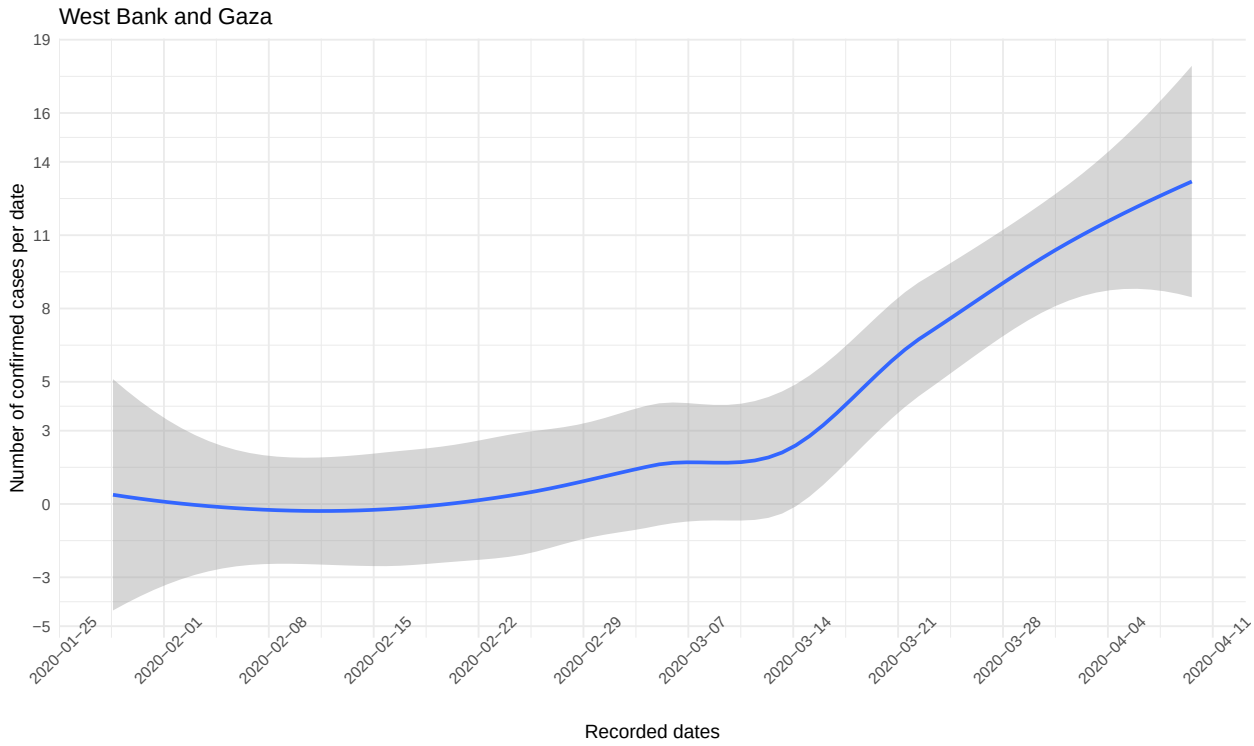


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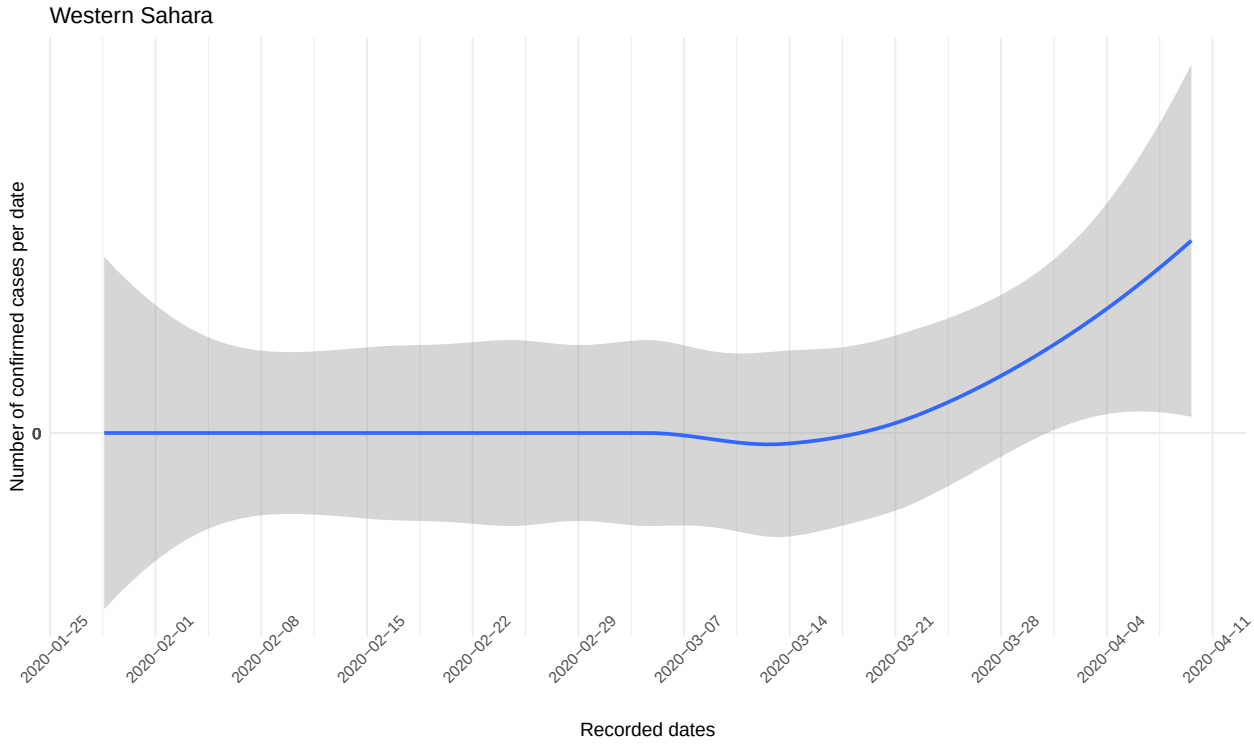


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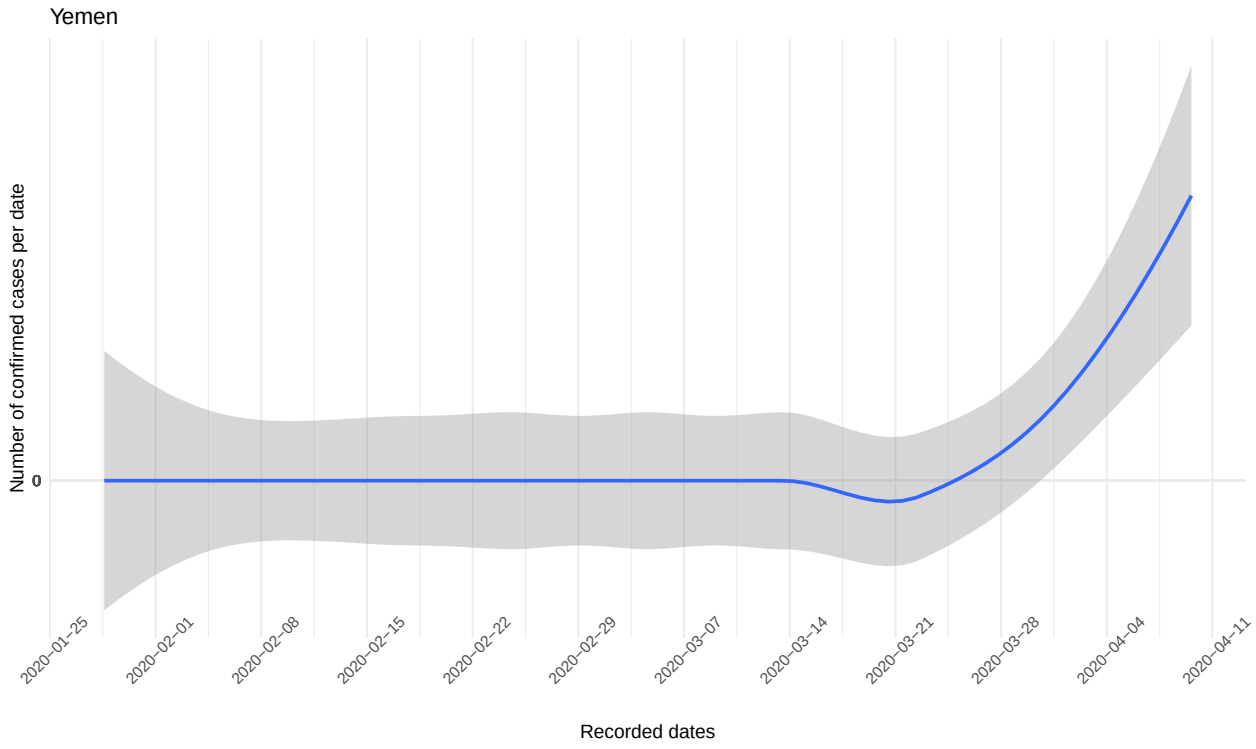


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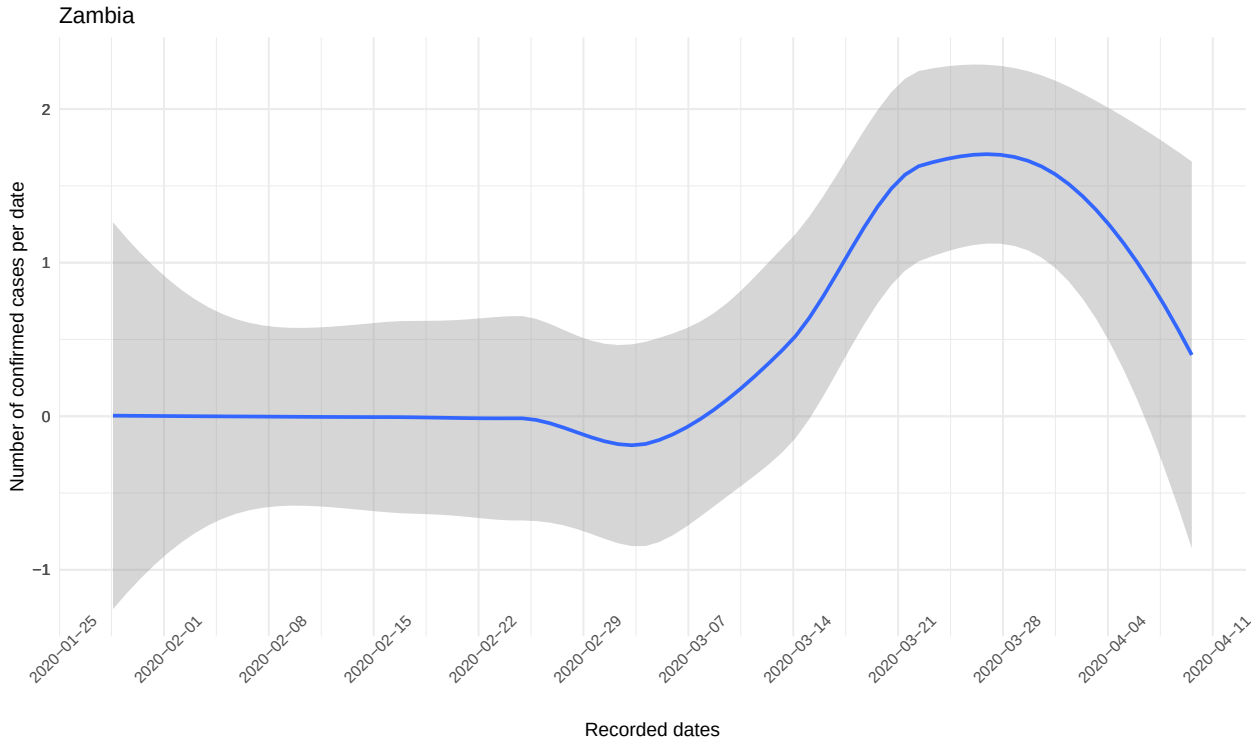


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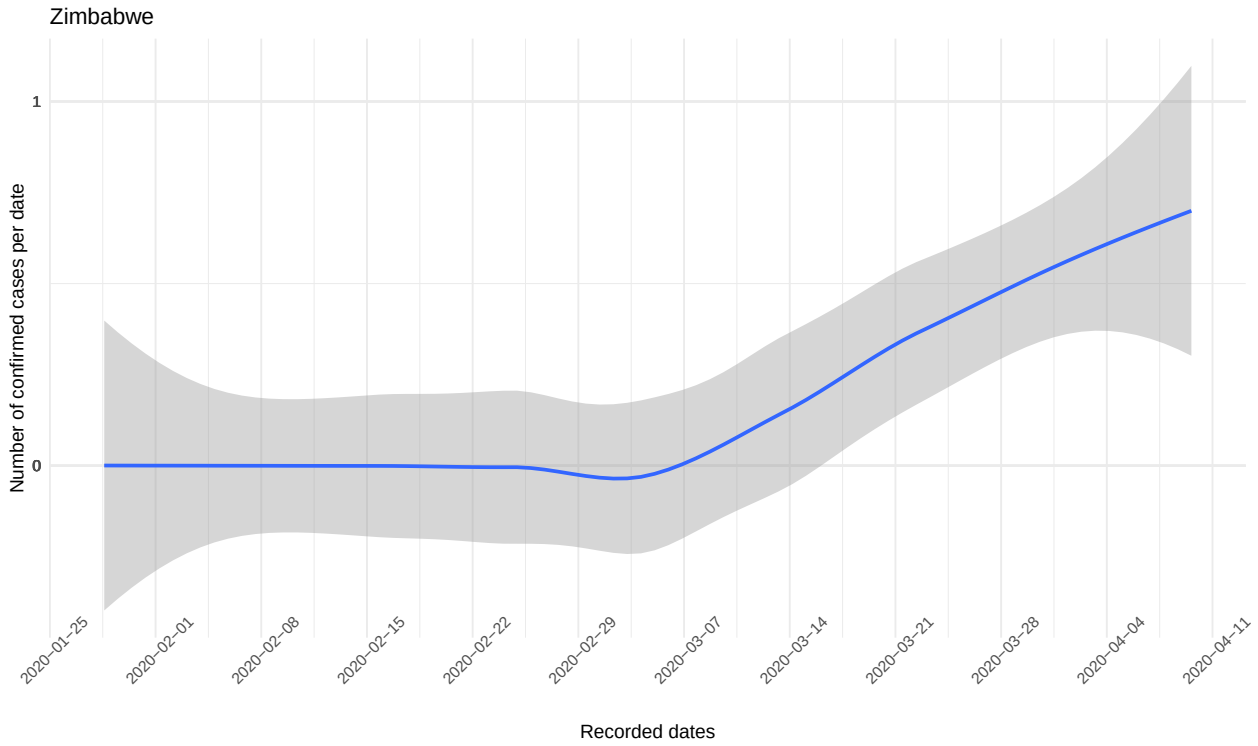



```
d5_glo <- d4_glo

cl <- makeCluster(parallel::detectCores())
registerDoParallel(cl)

tmp = foreach (i = 1:nrow(d5_glo), .combine = 'c', .inorder=T) %dopar% {
  cty = as.character(d4_glo[i,'Country/Region'])
  dt = d4_glo [i, 'dated']
  dts = d4_glo[order(as.Date(d4_glo[which(d4_glo$`Country/Region` == cty), 'dated'])),'dated']
  dt_pos = which(dts == dt)
  if (dt_pos > 1){
    prev_dt = dts[dt_pos-1]
    d4_glo[i,'n_bydate'] - d4_glo[which(d4_glo[,'Country/Region'] == cty &
                                          d4_glo[,'dated'] == prev_dt),'n_bydate']
  }else{
    0
  }
}
stopCluster(cl)

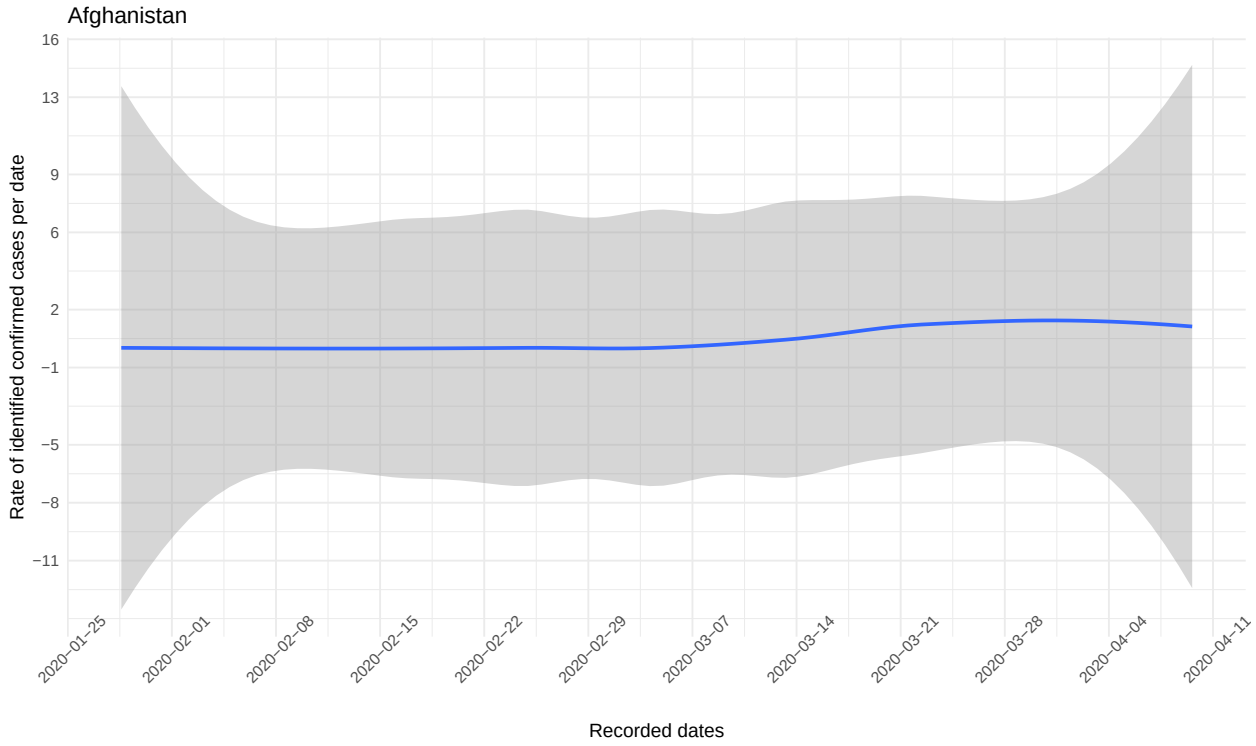
d4_glo$n_rate_bydate = unlist(tmp)

cty_uq = unique(d4_glo$`Country/Region`)
for (i in 1:length(cty_uq)) {
  df <- d4_glo %>% filter(`Country/Region` == cty_uq[i])

  plt <- ggplot(df, aes(dated, n_rate_bydate)) +
  geom_smooth() +
  ggtitle(cty_uq[i]) +
  scale_x_date('Recorded dates',
```

```
                breaks = function(x) seq.Date(from = min(x),
                                              to = max(x),
                                              by = "1 week")) +
  scale_y_continuous('Rate of identified confirmed cases per date',
                     breaks = function (x) round(seq.int(from = min(x),
                                to = max(x),
                                length.out = 10))) +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45),
        legend.position = "bottom",
        legend.title = element_blank()) +
  guides(col = guide_legend(nrow = 20))
  print(plt)
}
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

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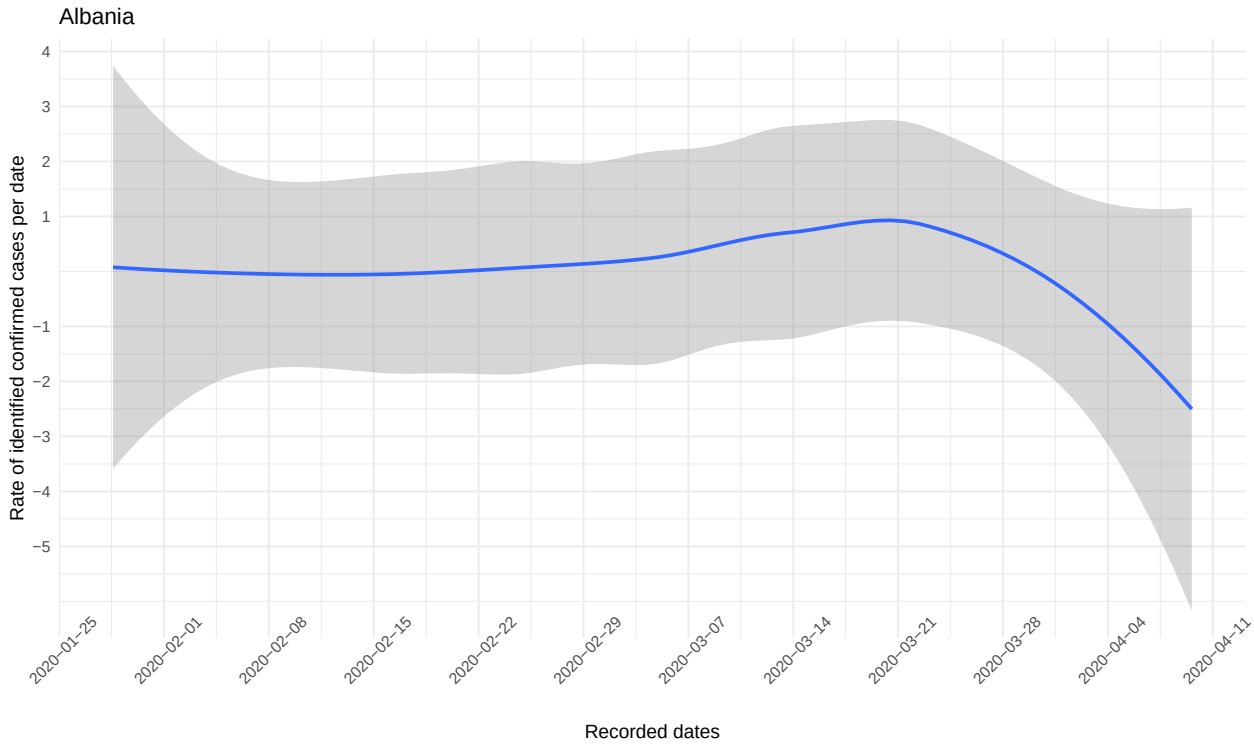


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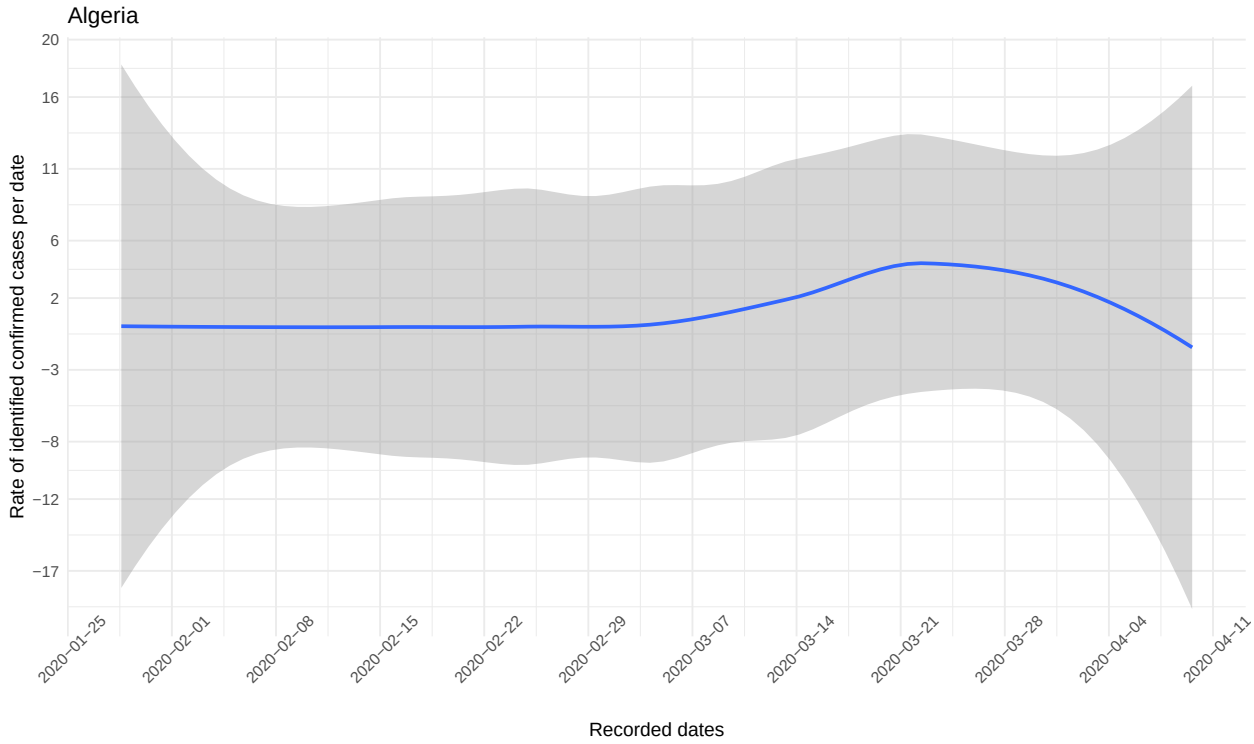


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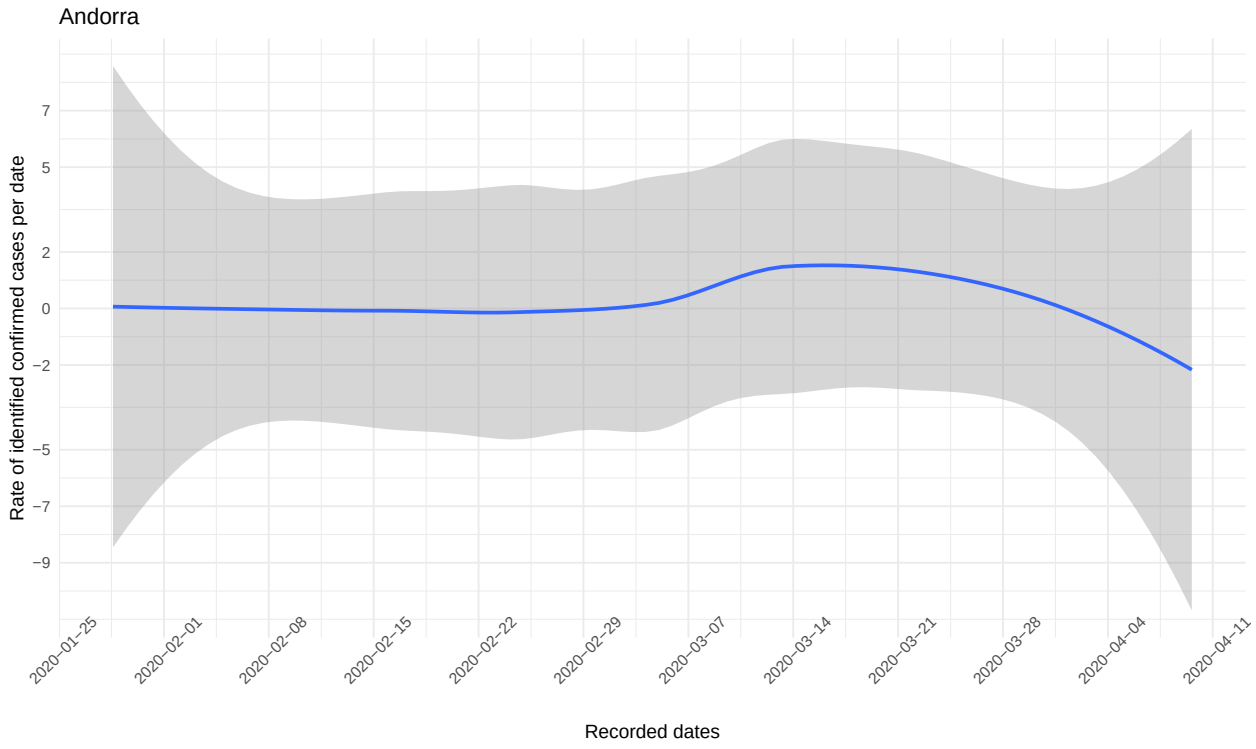


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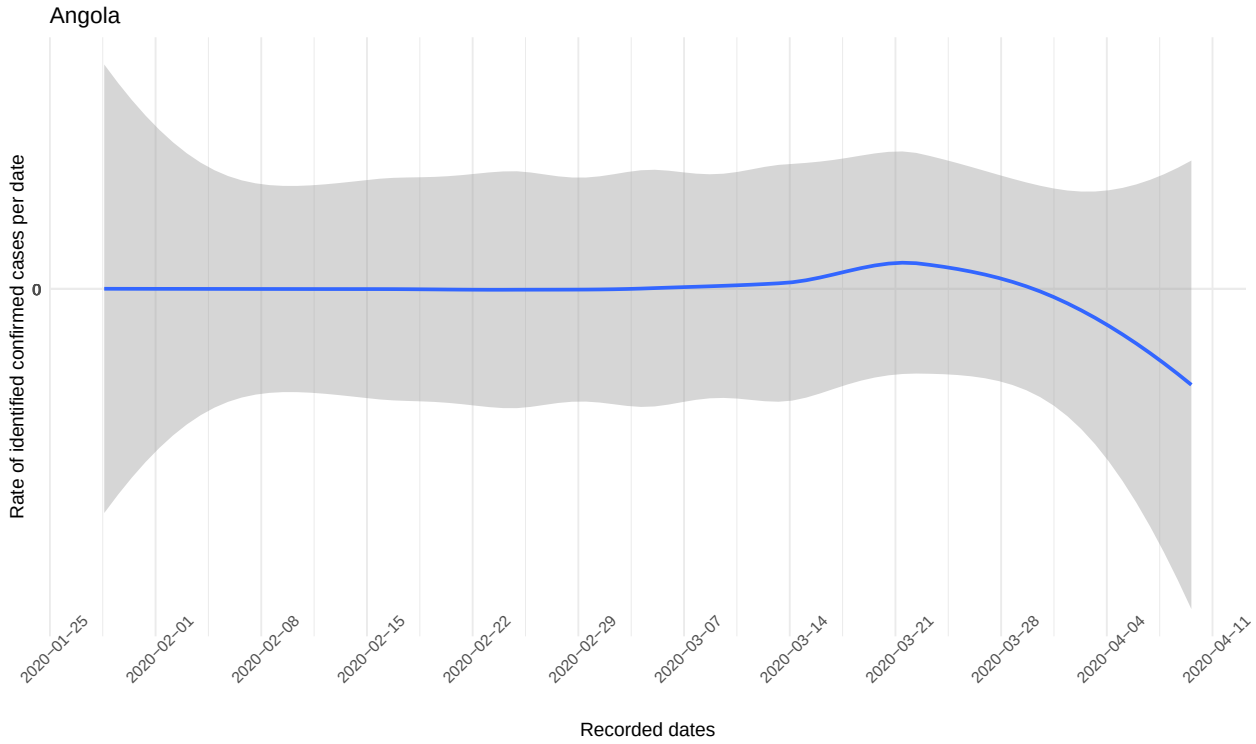


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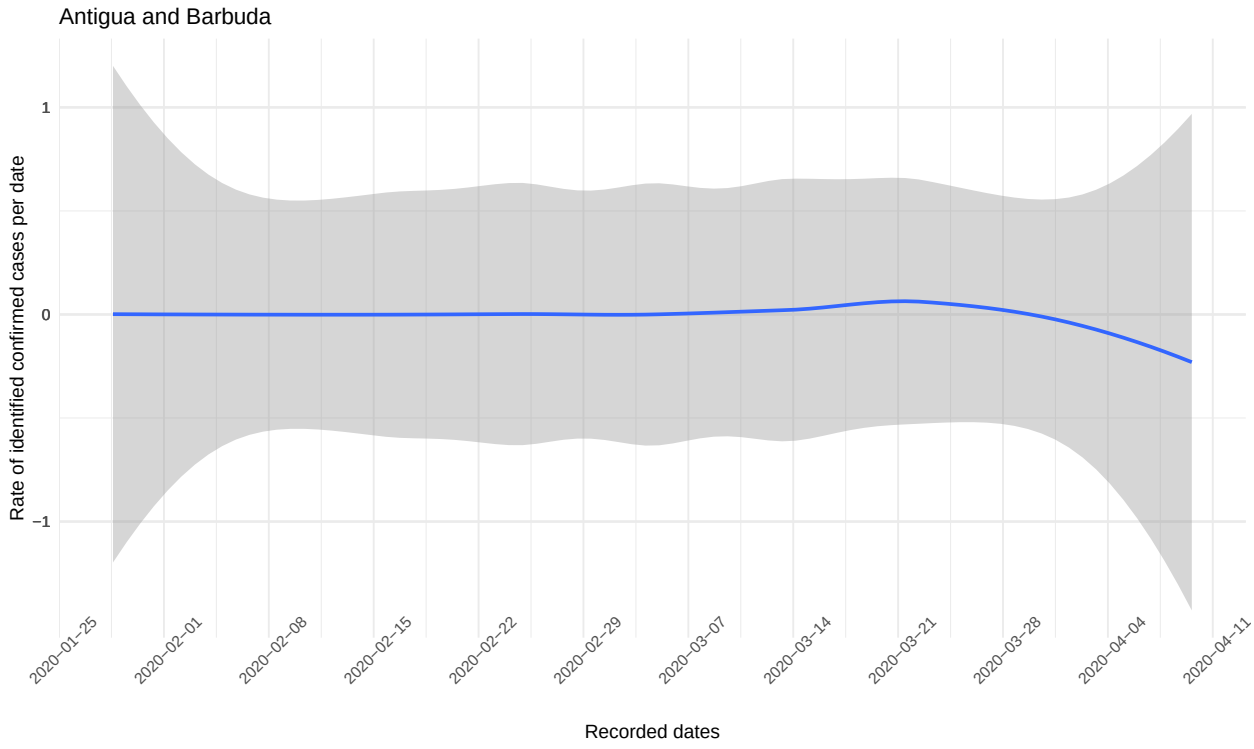


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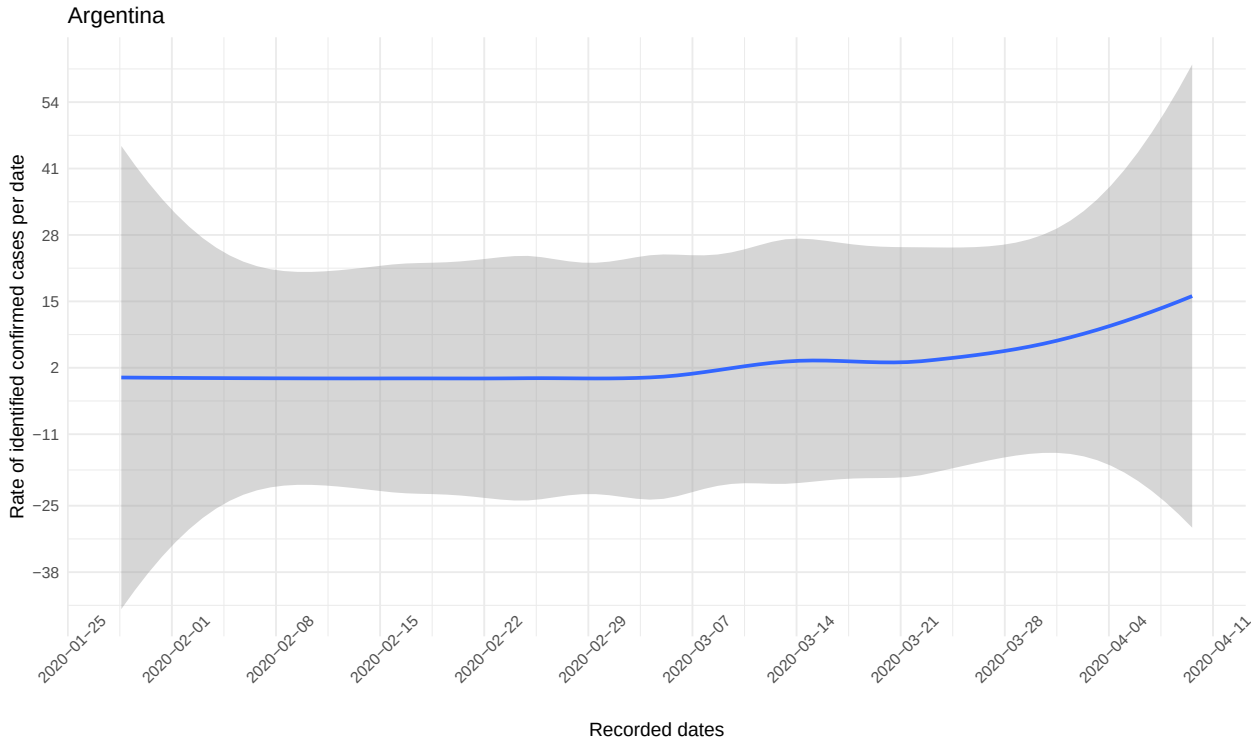


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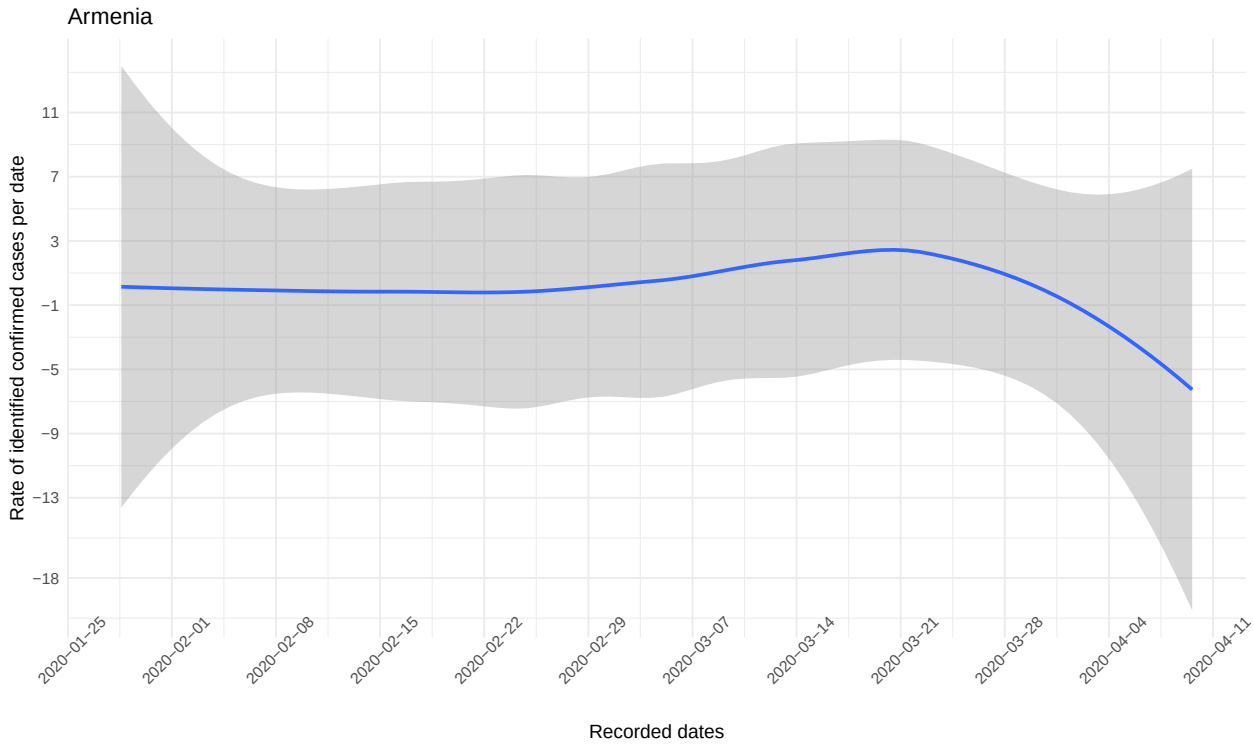


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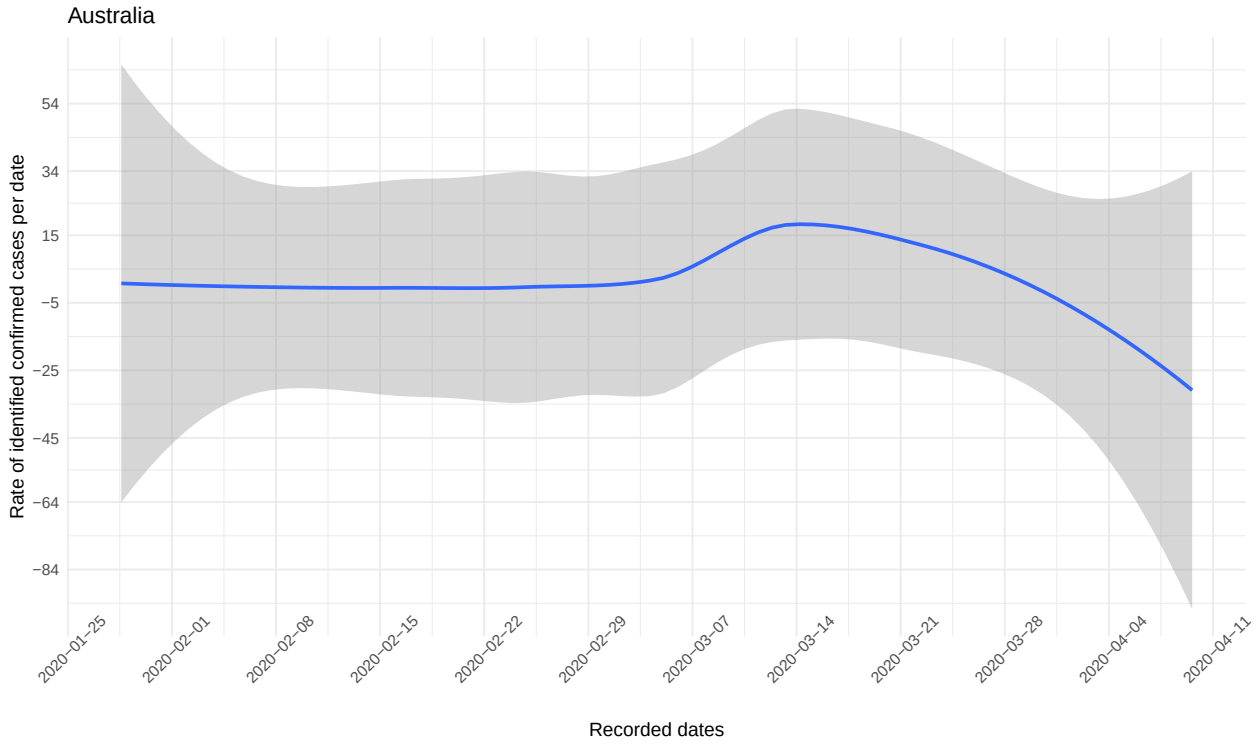


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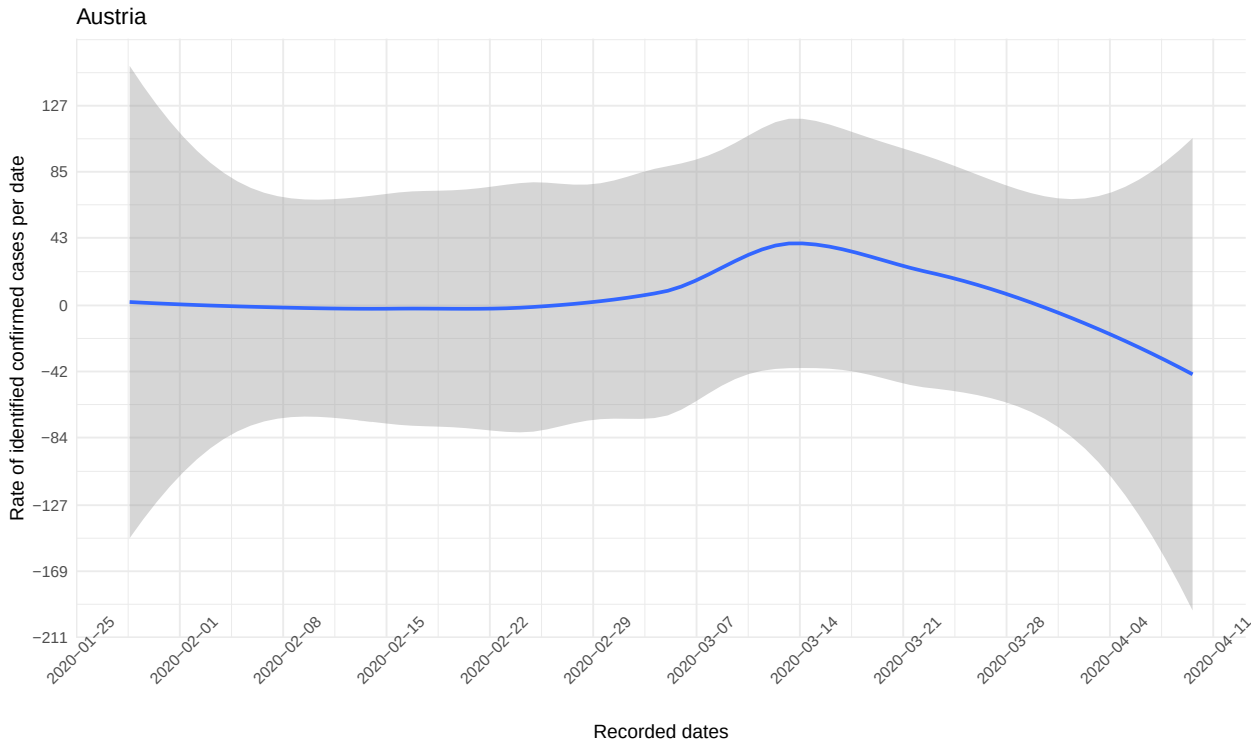


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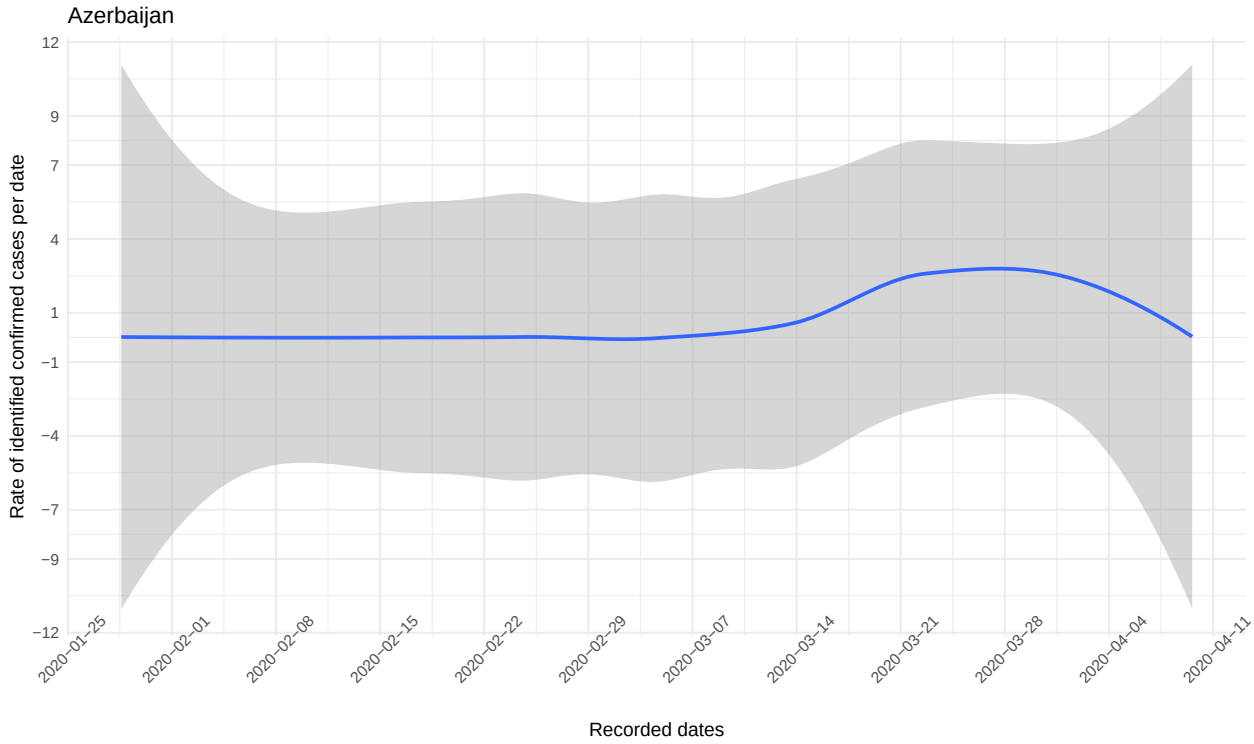


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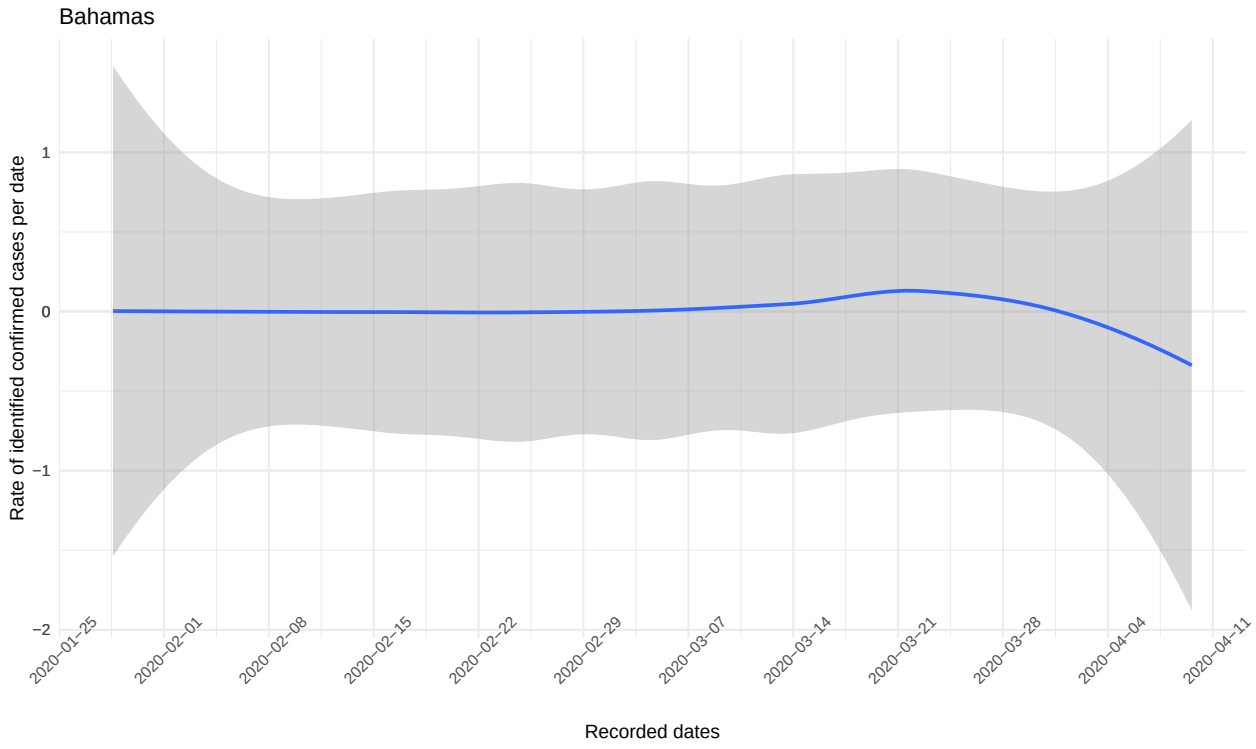


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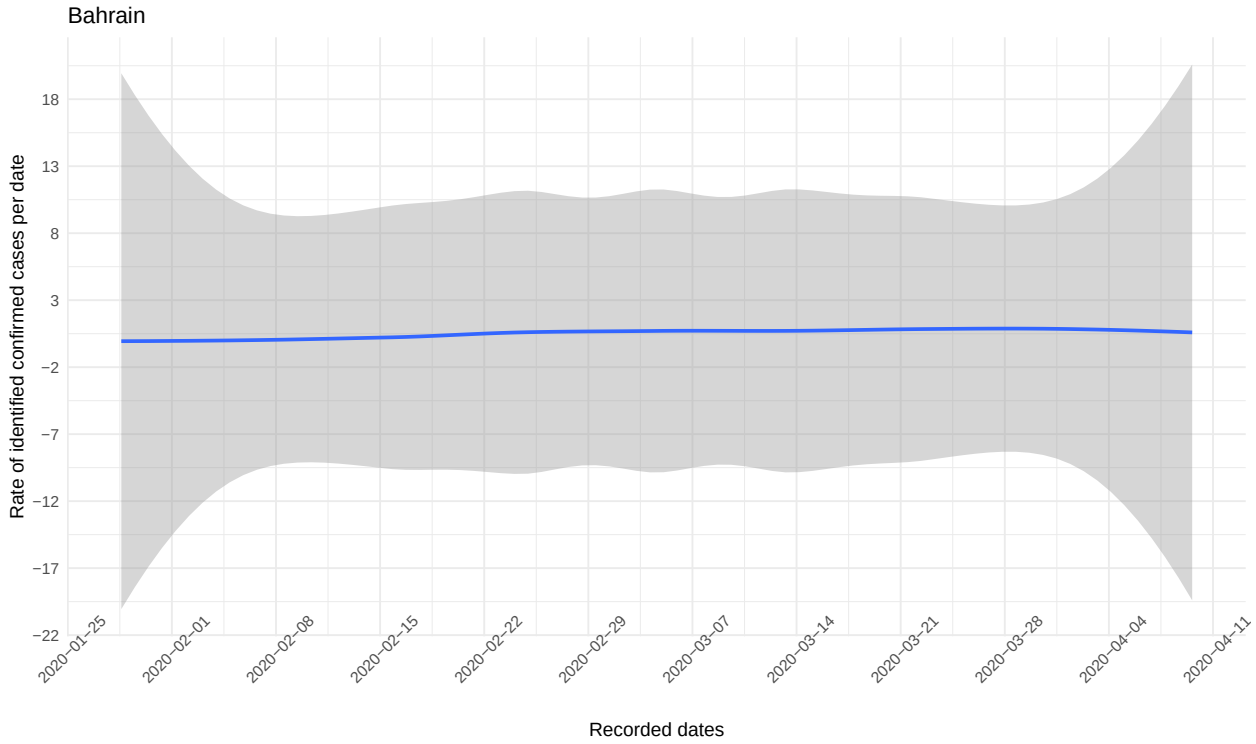


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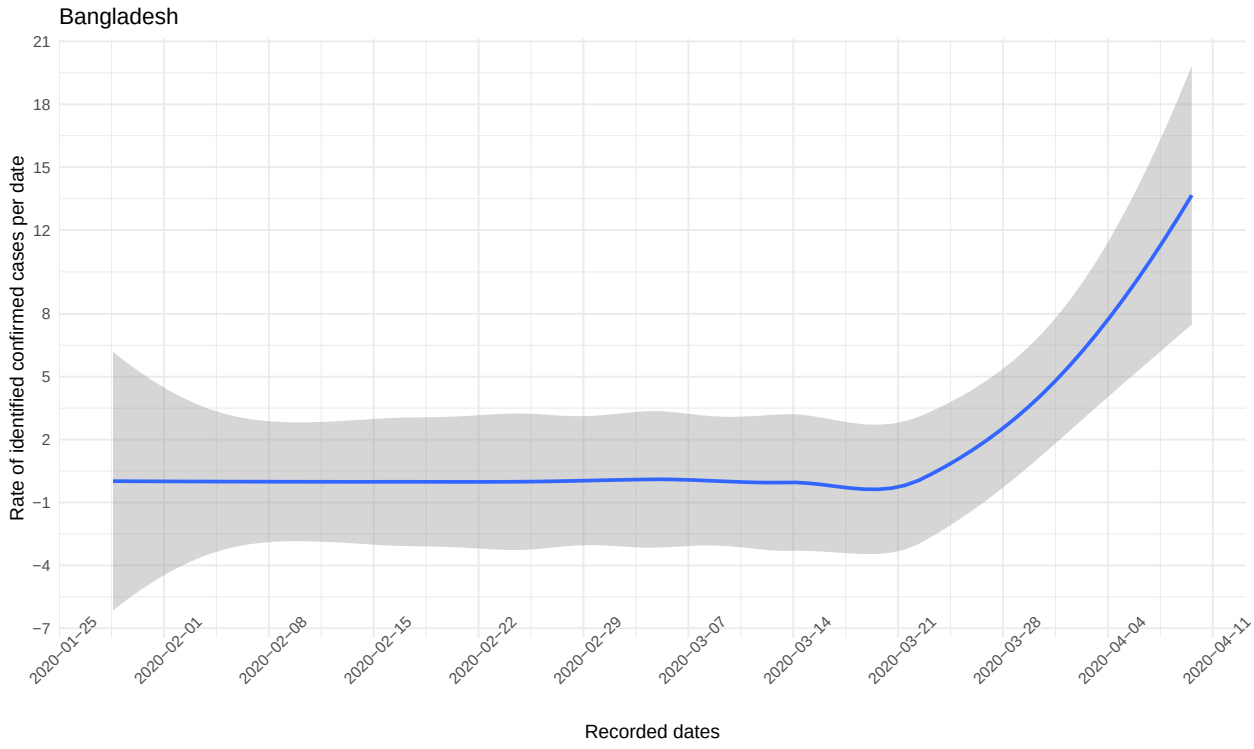


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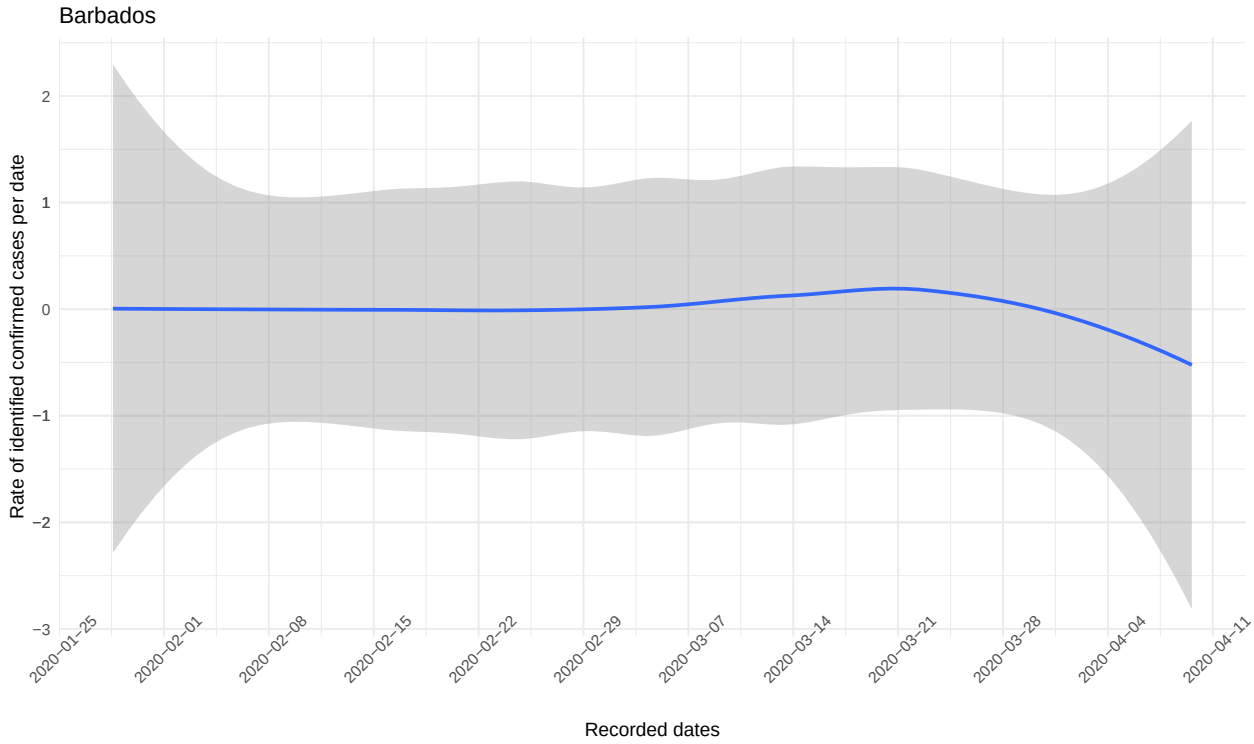


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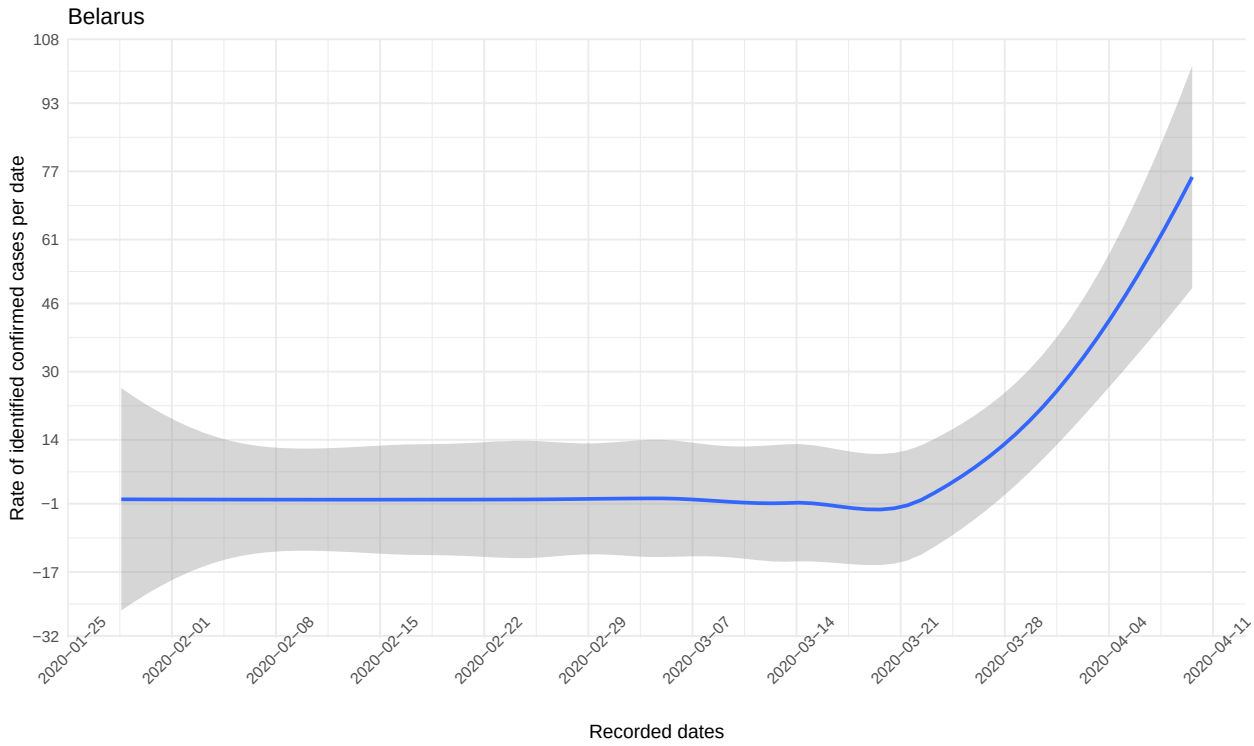


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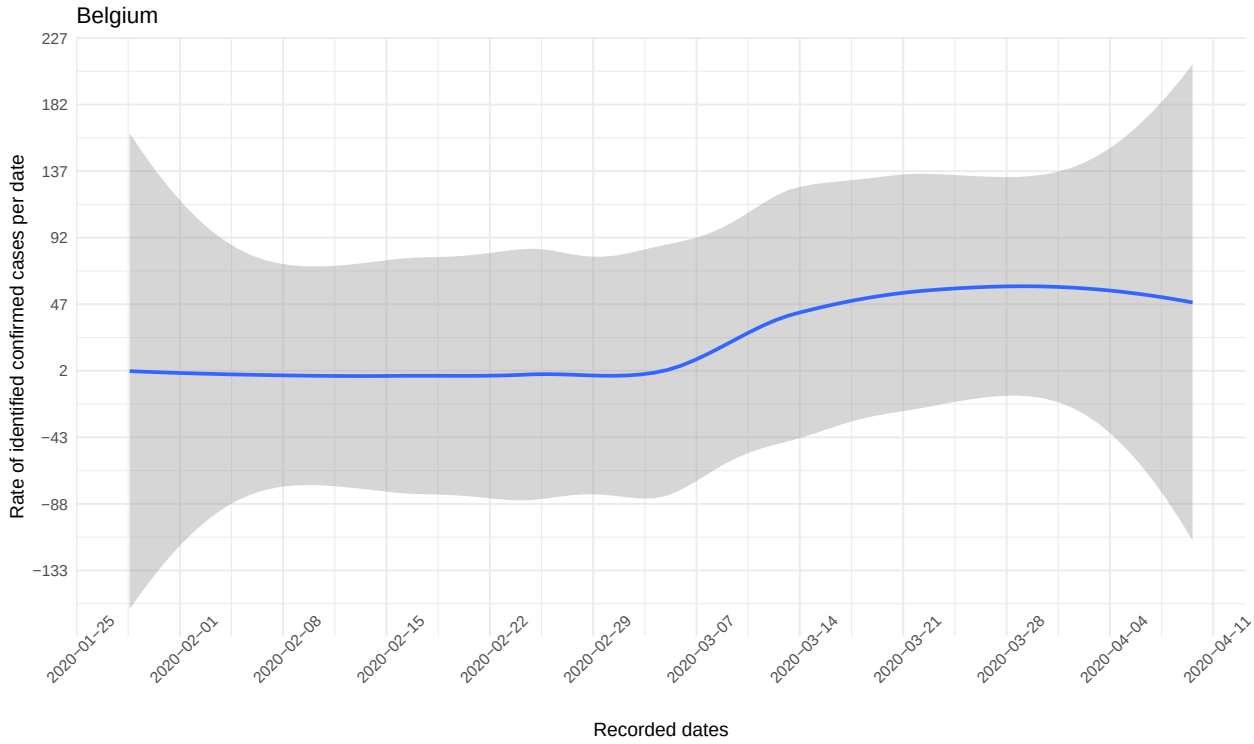


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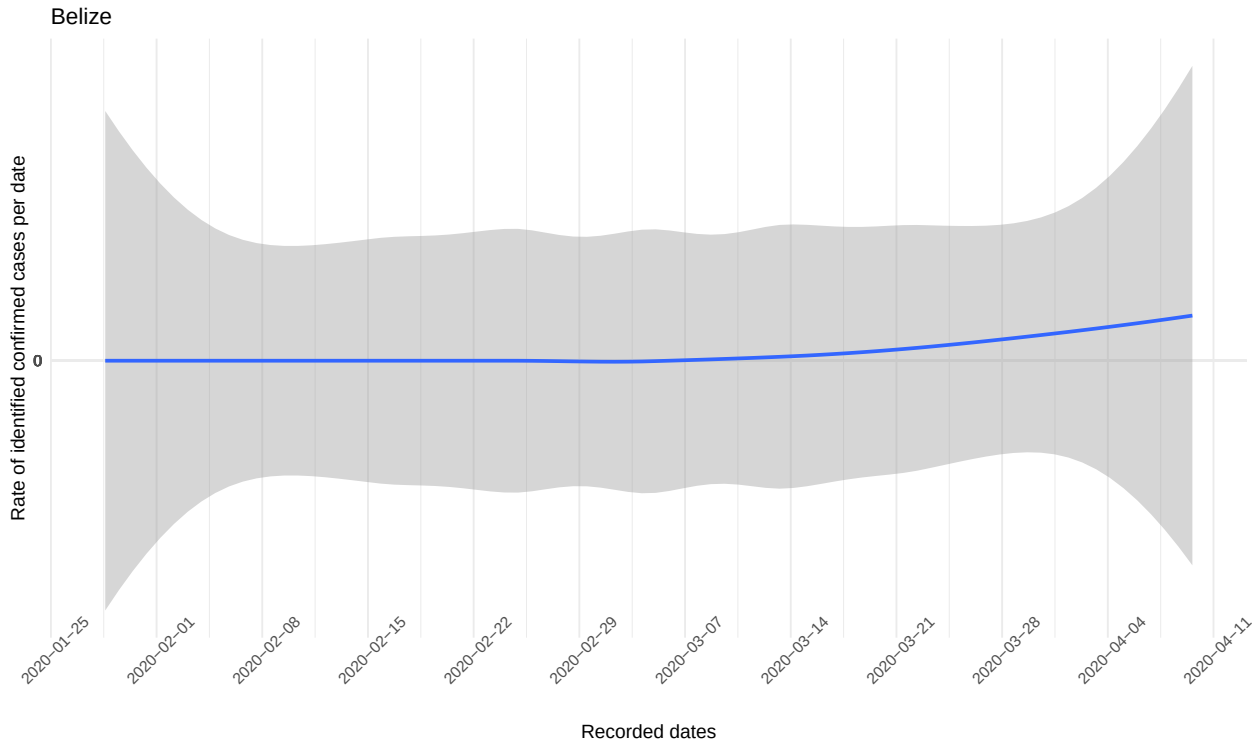


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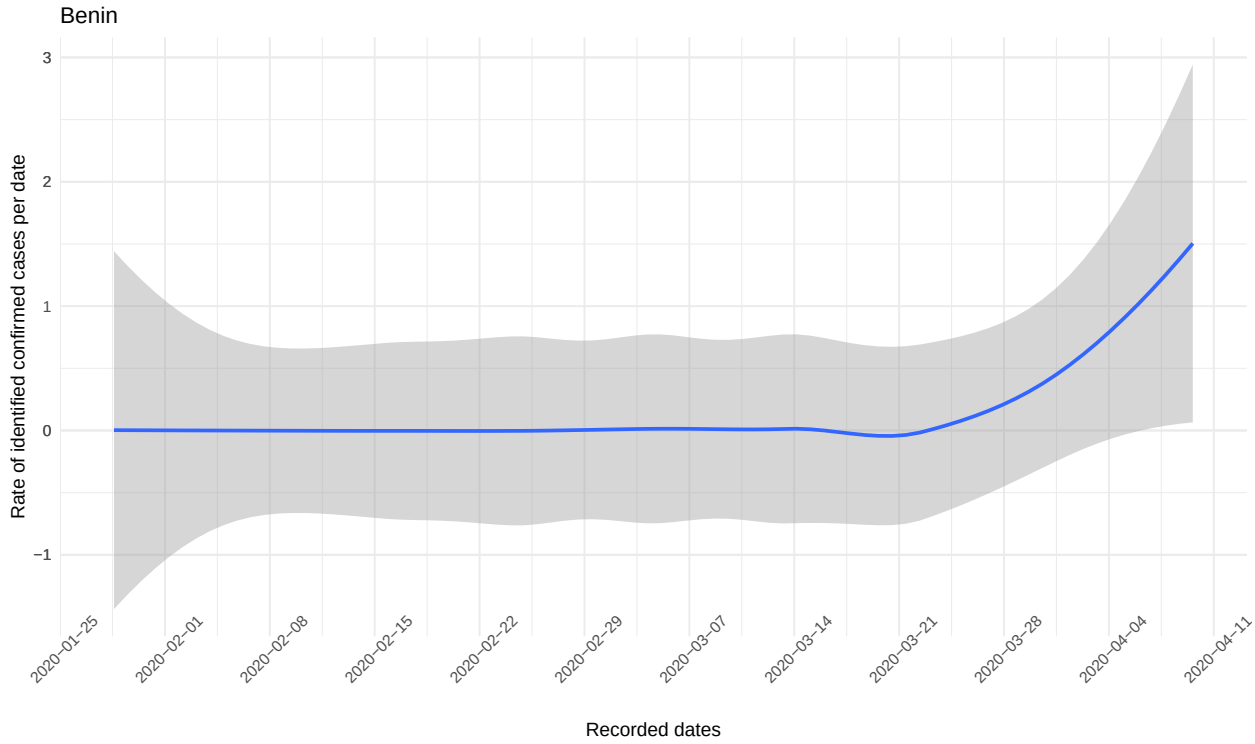


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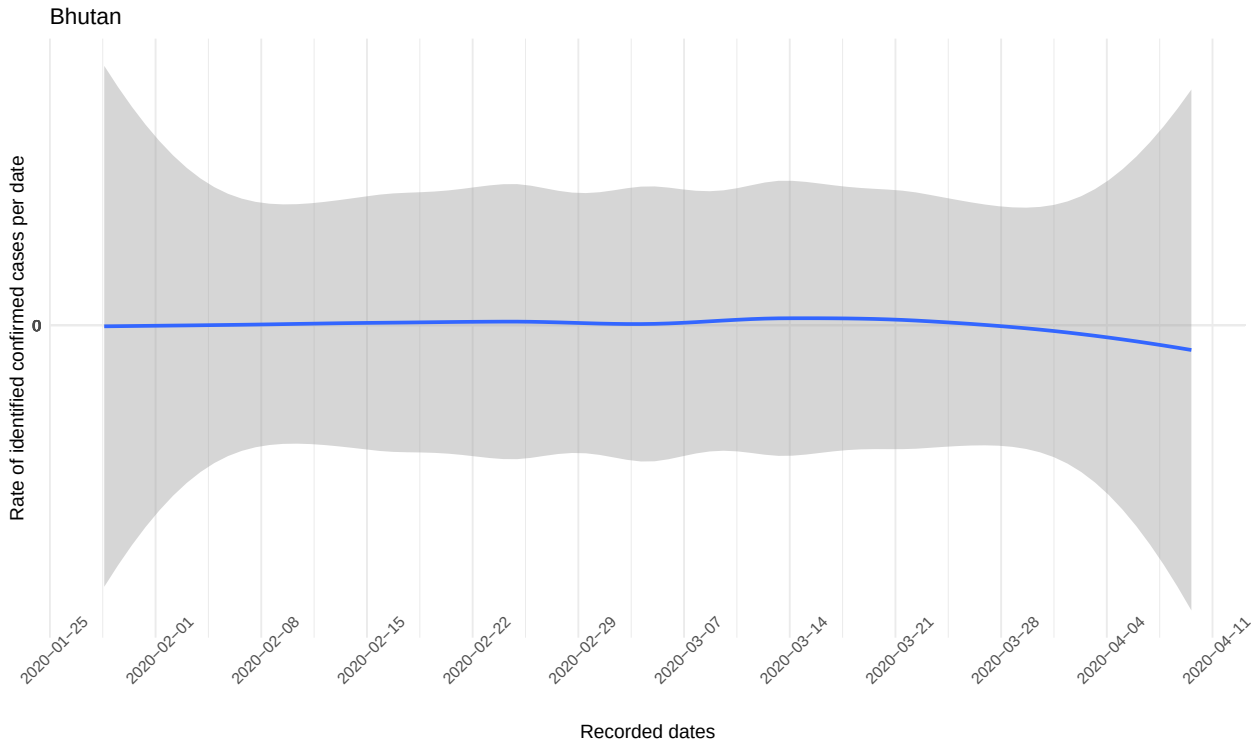


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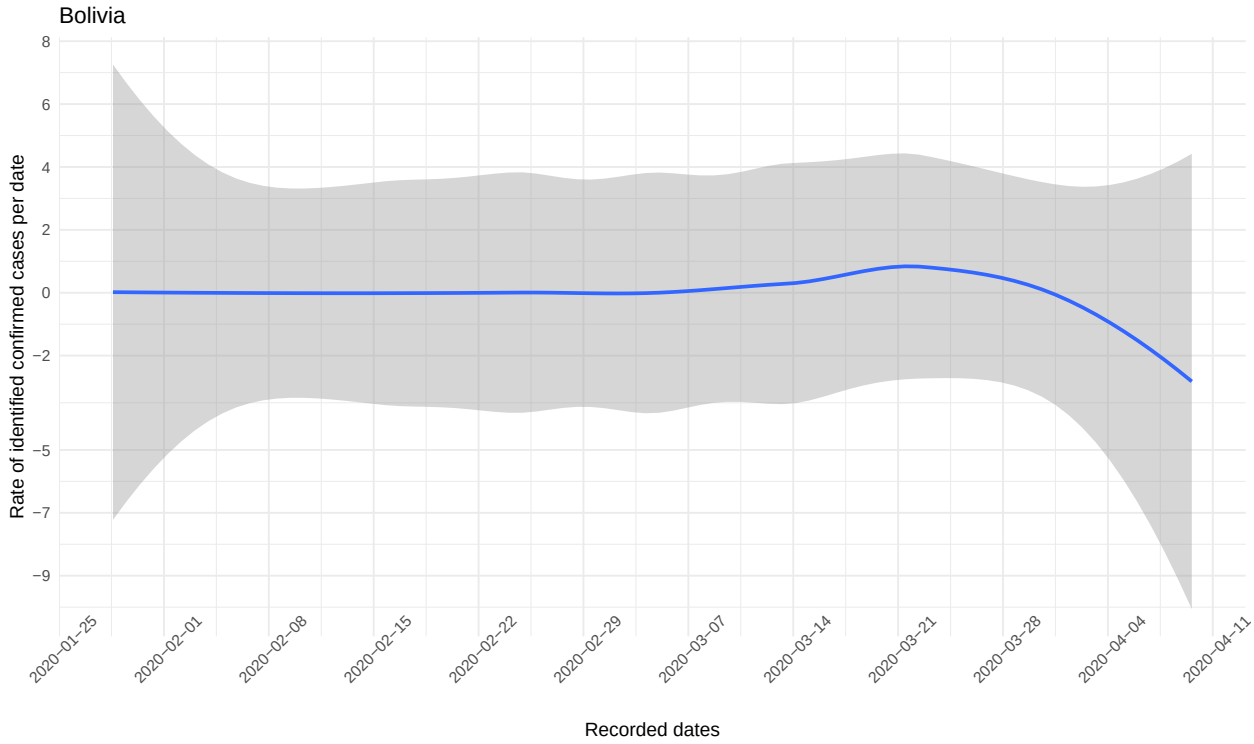


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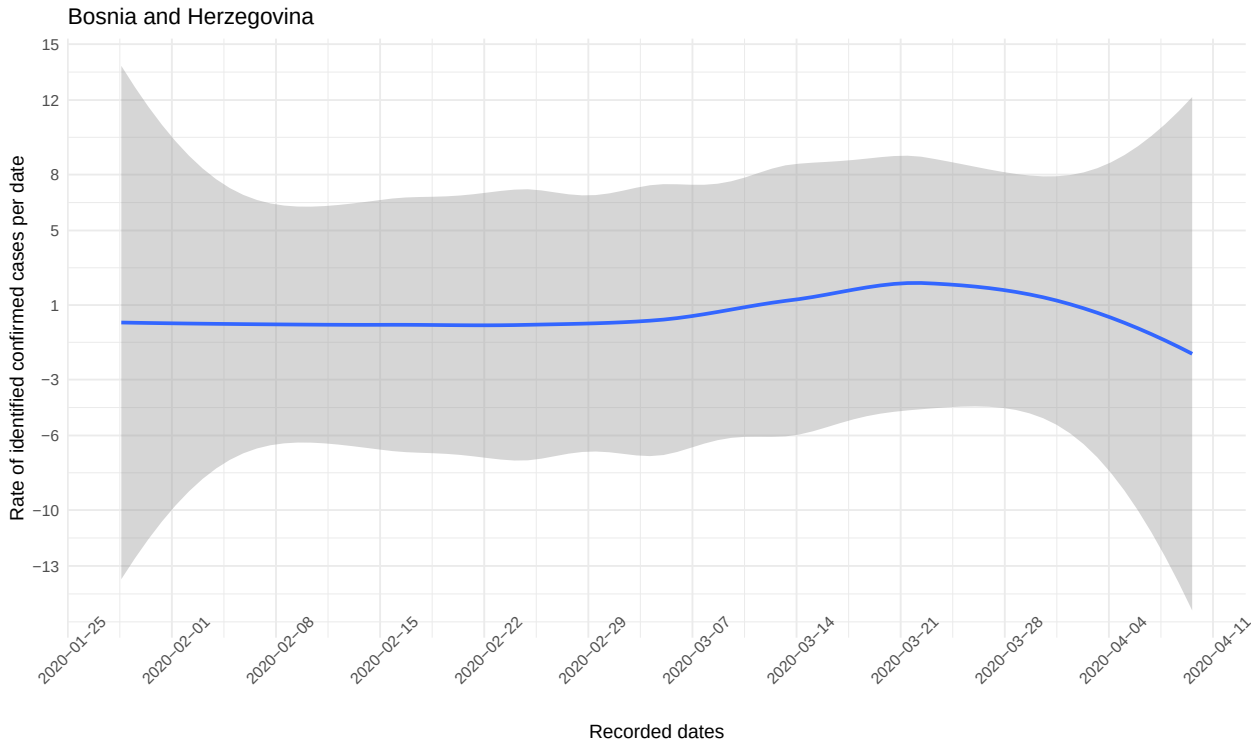


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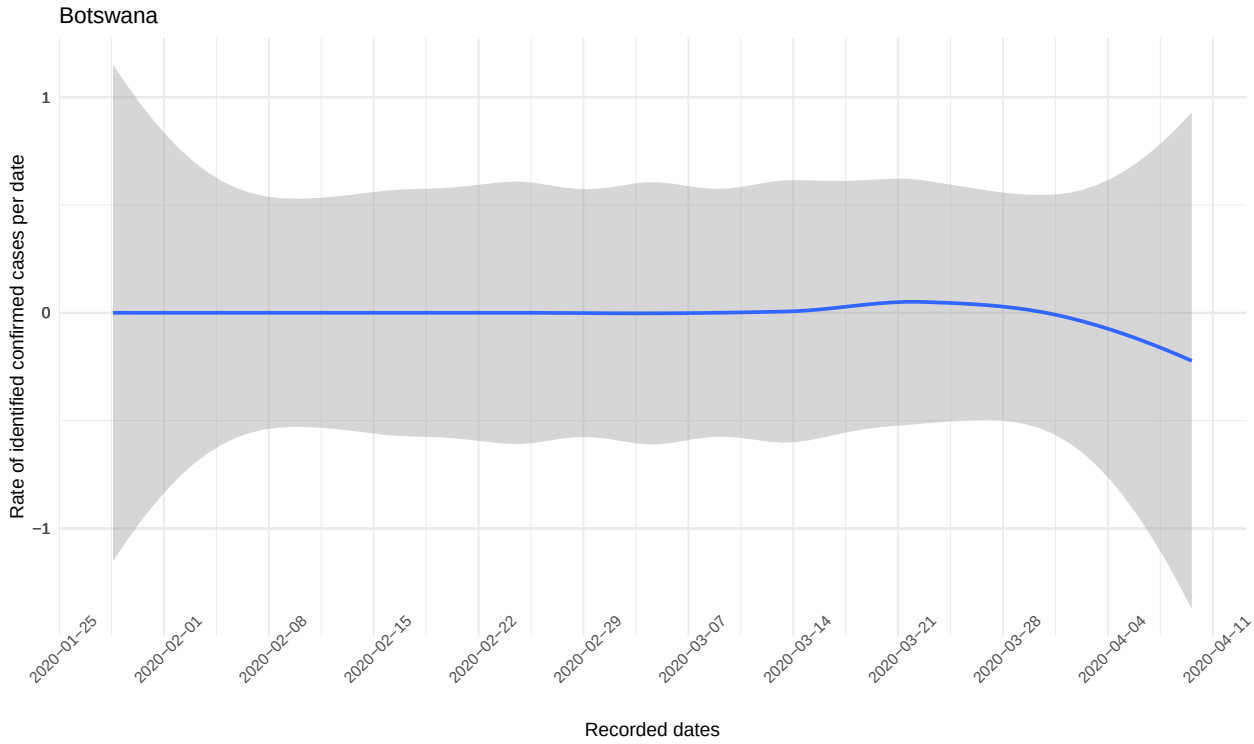


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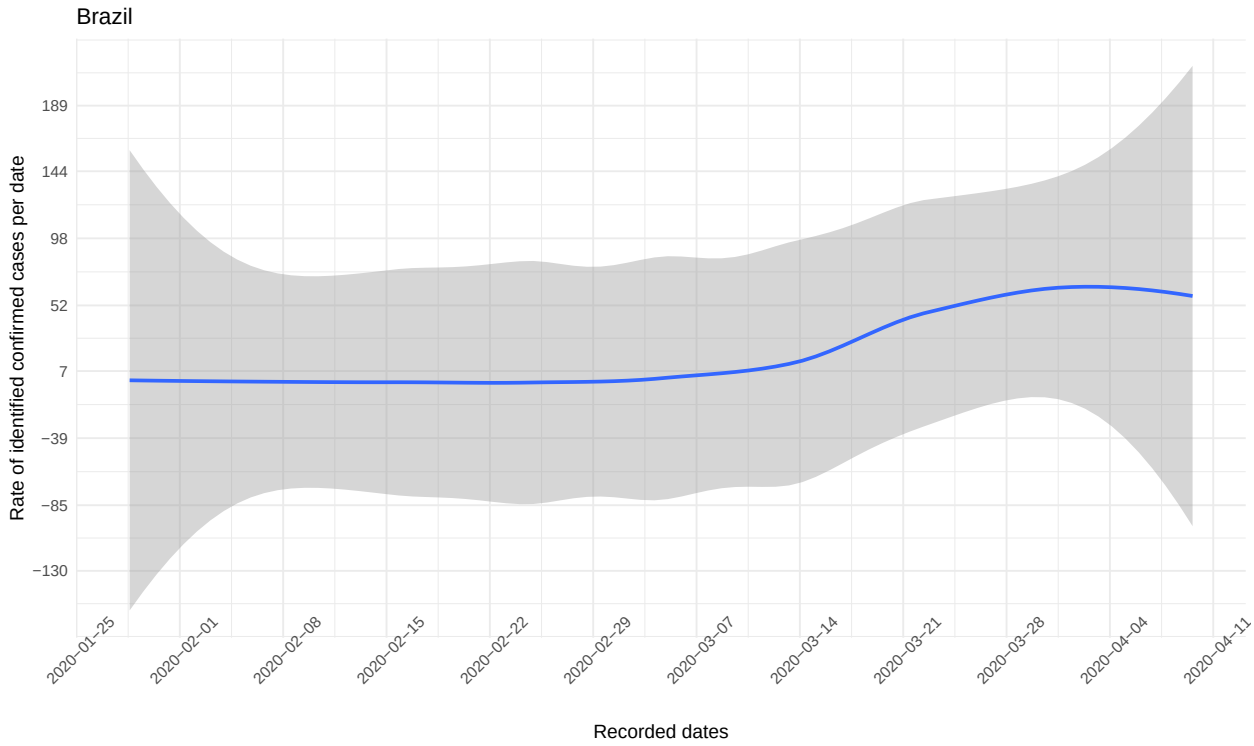


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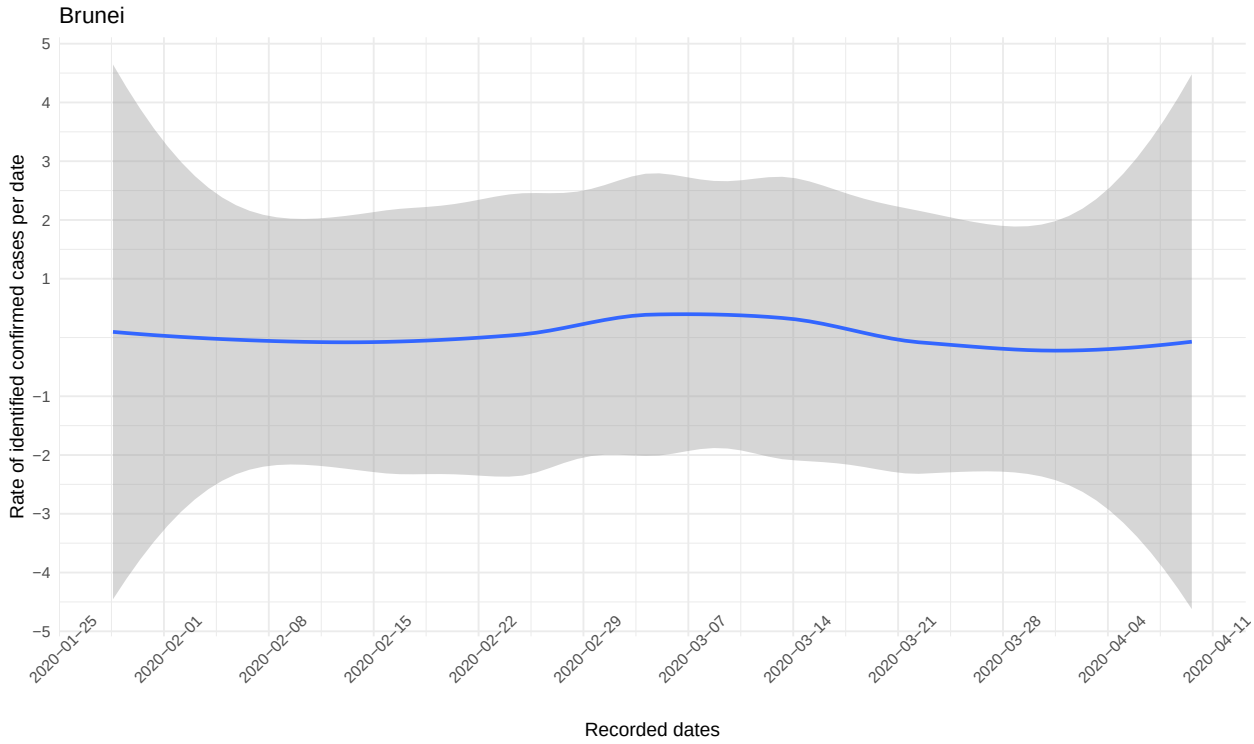


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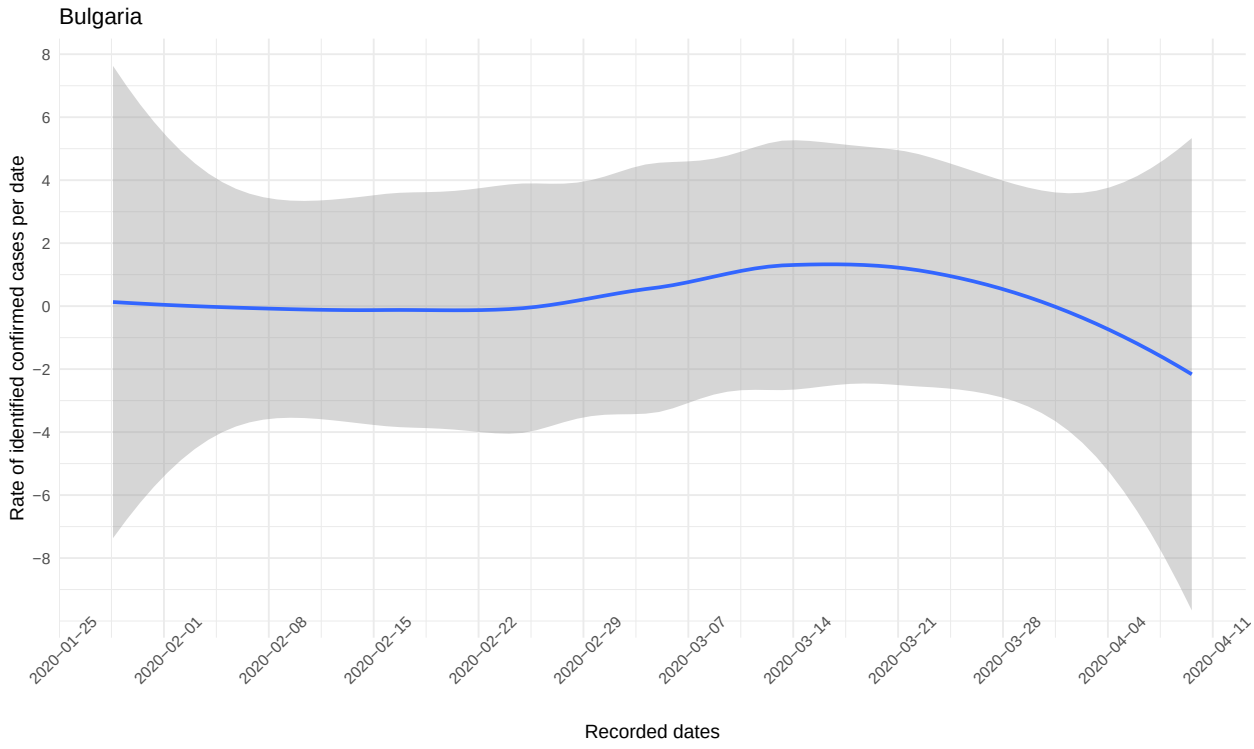


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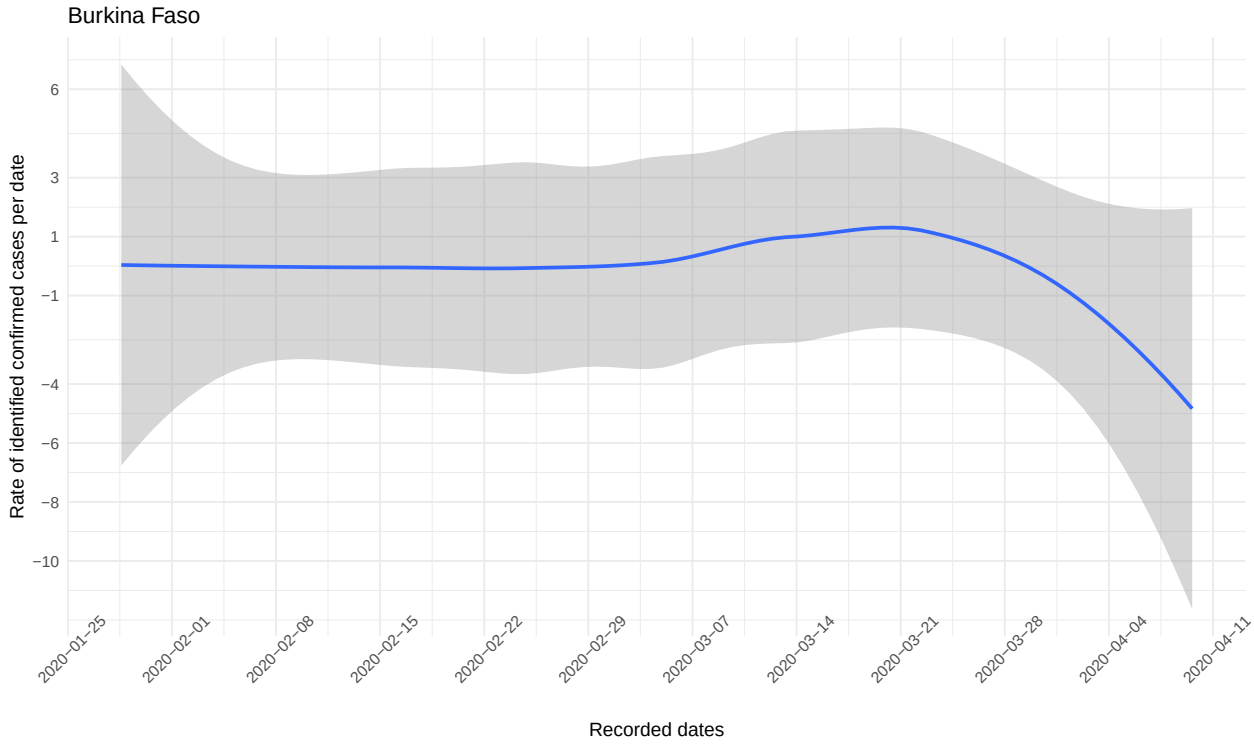


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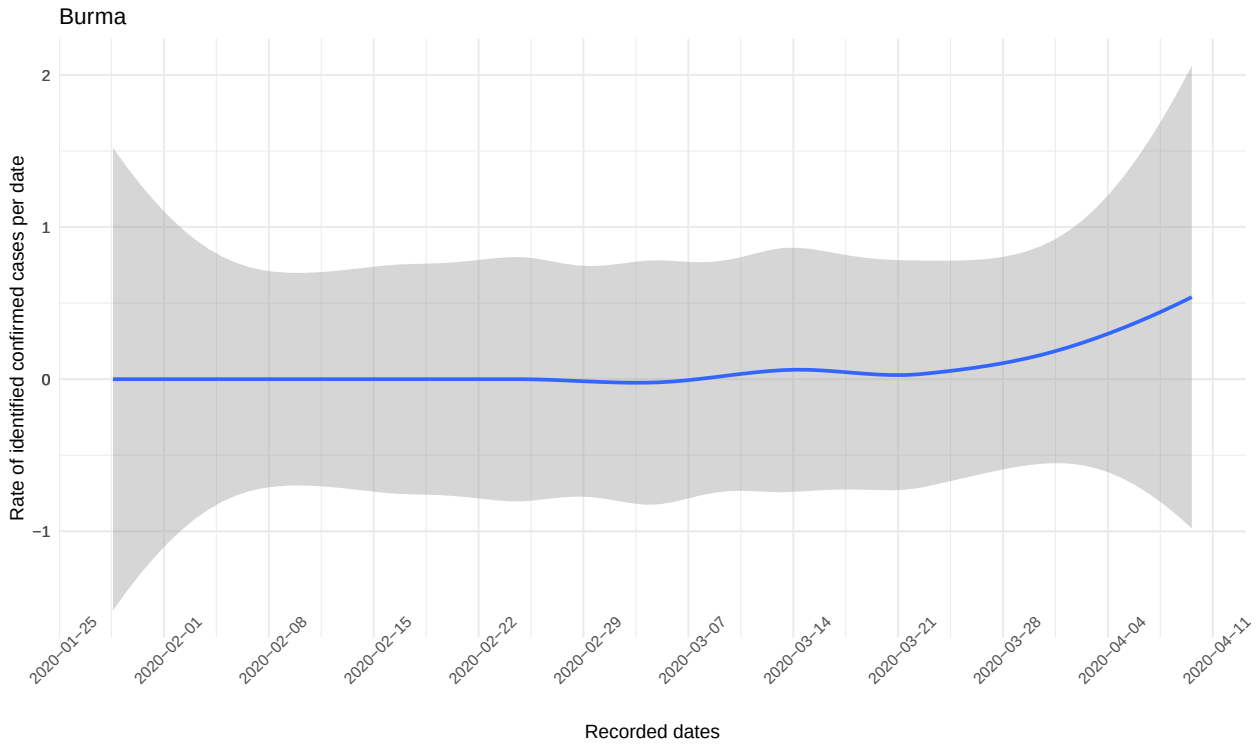


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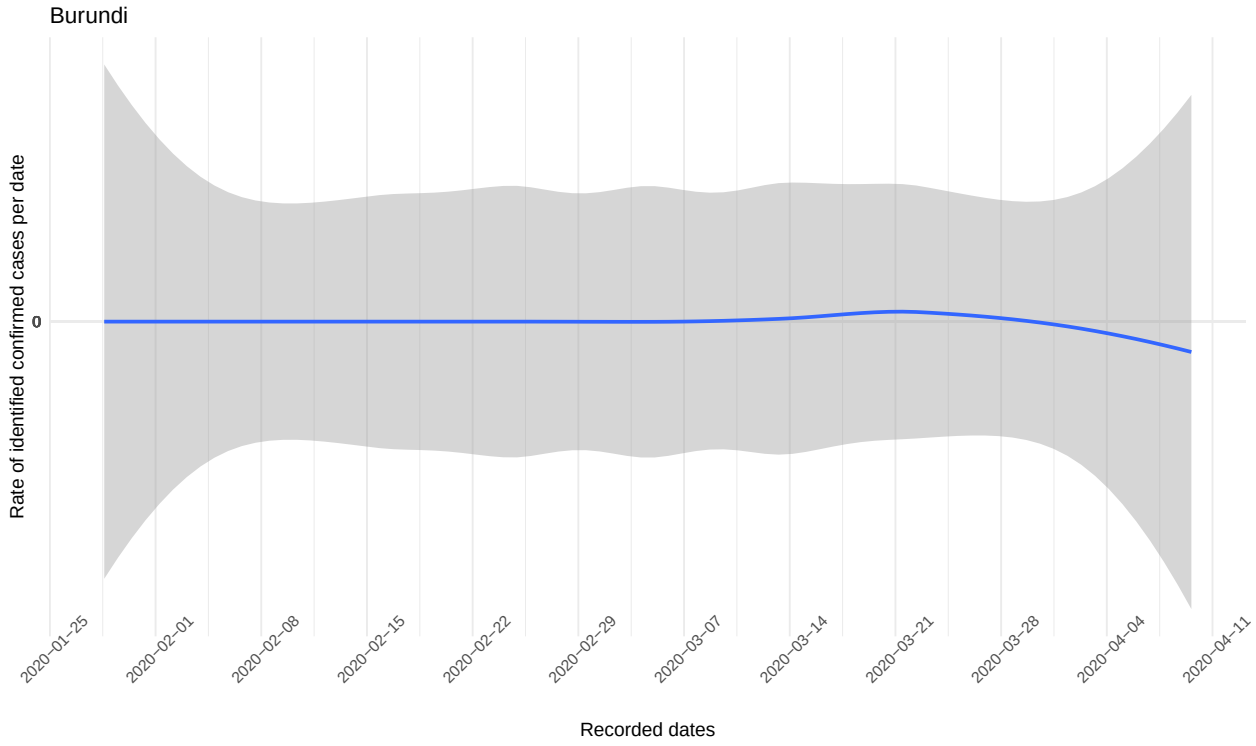


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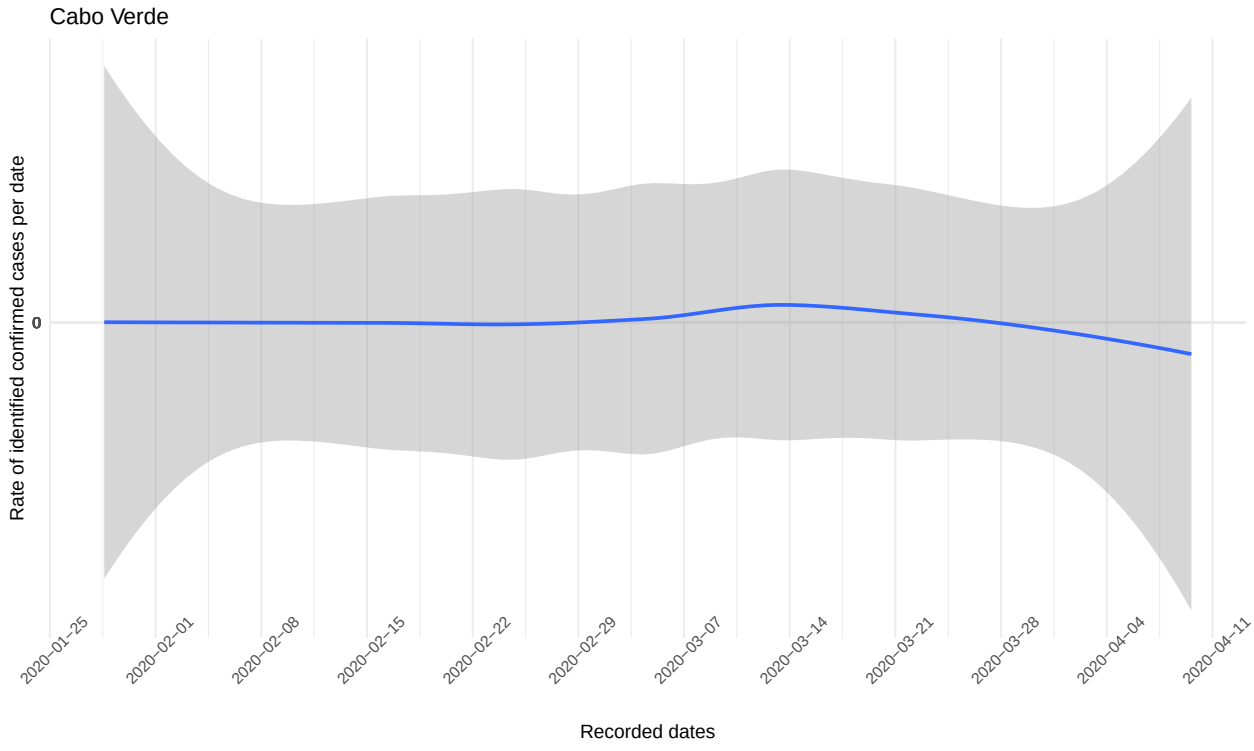


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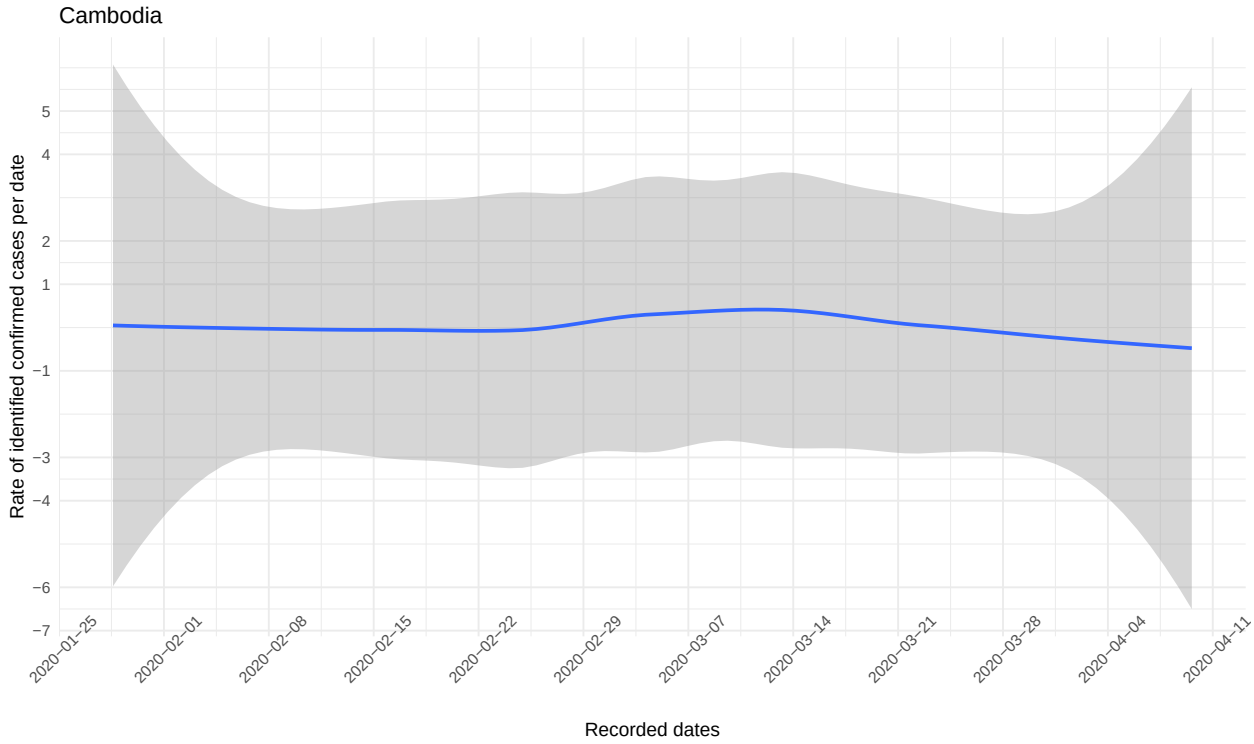


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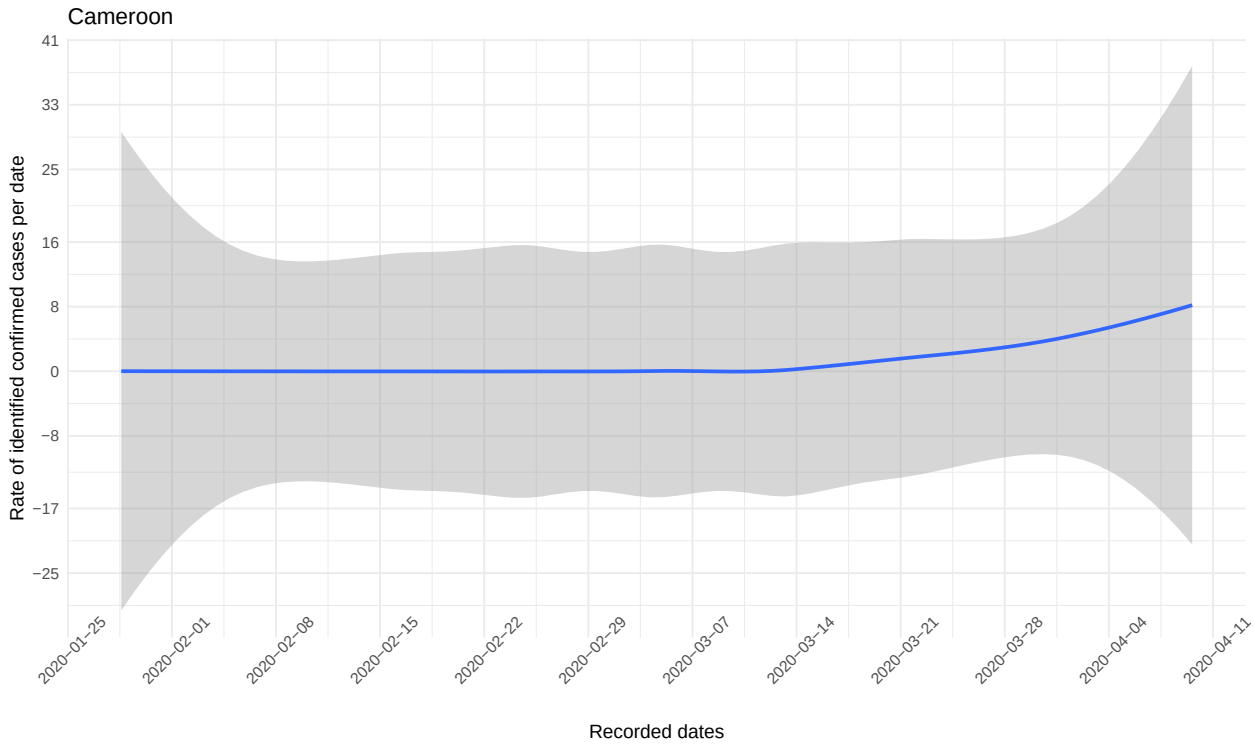


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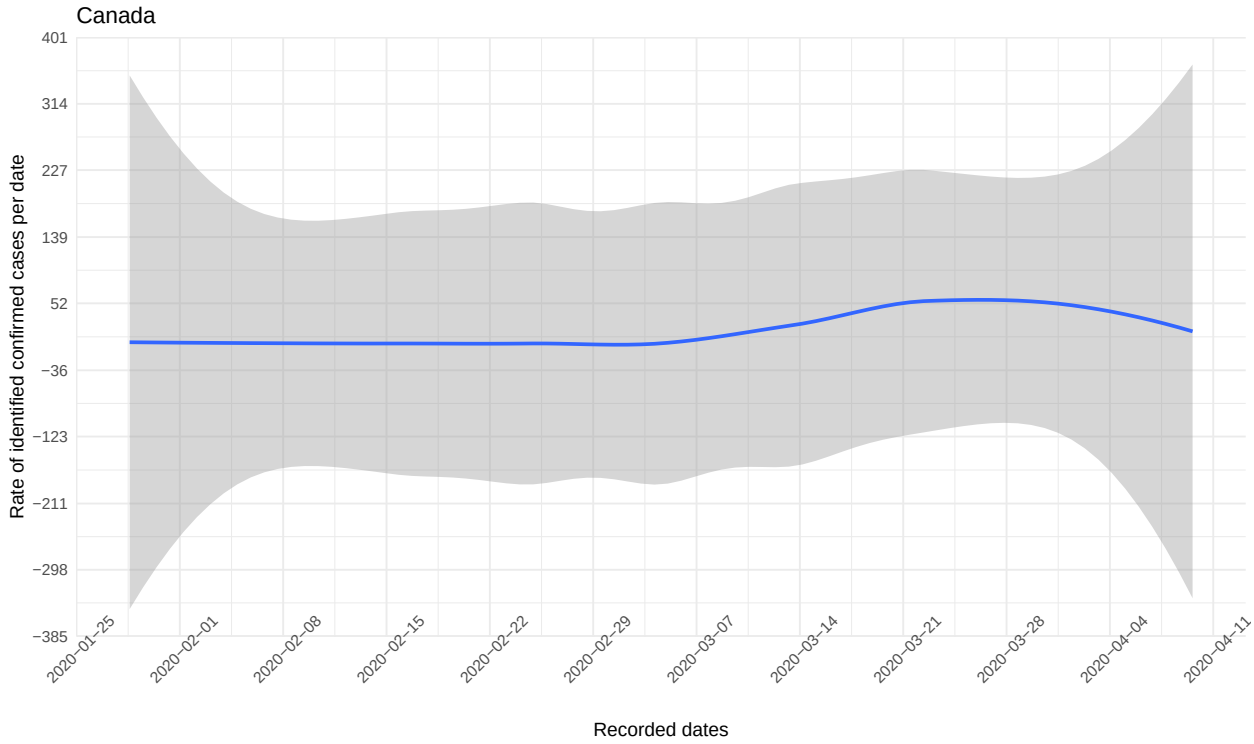


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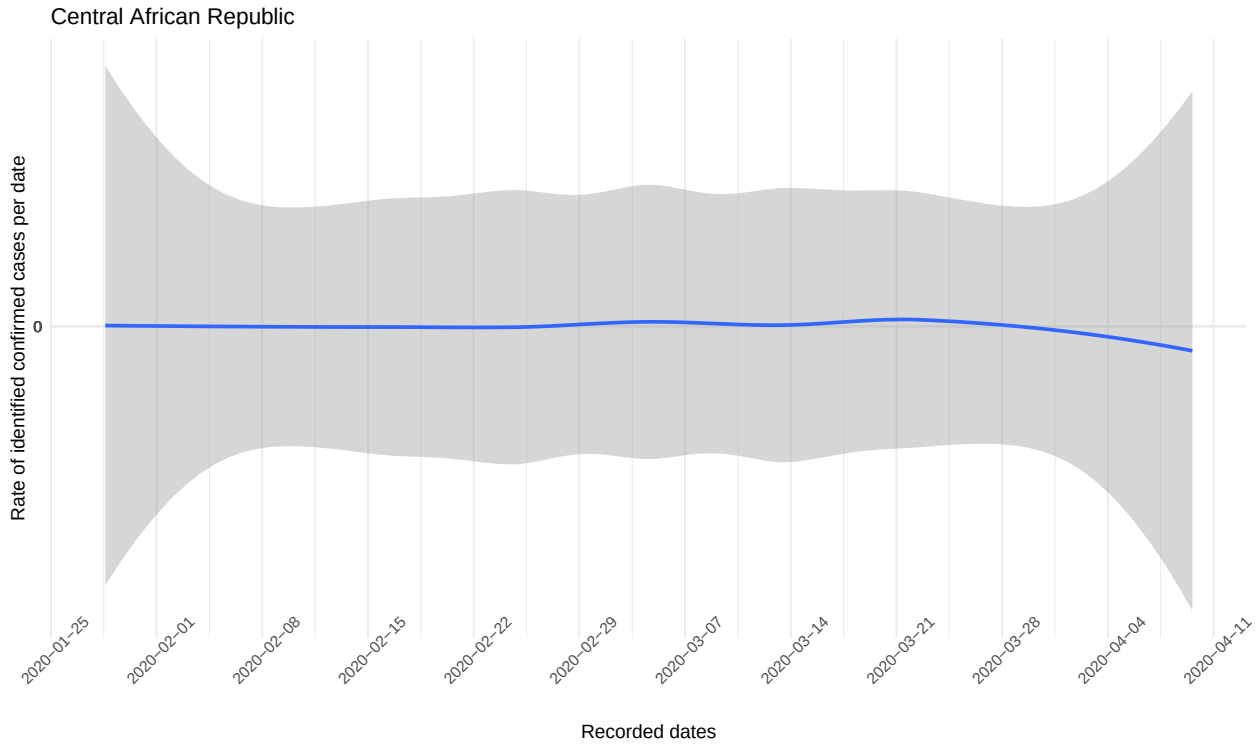


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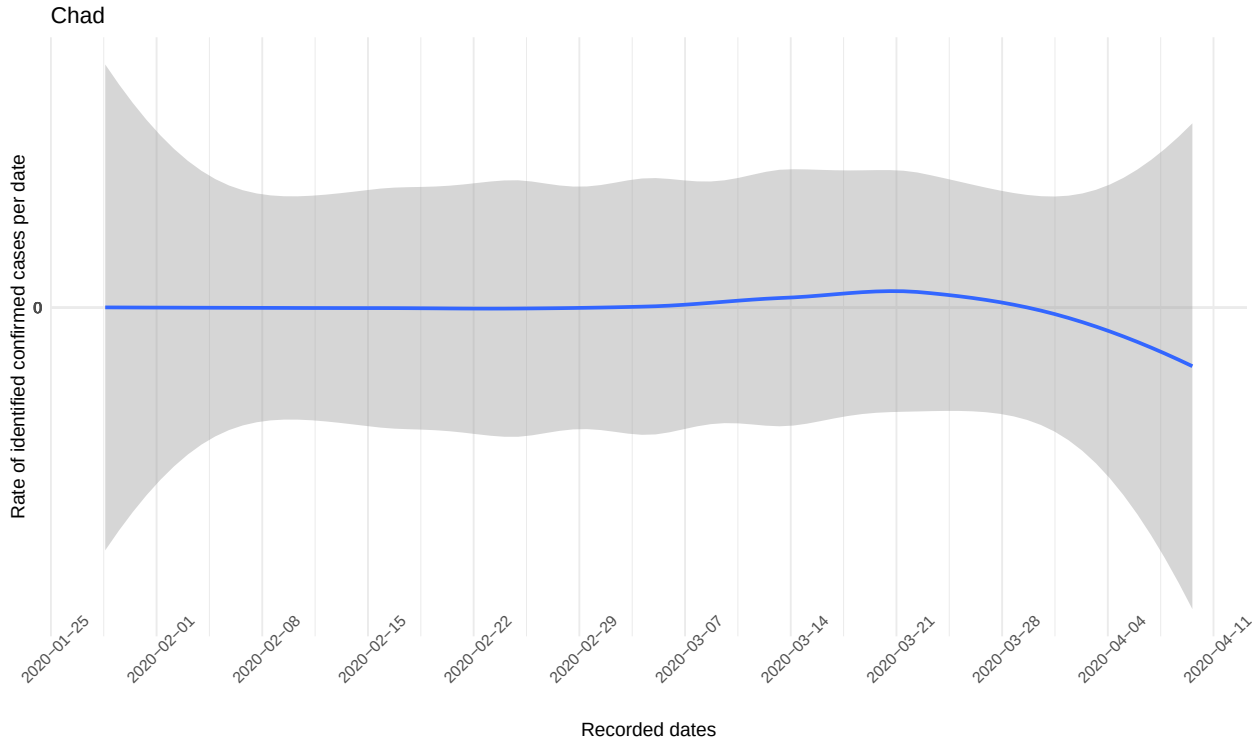


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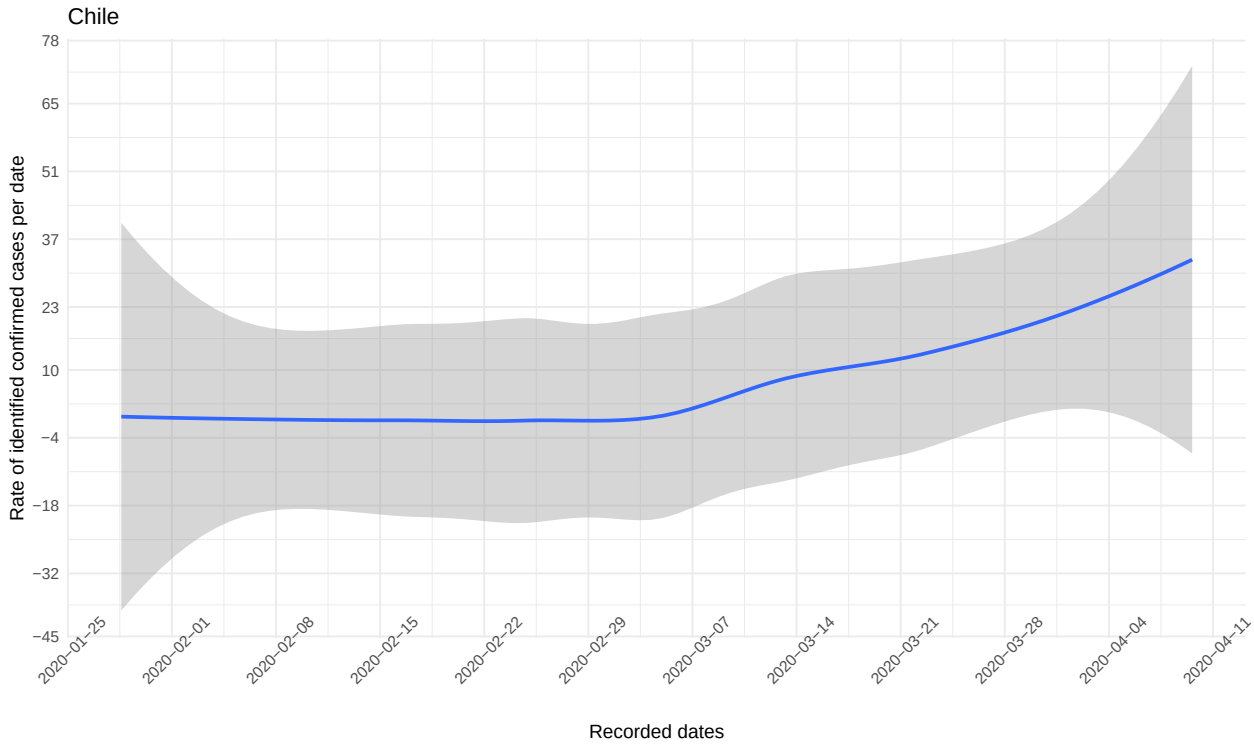


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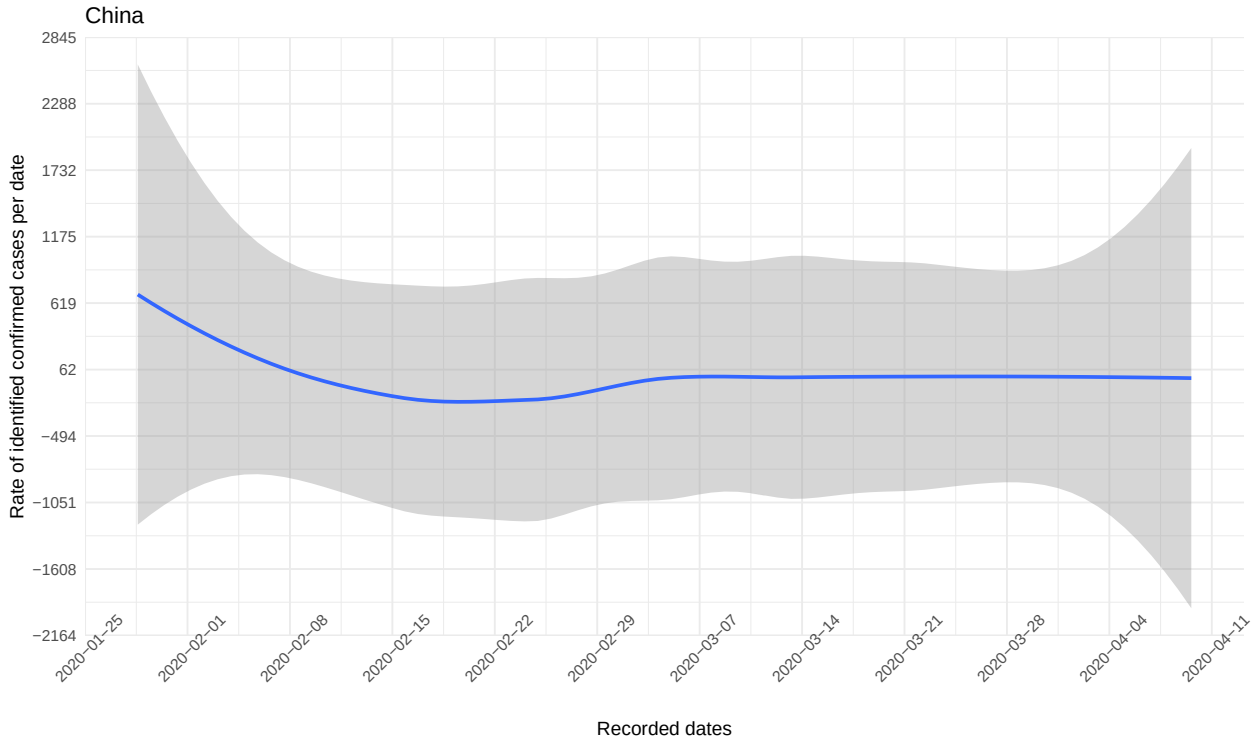


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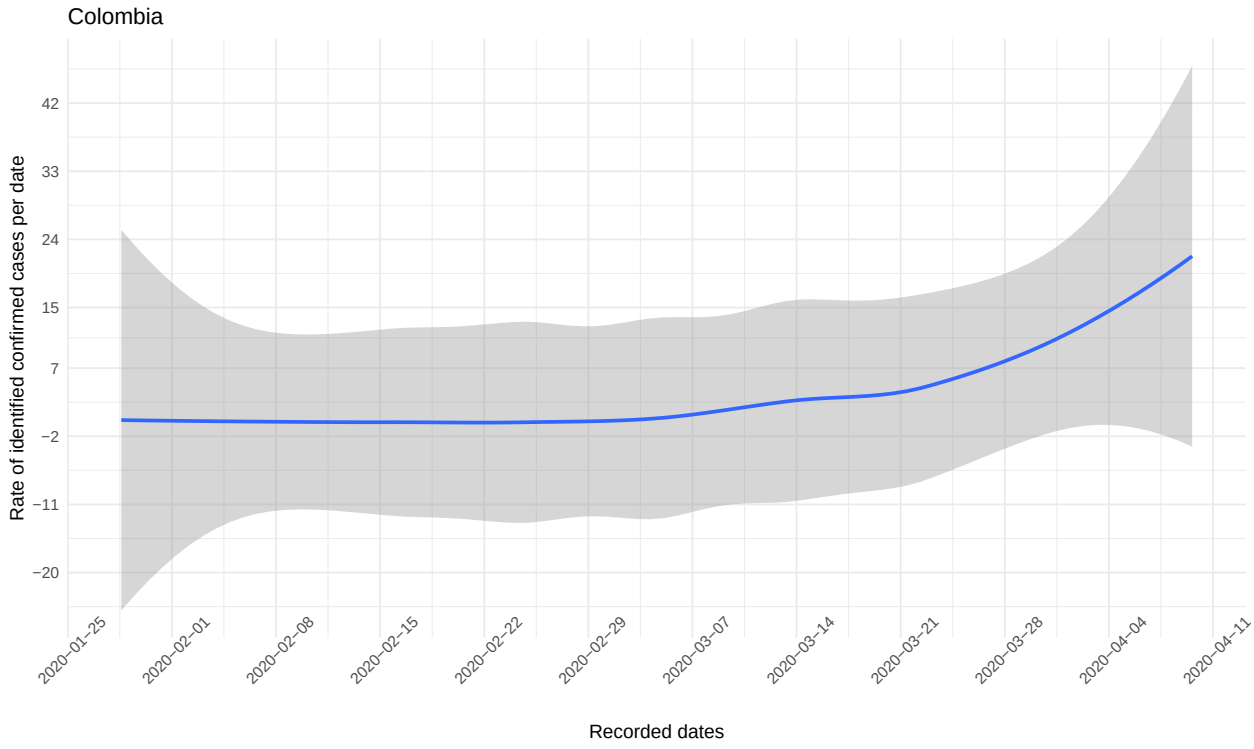


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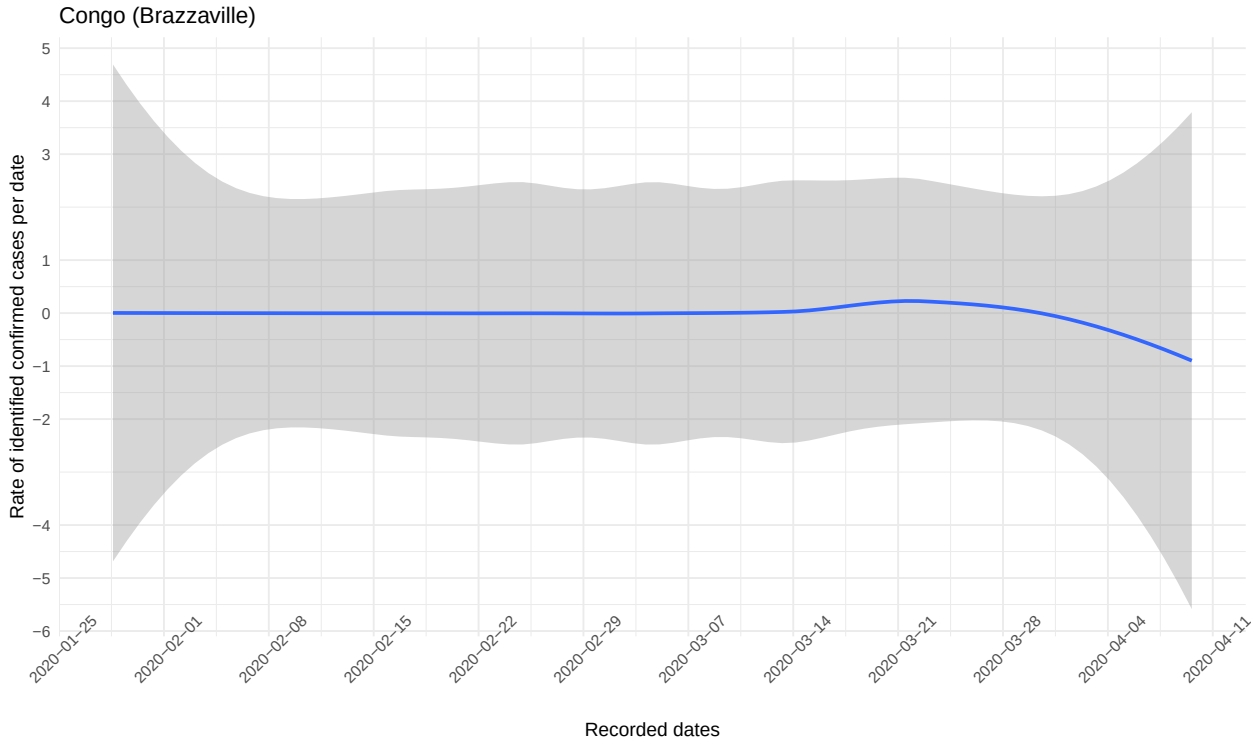


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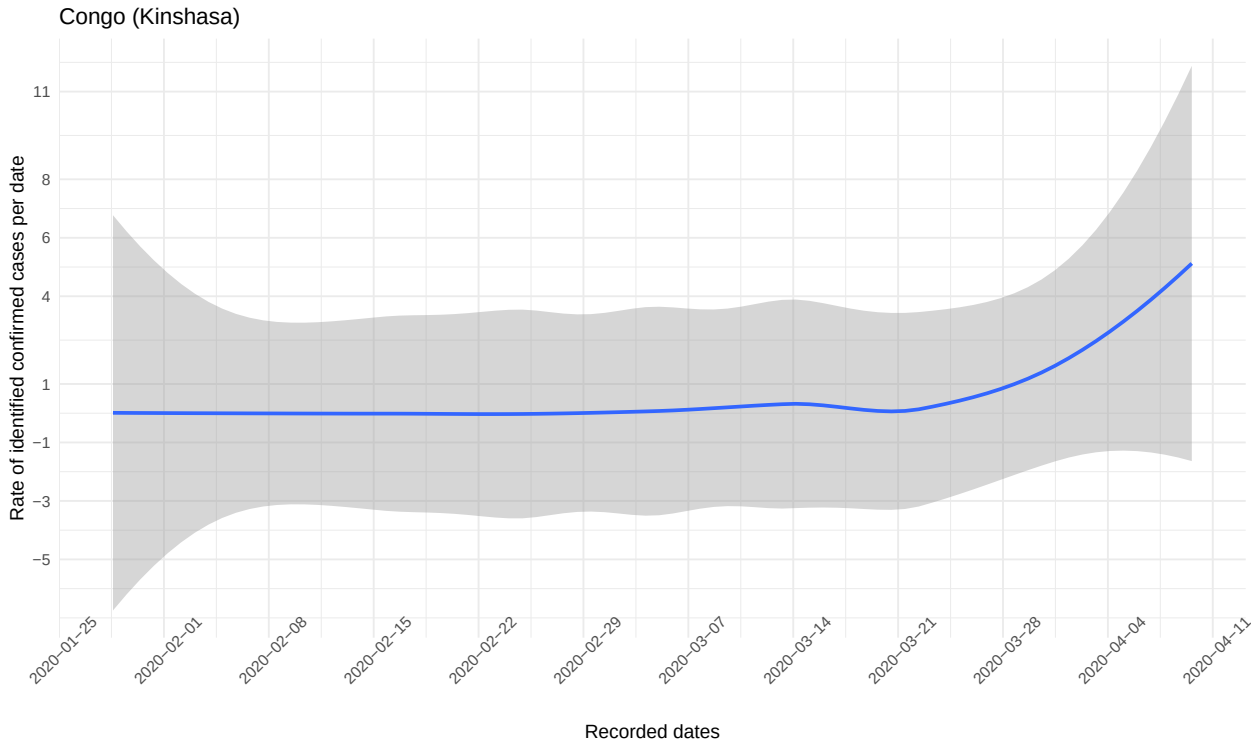


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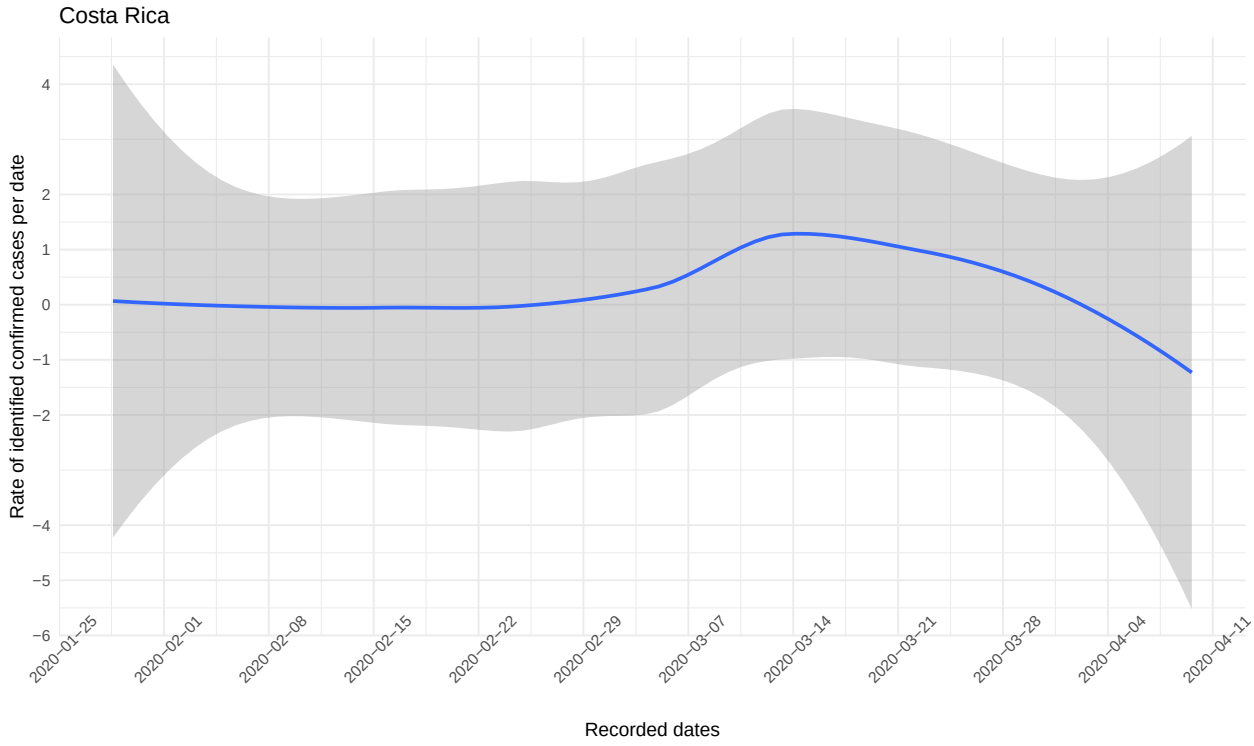


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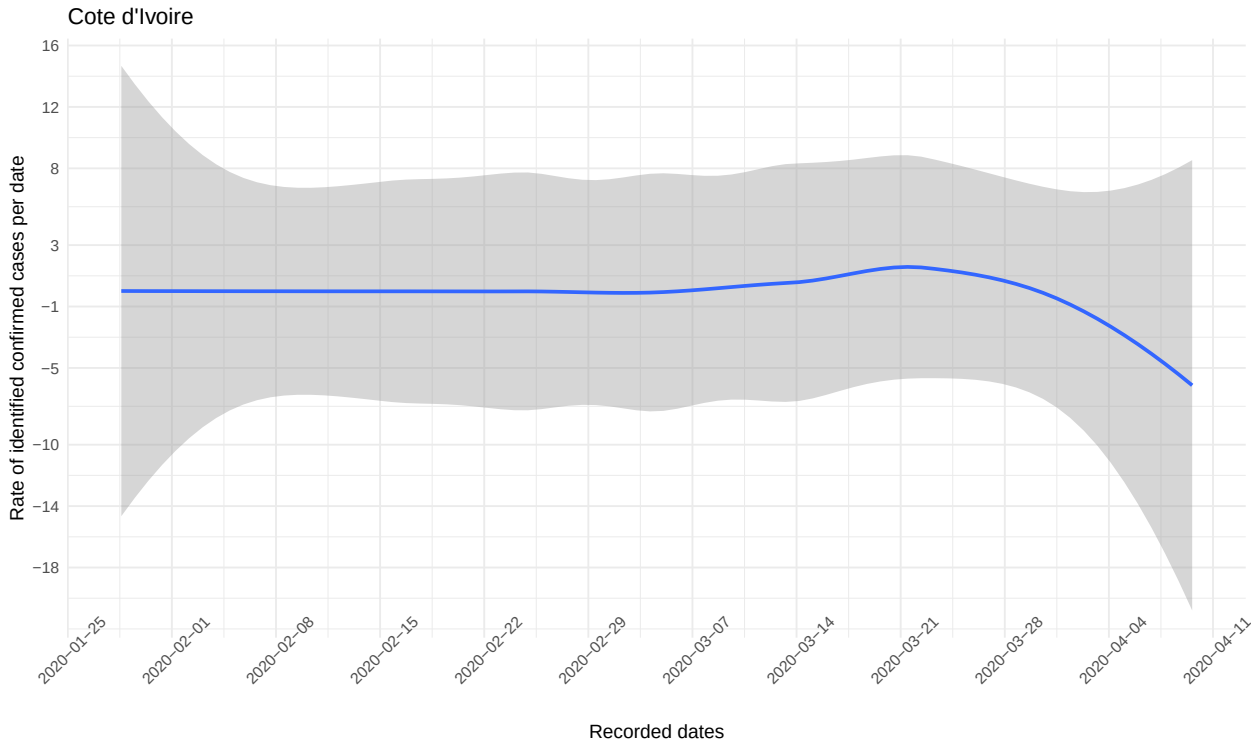


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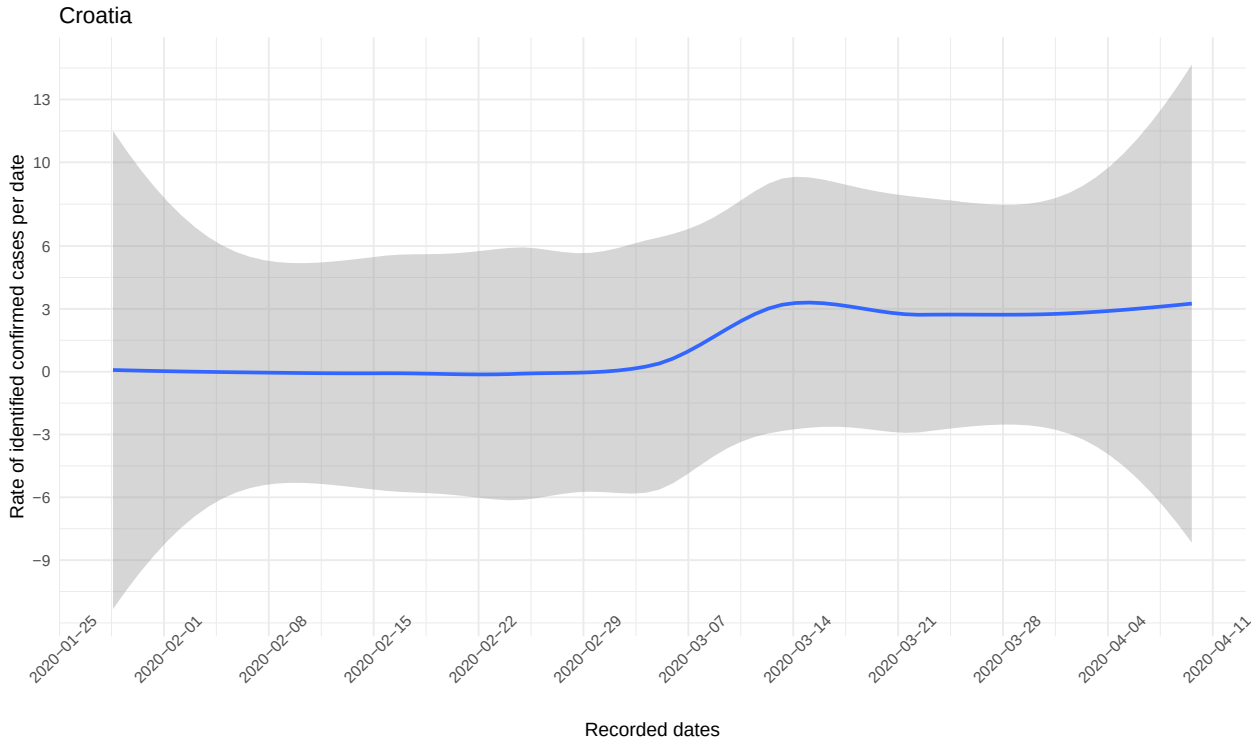


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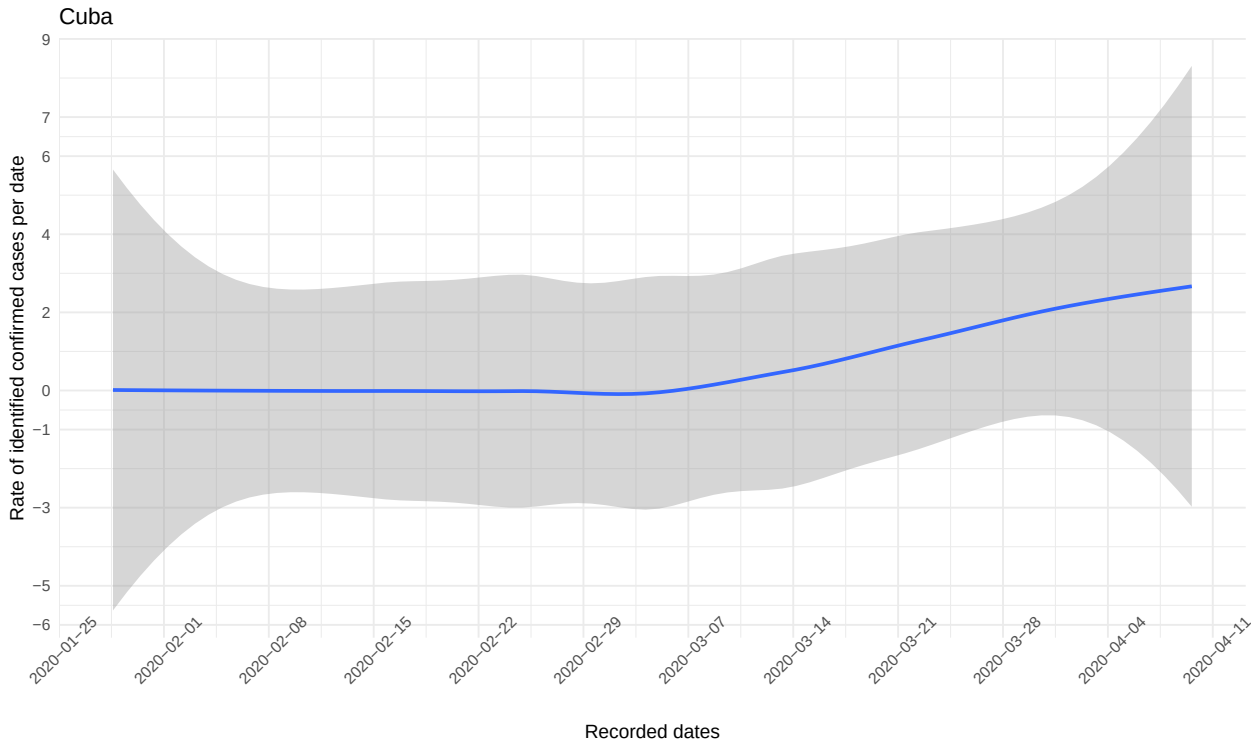


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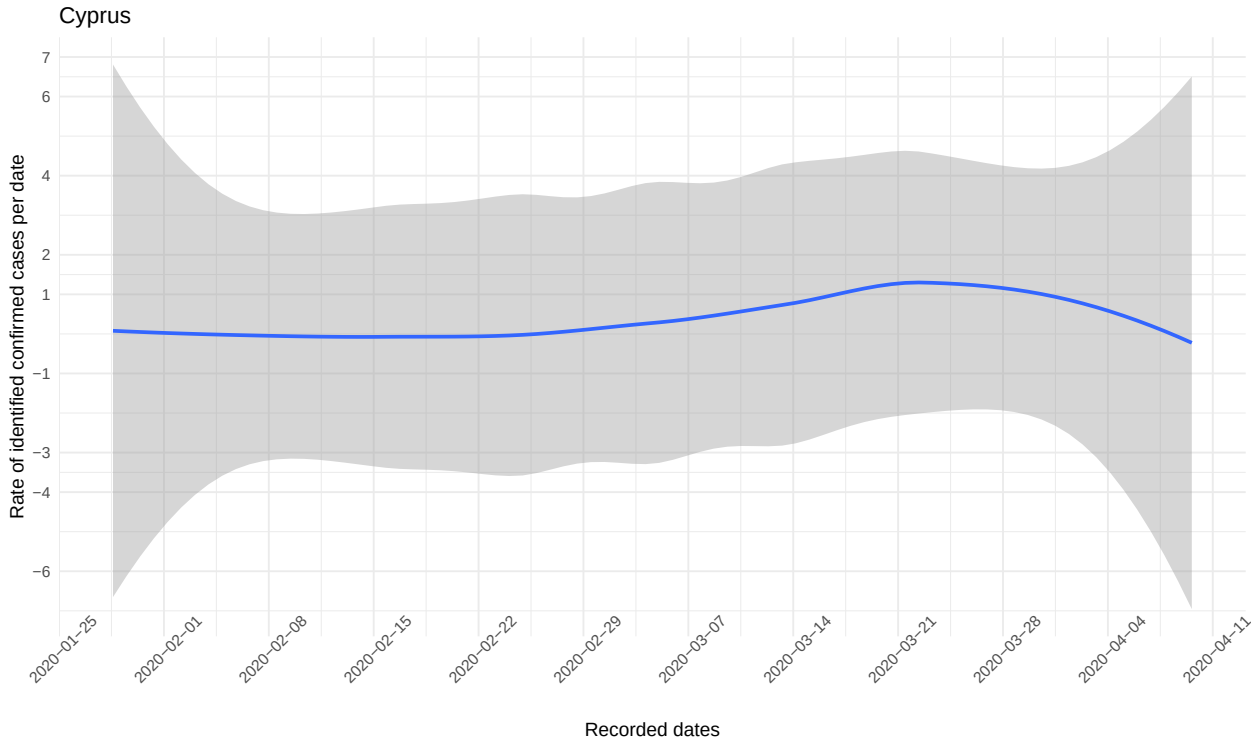


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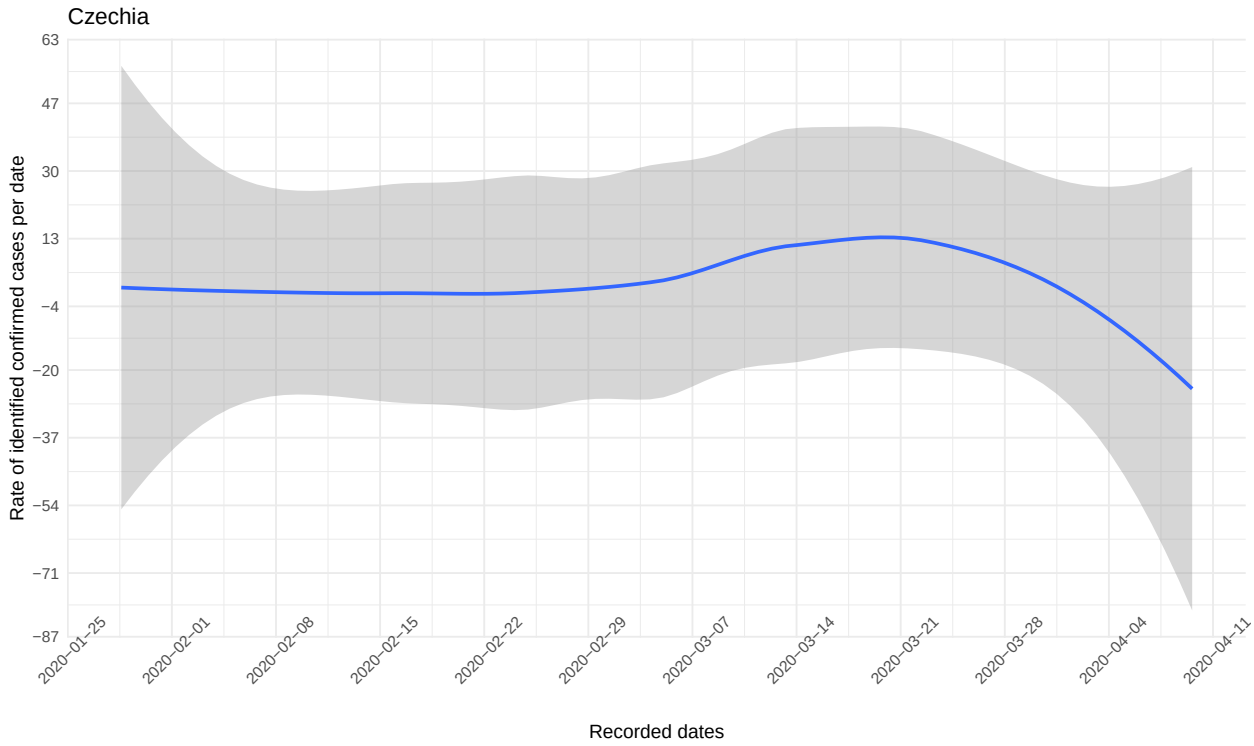


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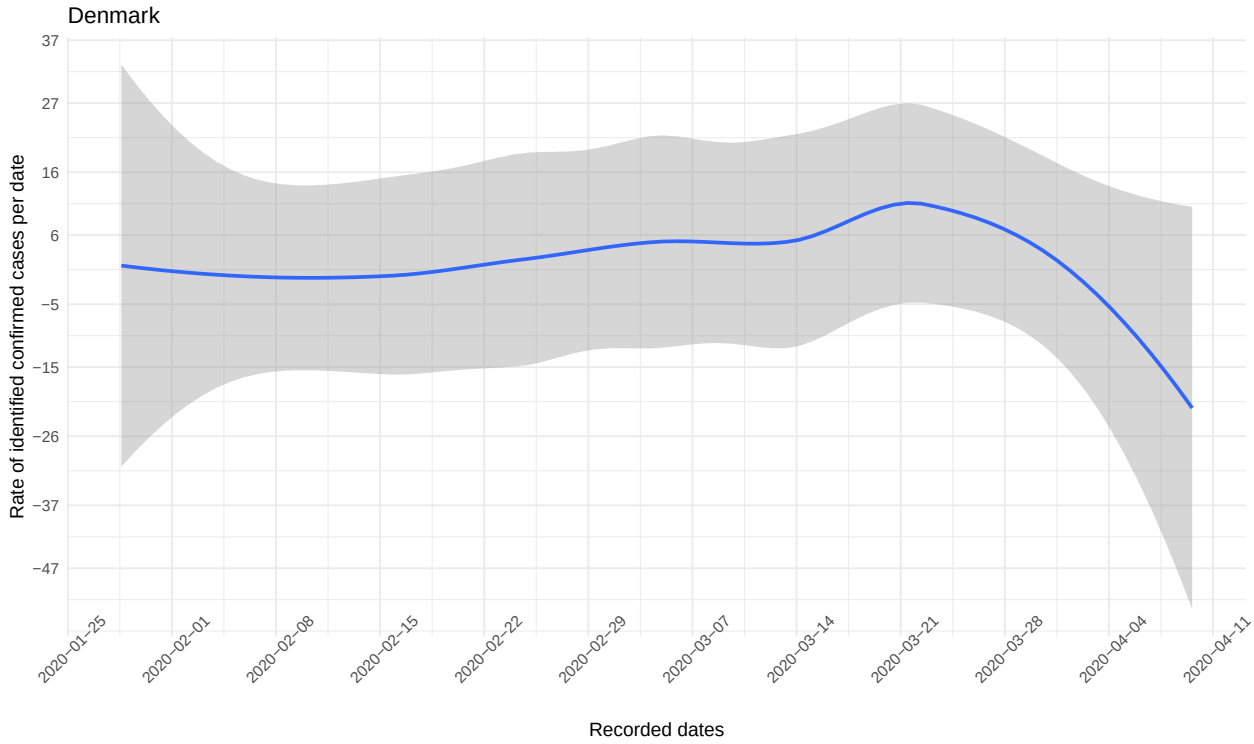


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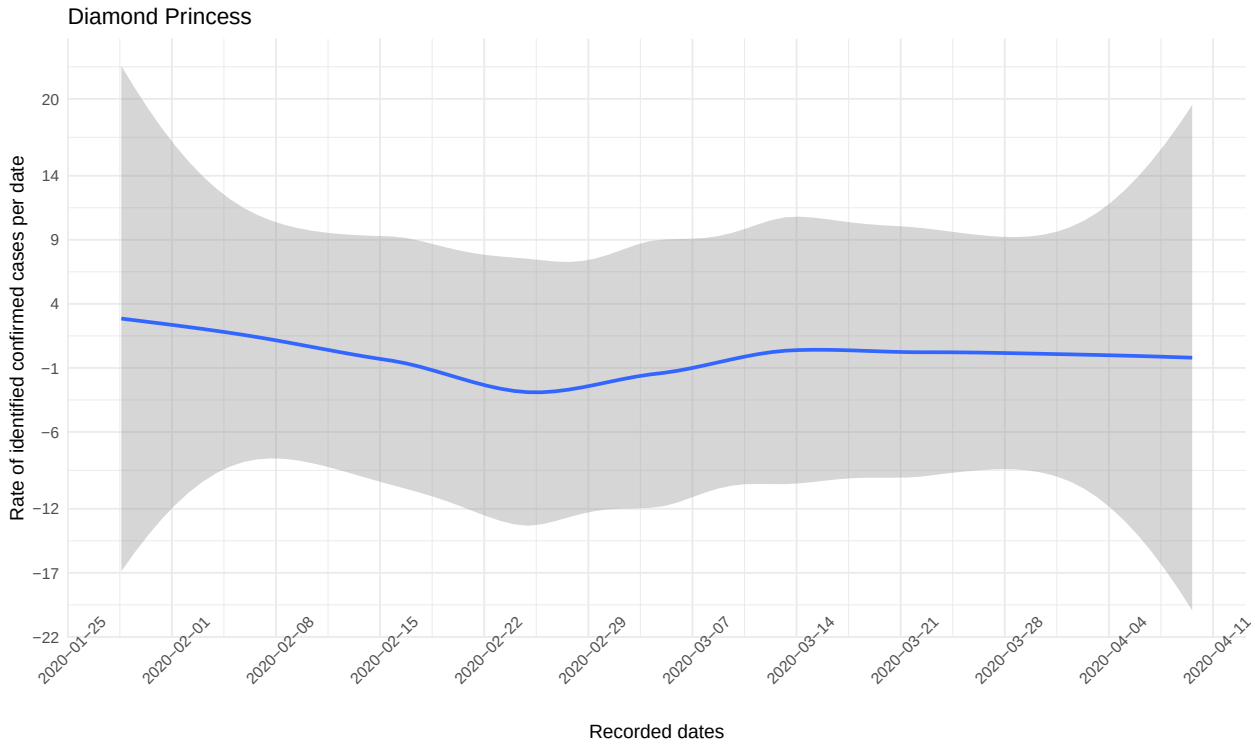


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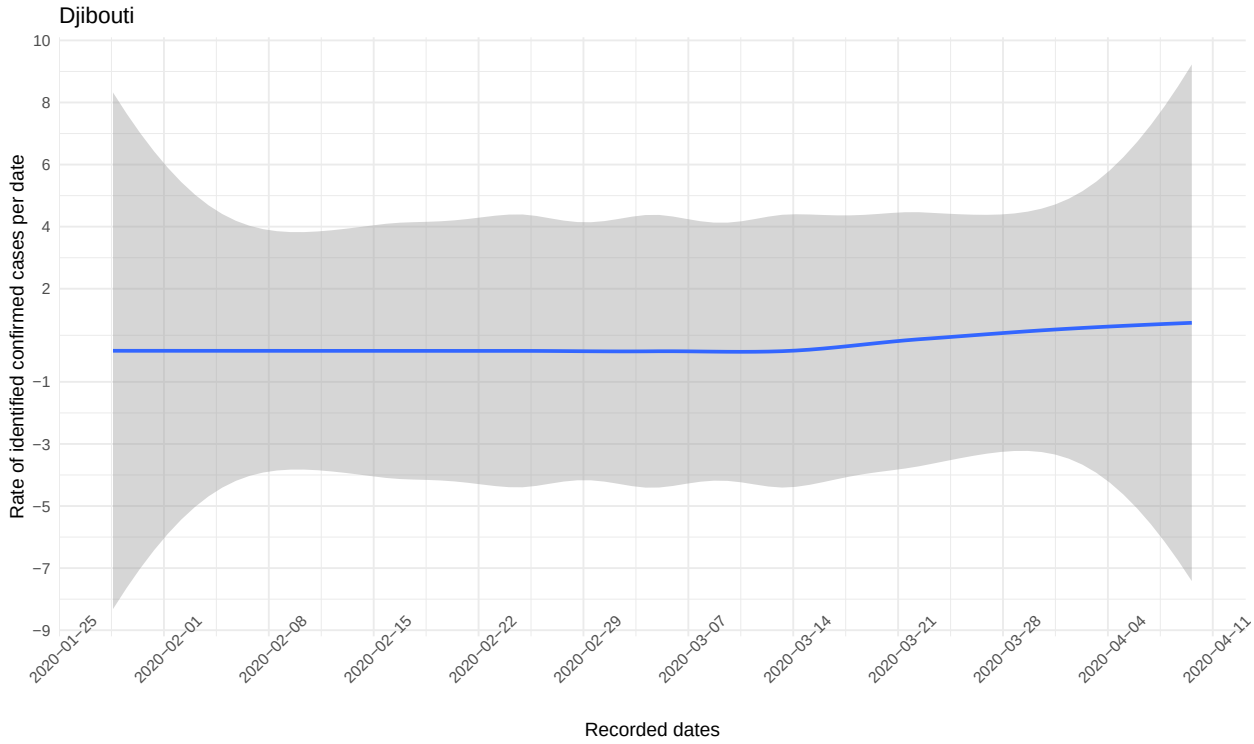


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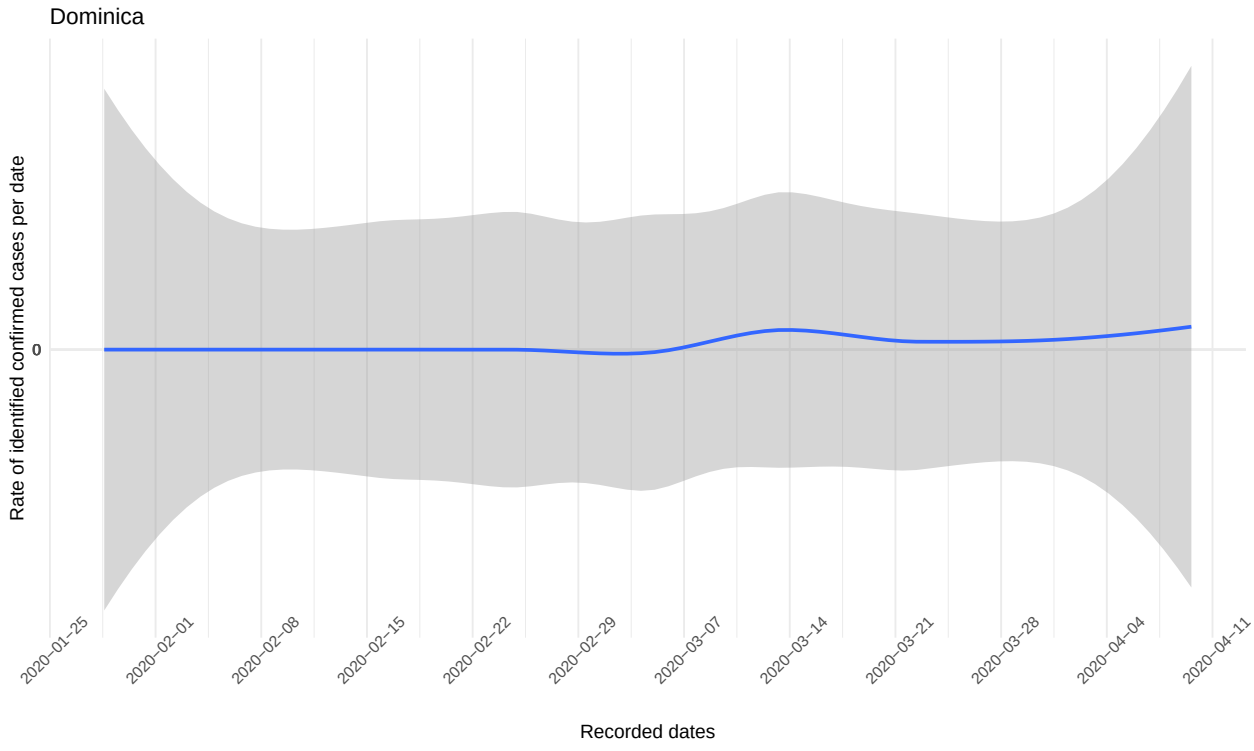


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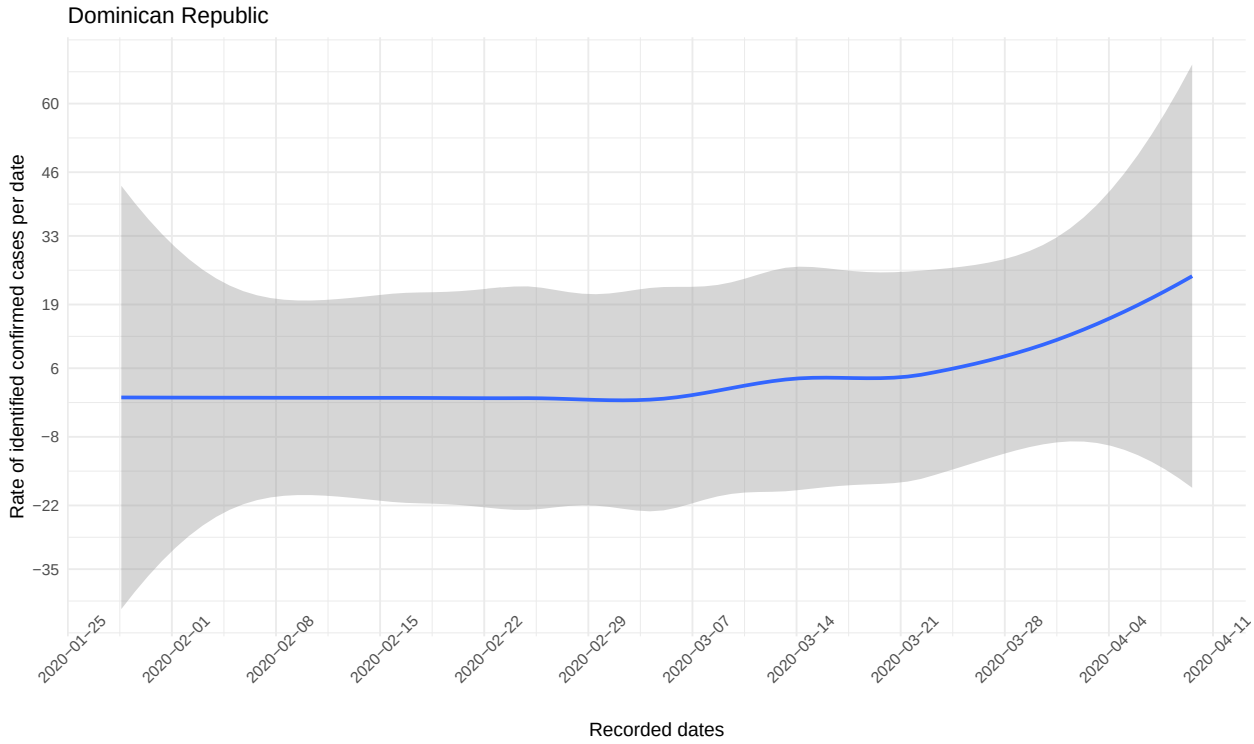


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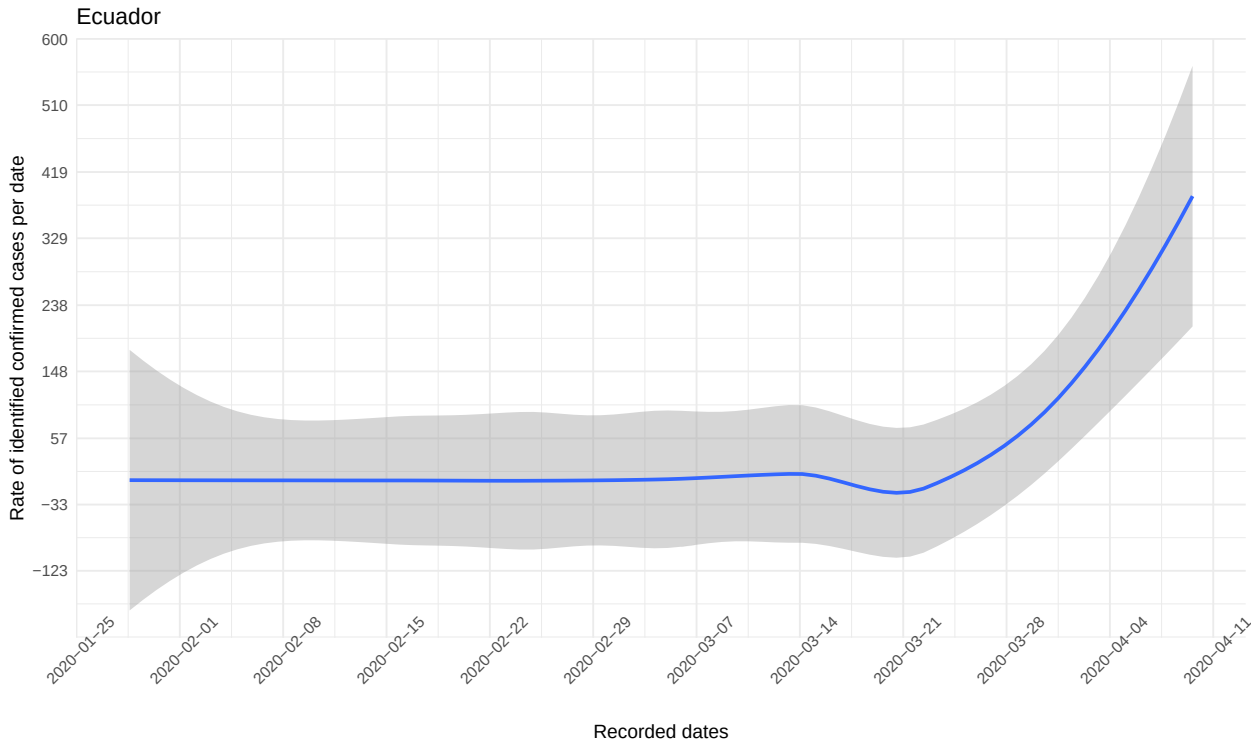


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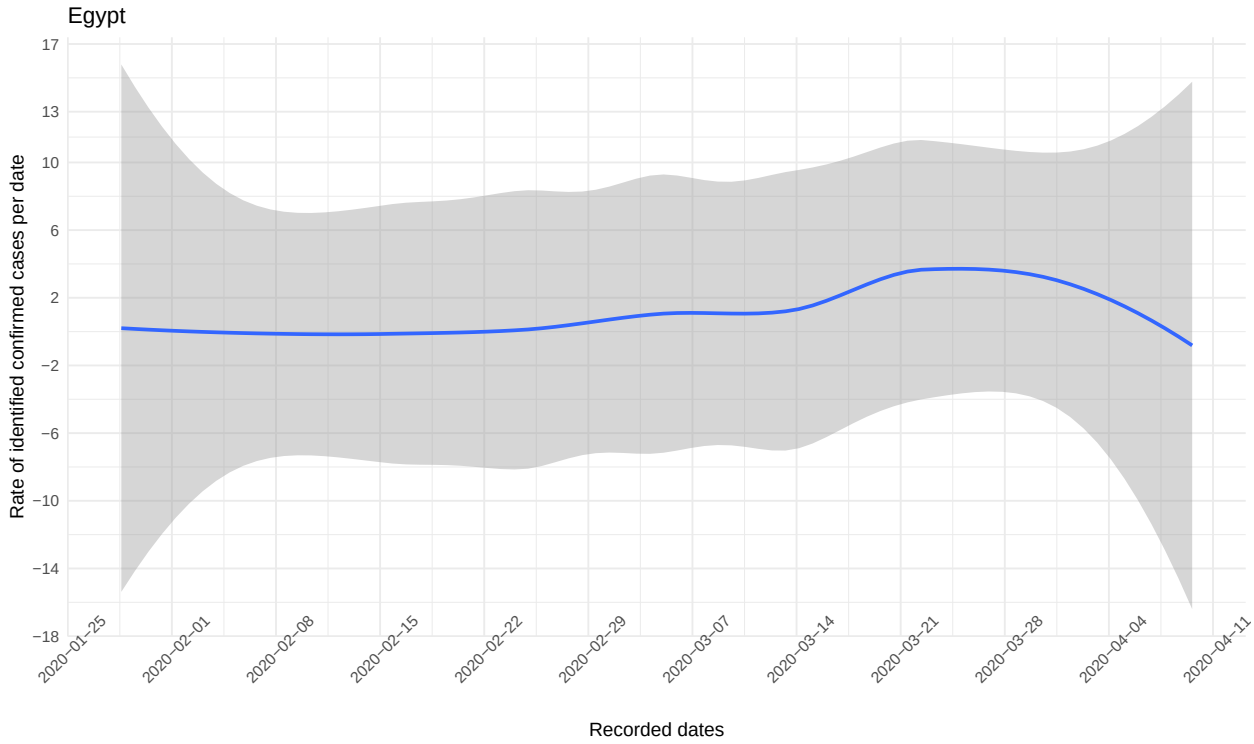


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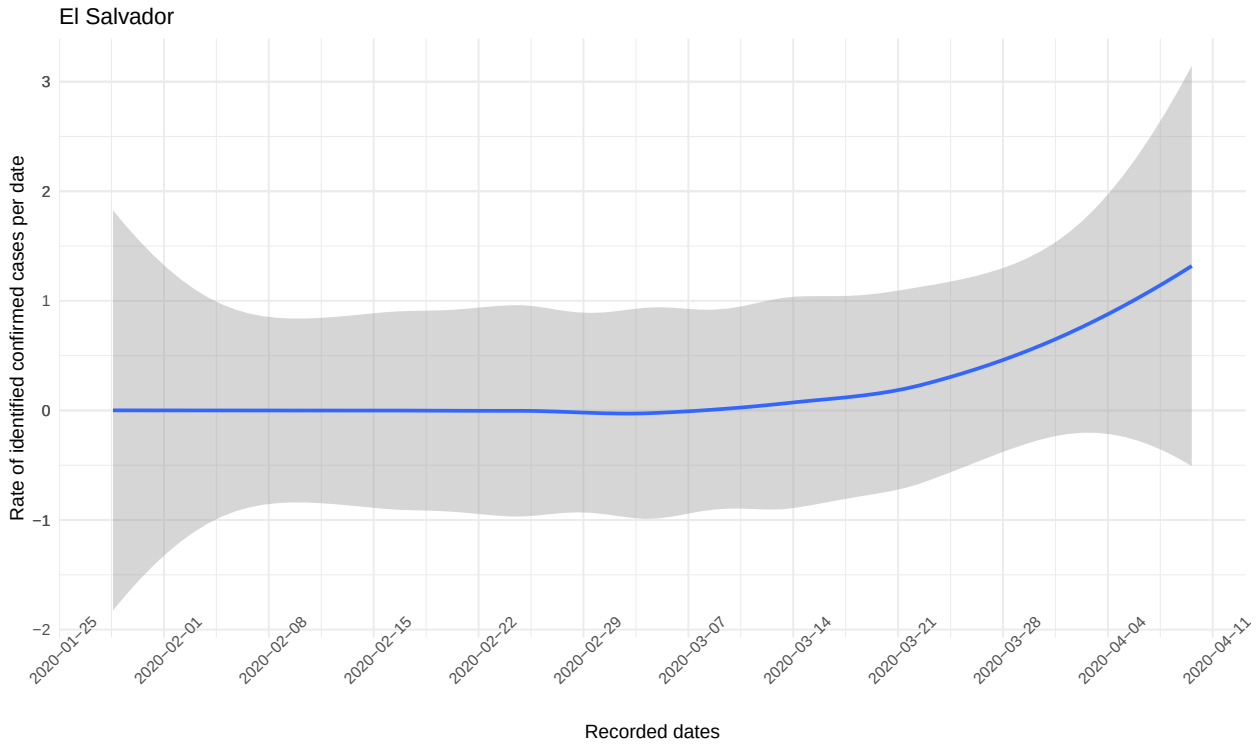


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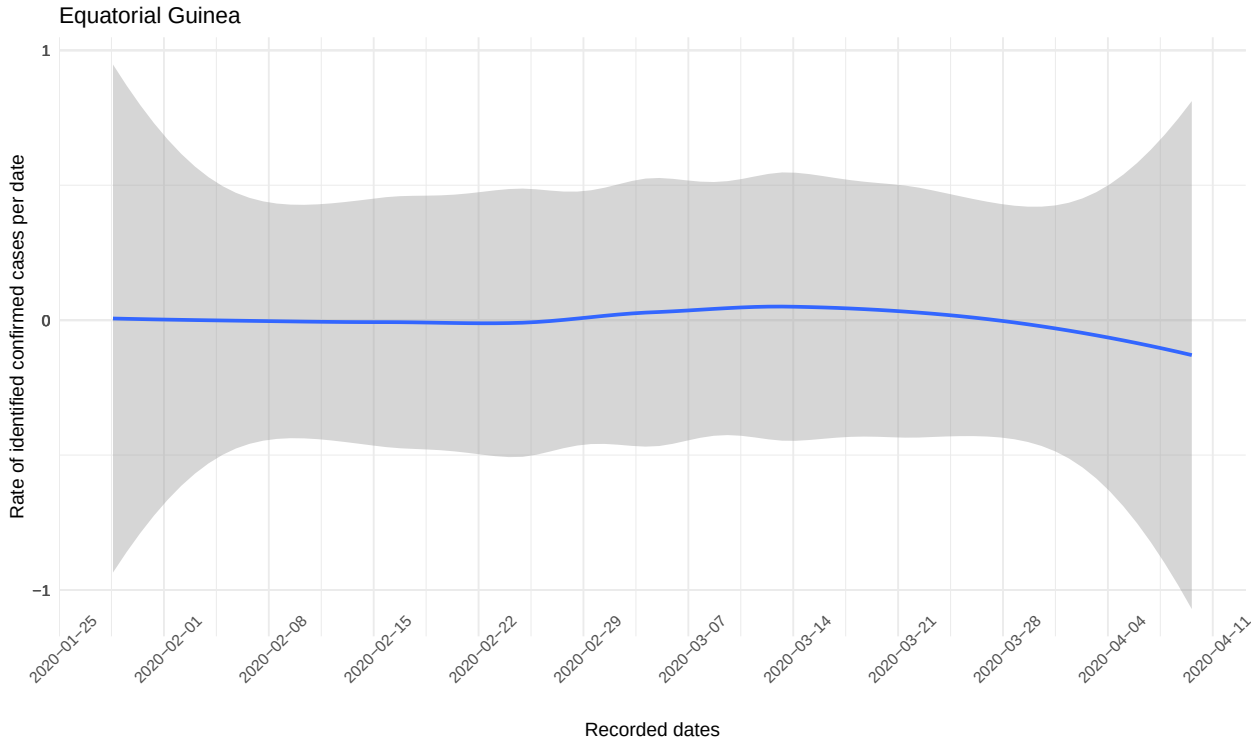


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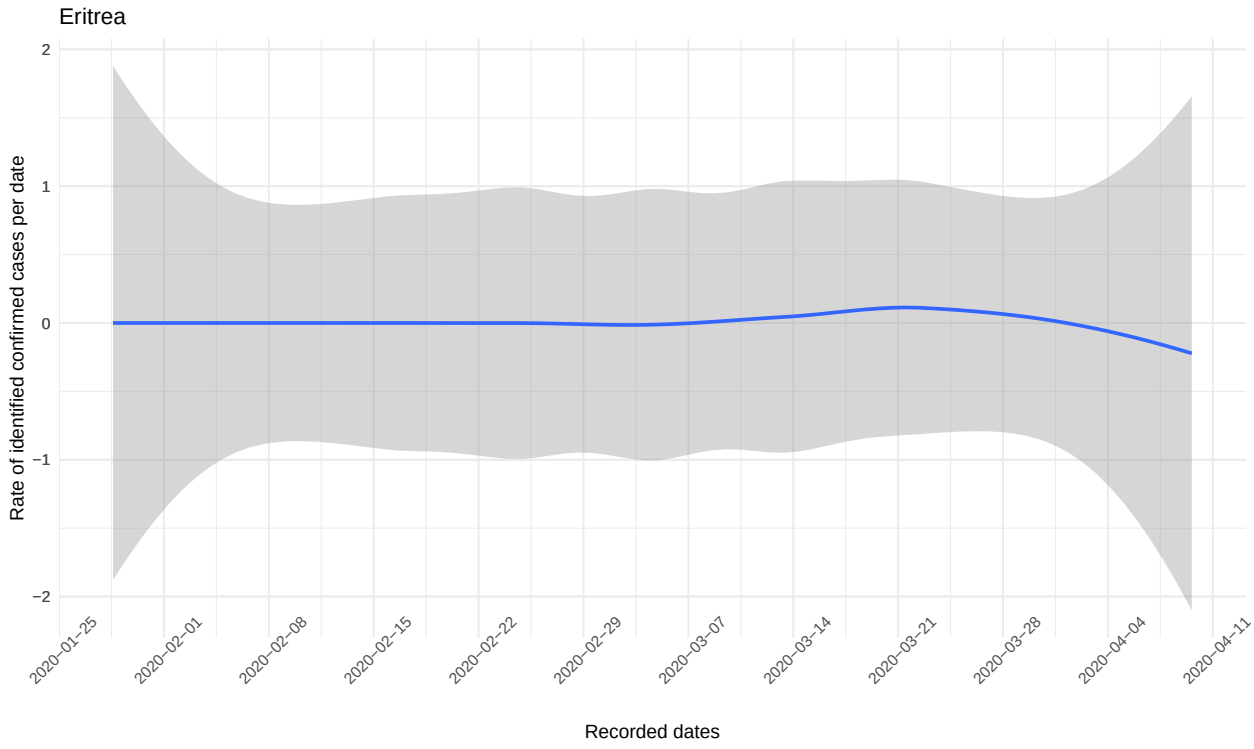


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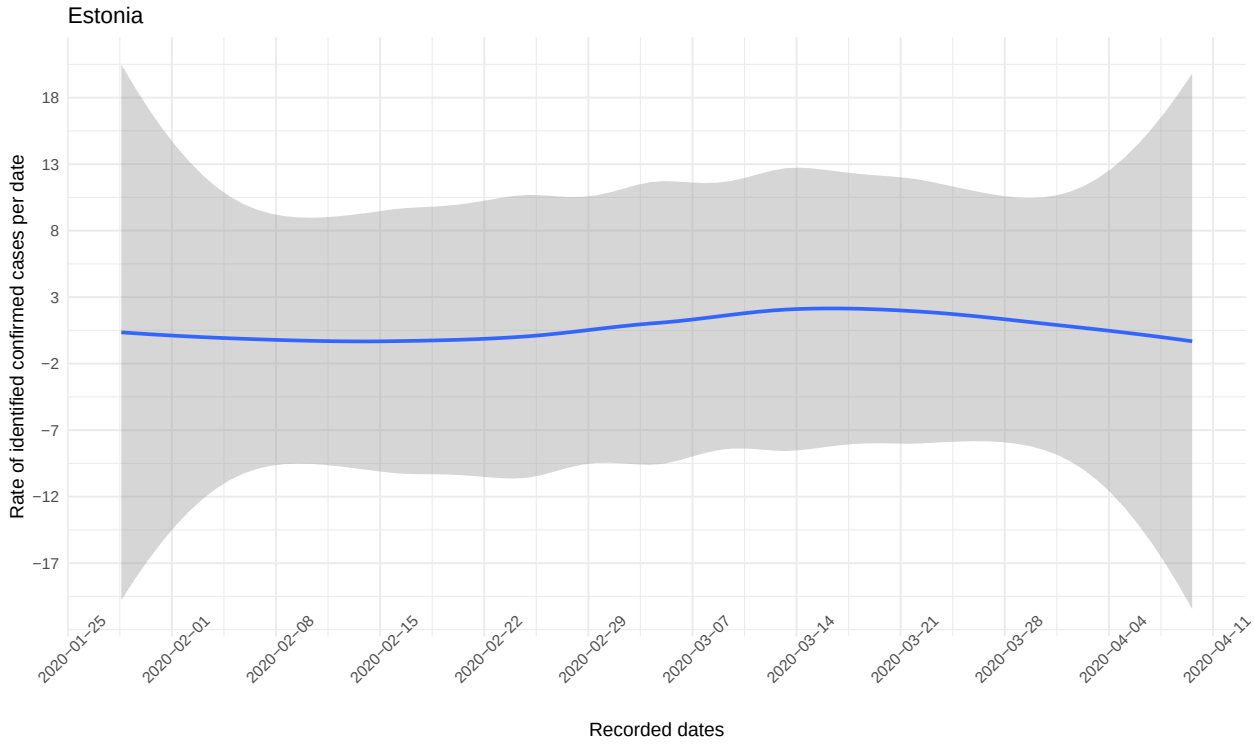


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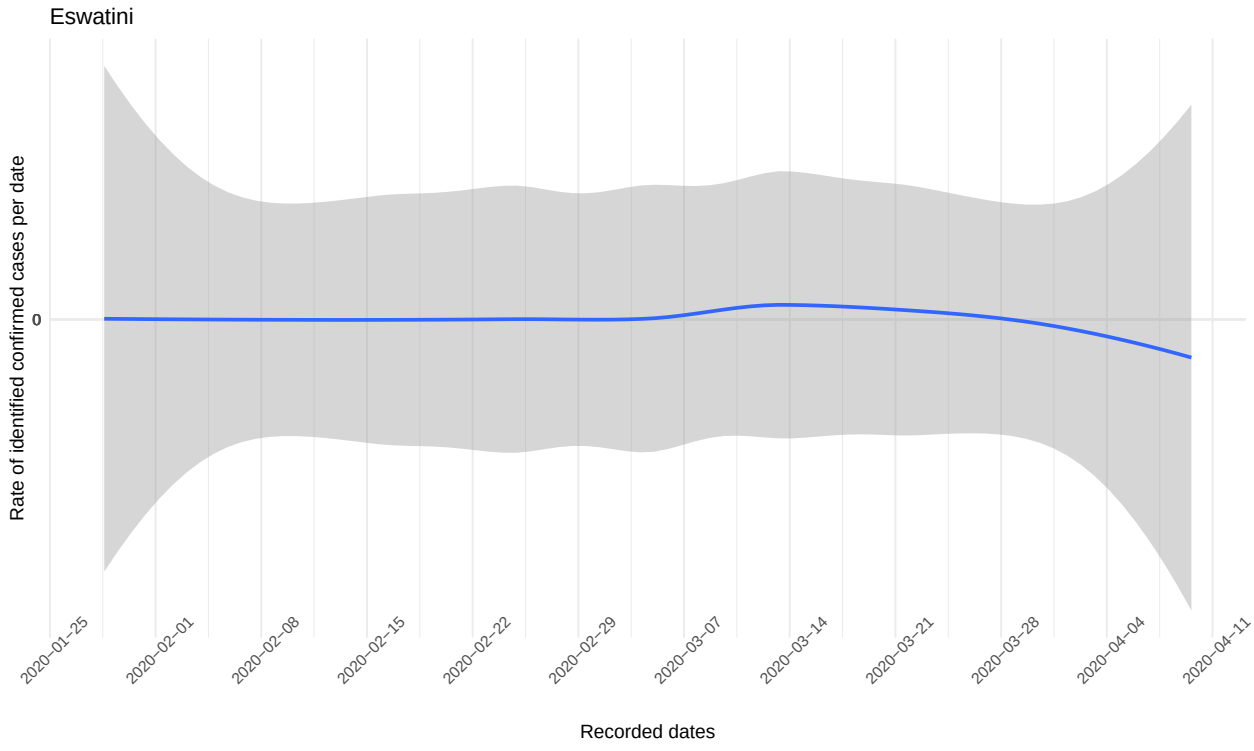


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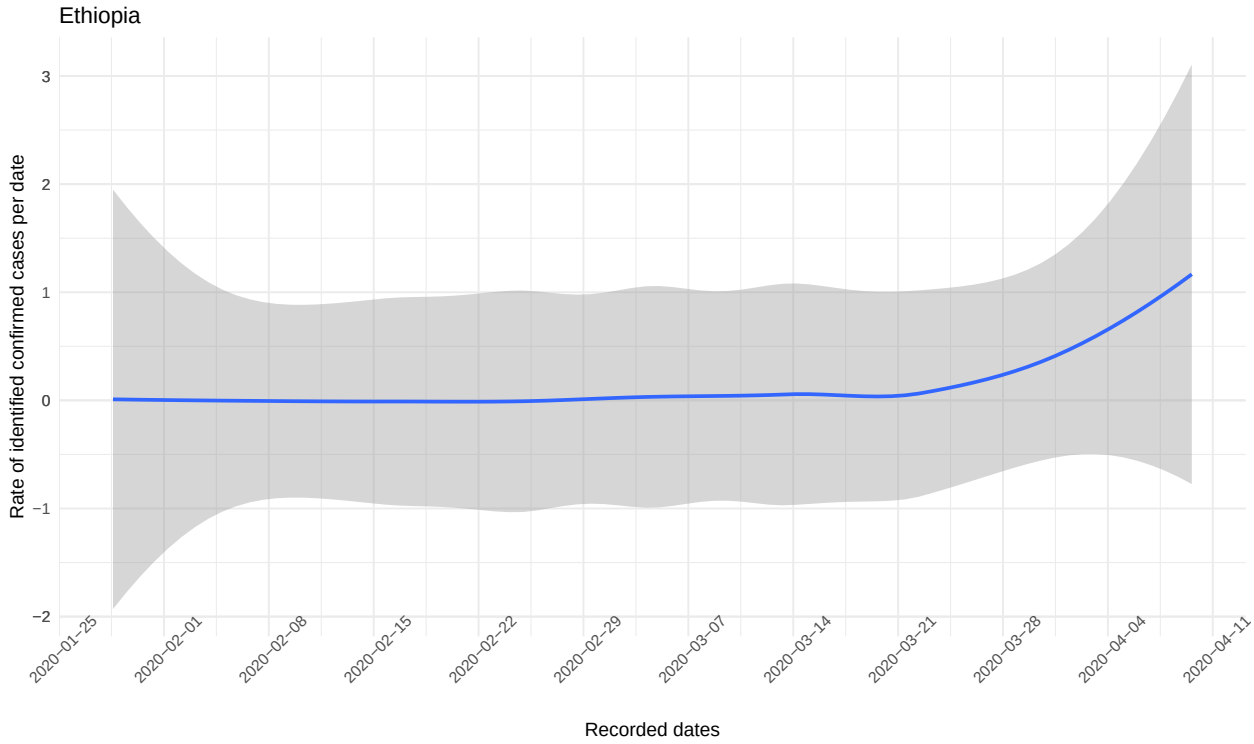


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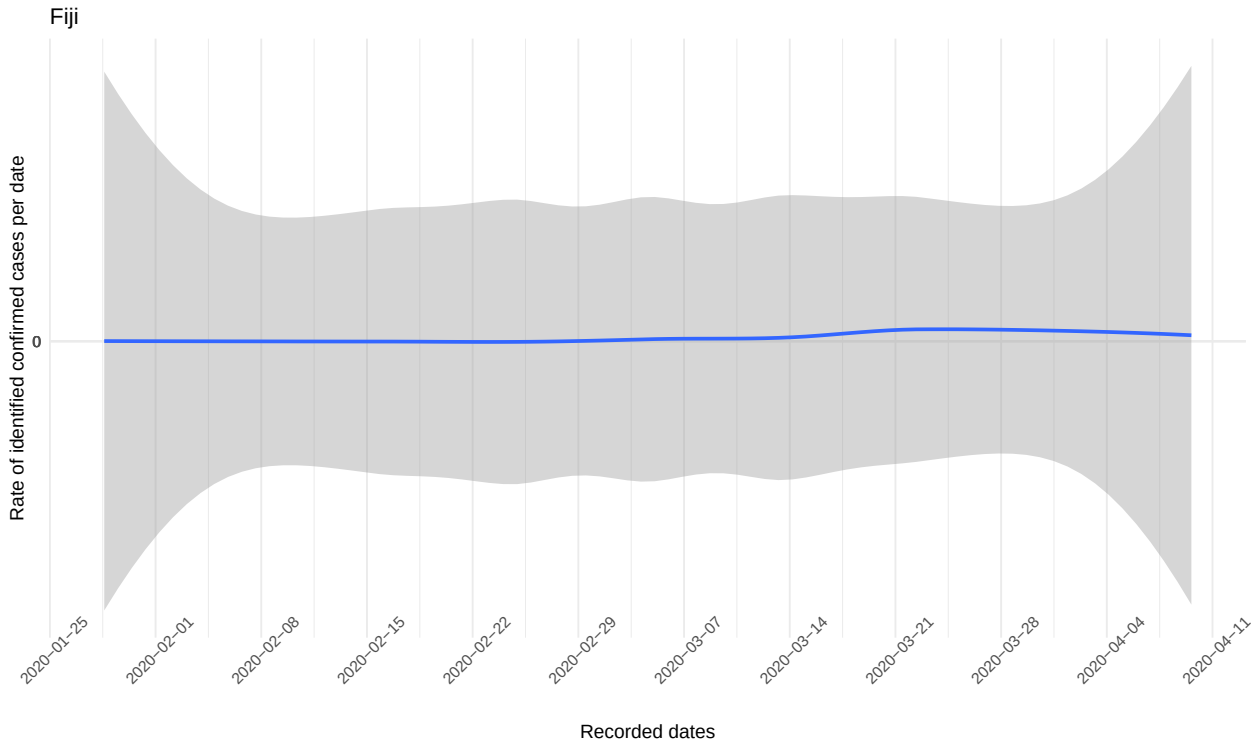


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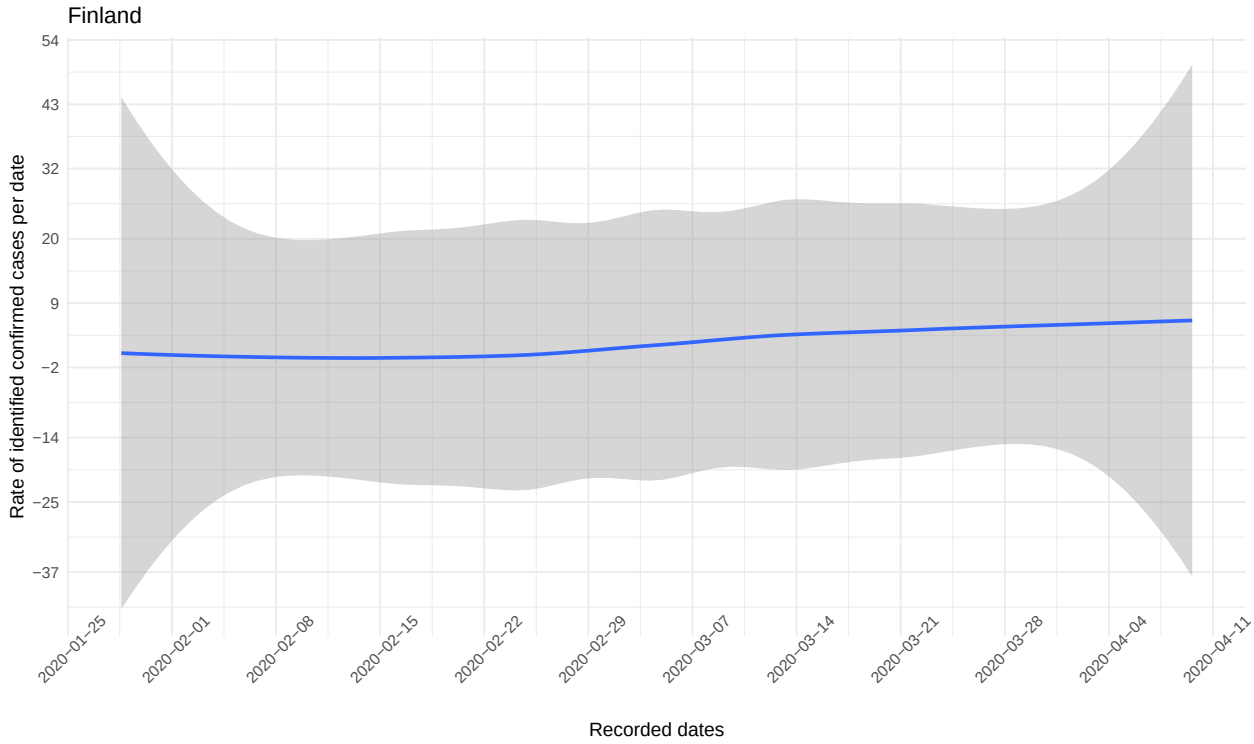


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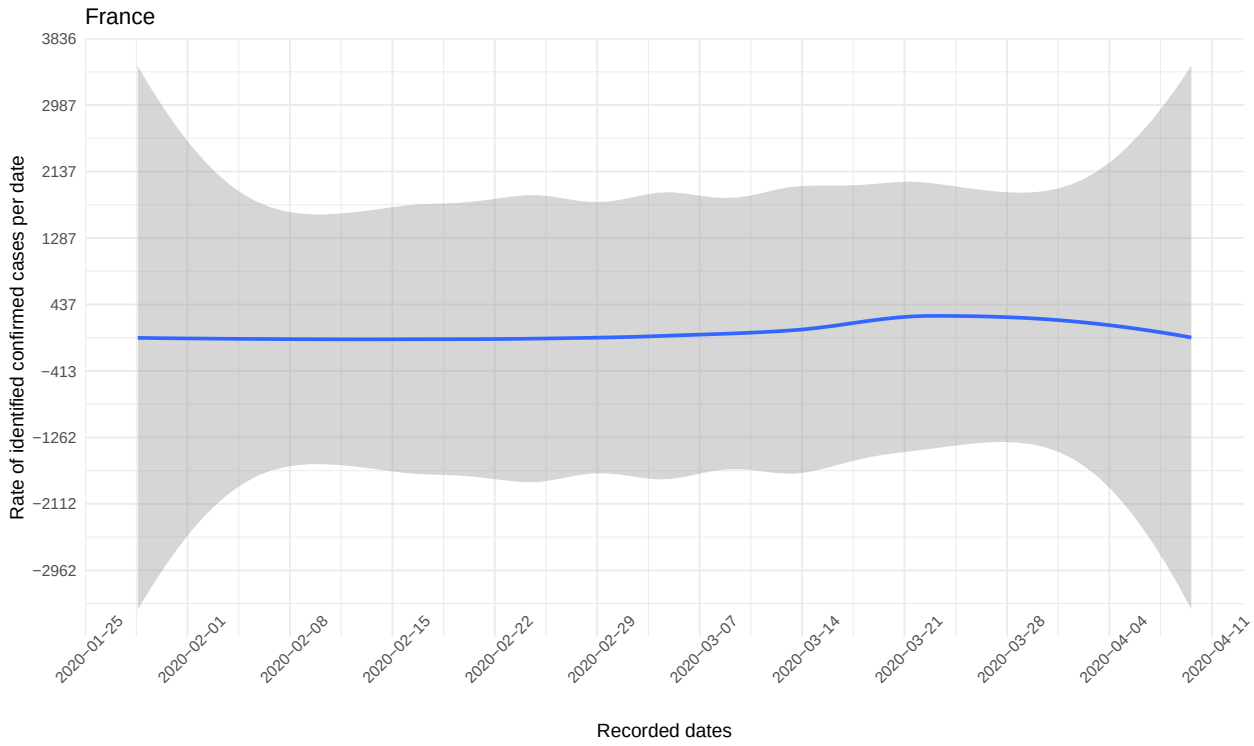


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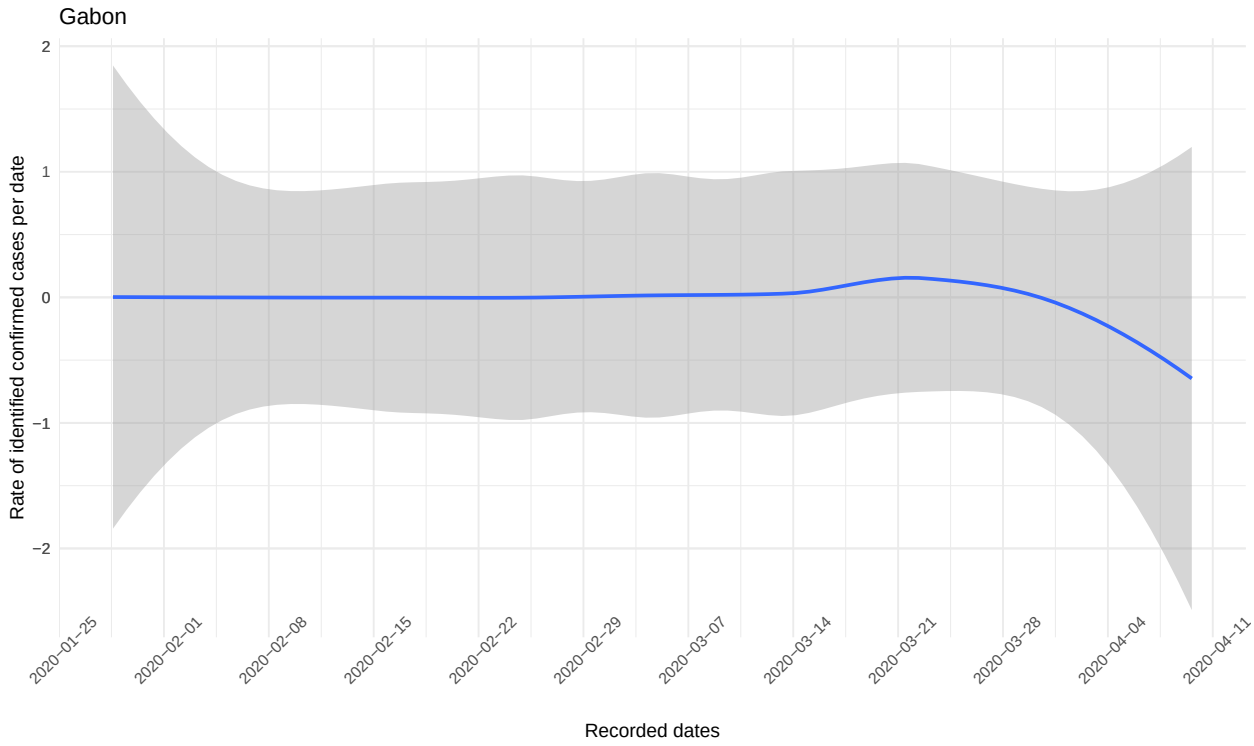


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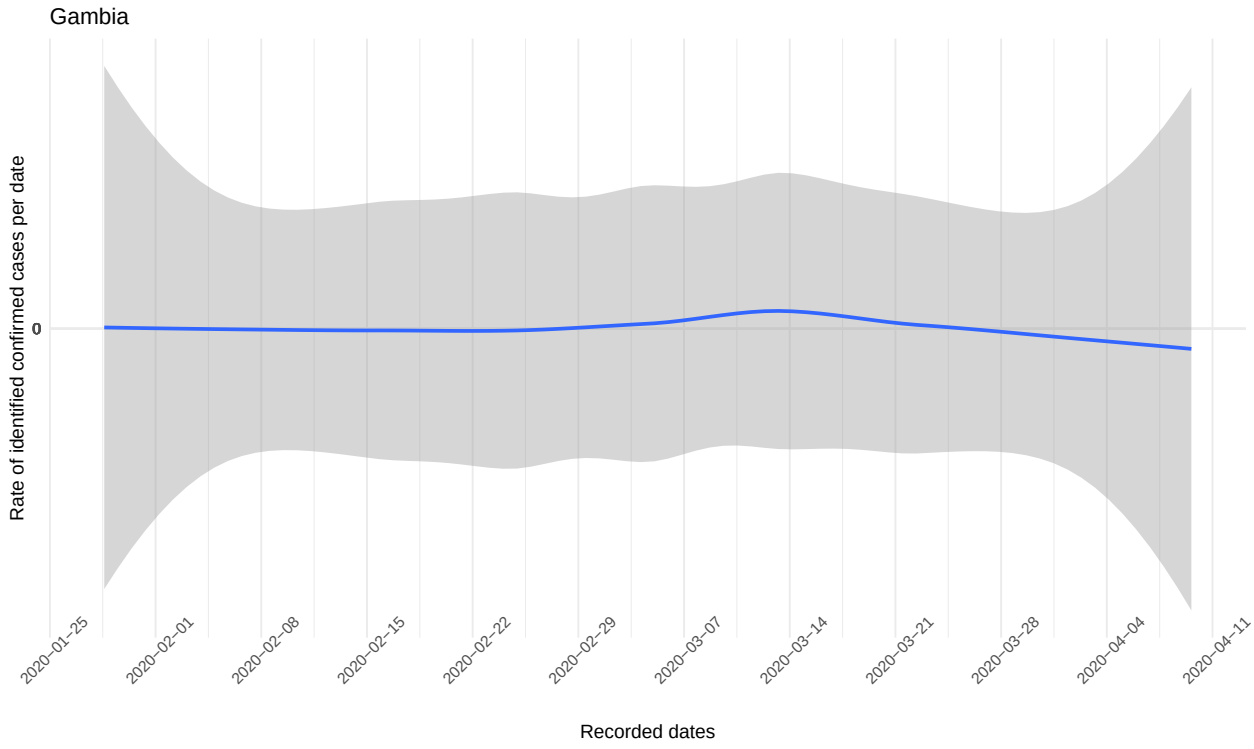


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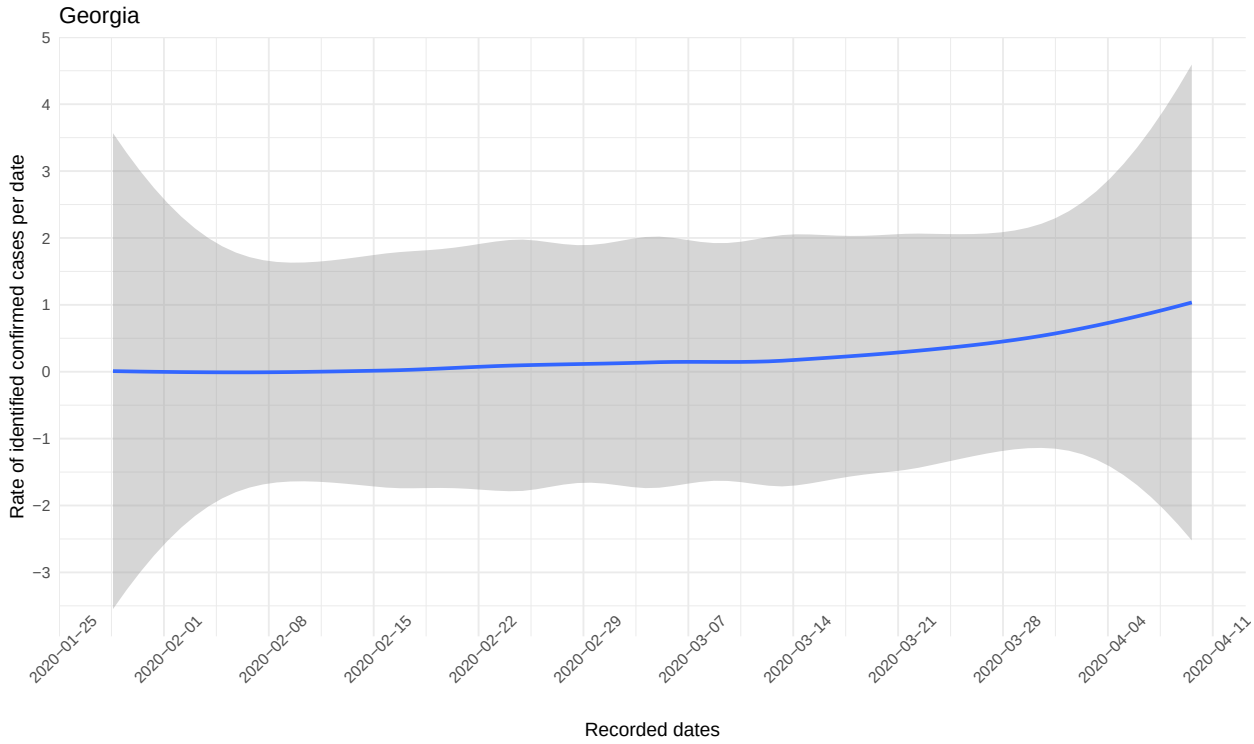


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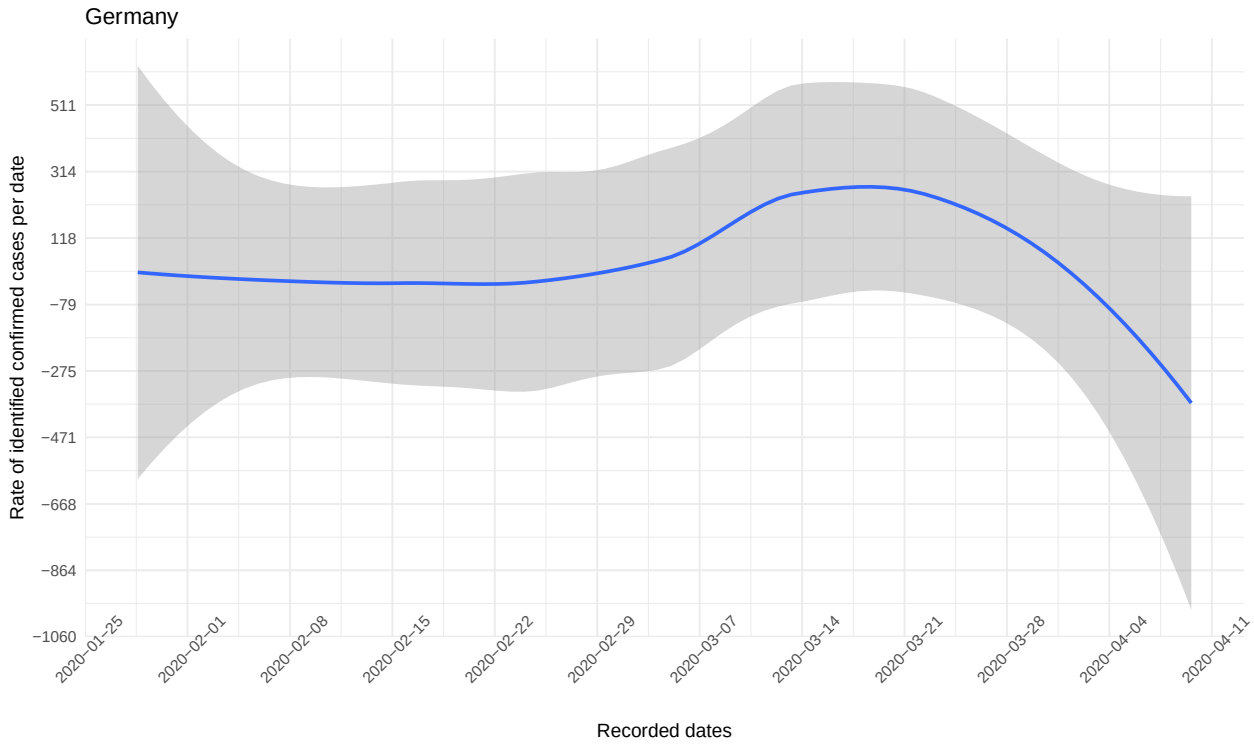


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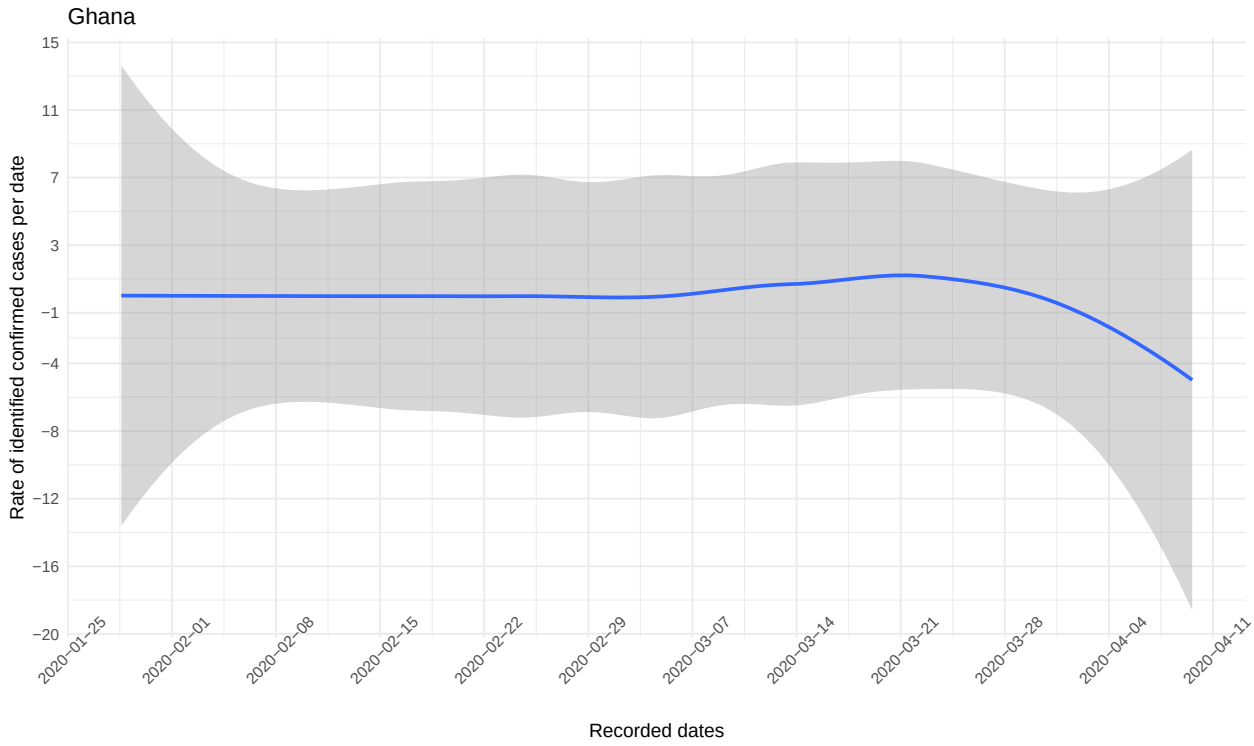


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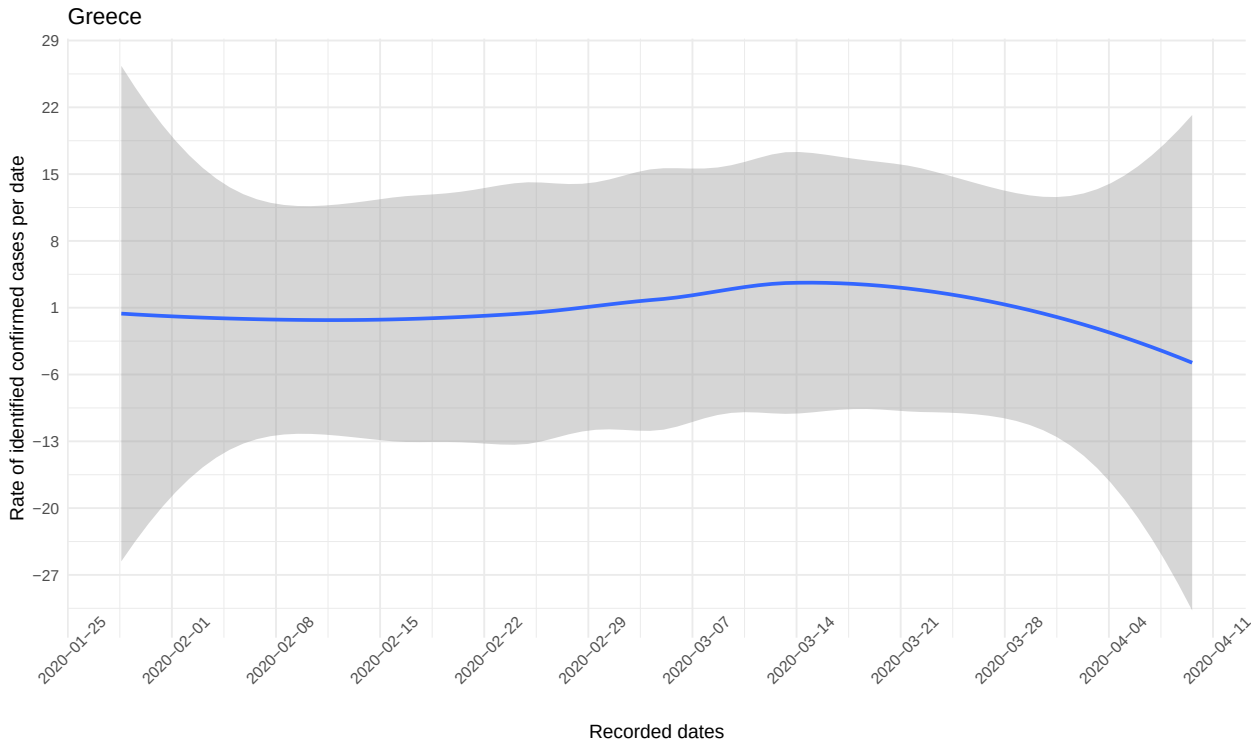


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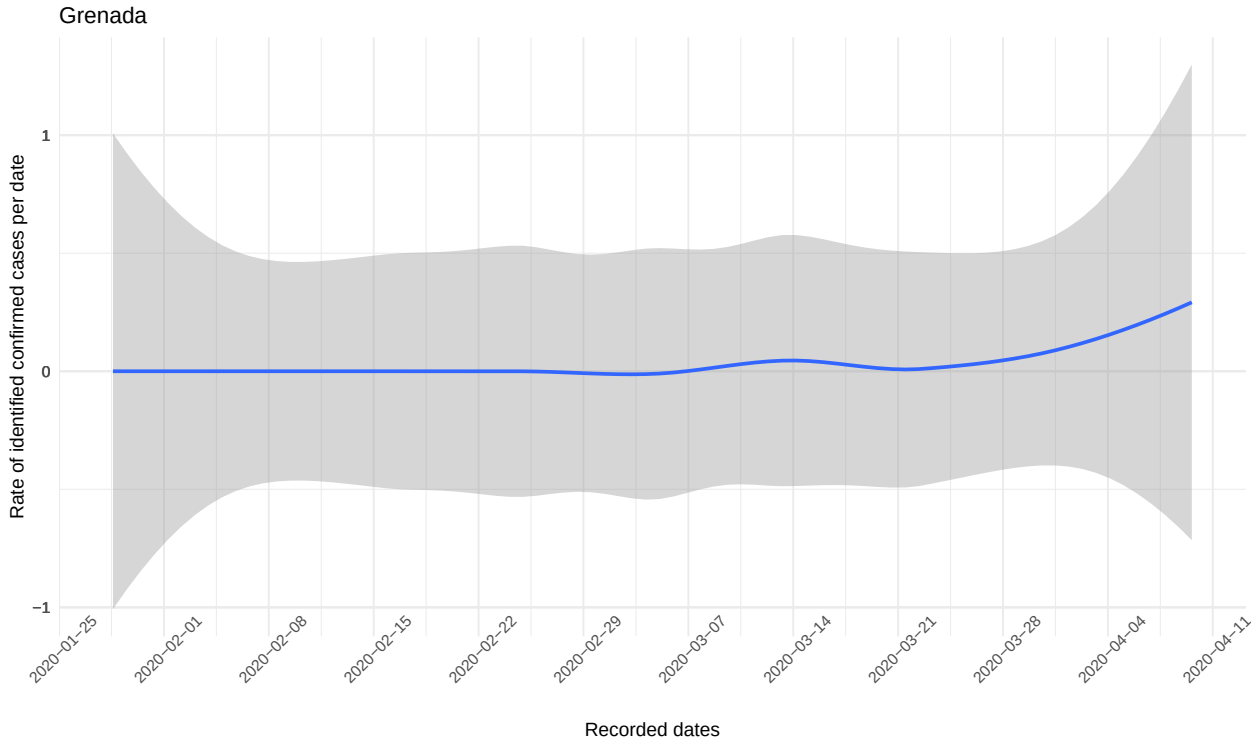


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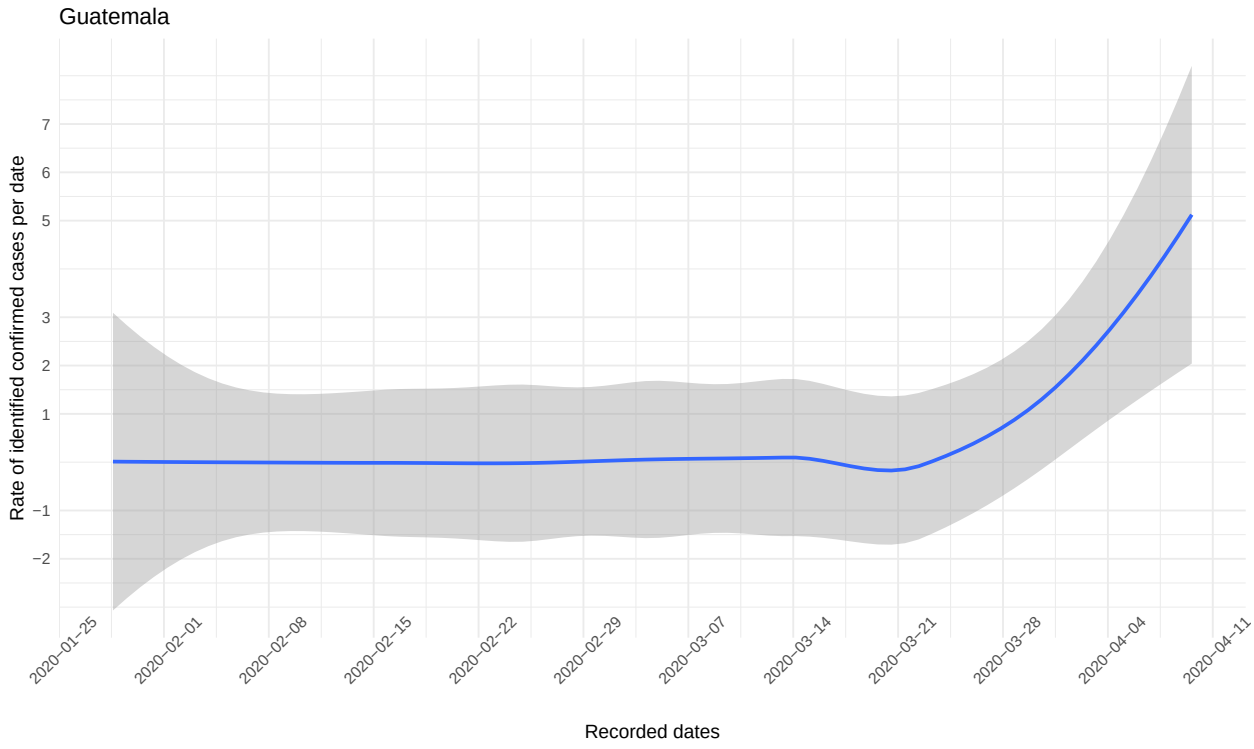


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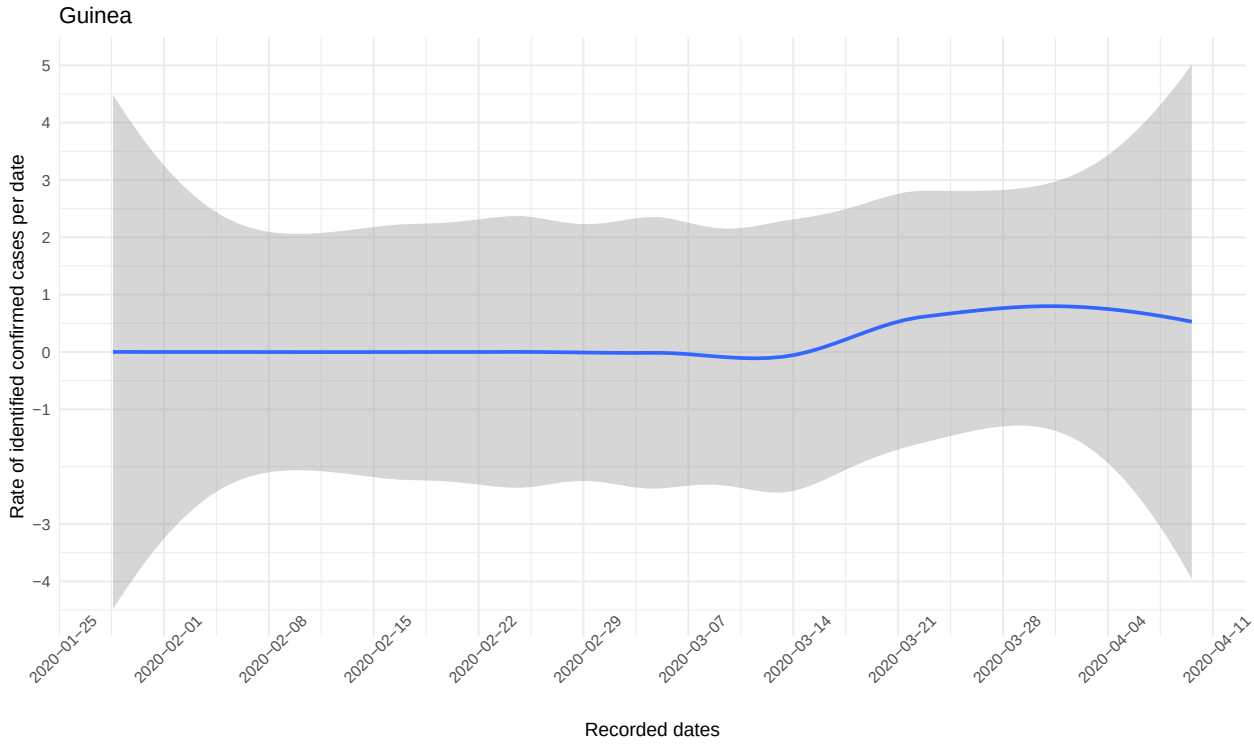


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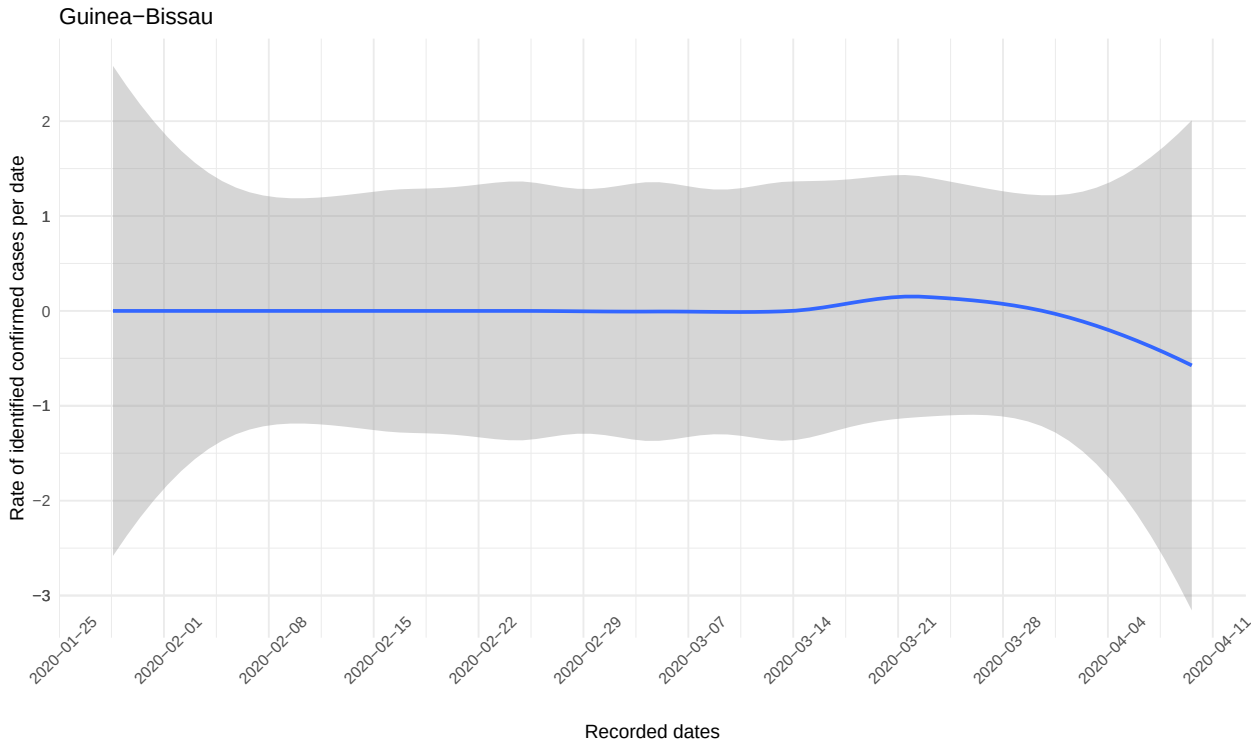


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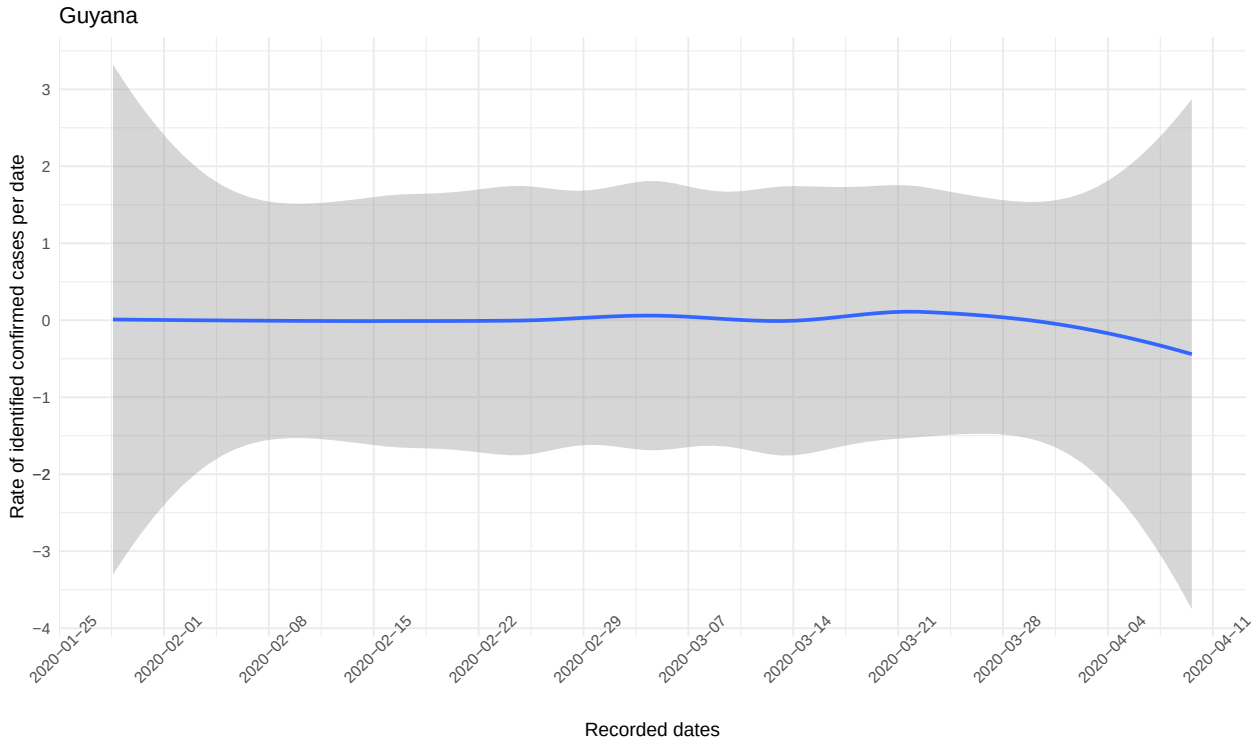


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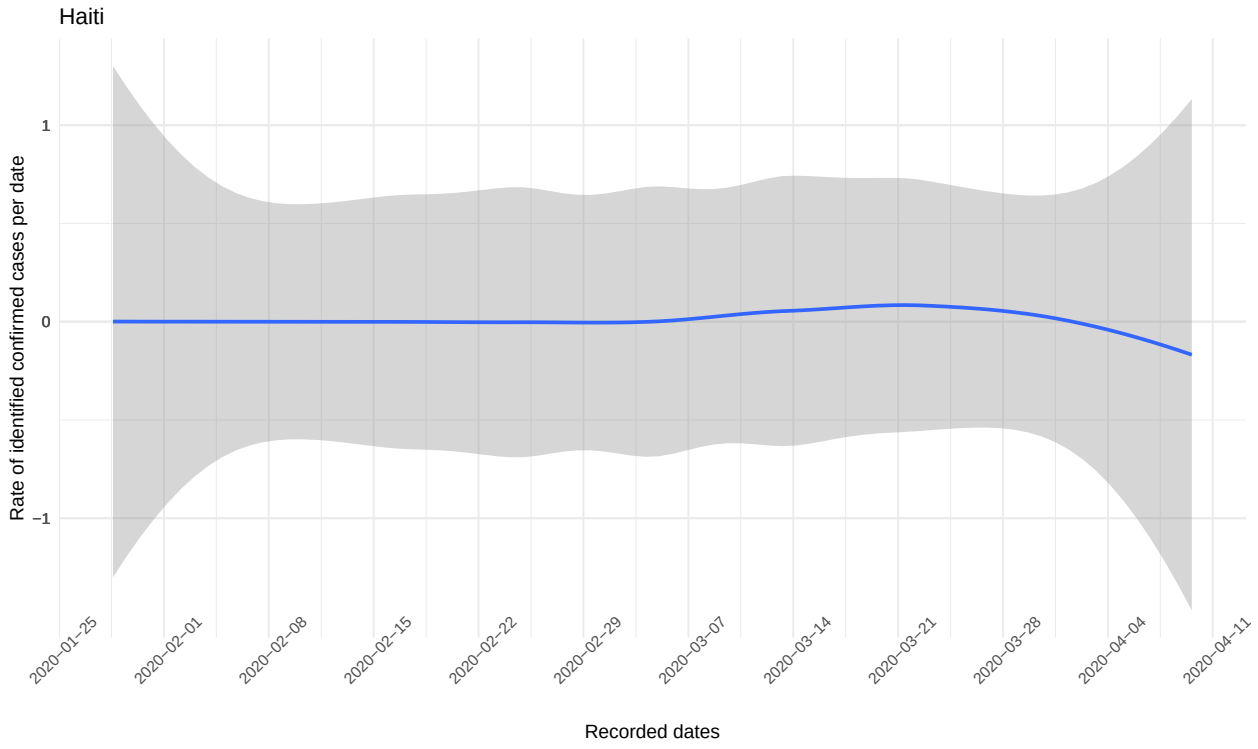


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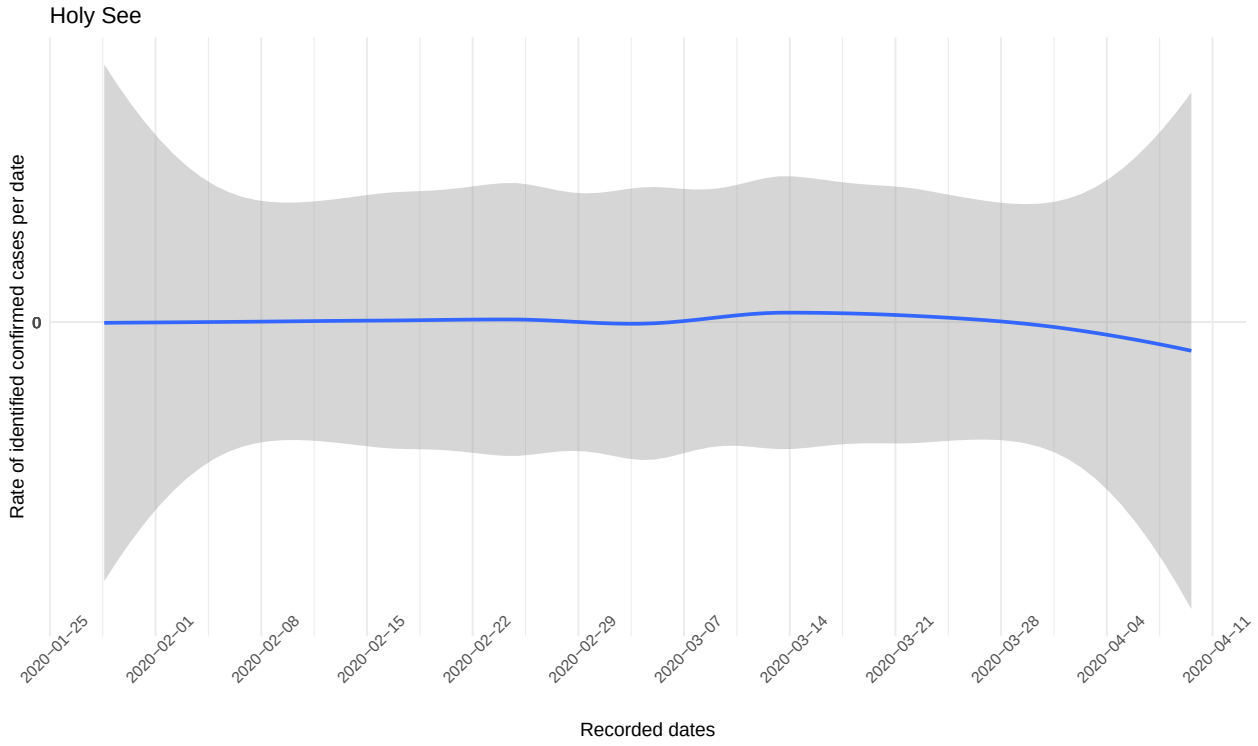


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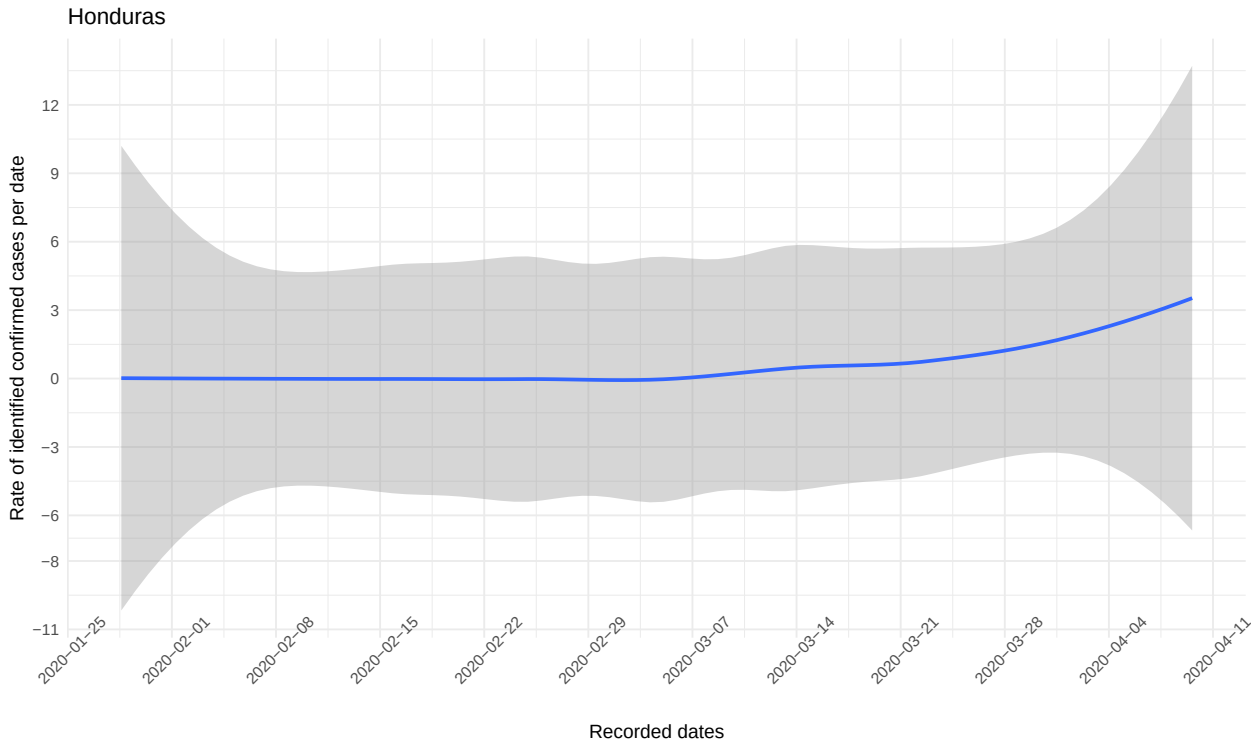


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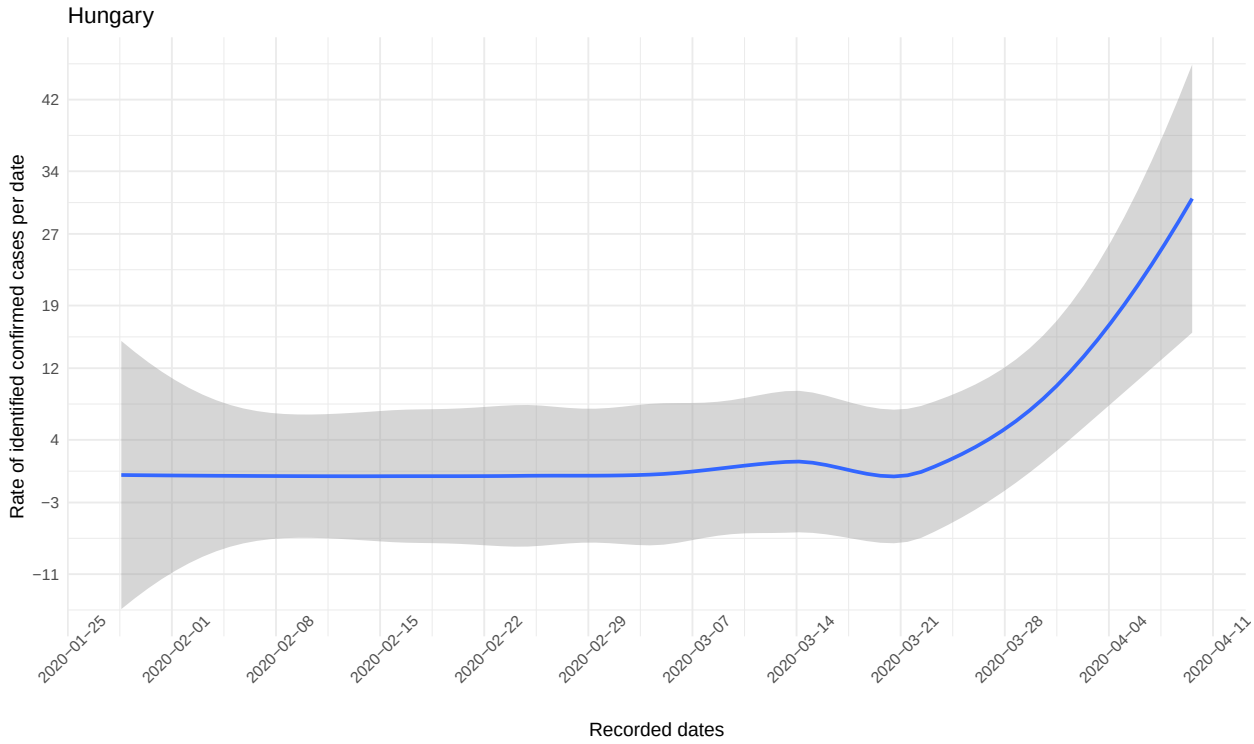


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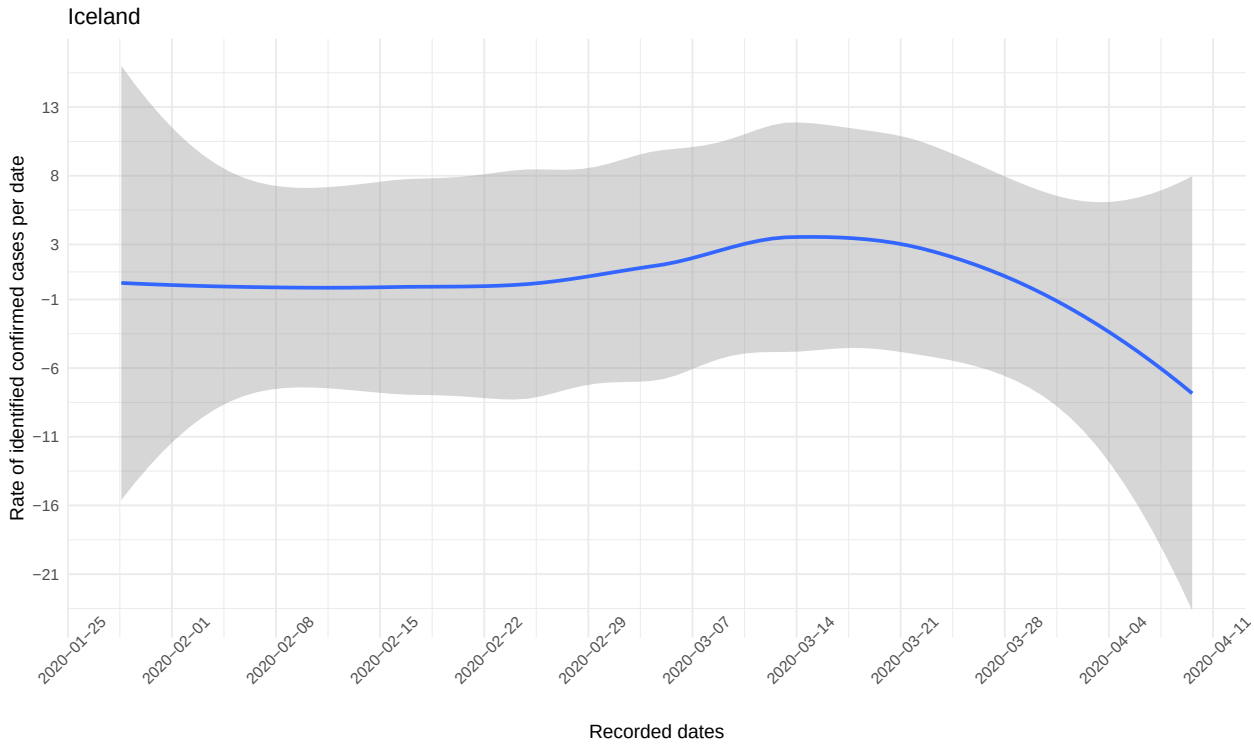


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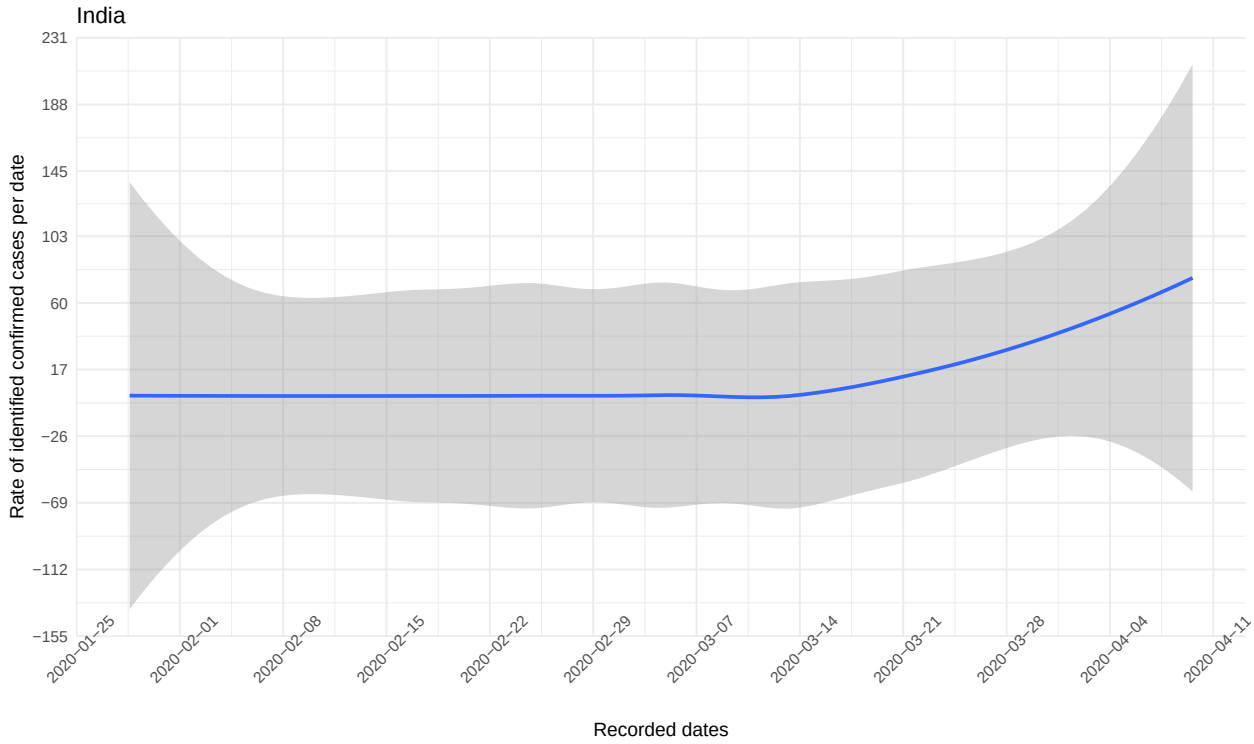


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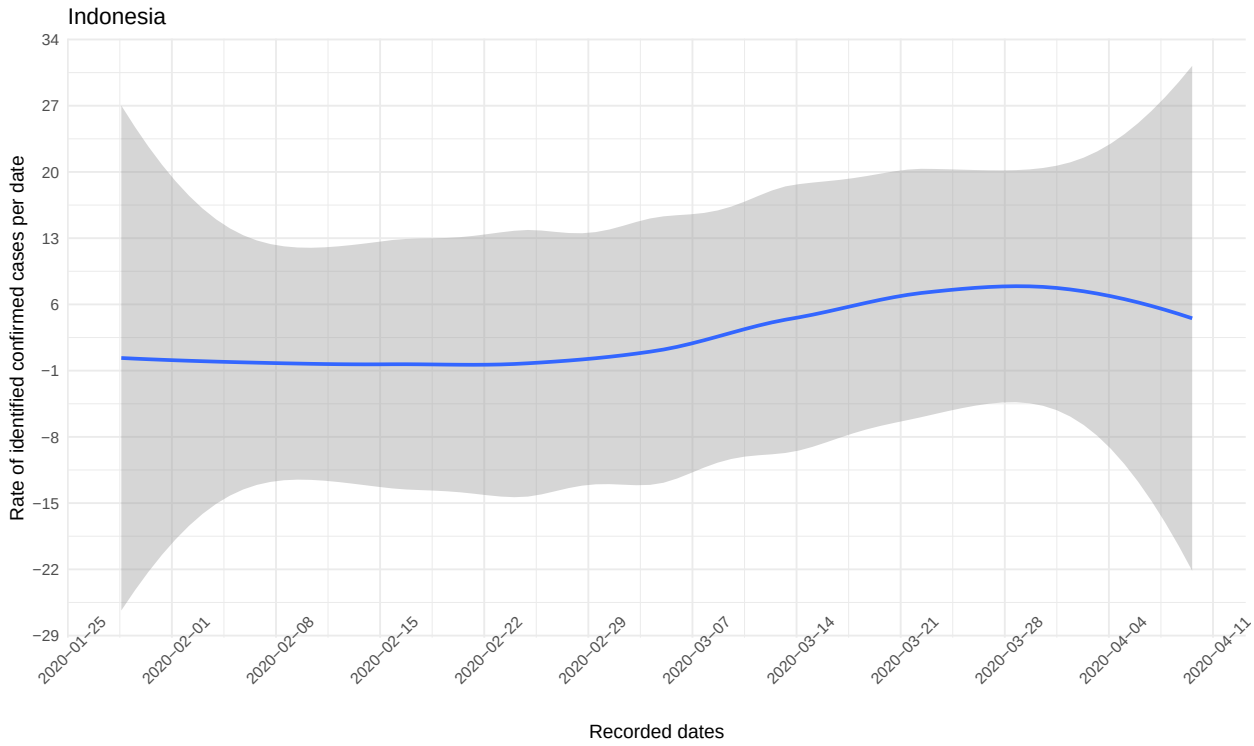


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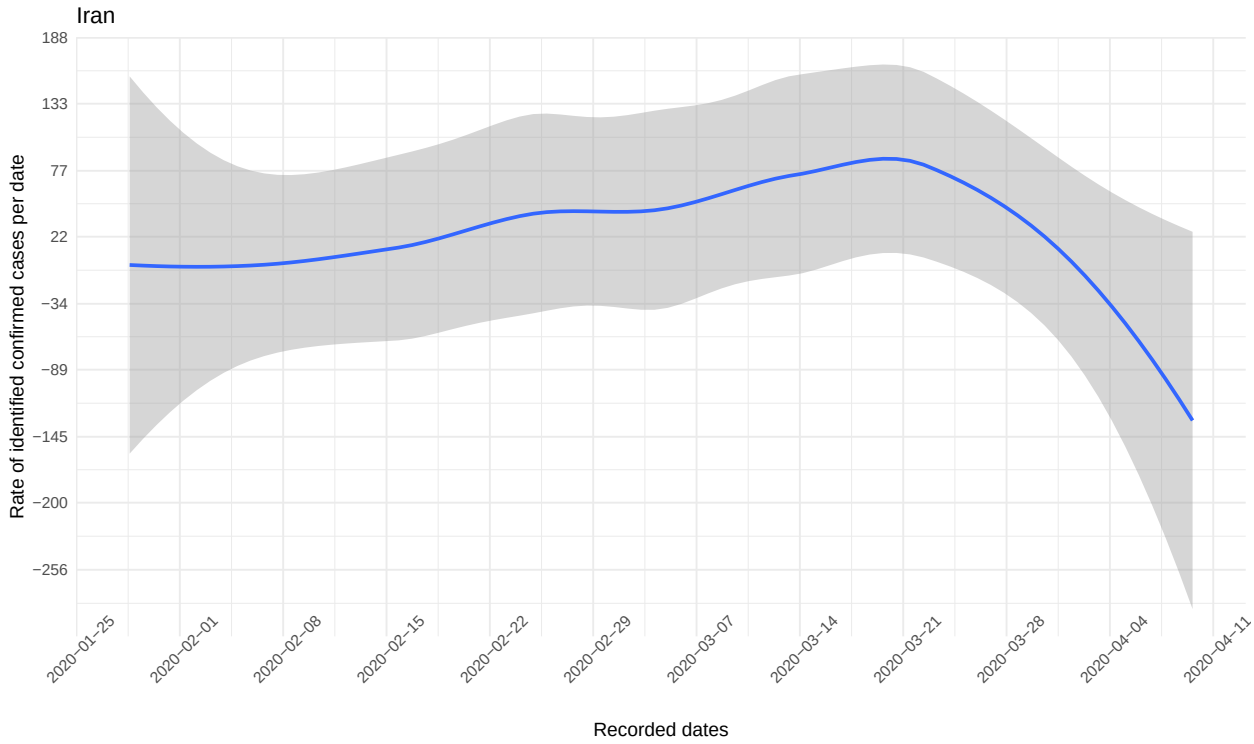


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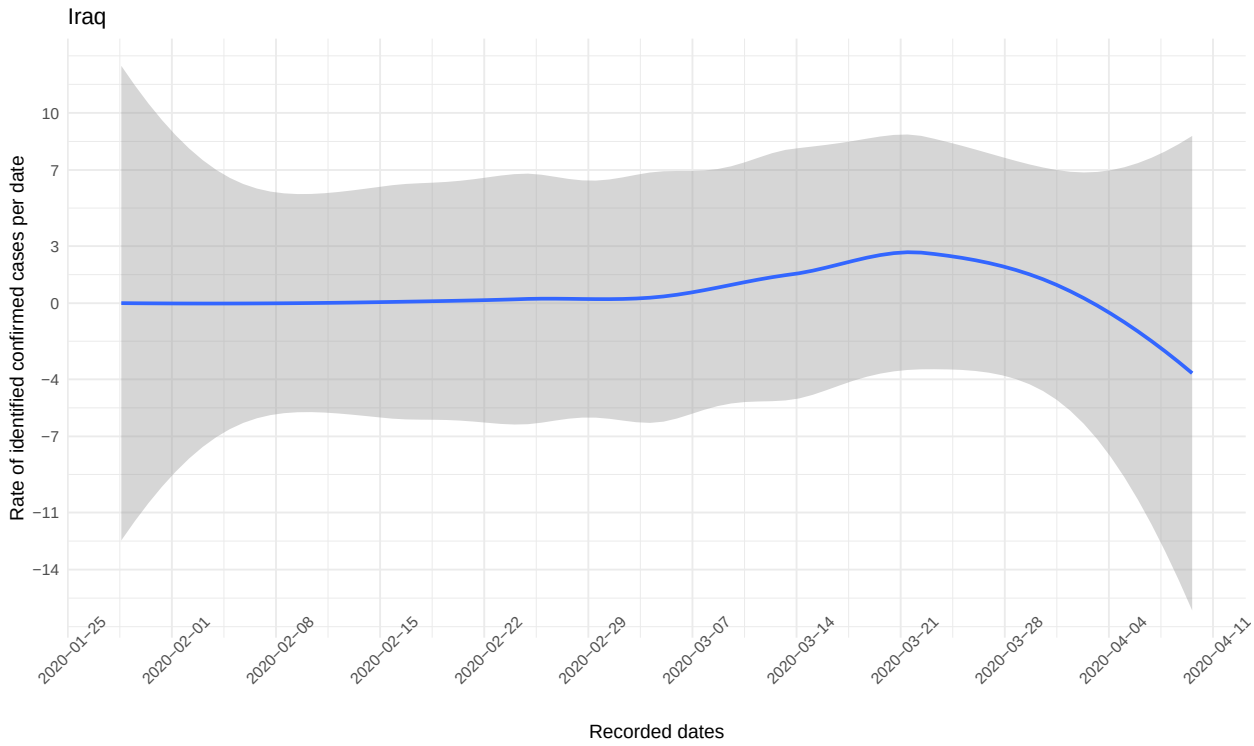


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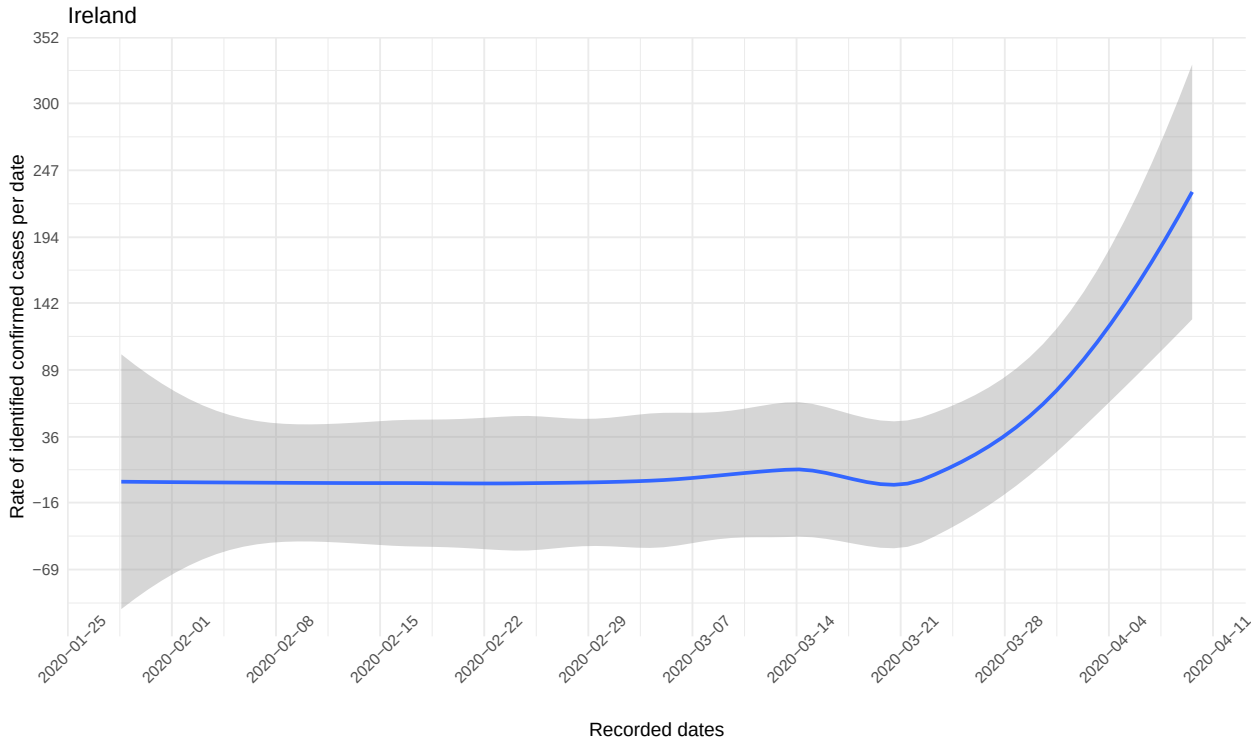


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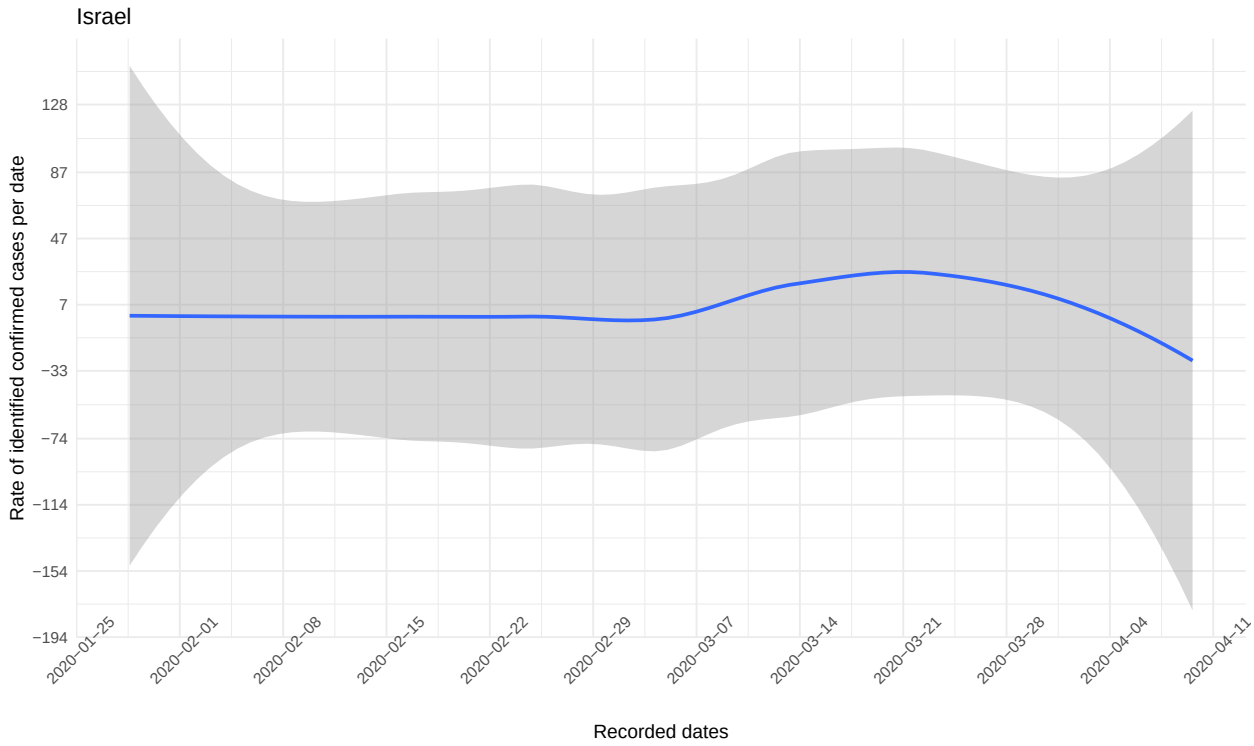


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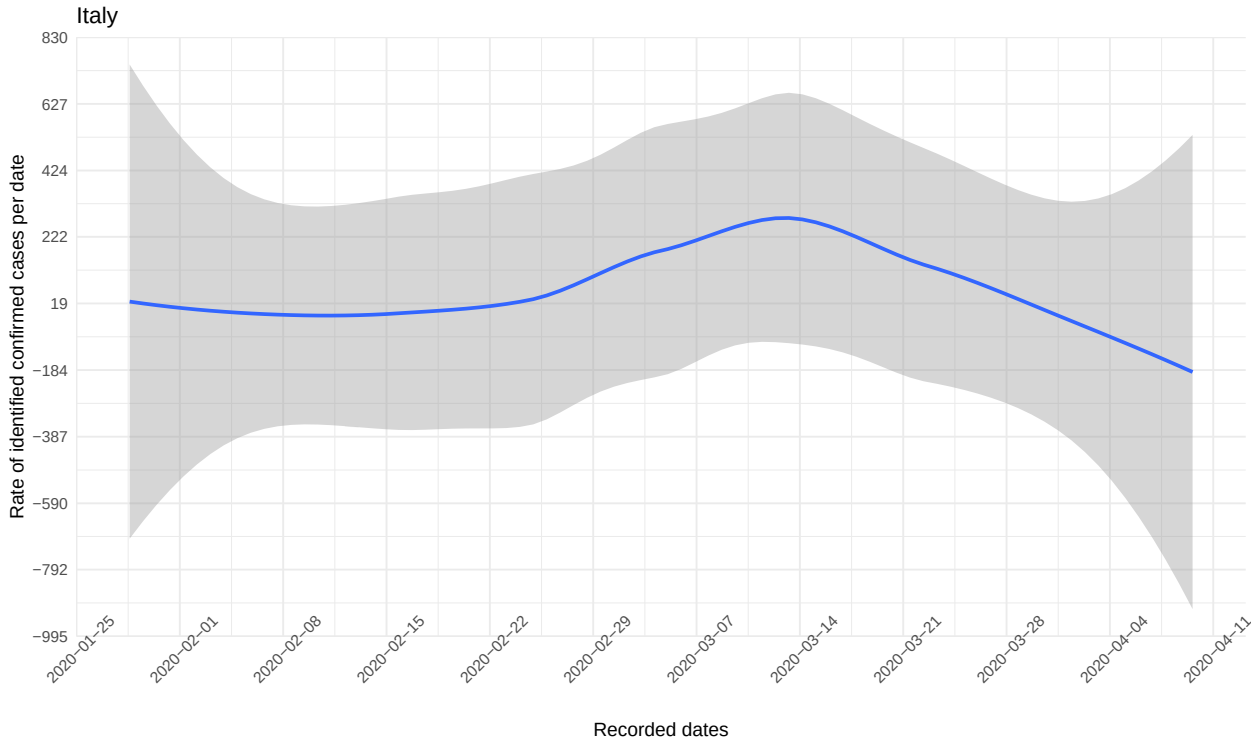


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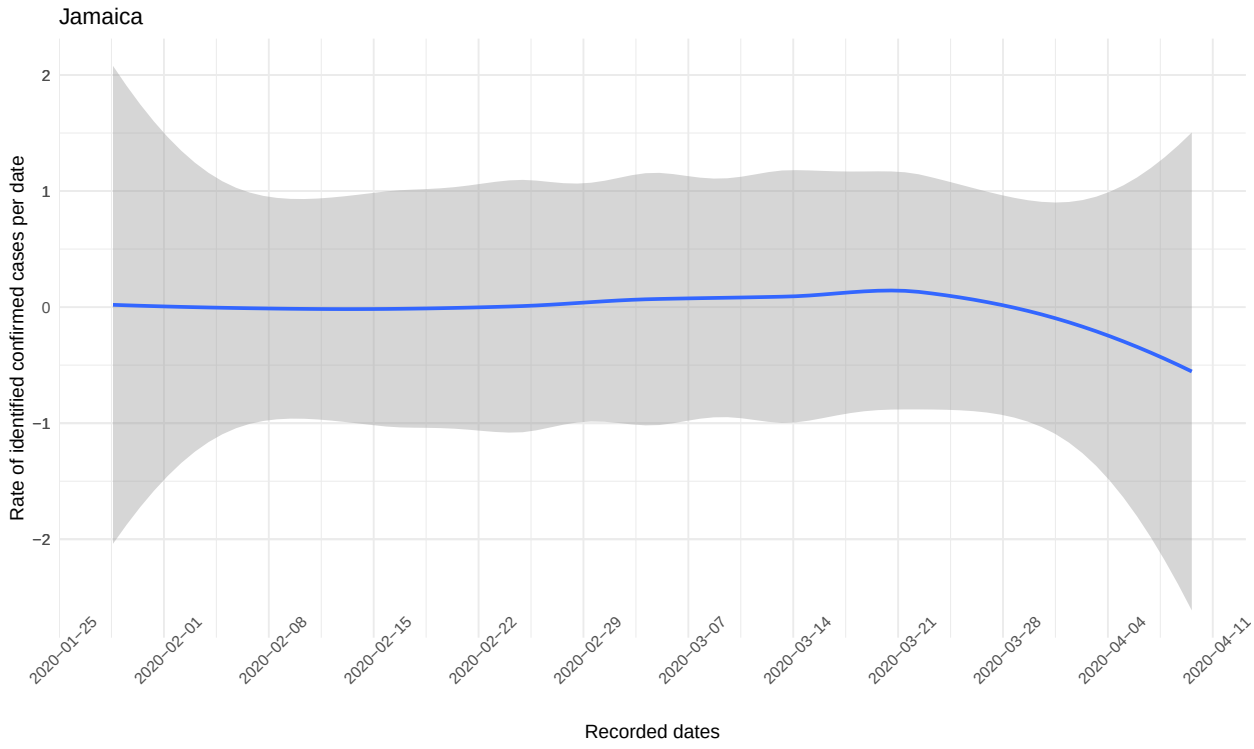


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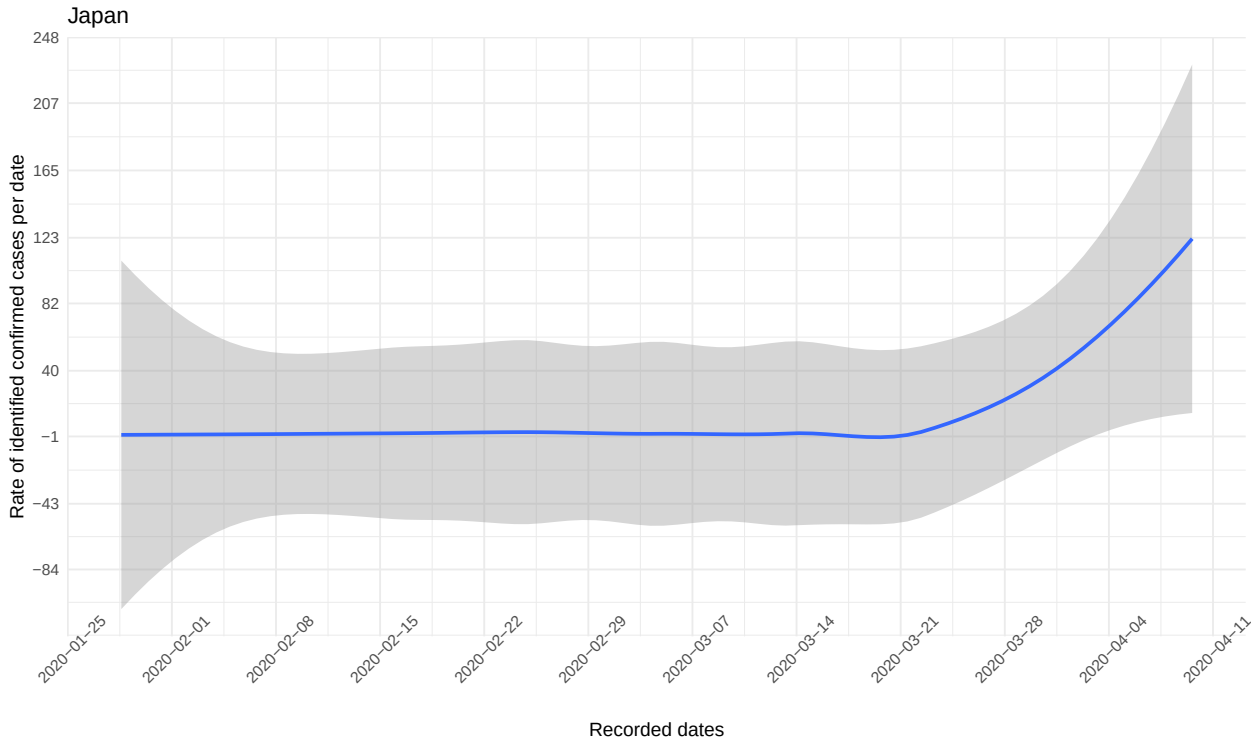


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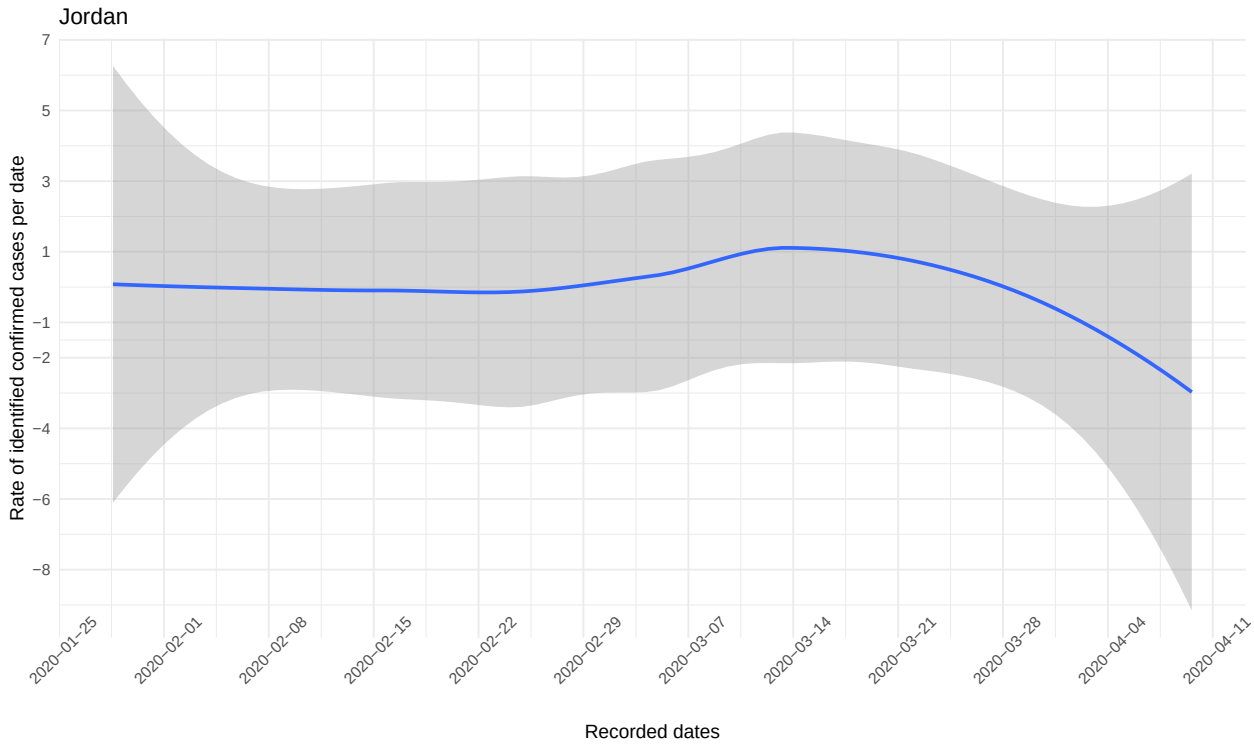


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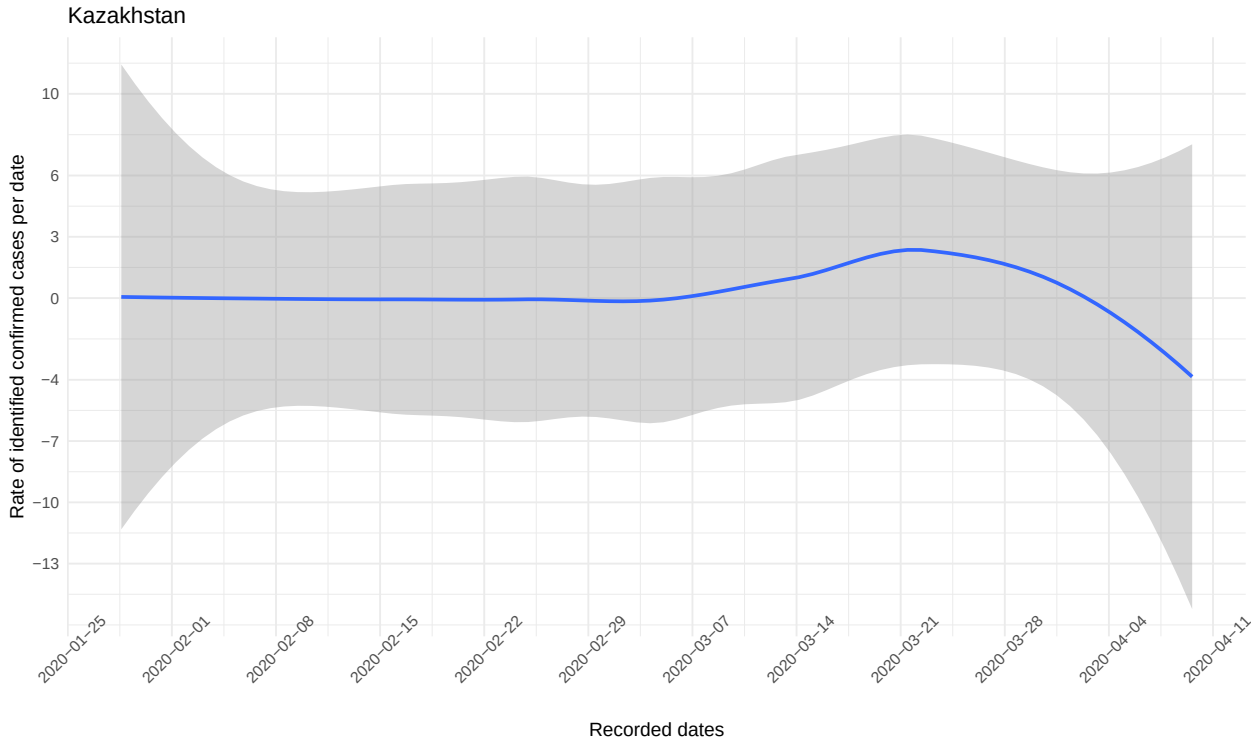


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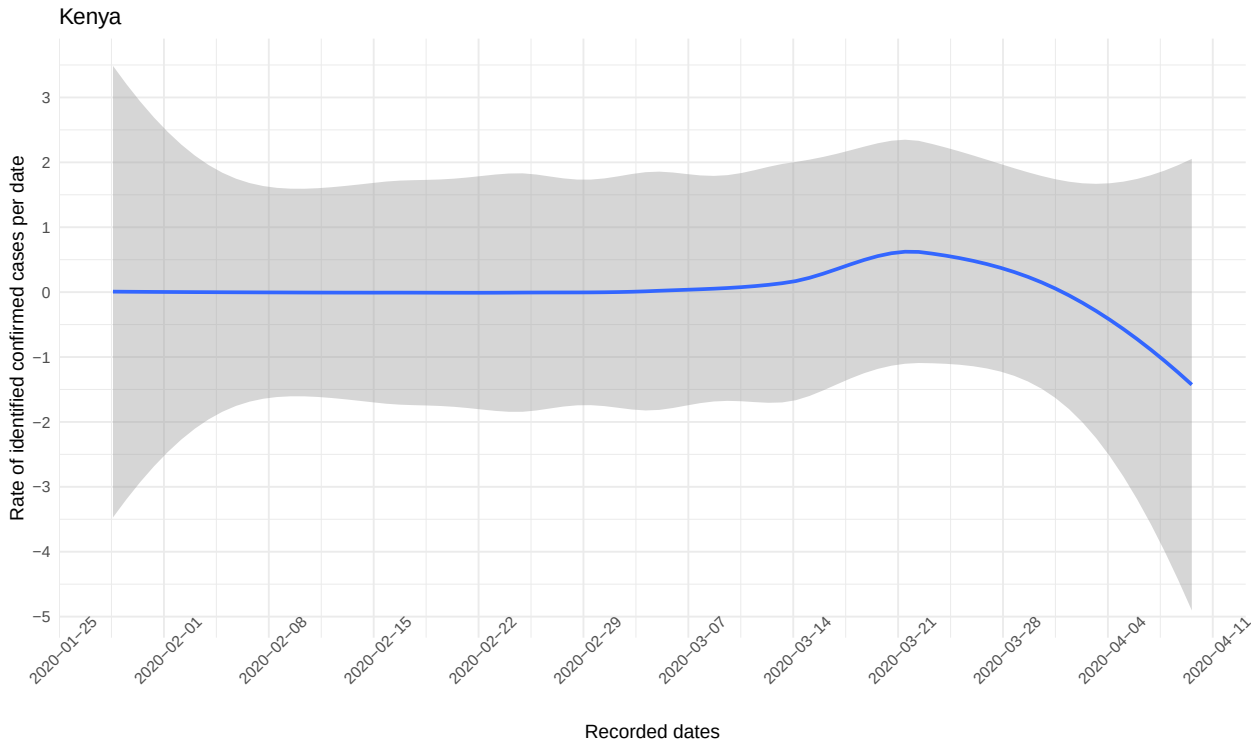


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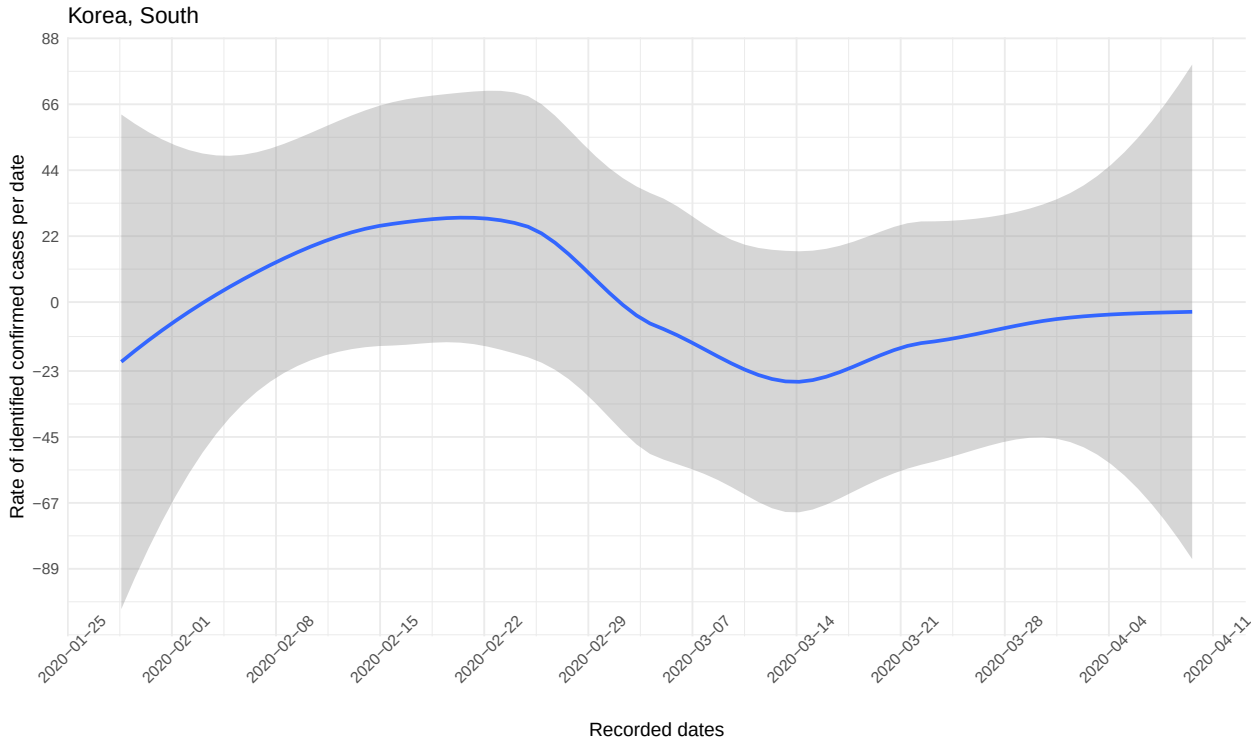


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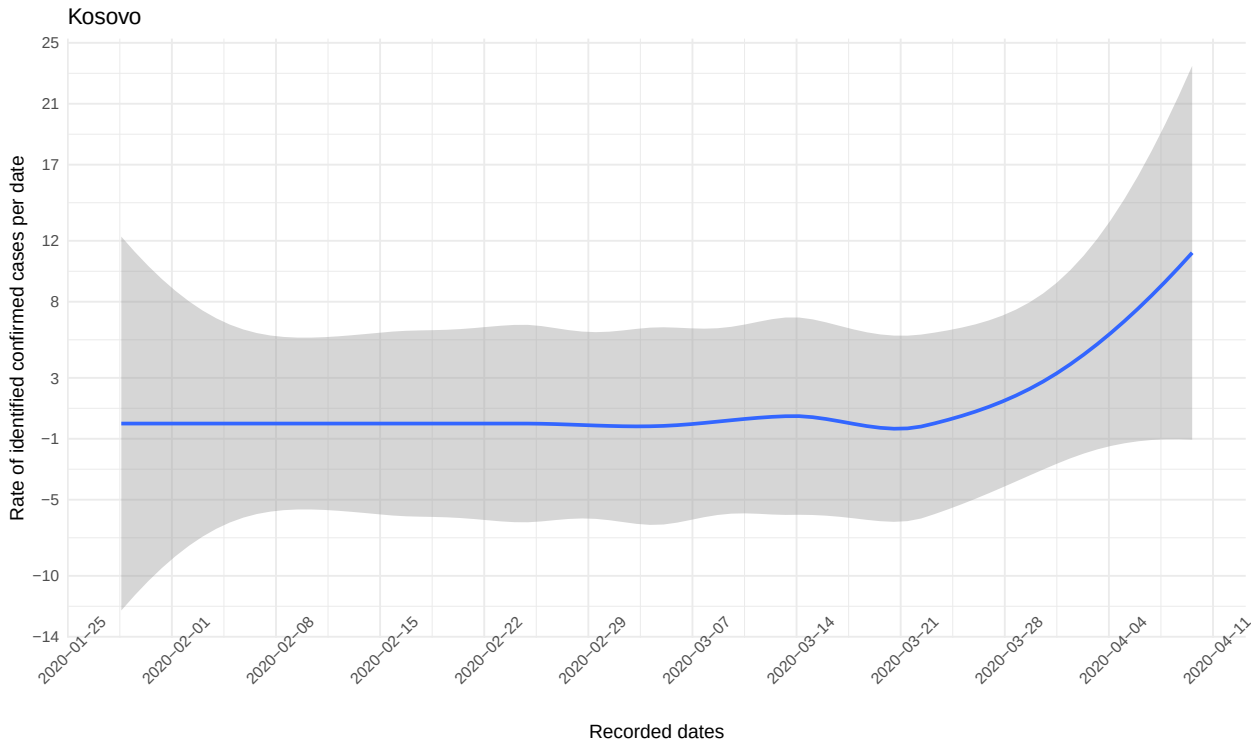


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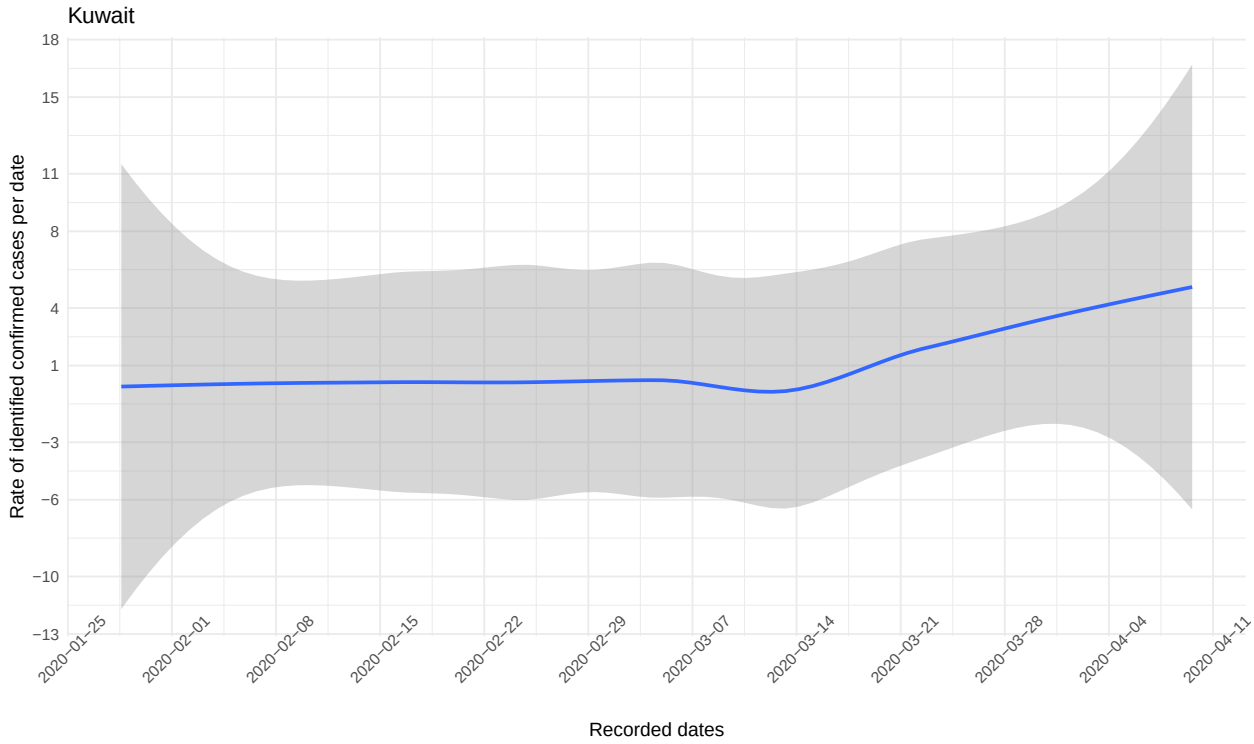


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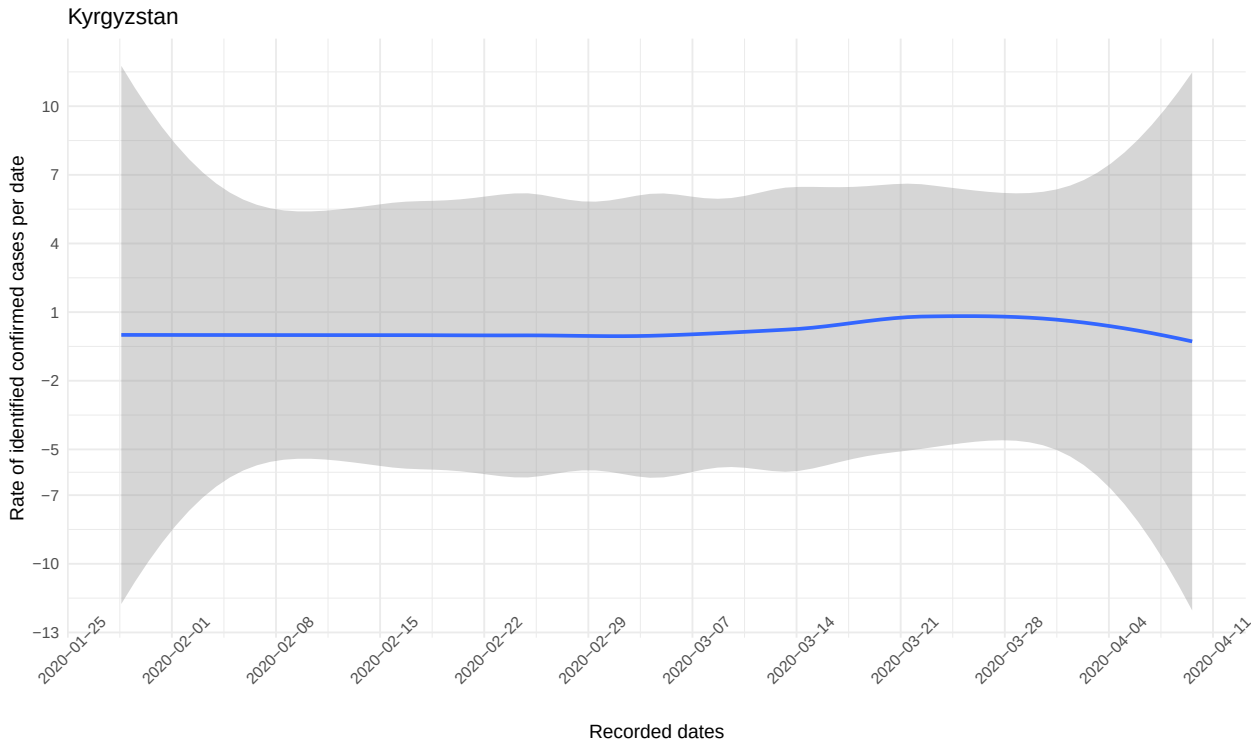


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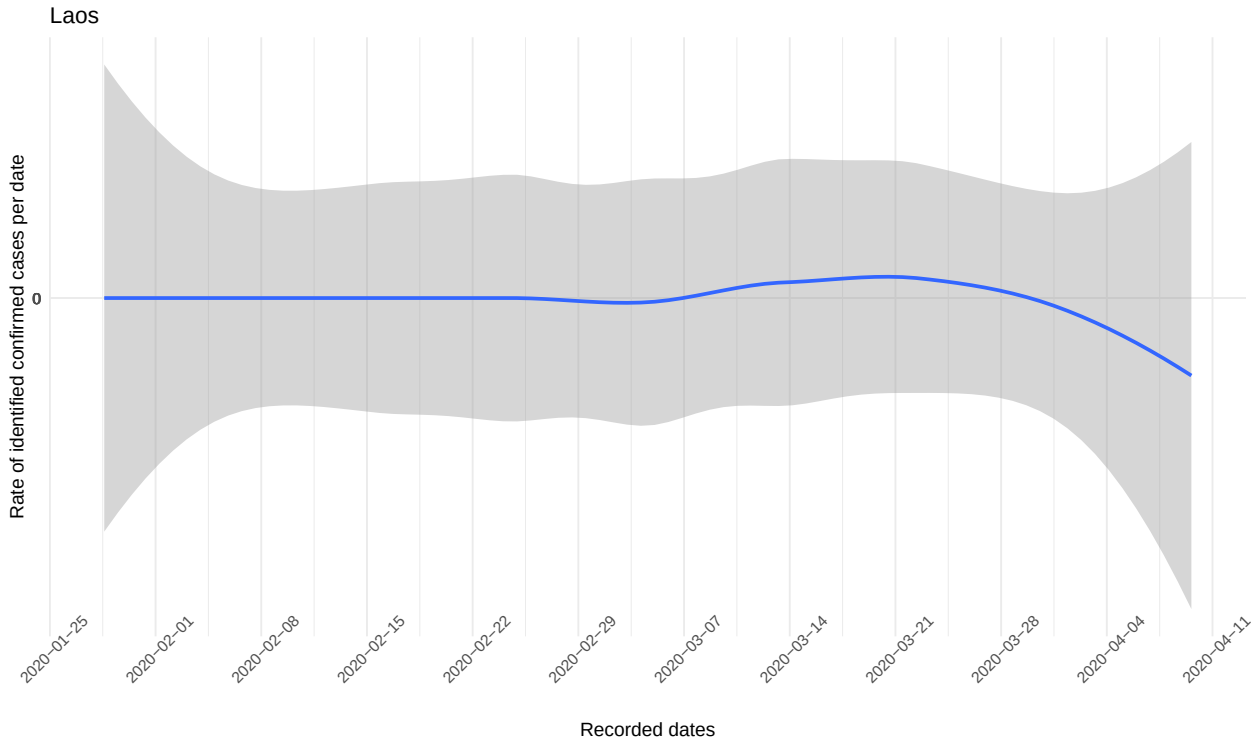


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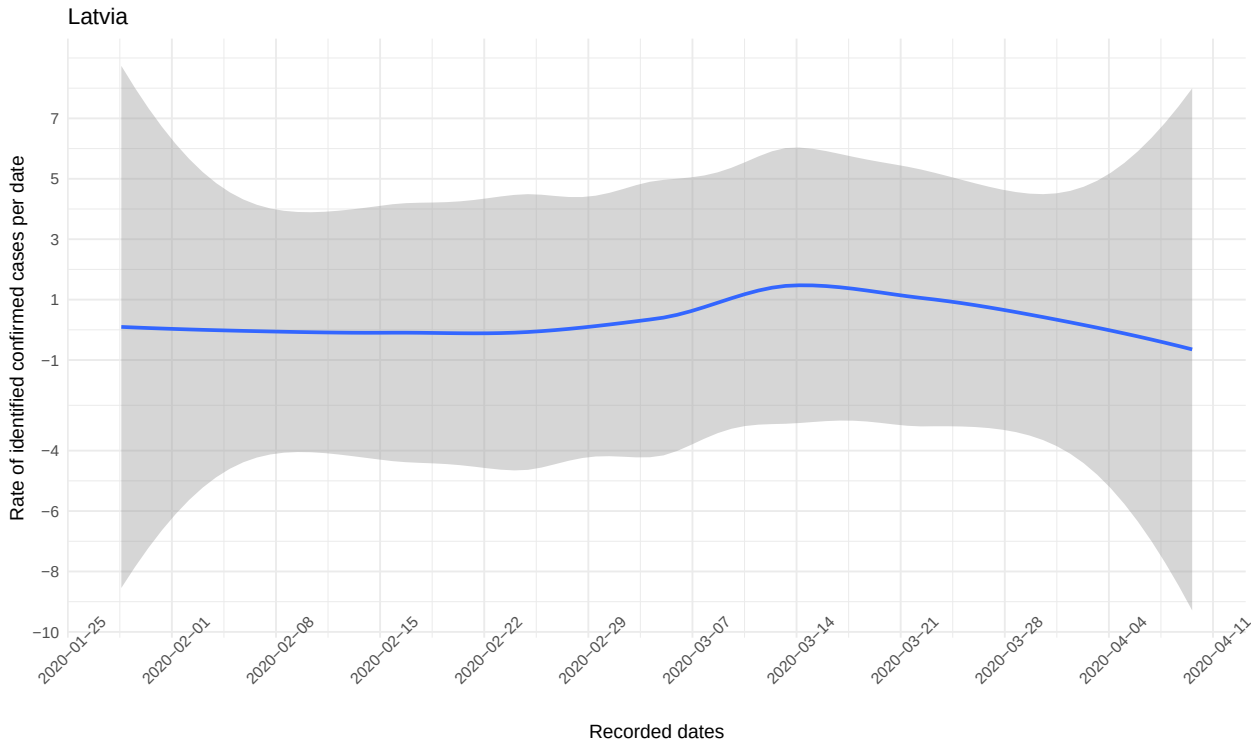


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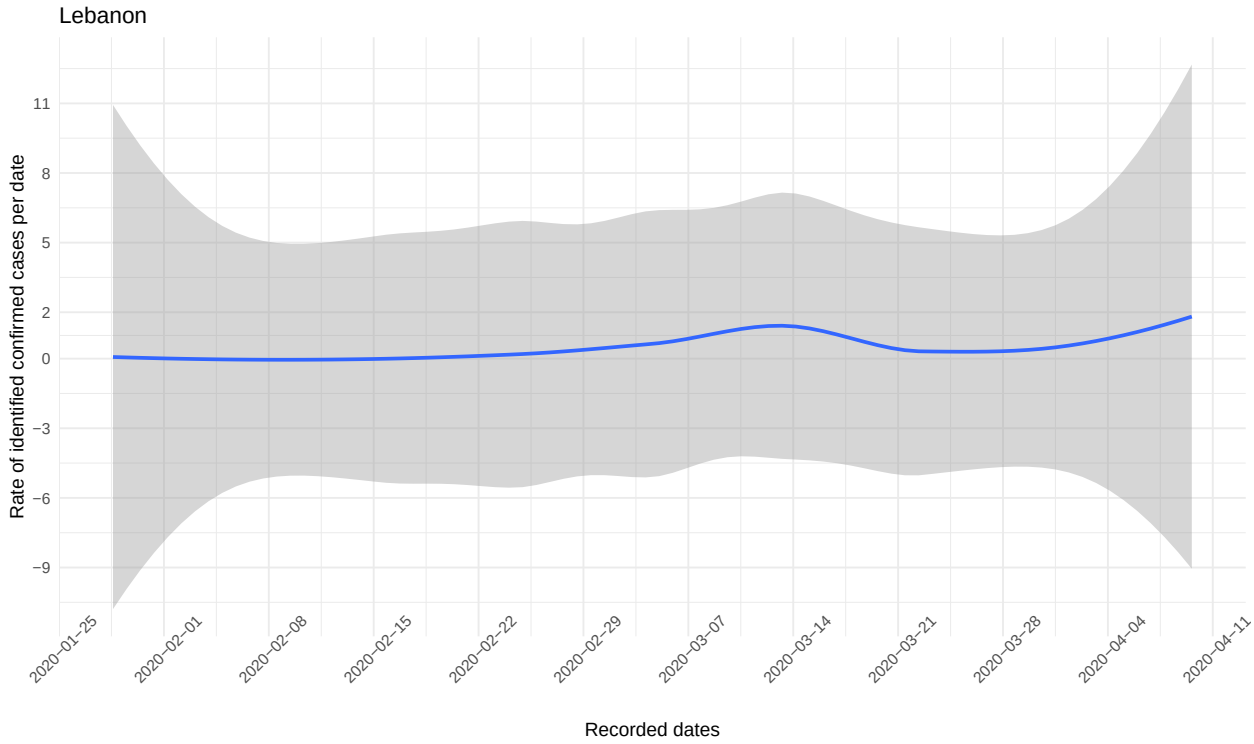


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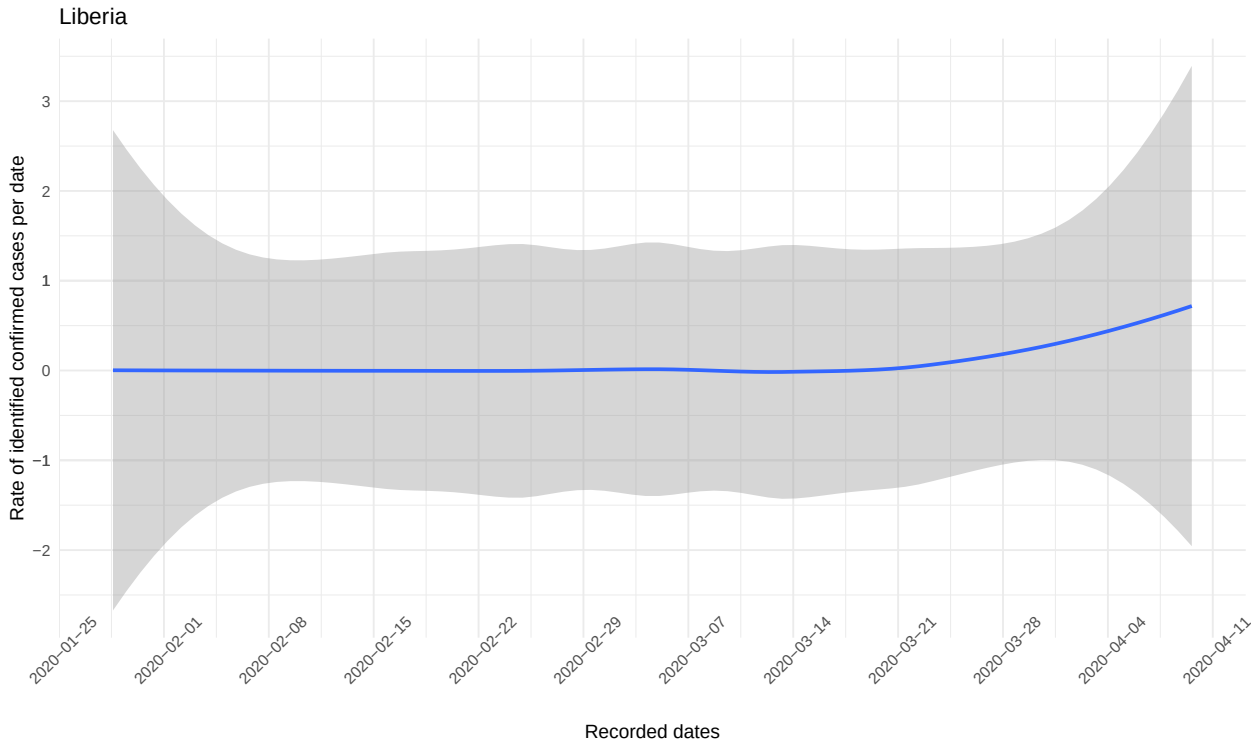


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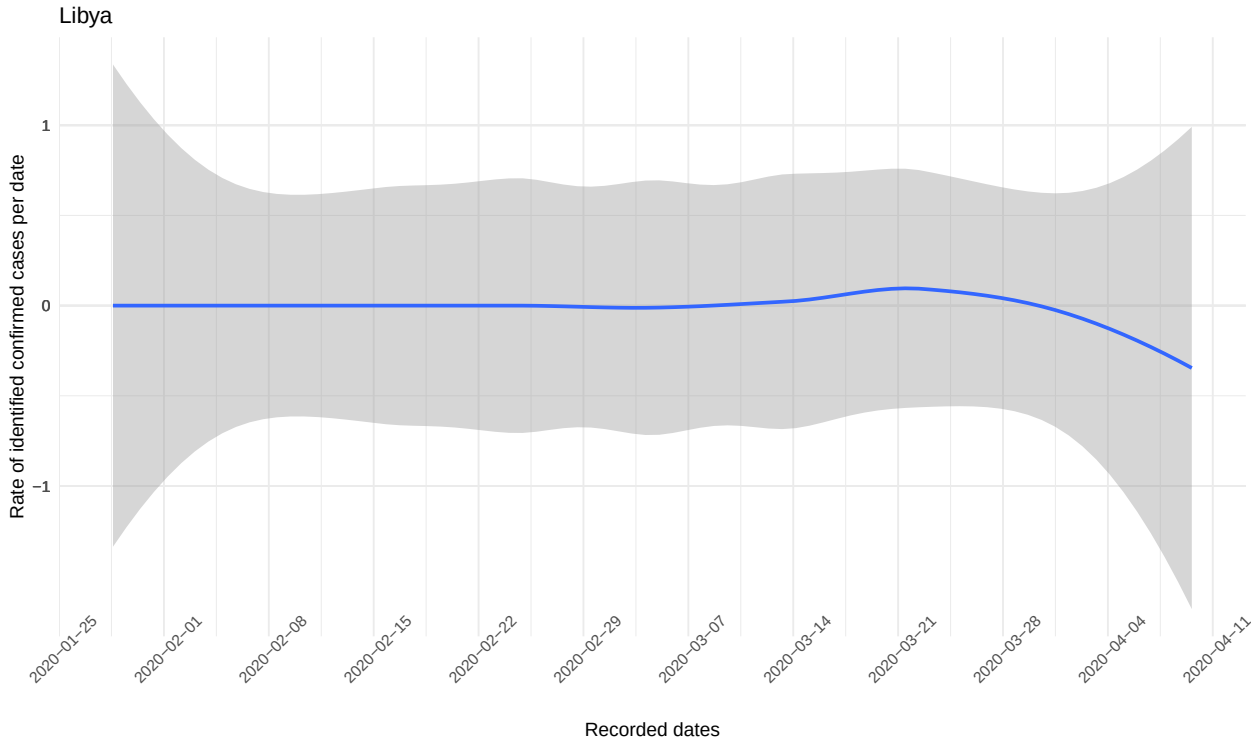


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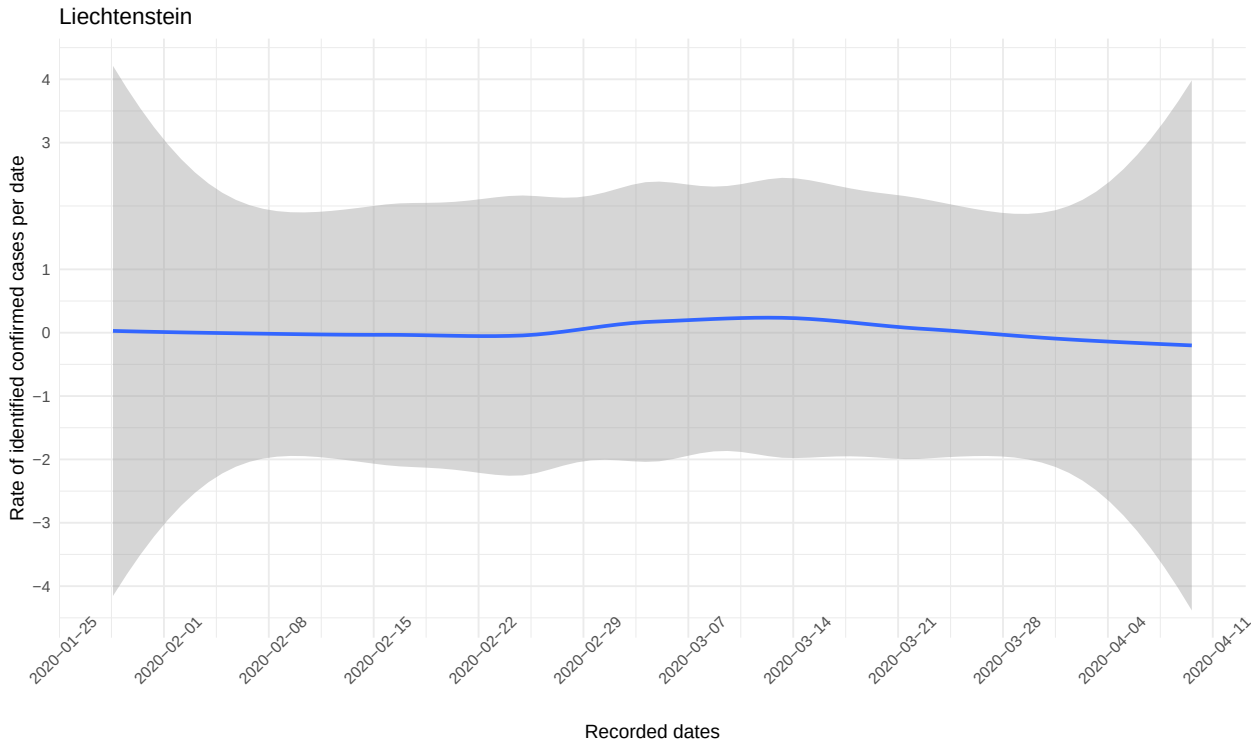


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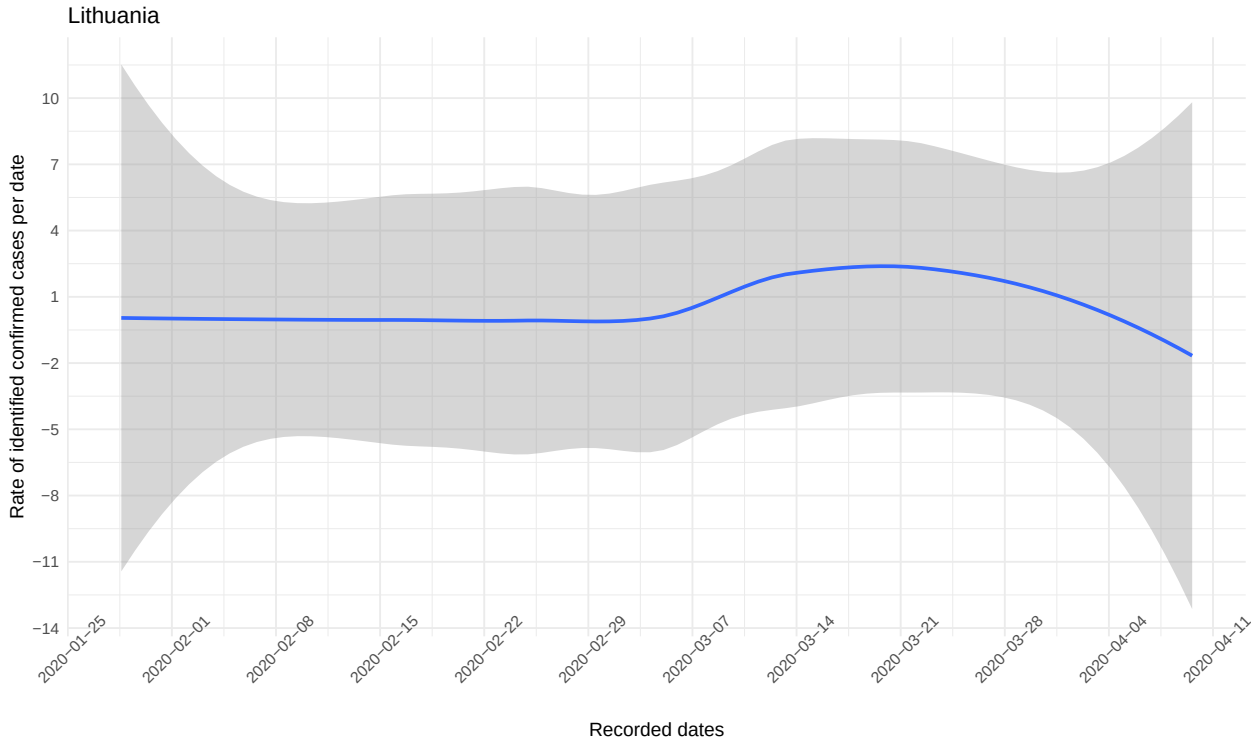


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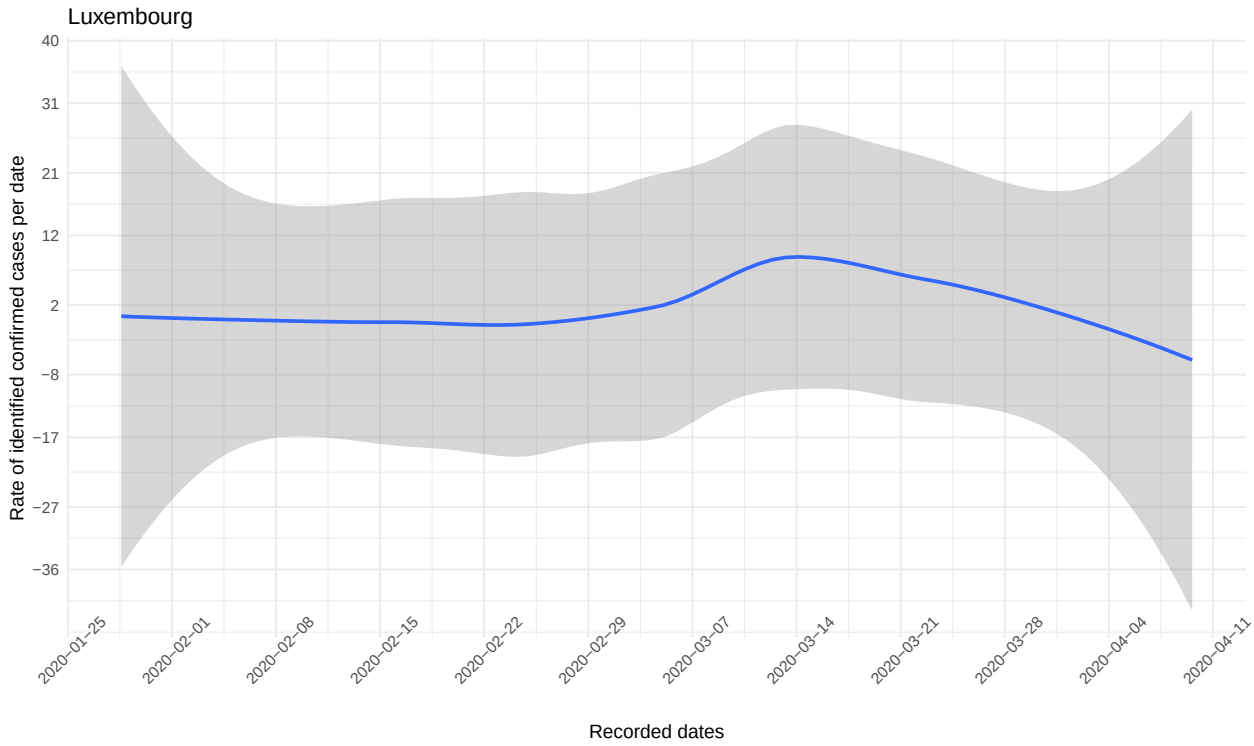


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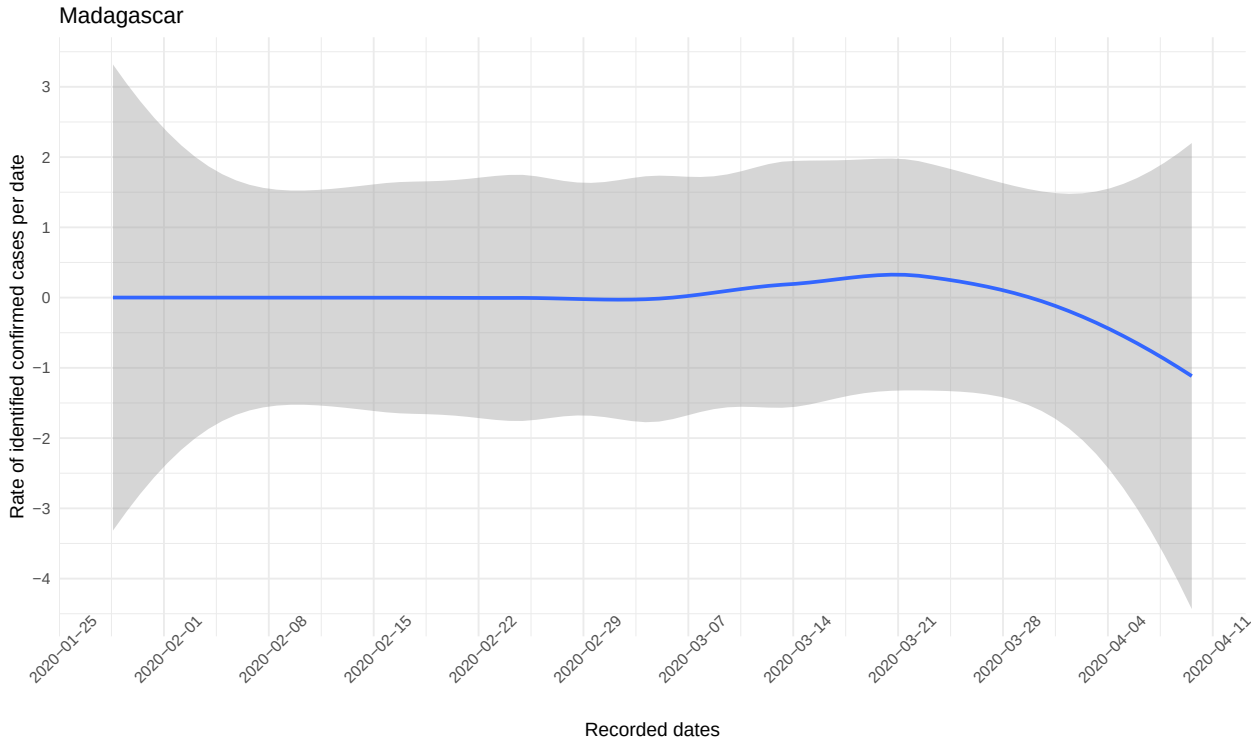


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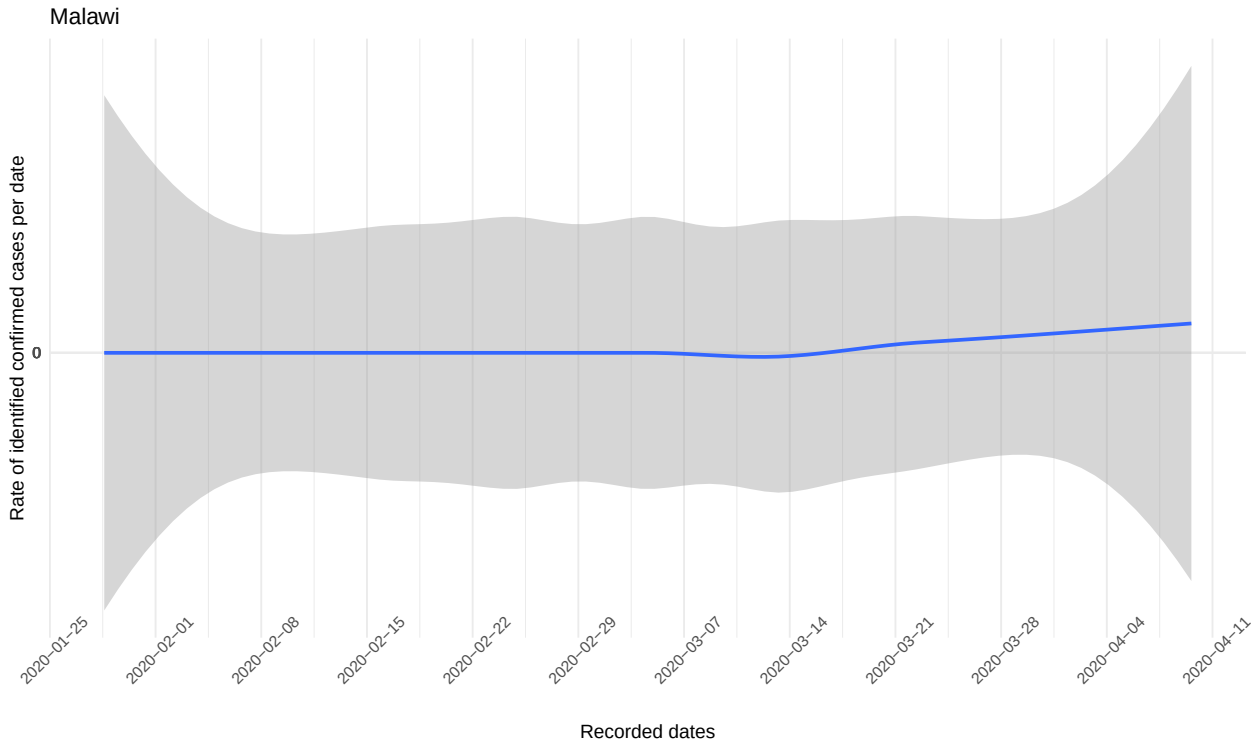


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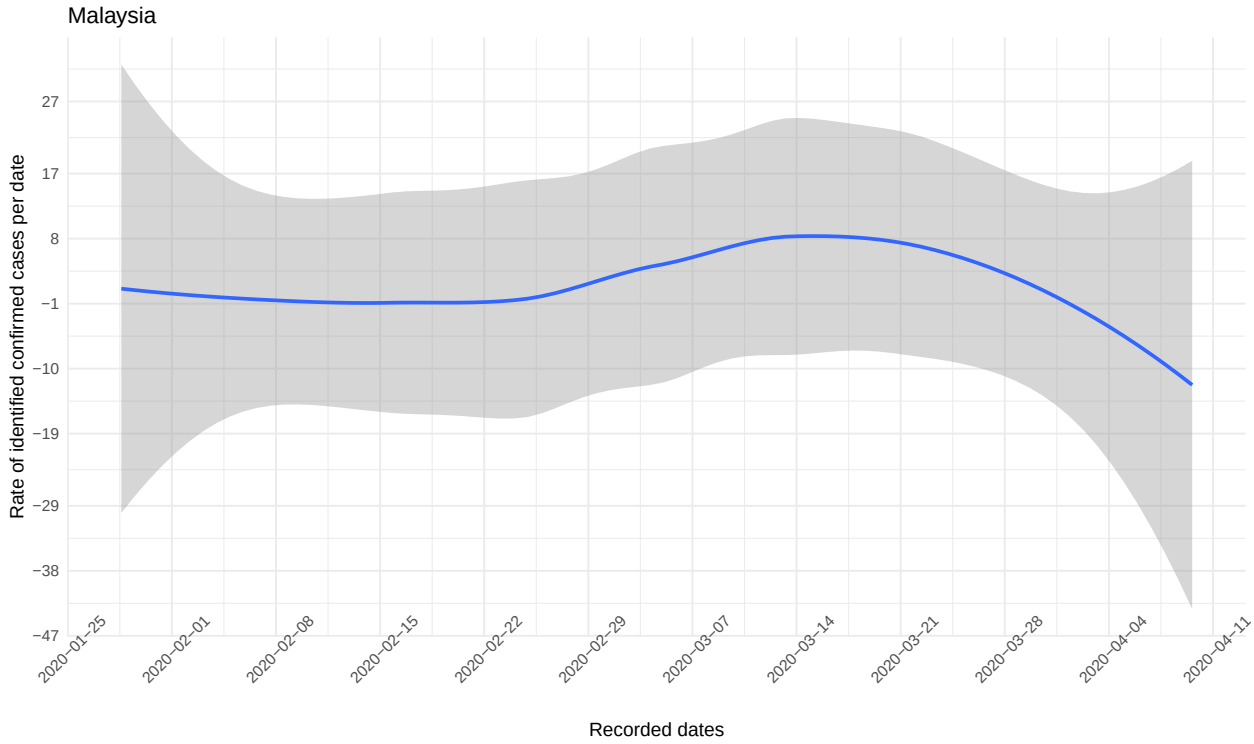


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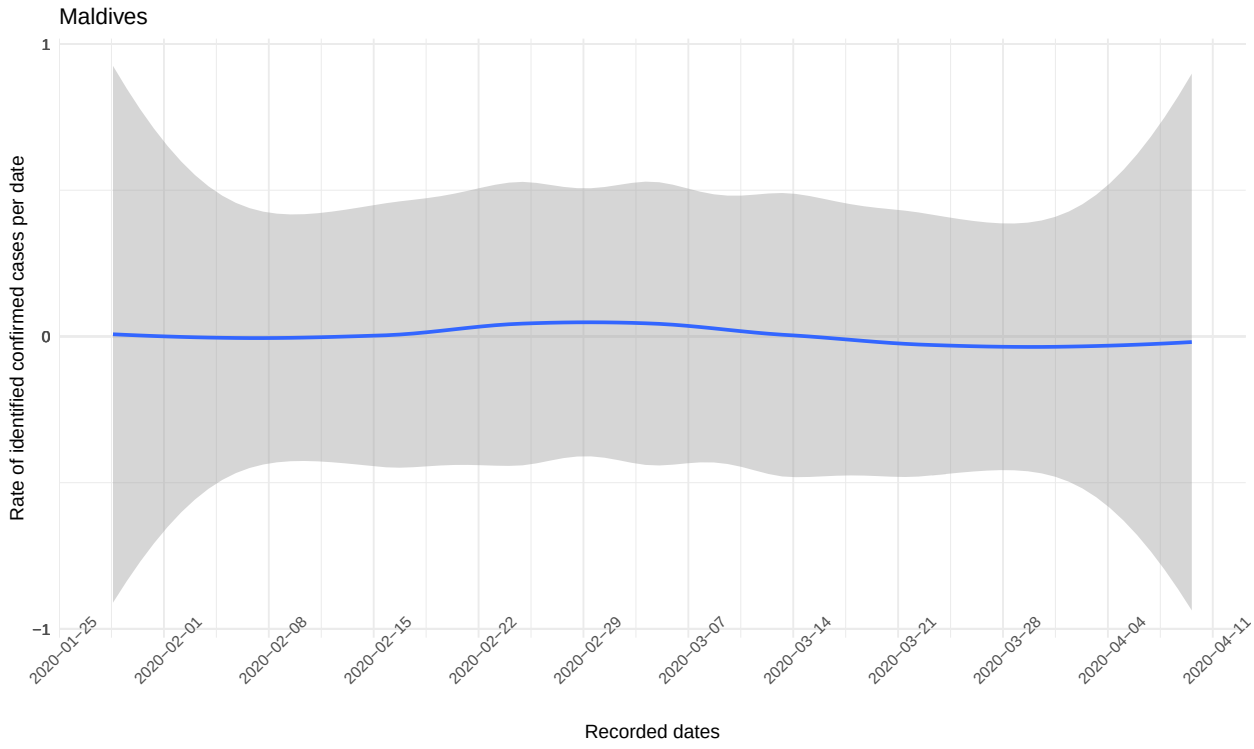


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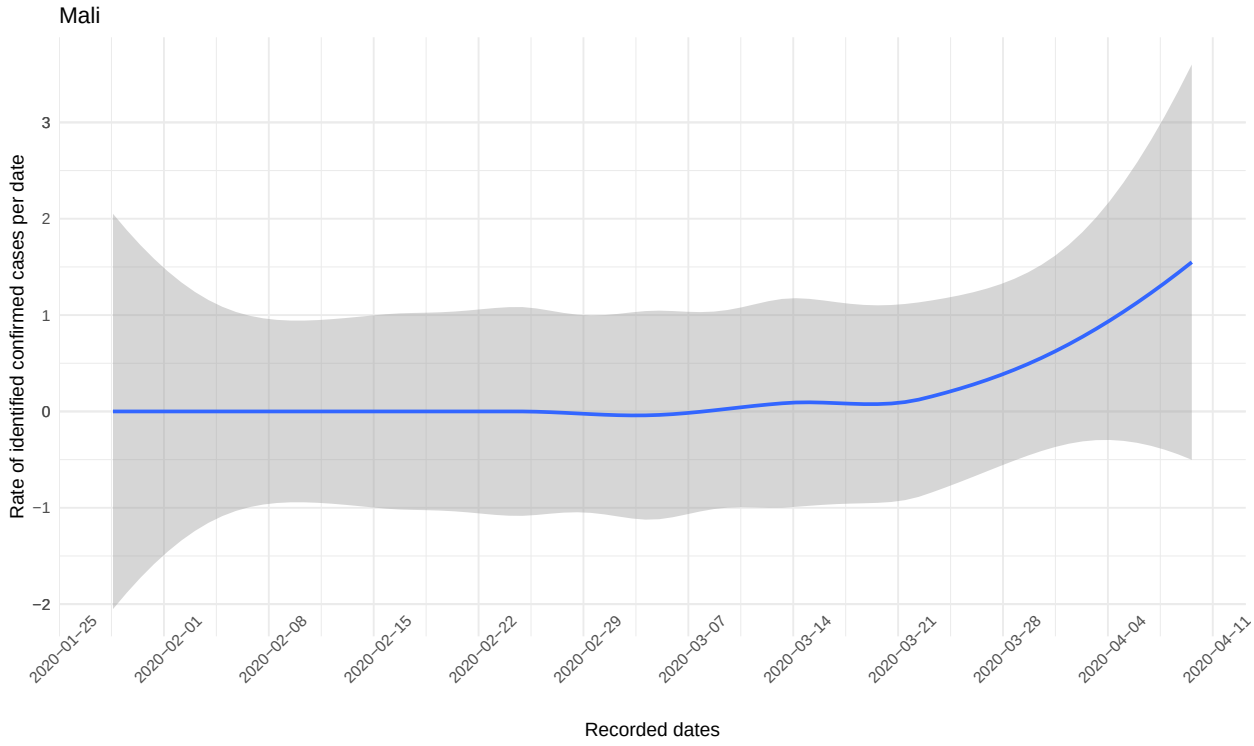


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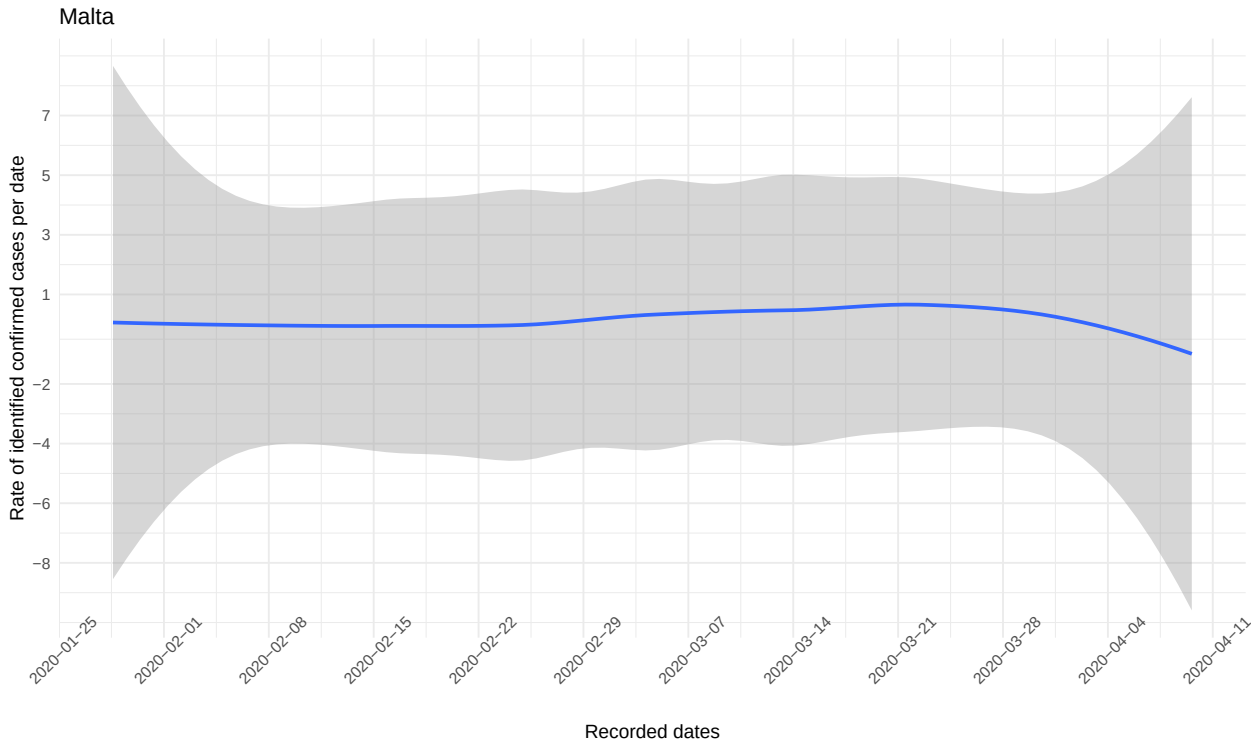


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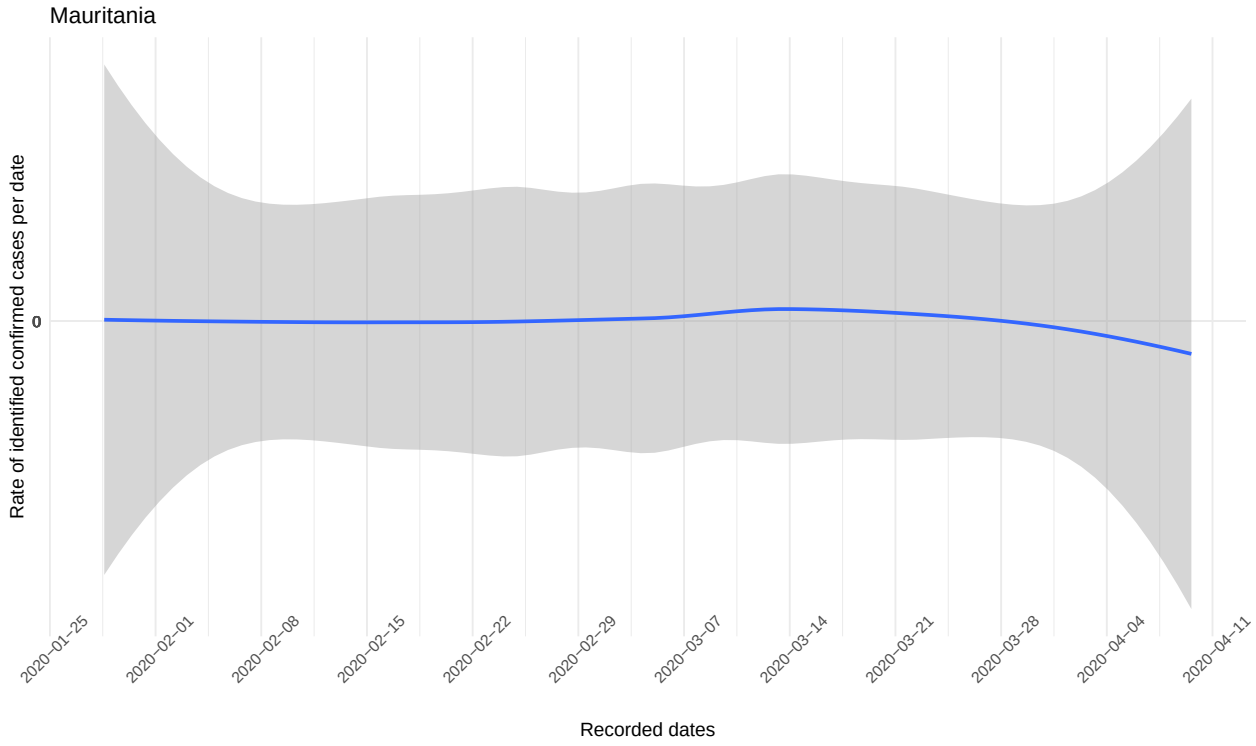


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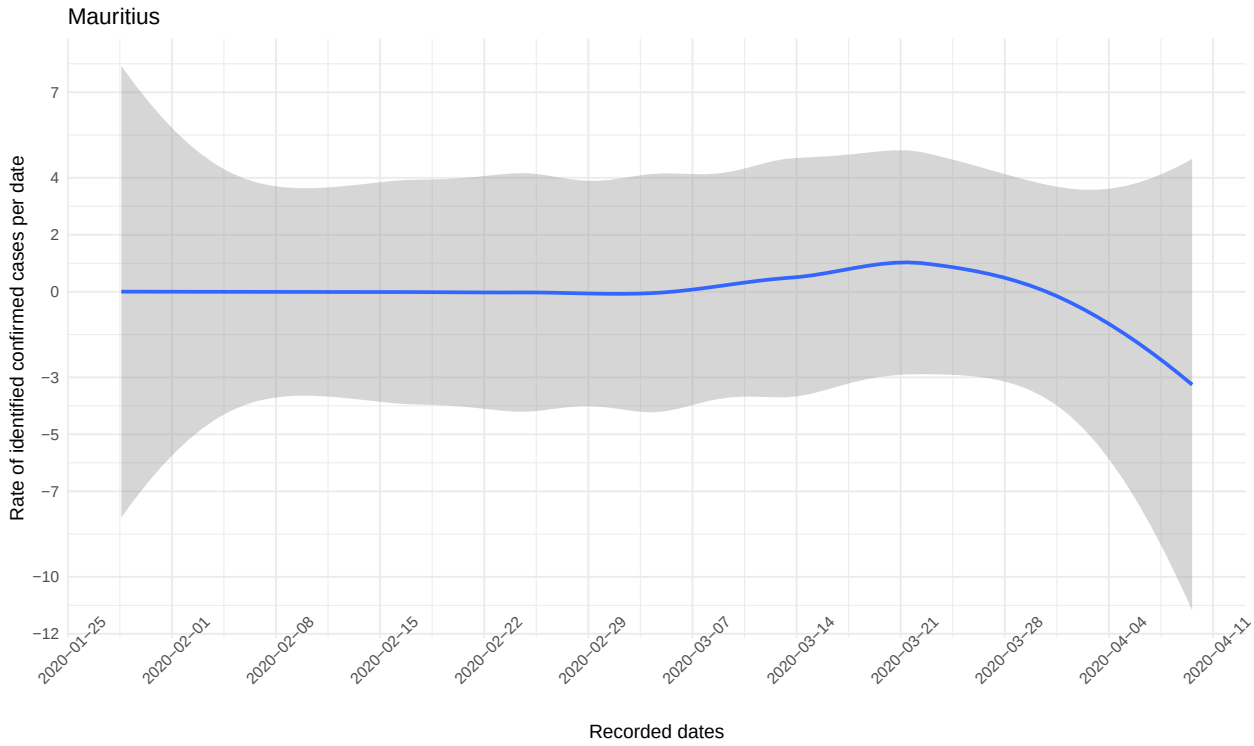


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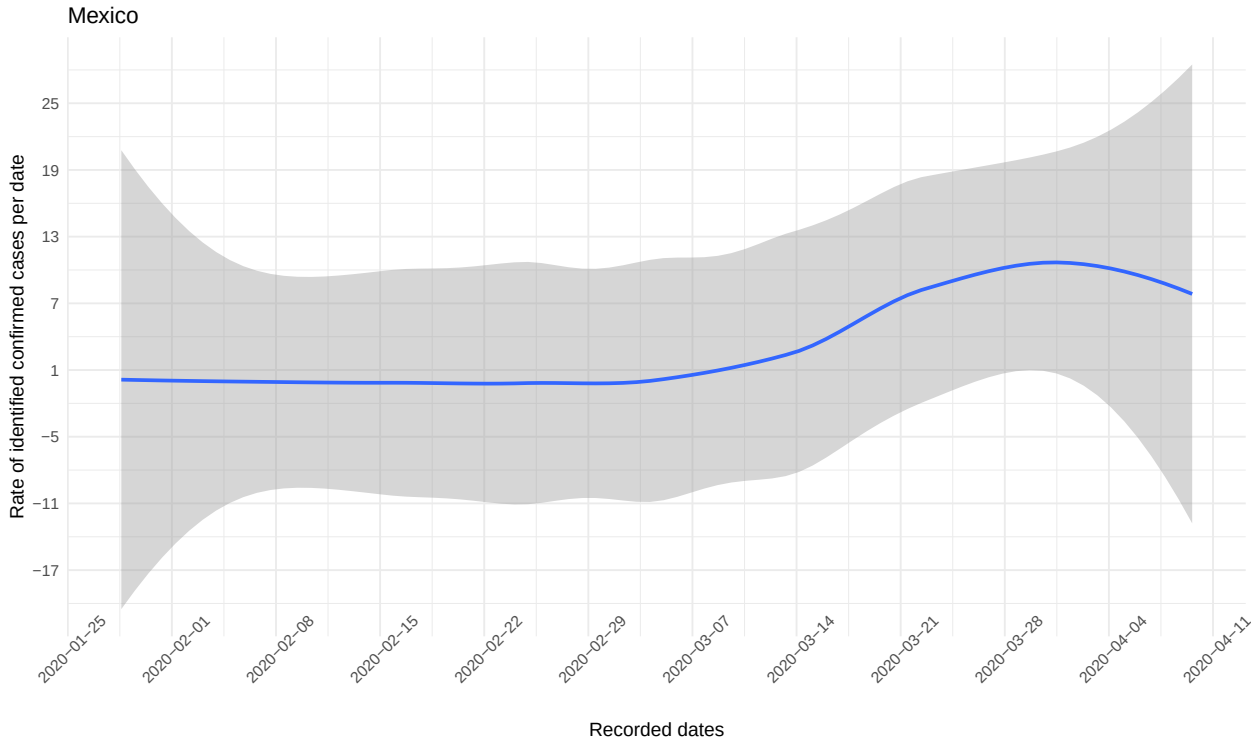


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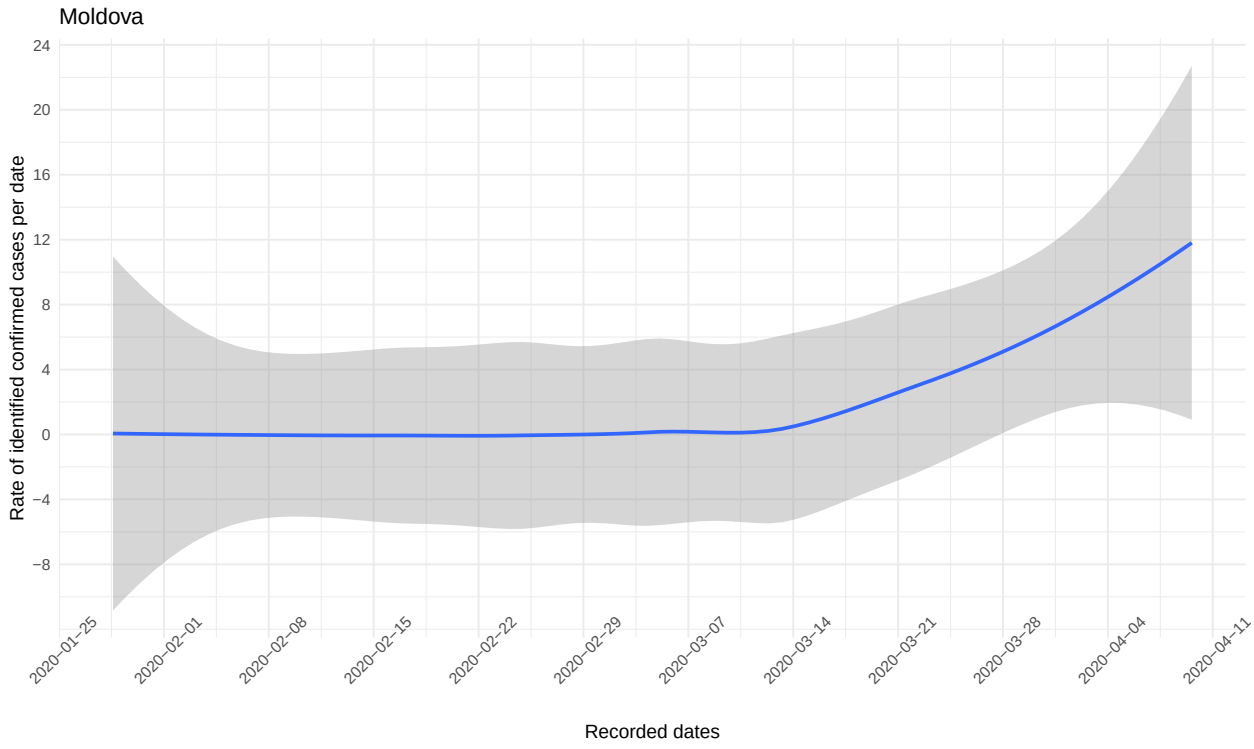


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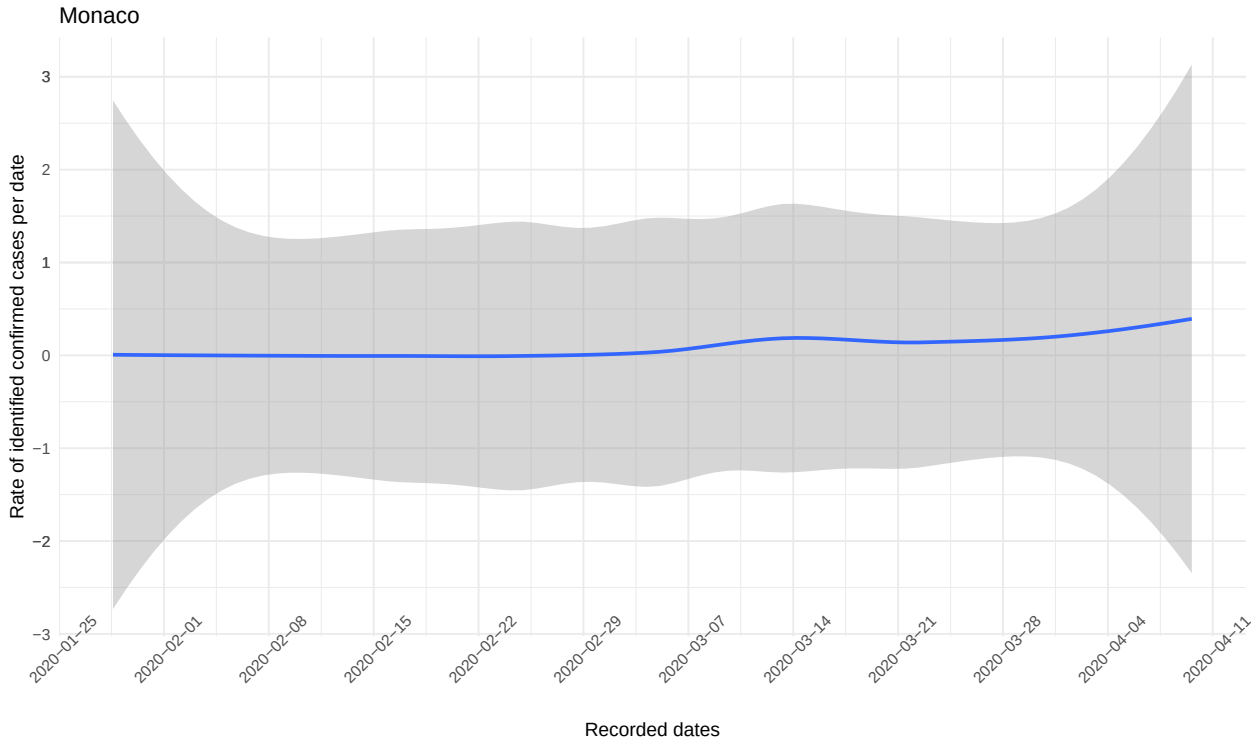


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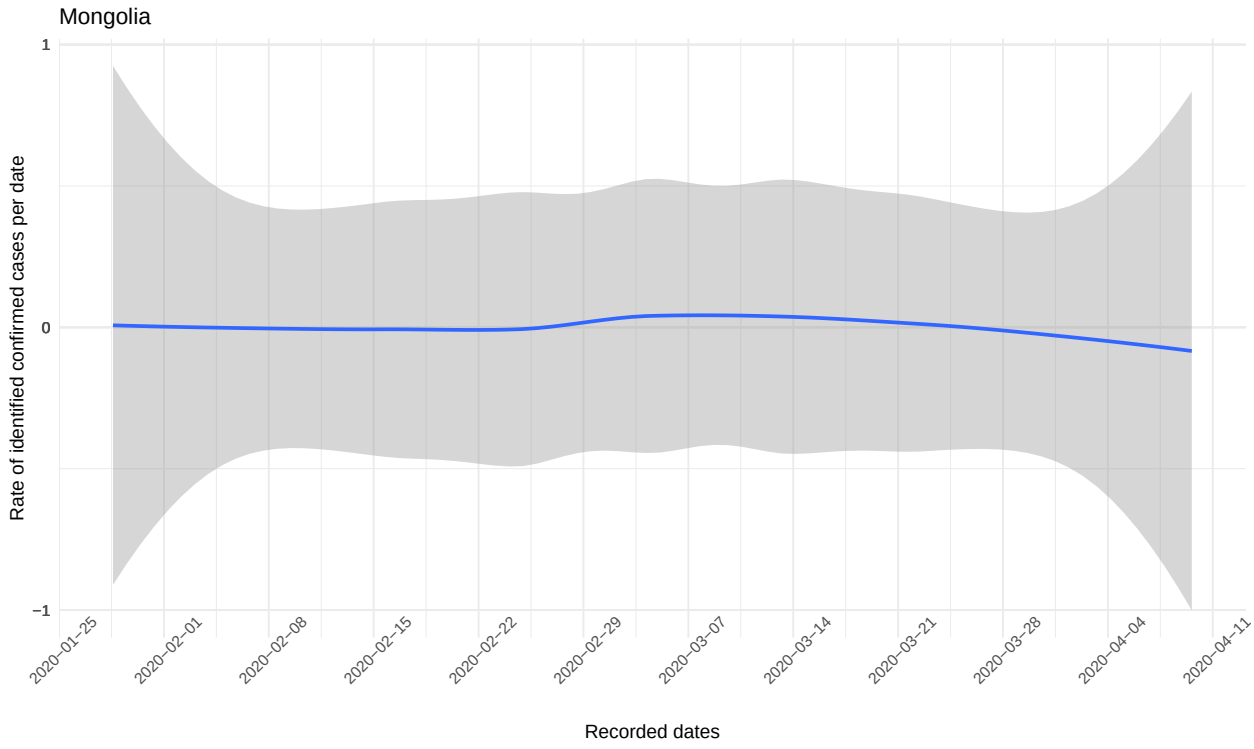


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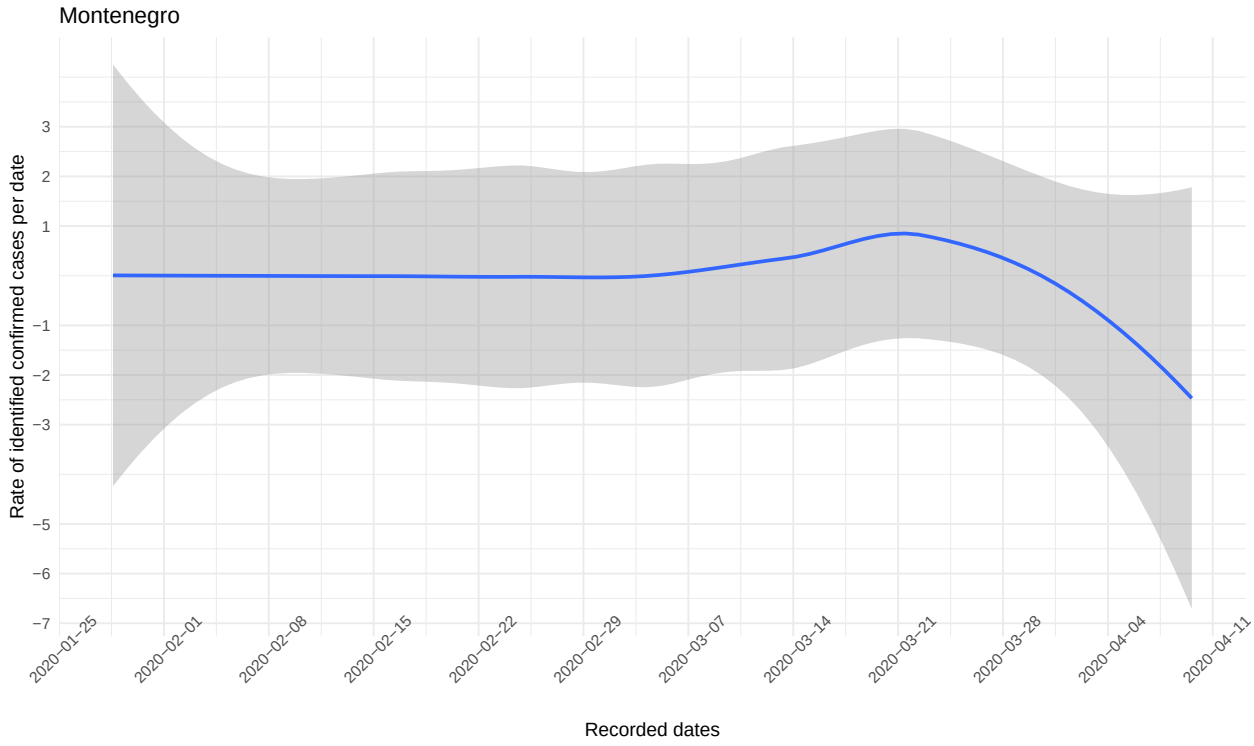


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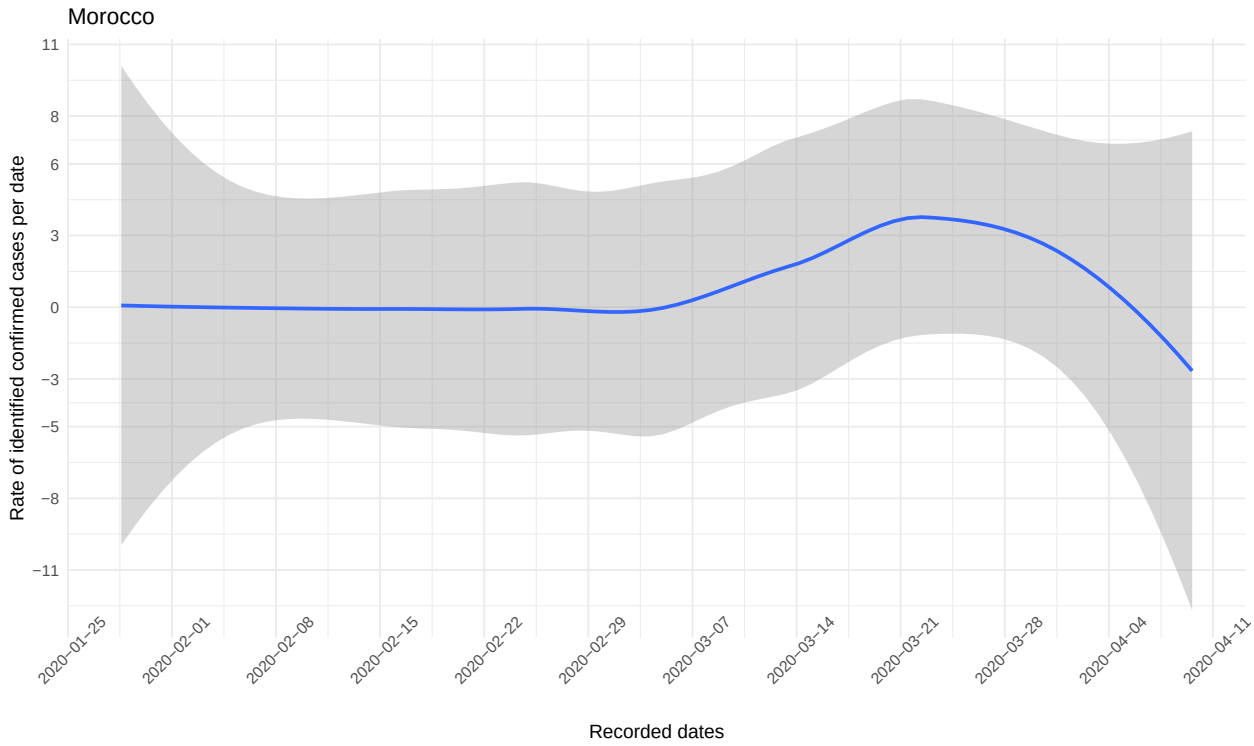


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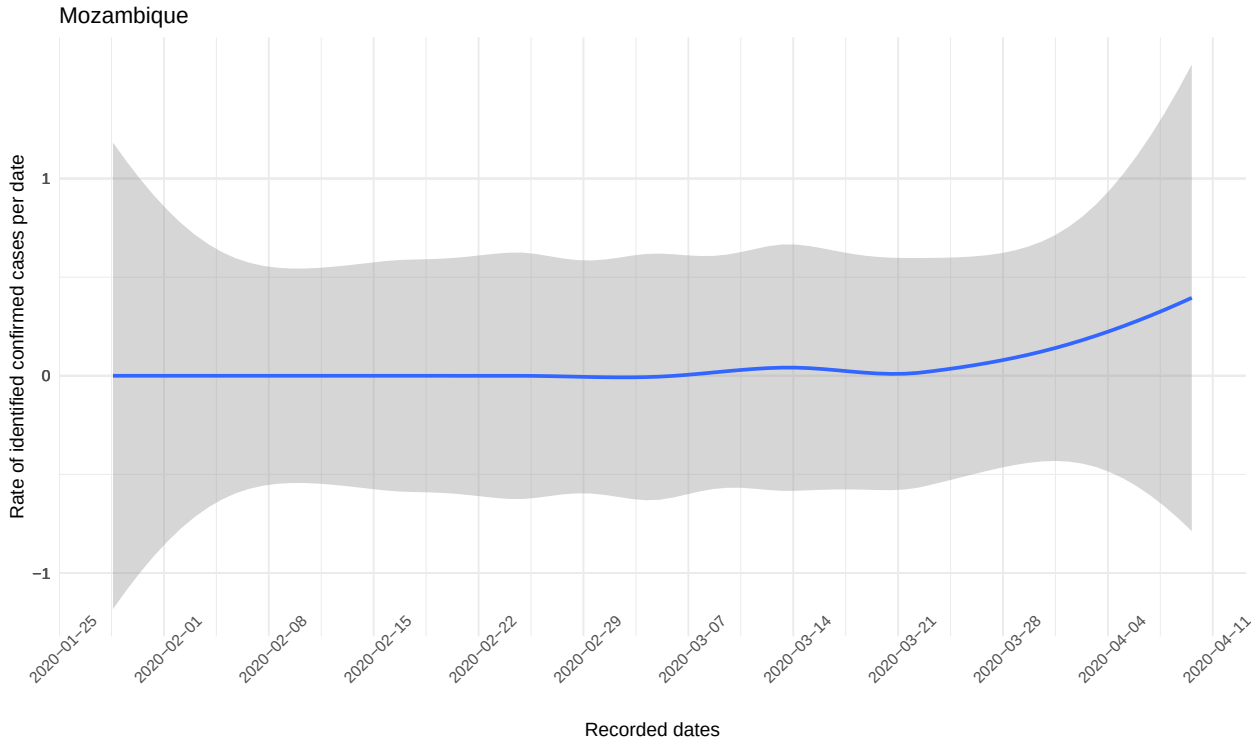


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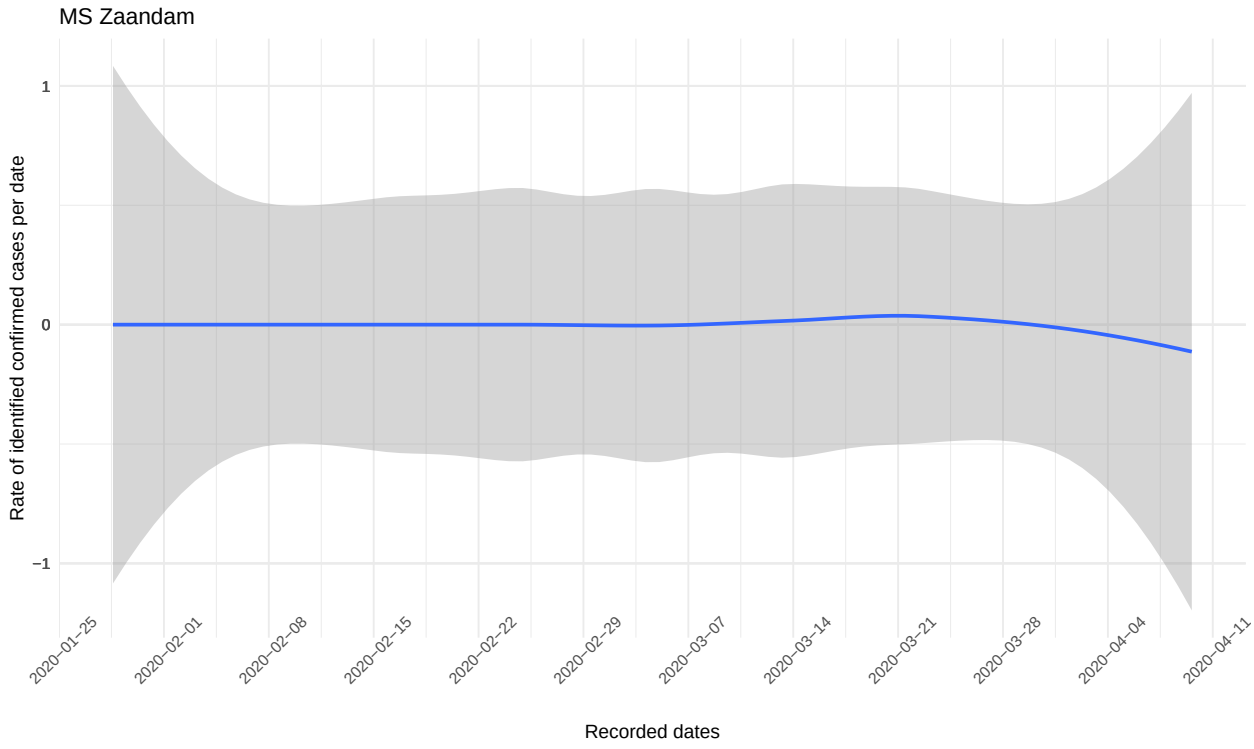


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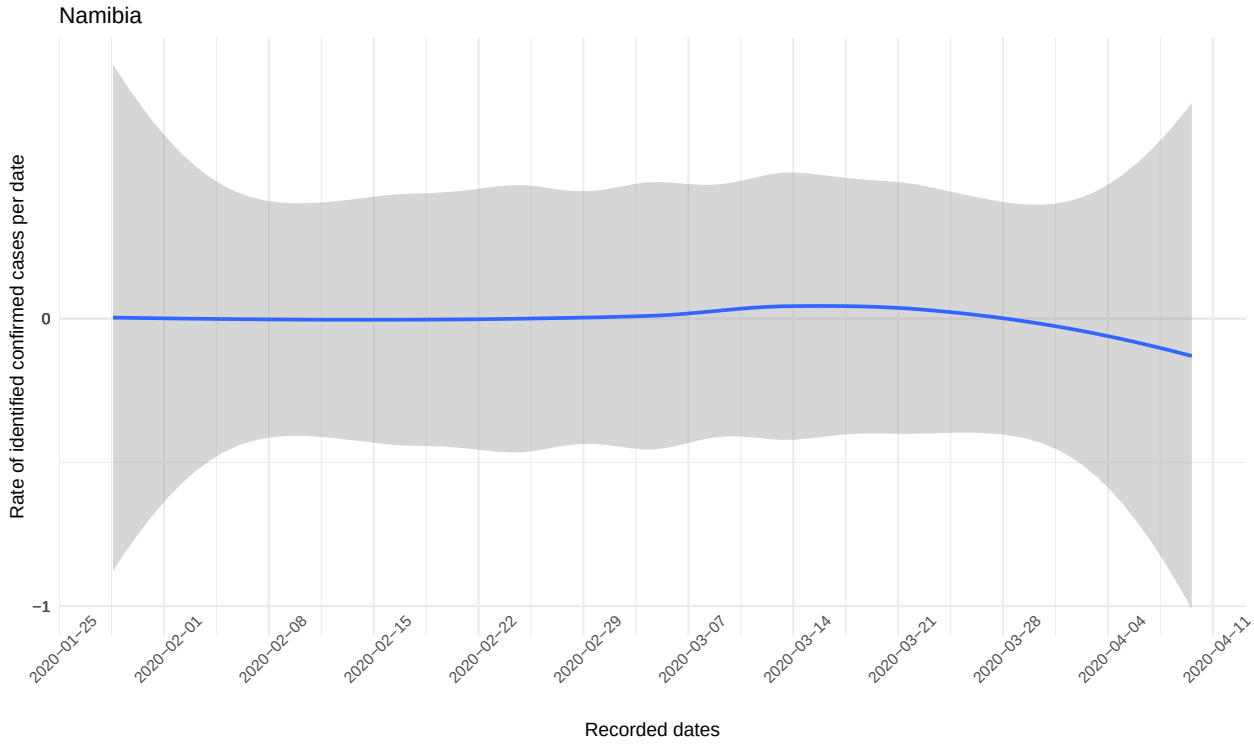


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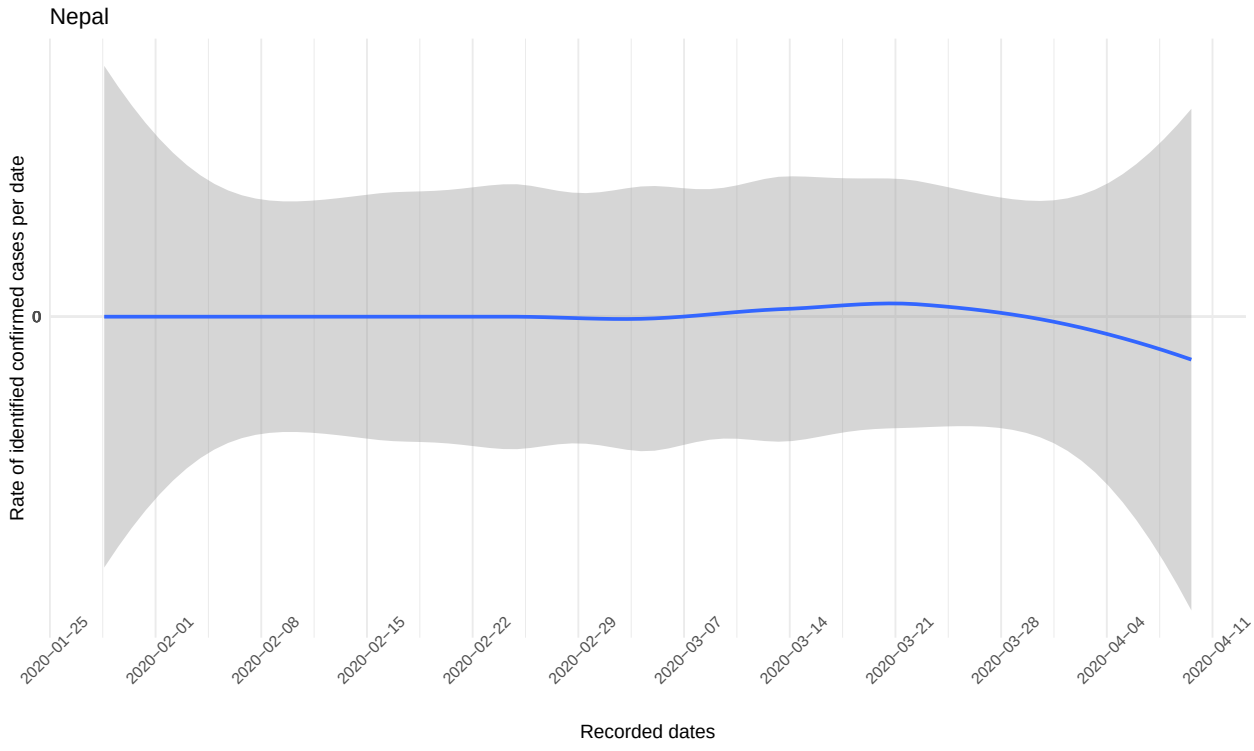


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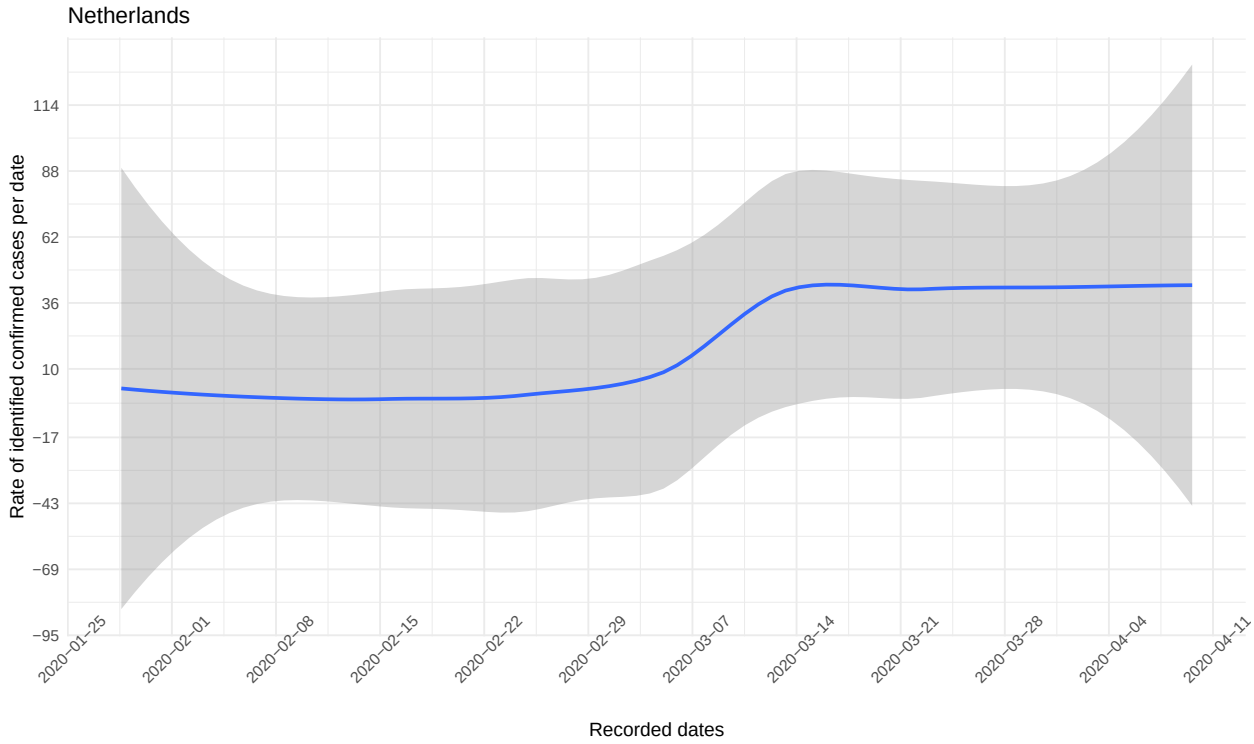


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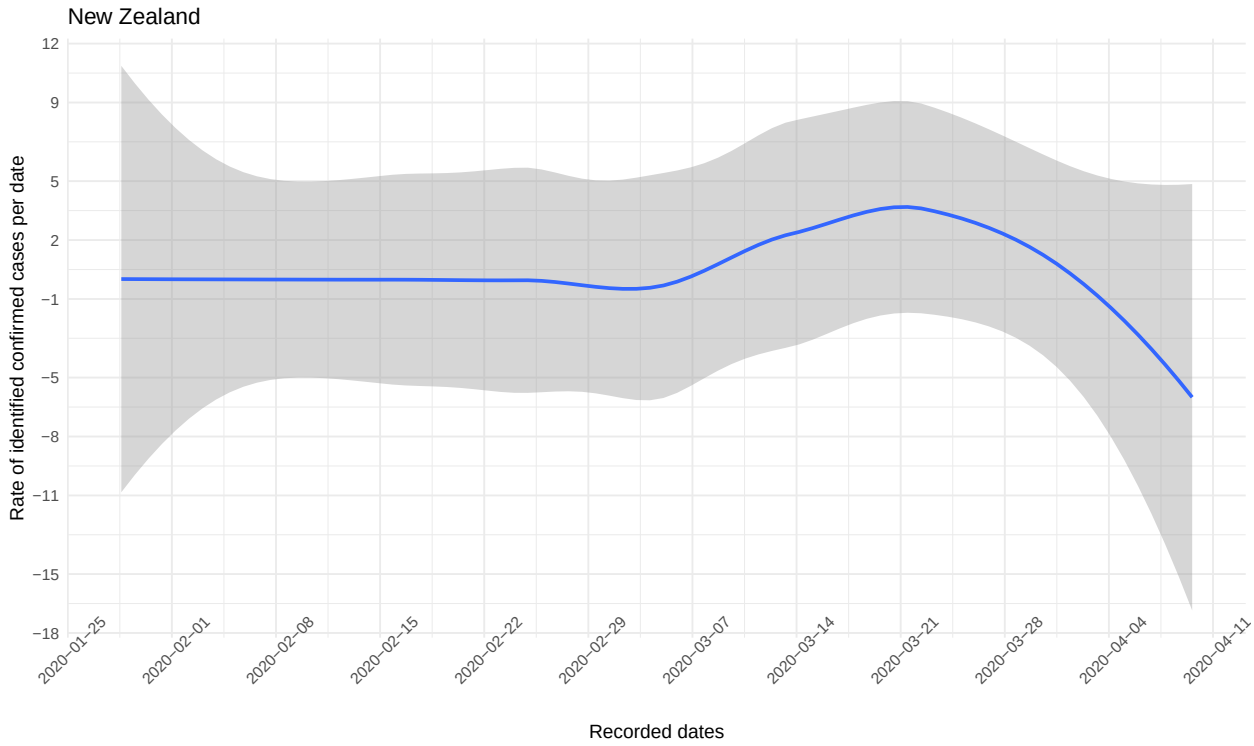


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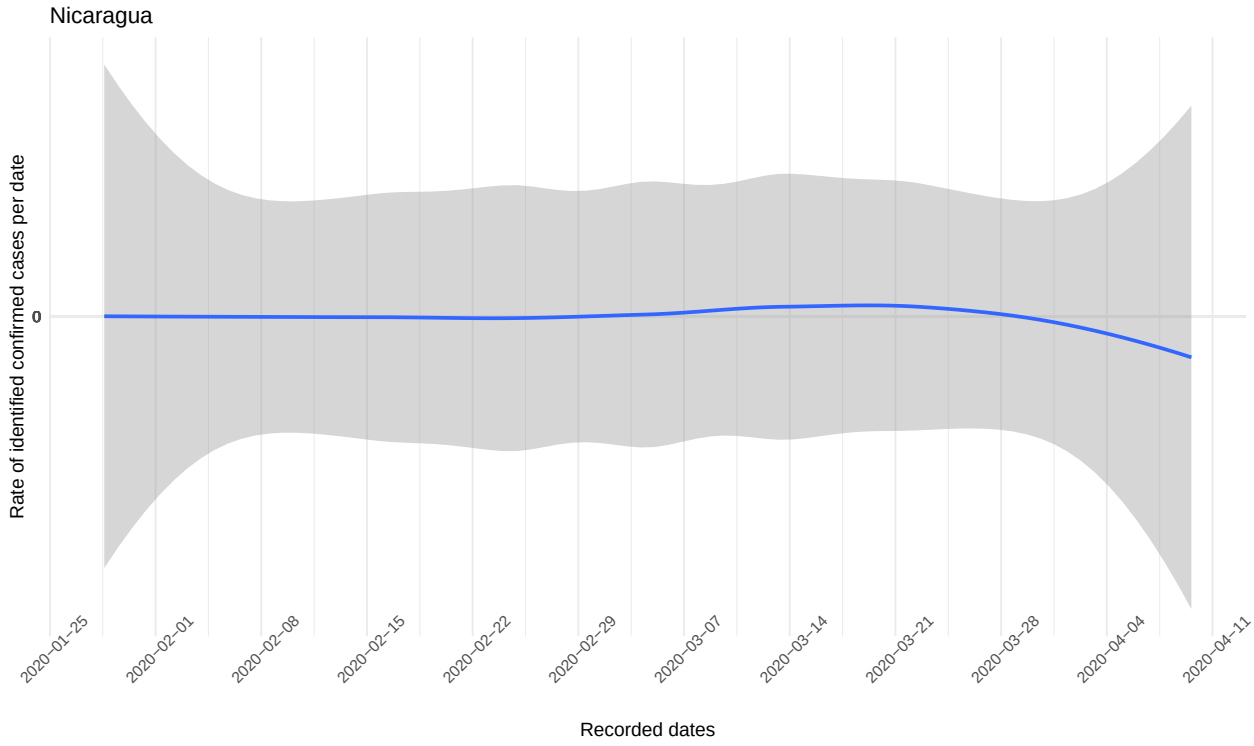


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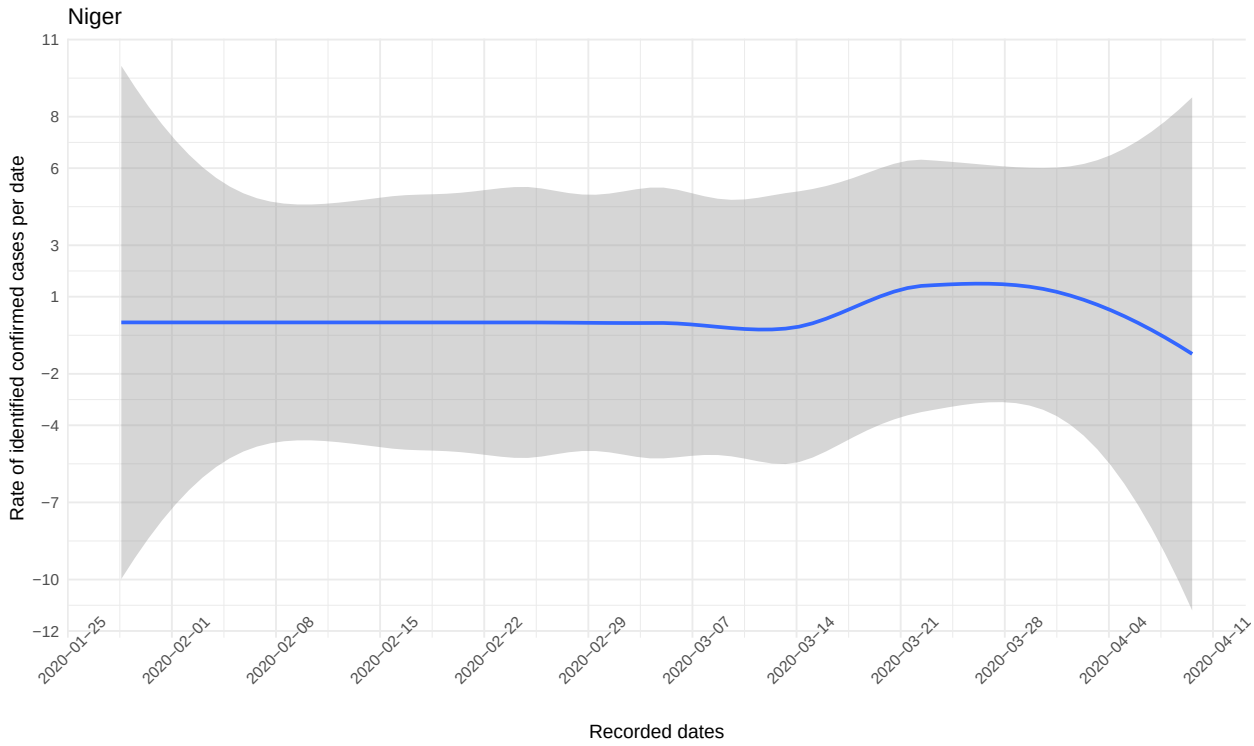


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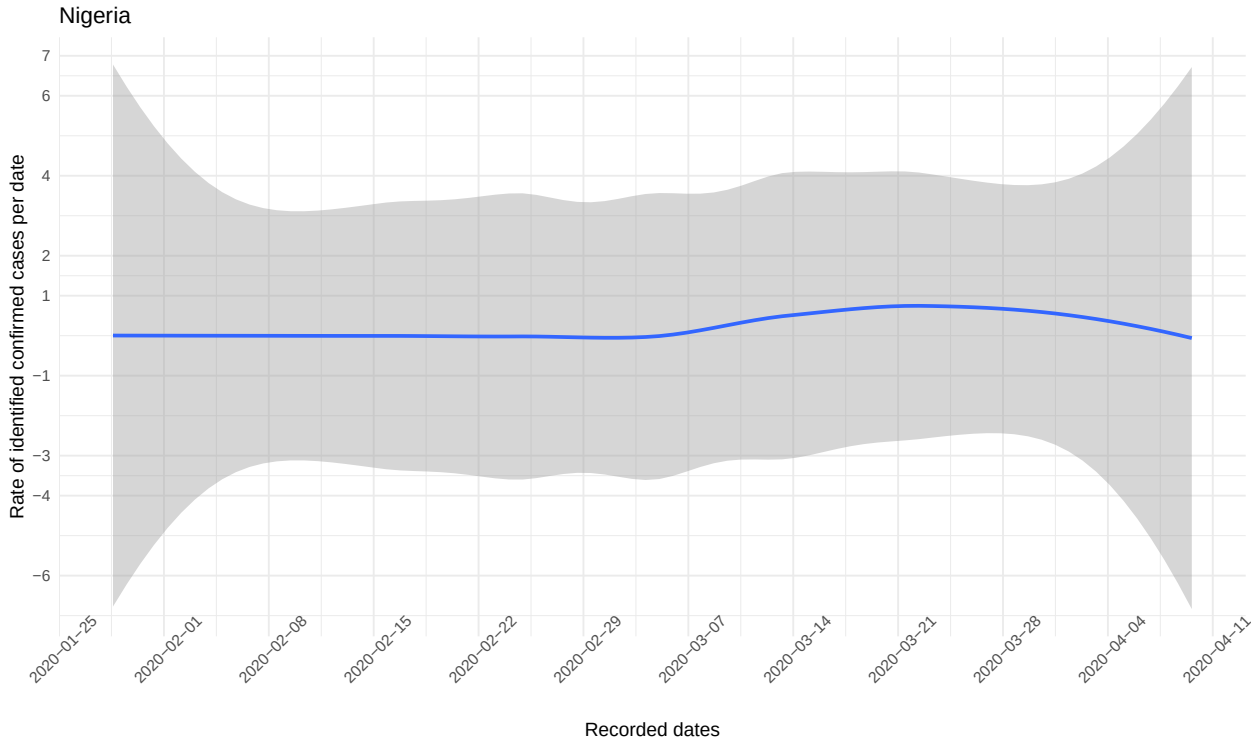


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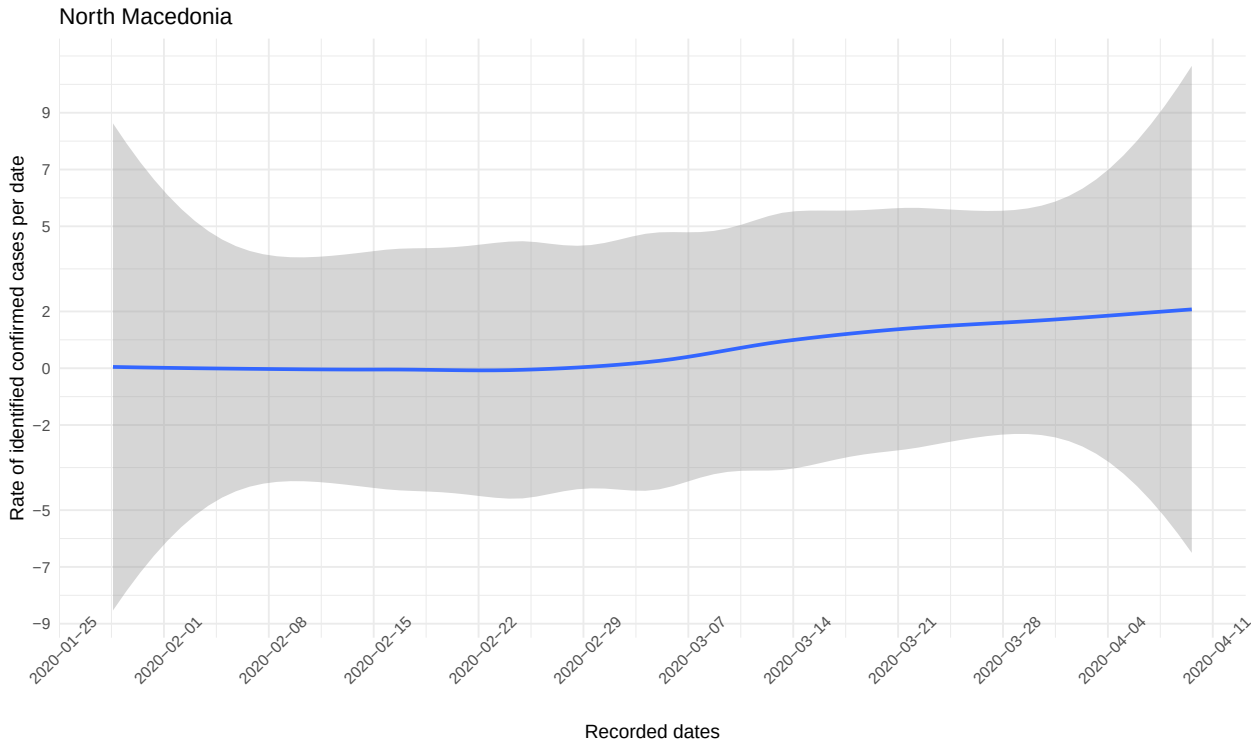


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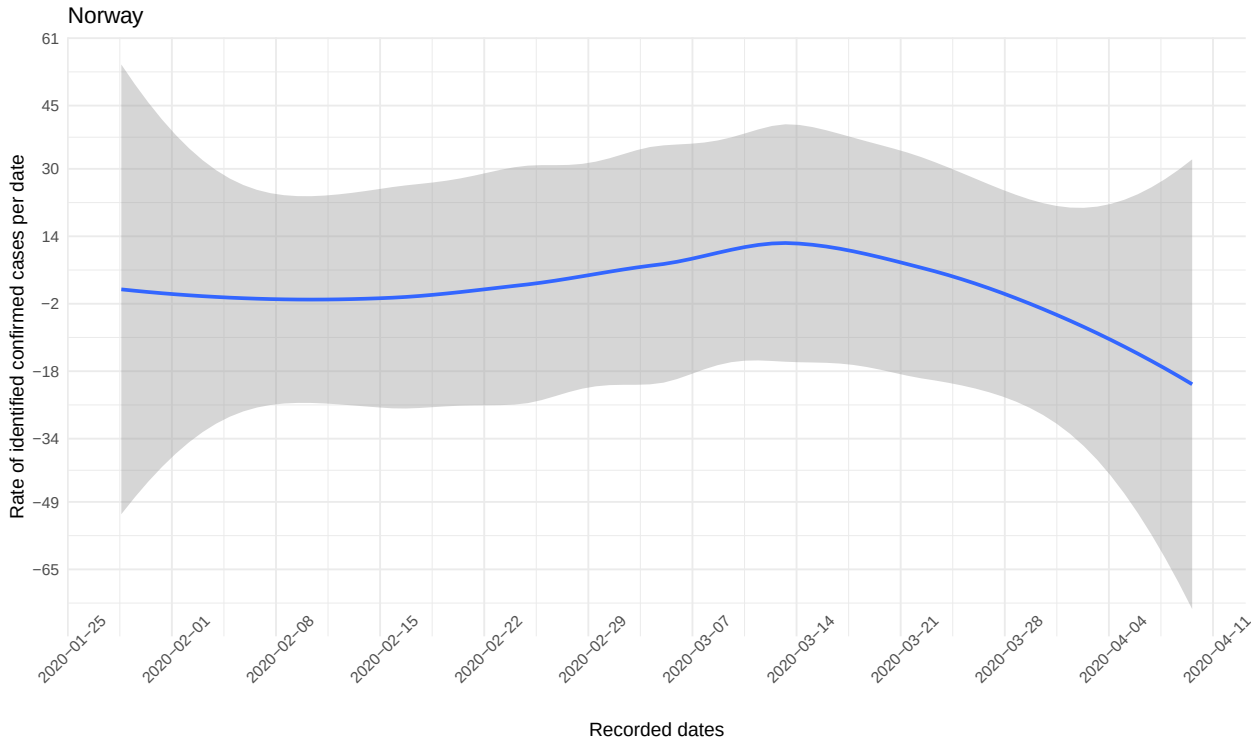


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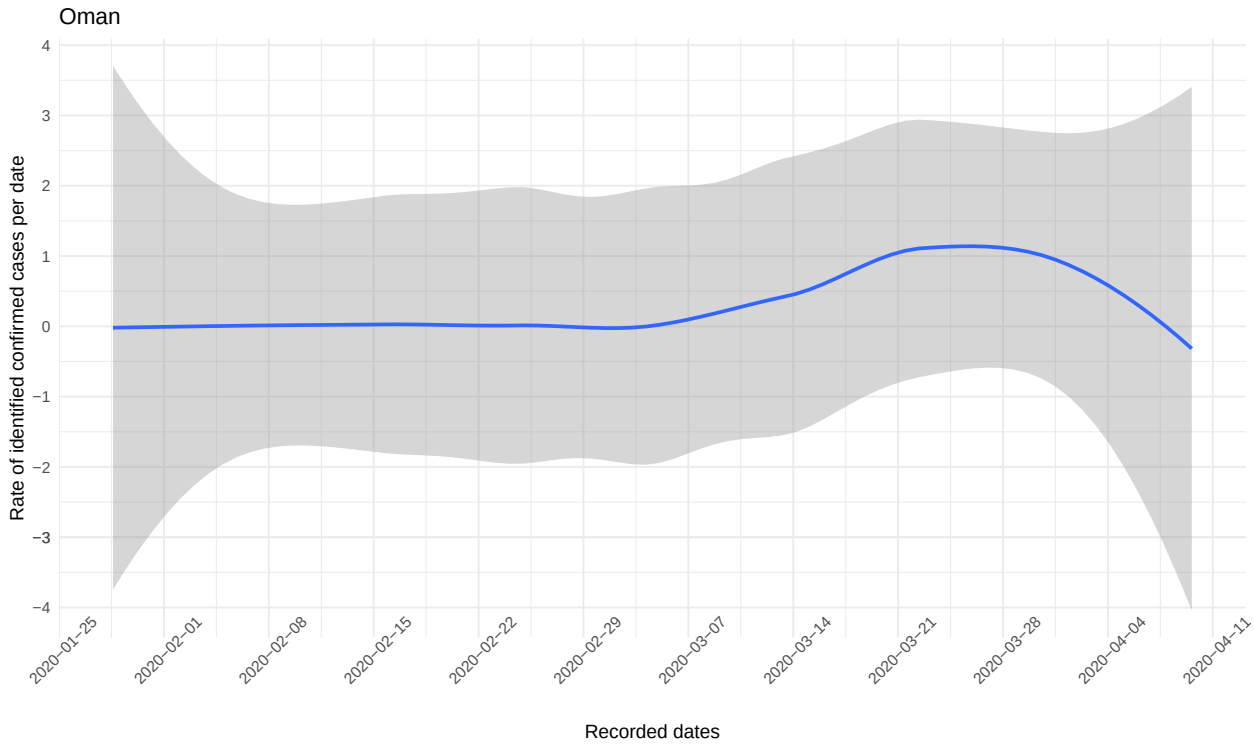


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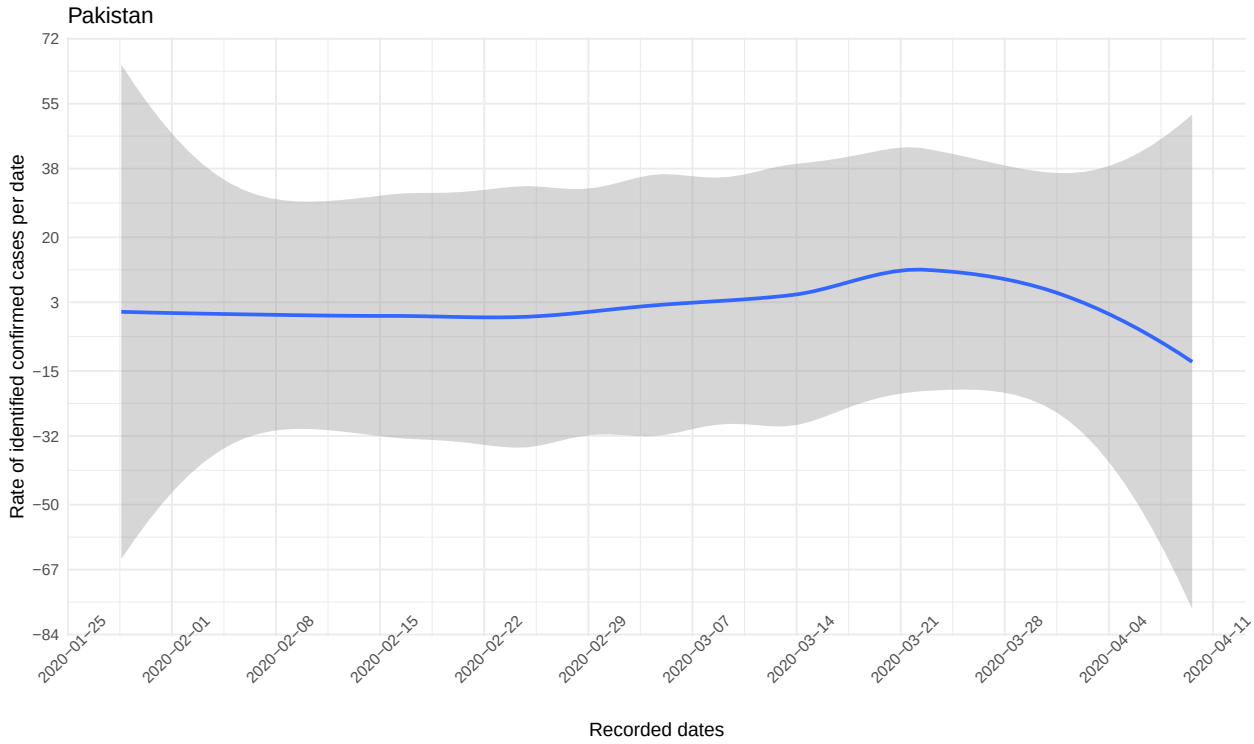


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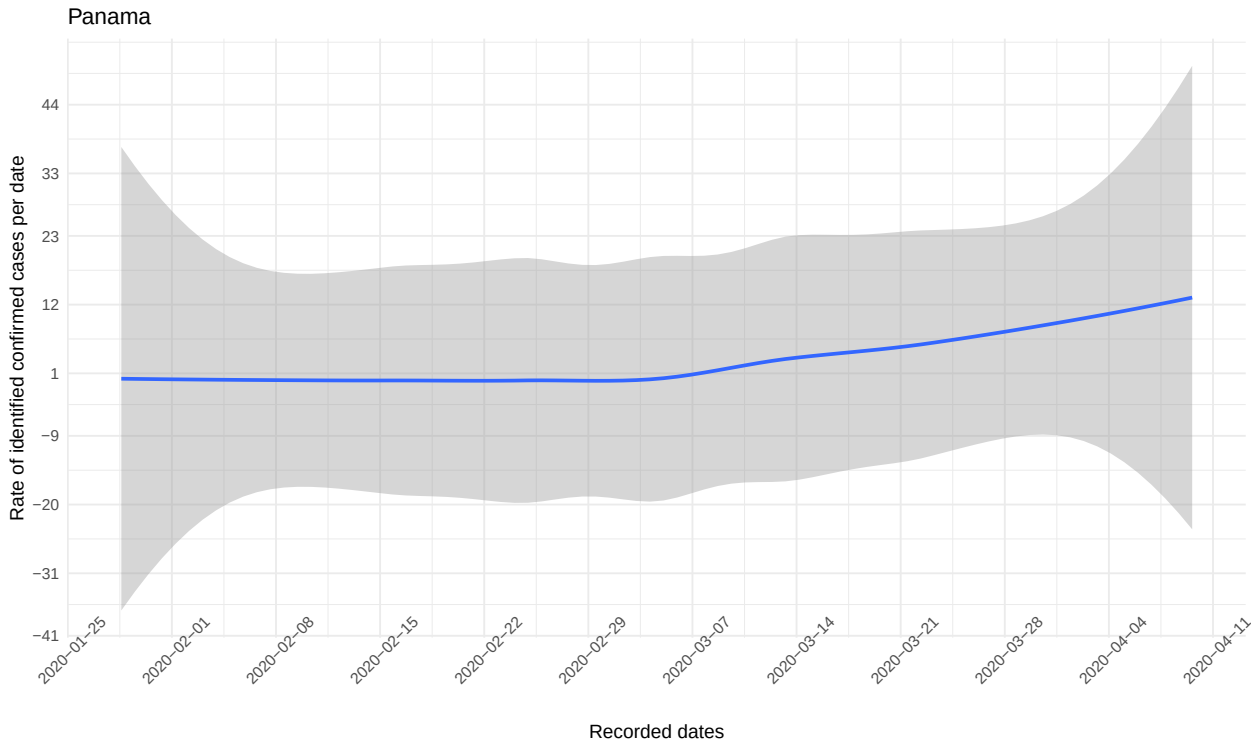


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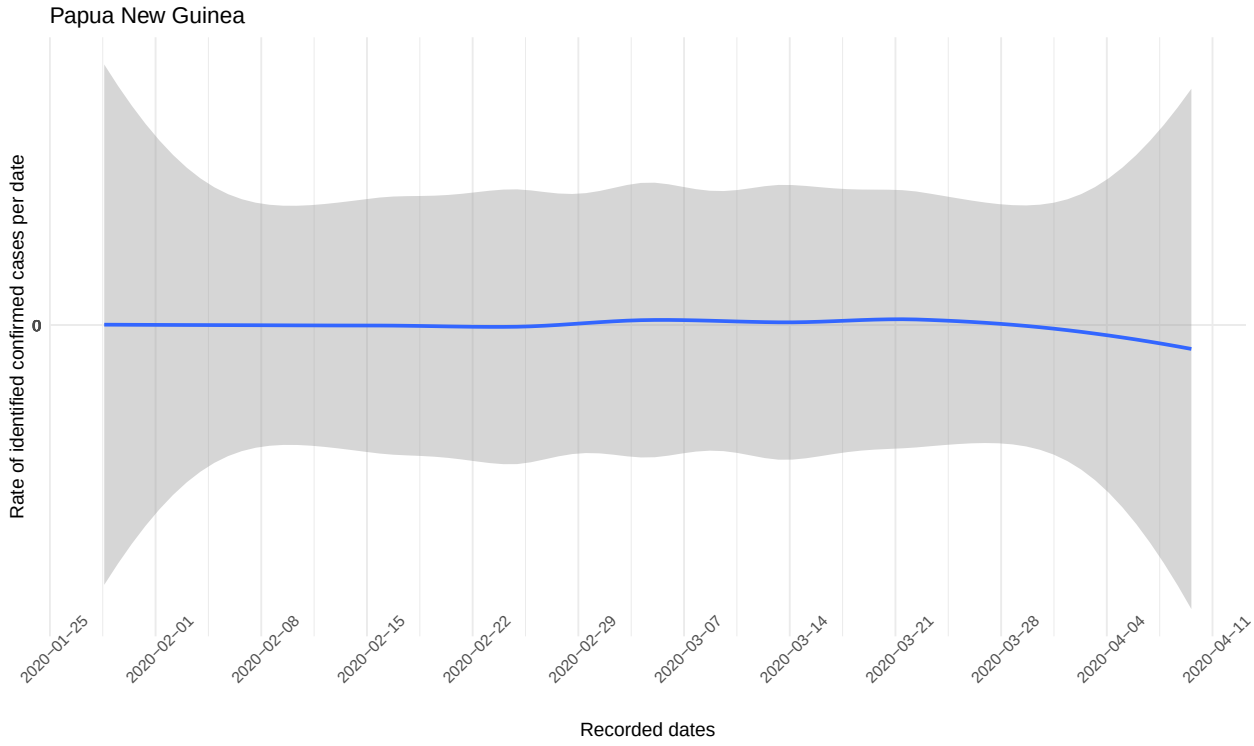


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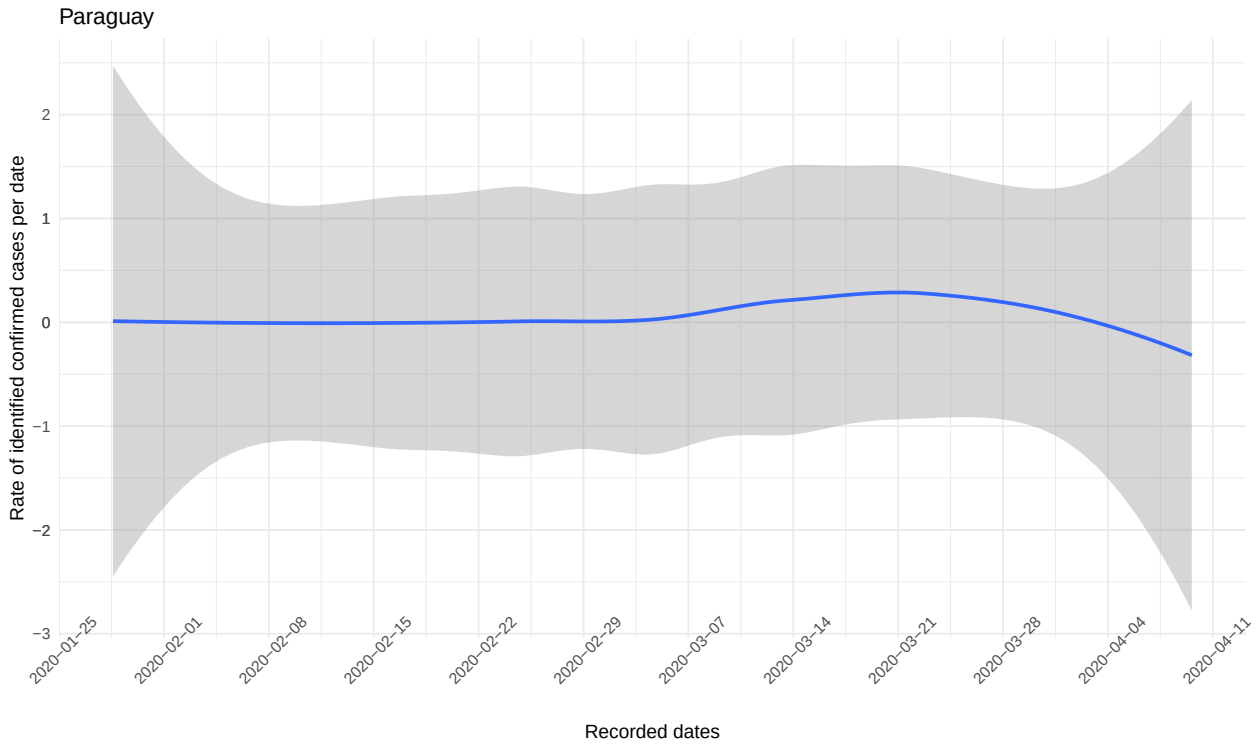


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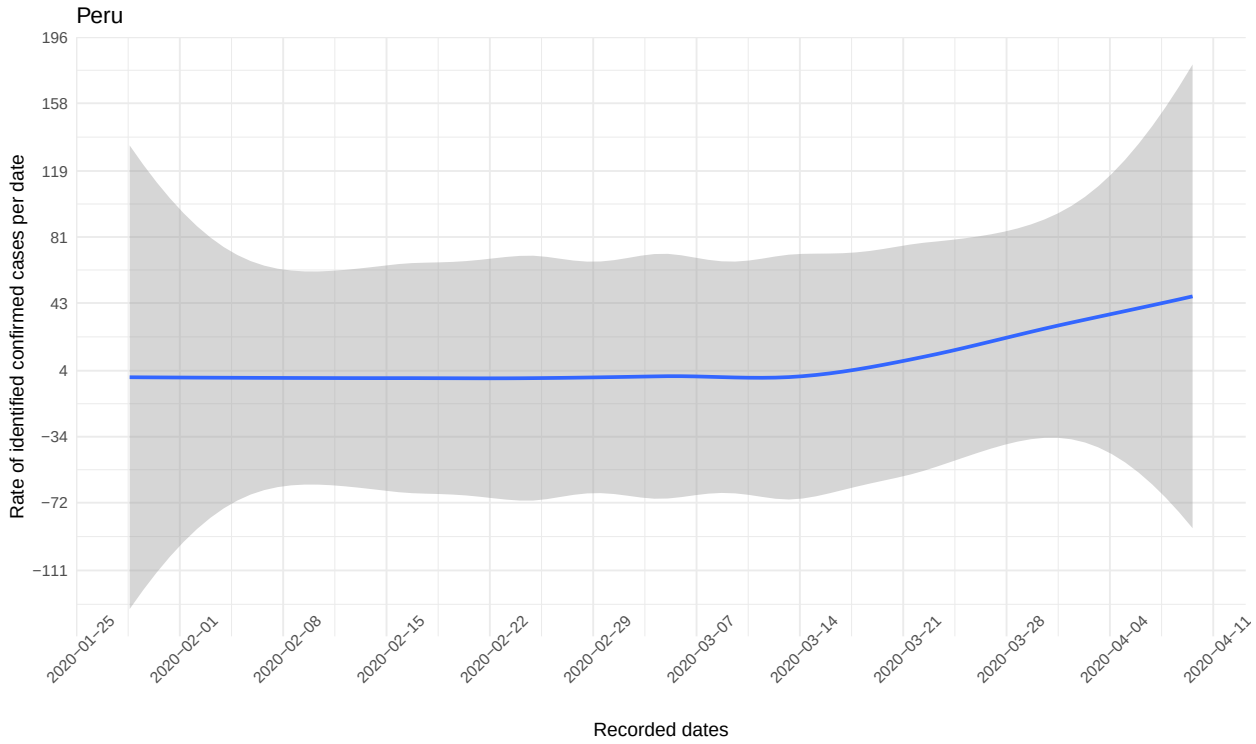


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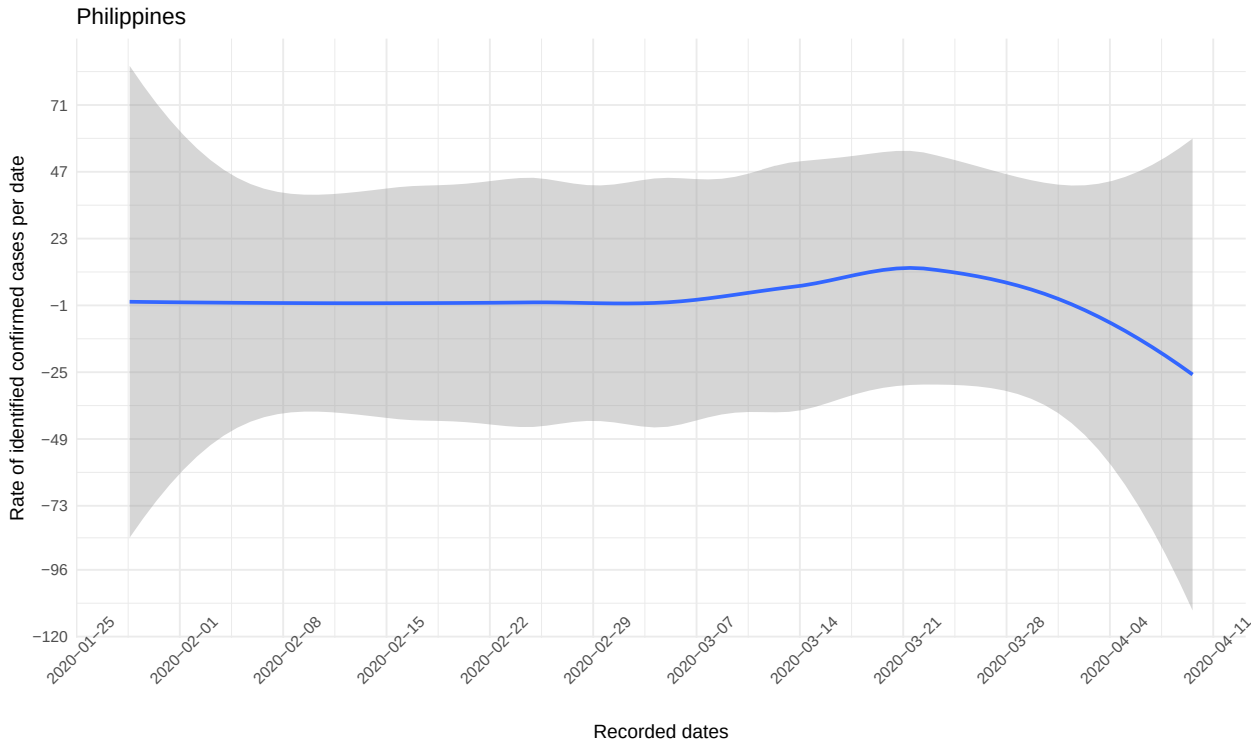


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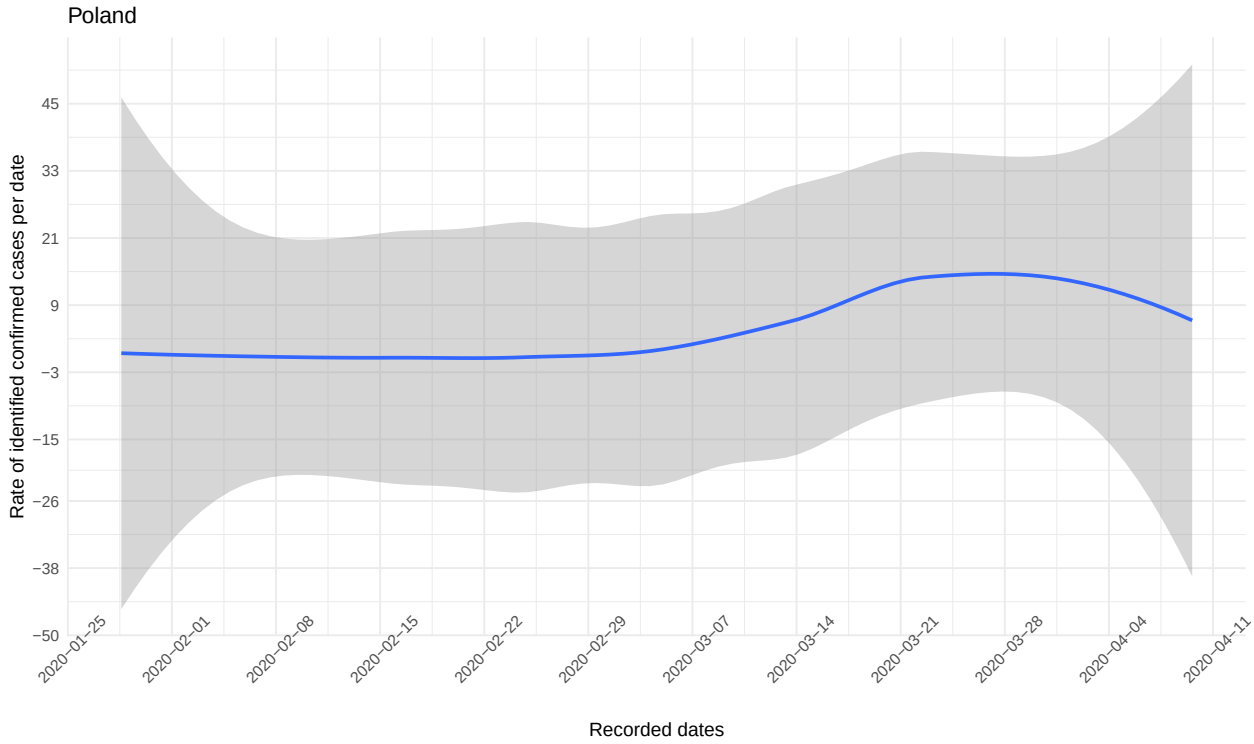


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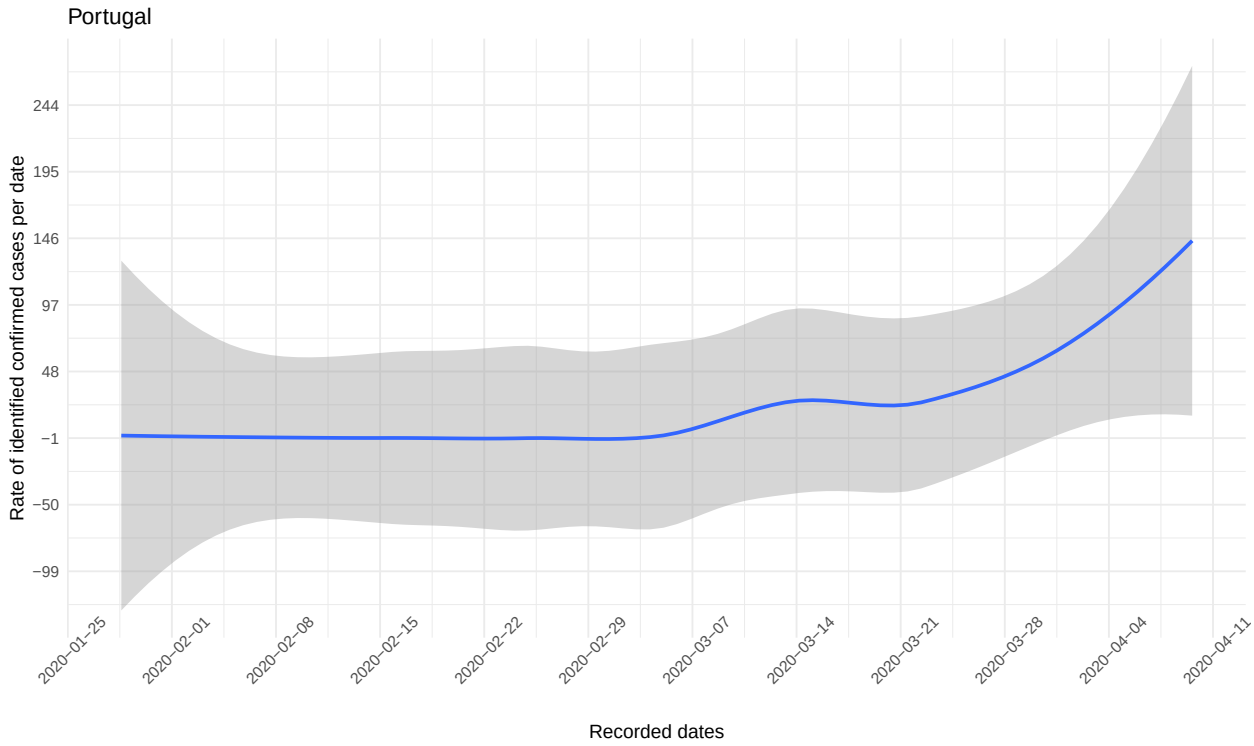


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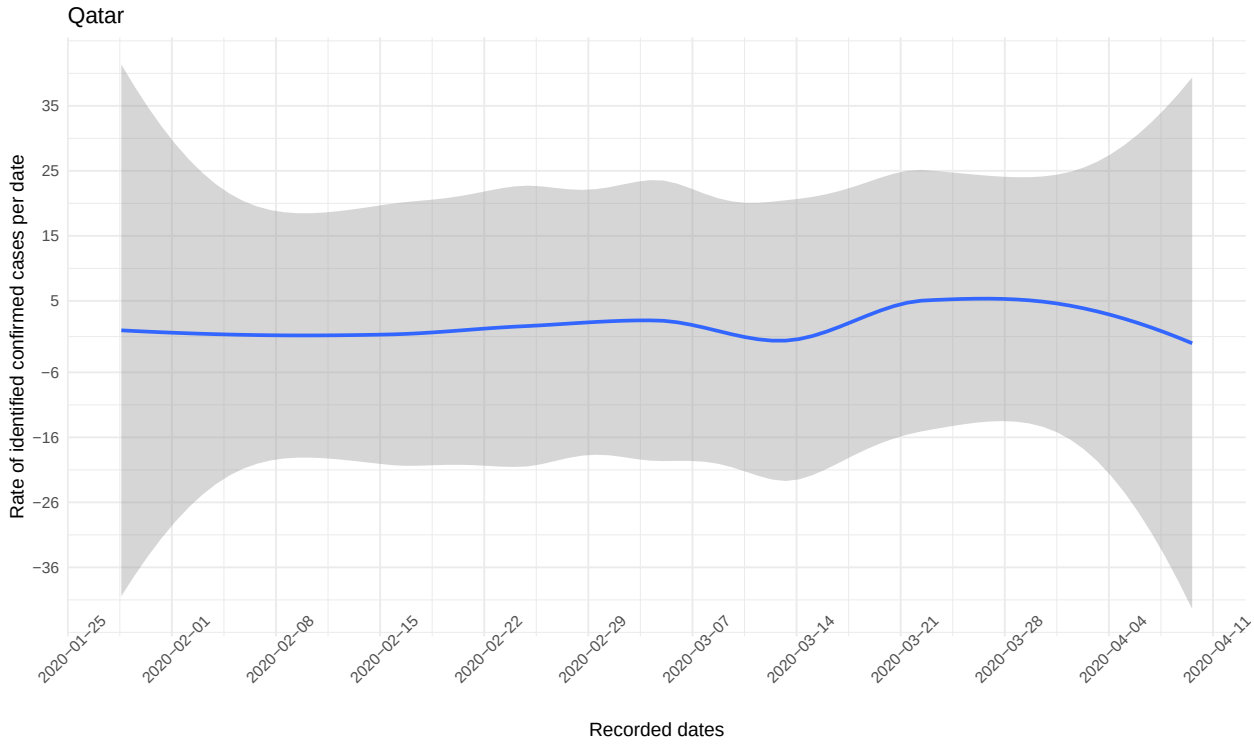


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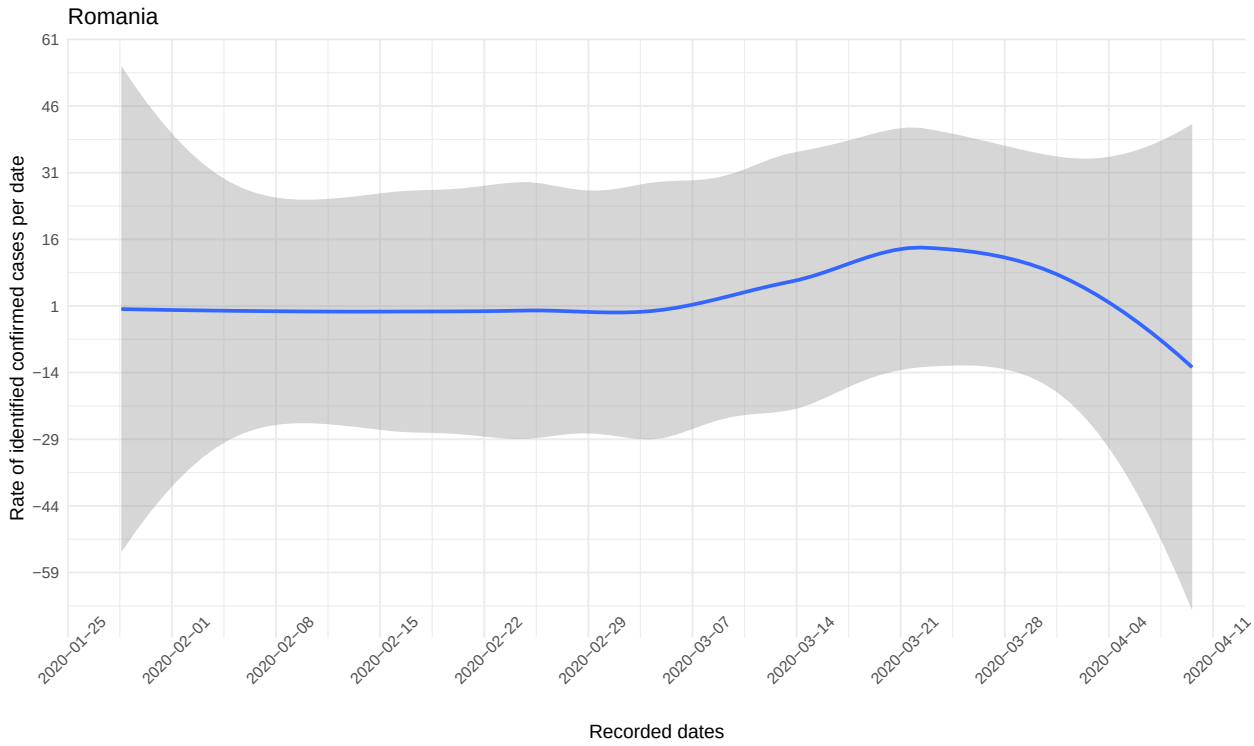


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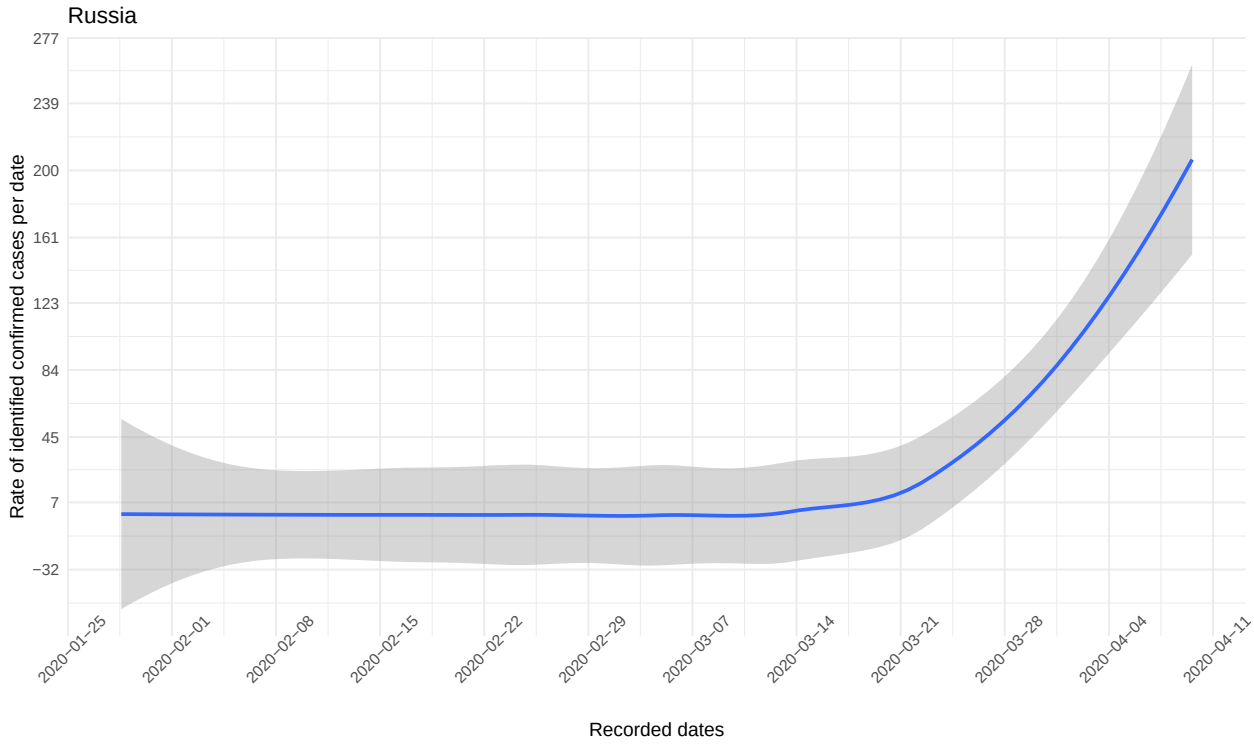


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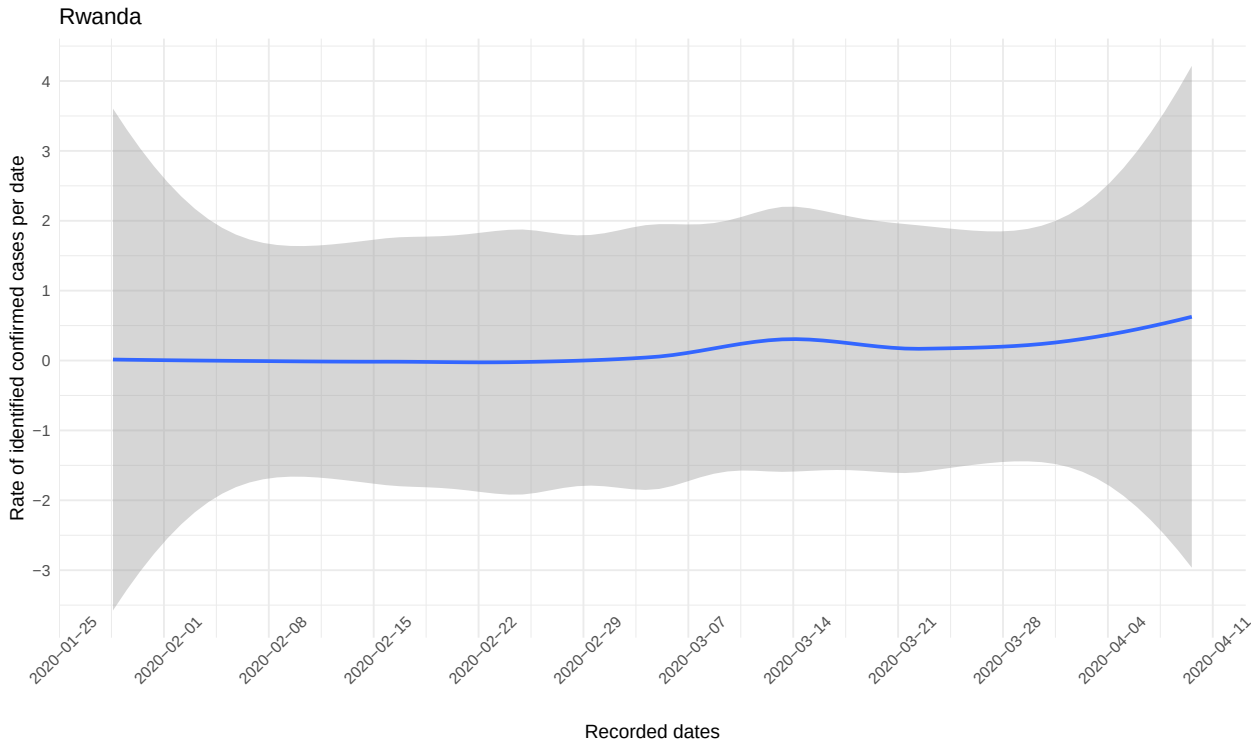


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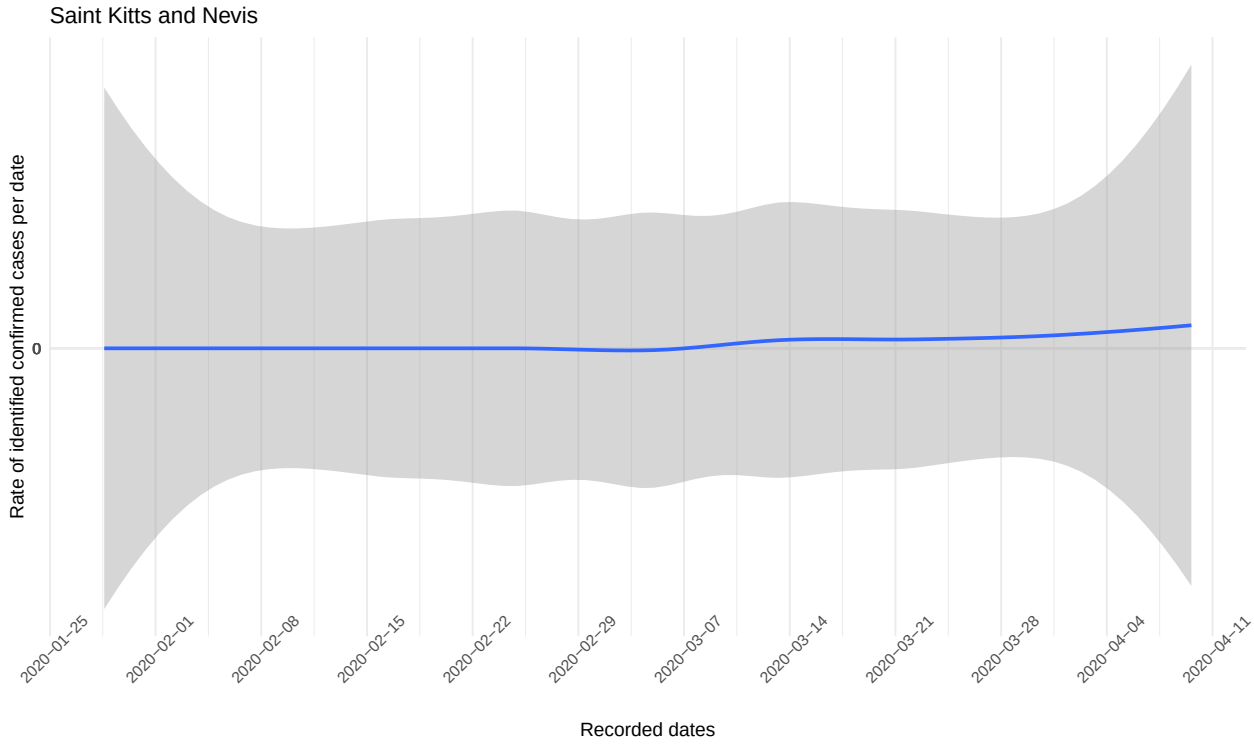


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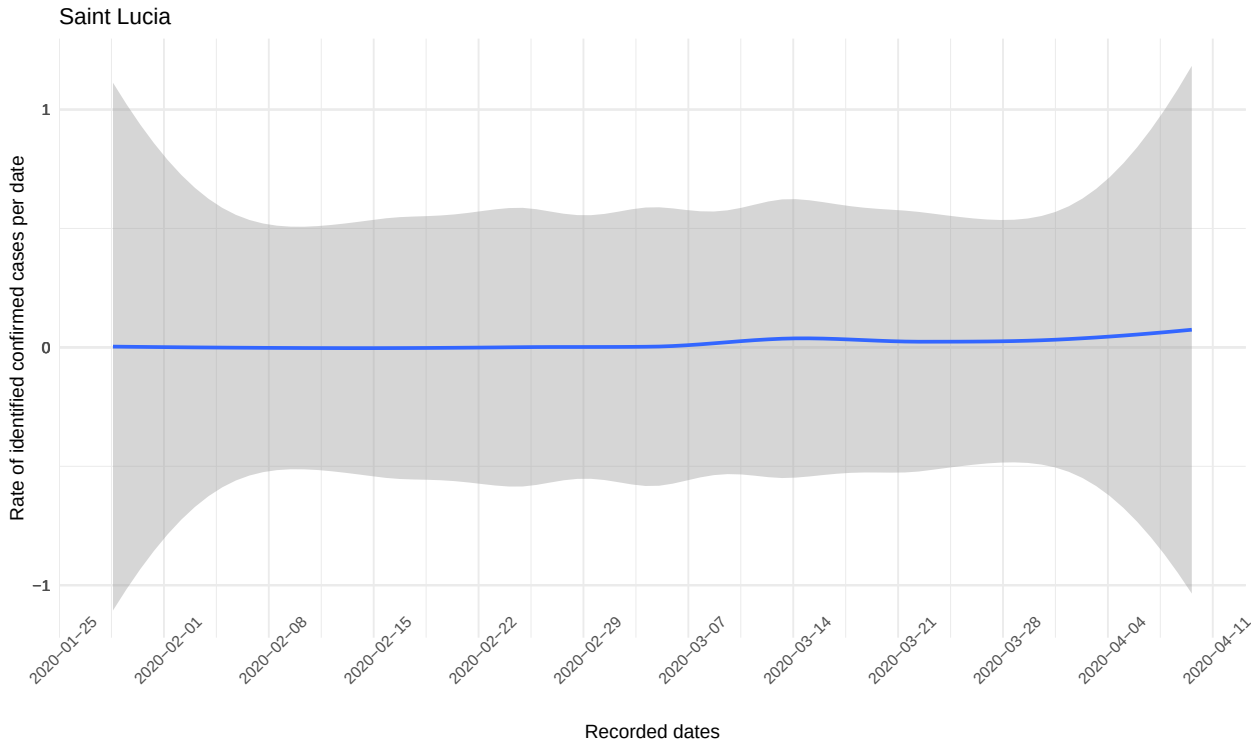


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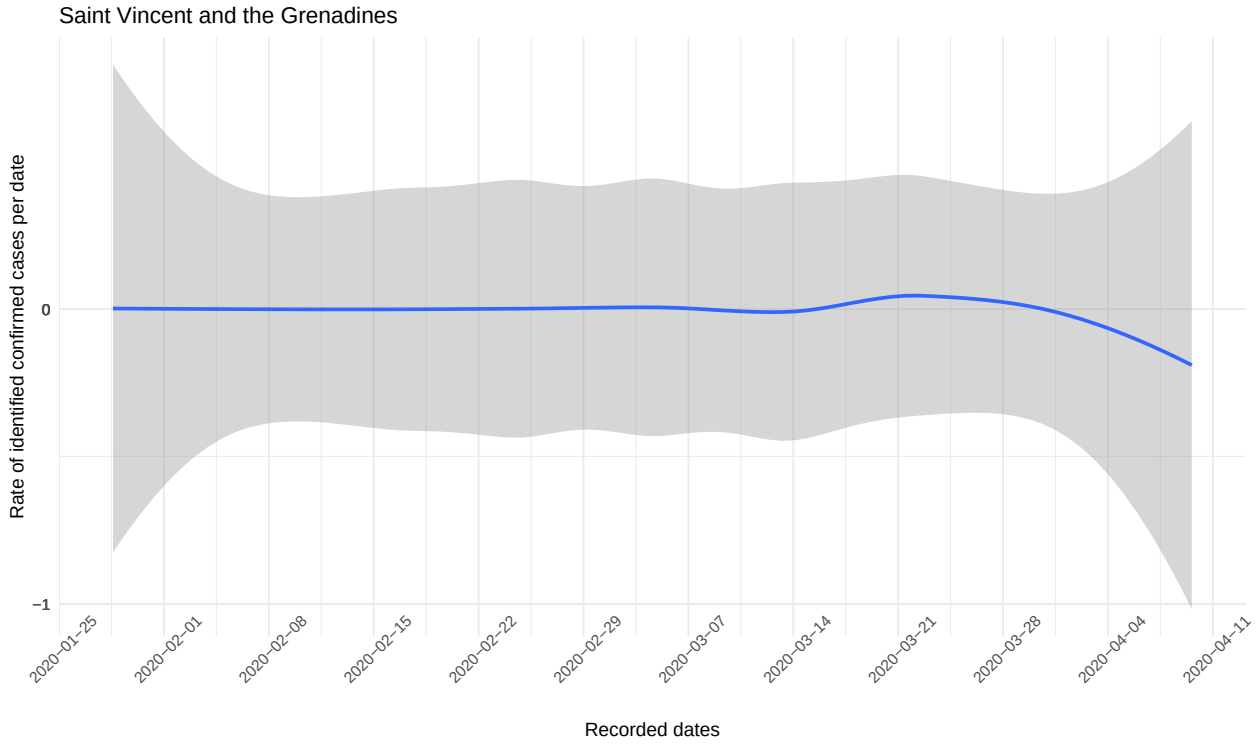


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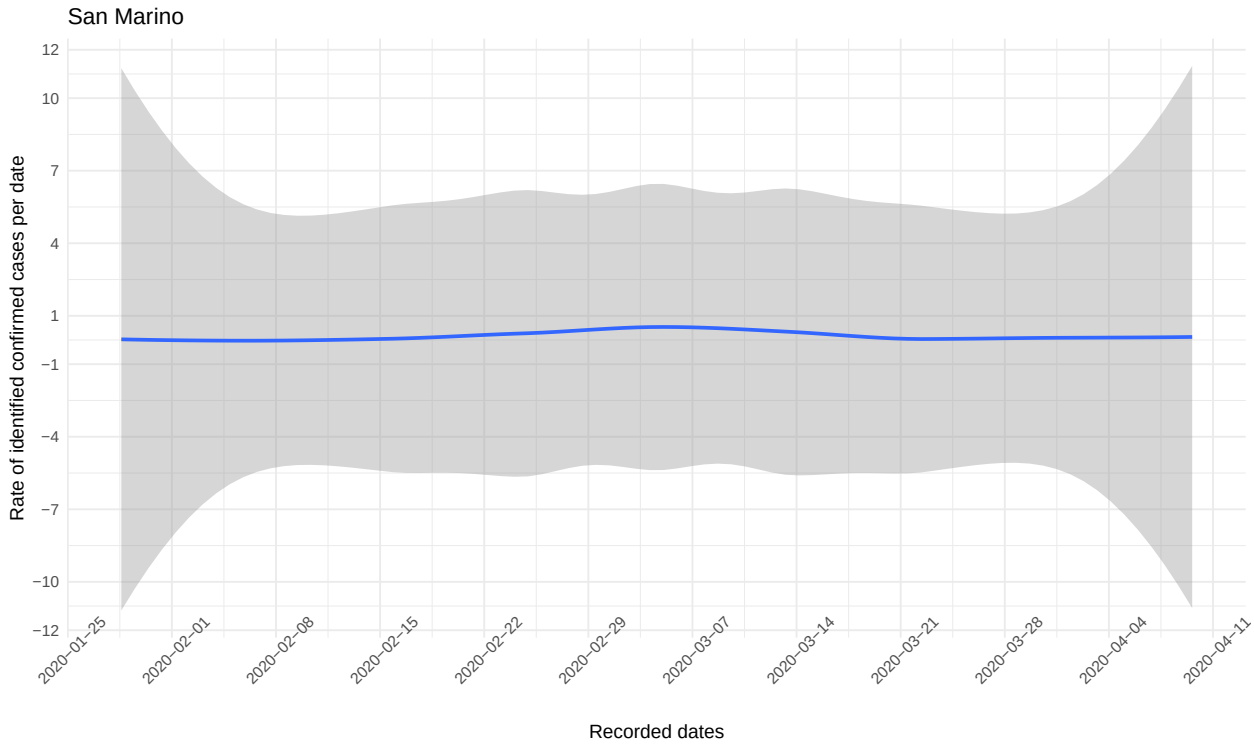


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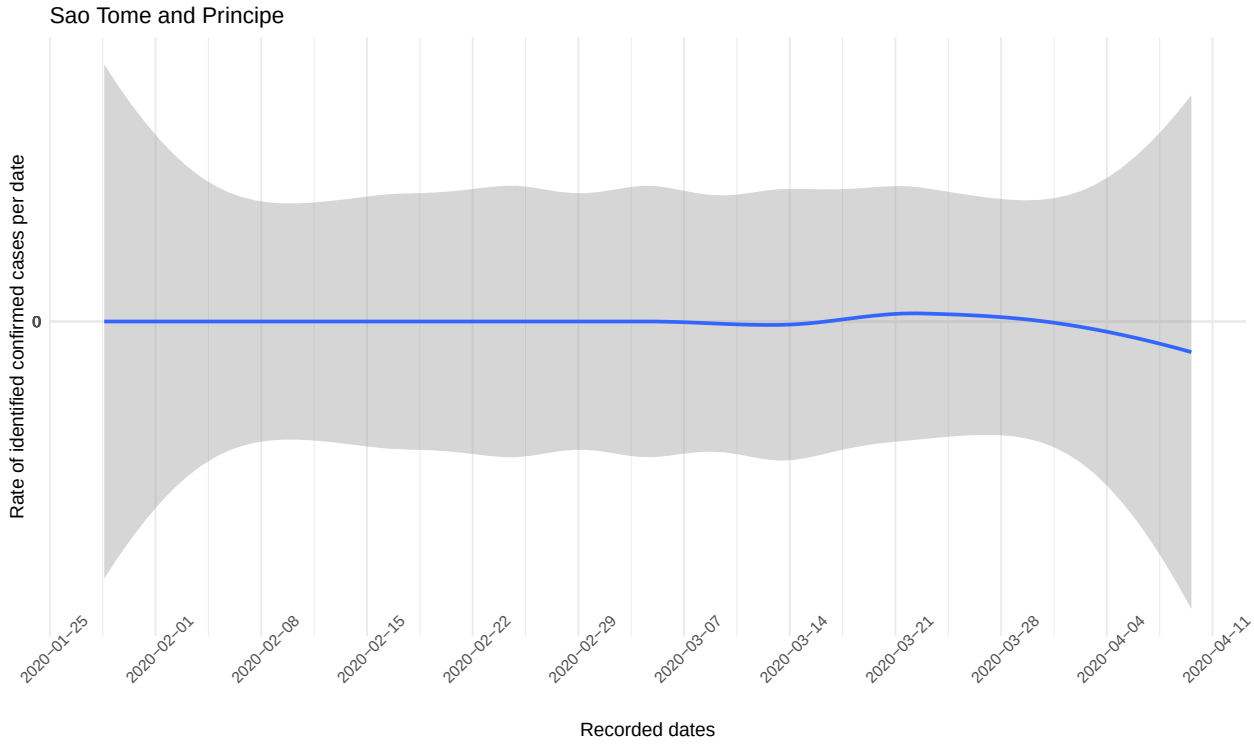


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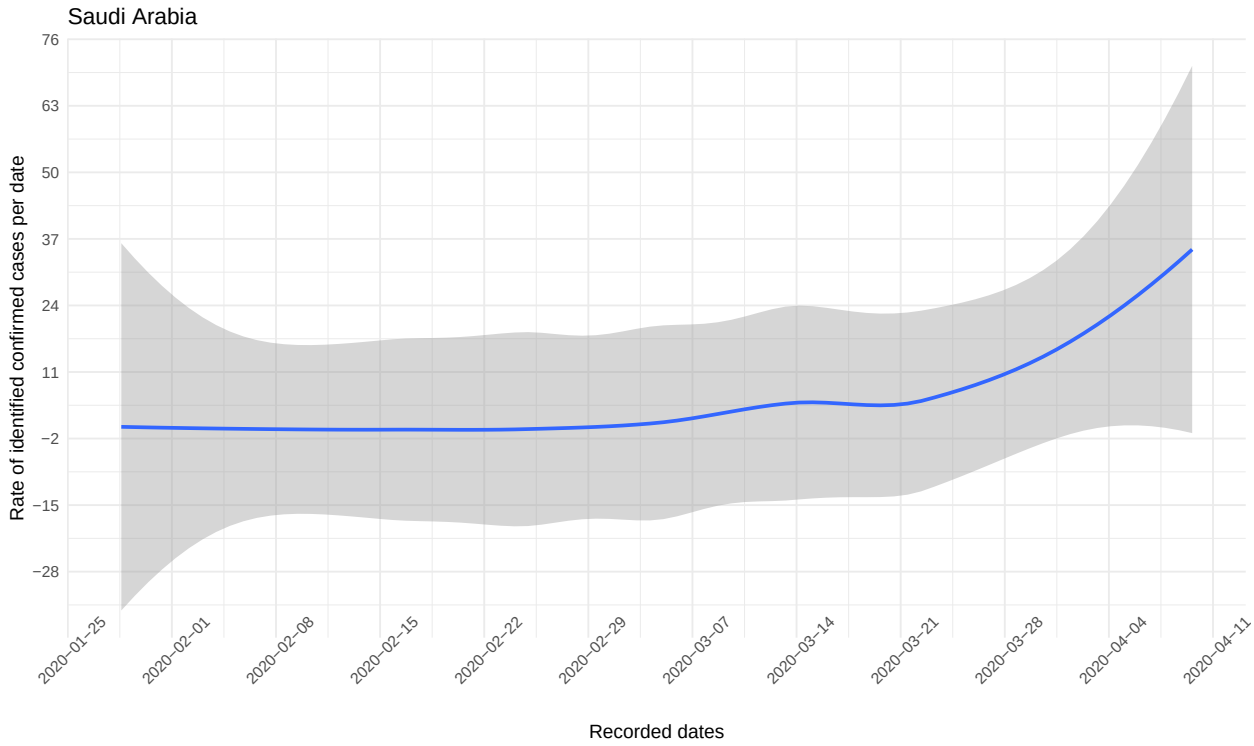


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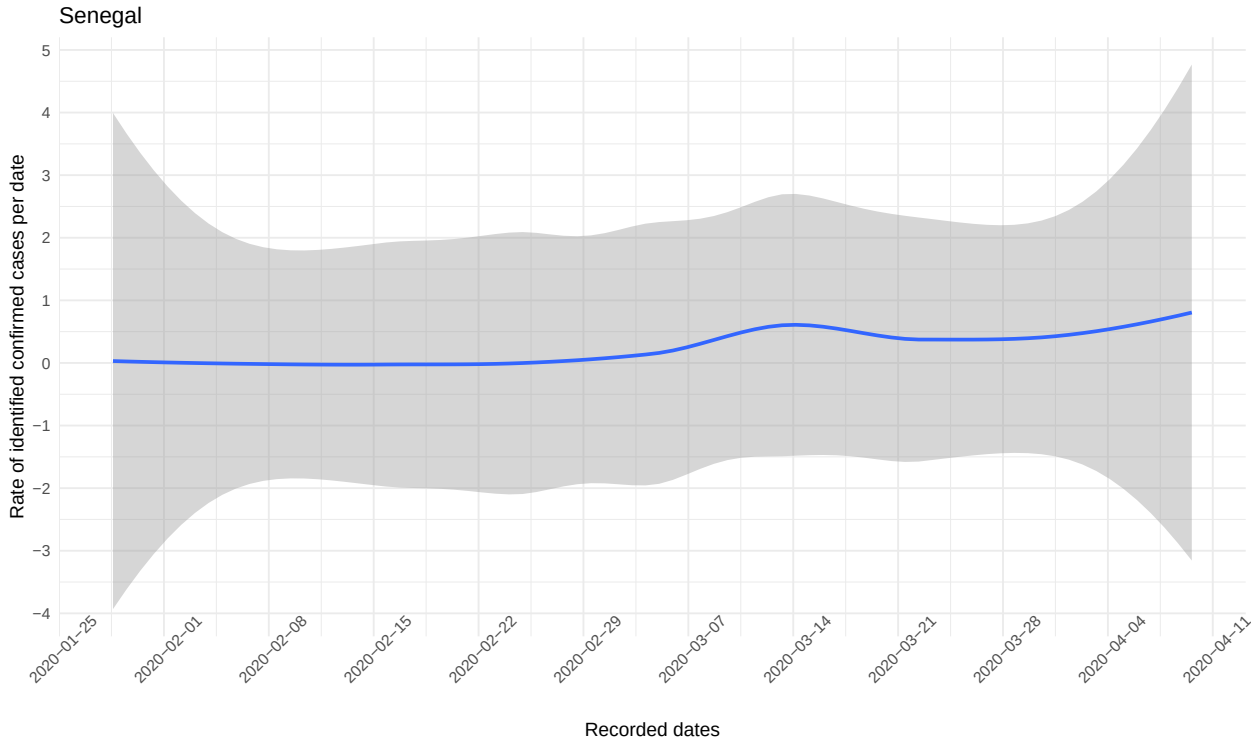


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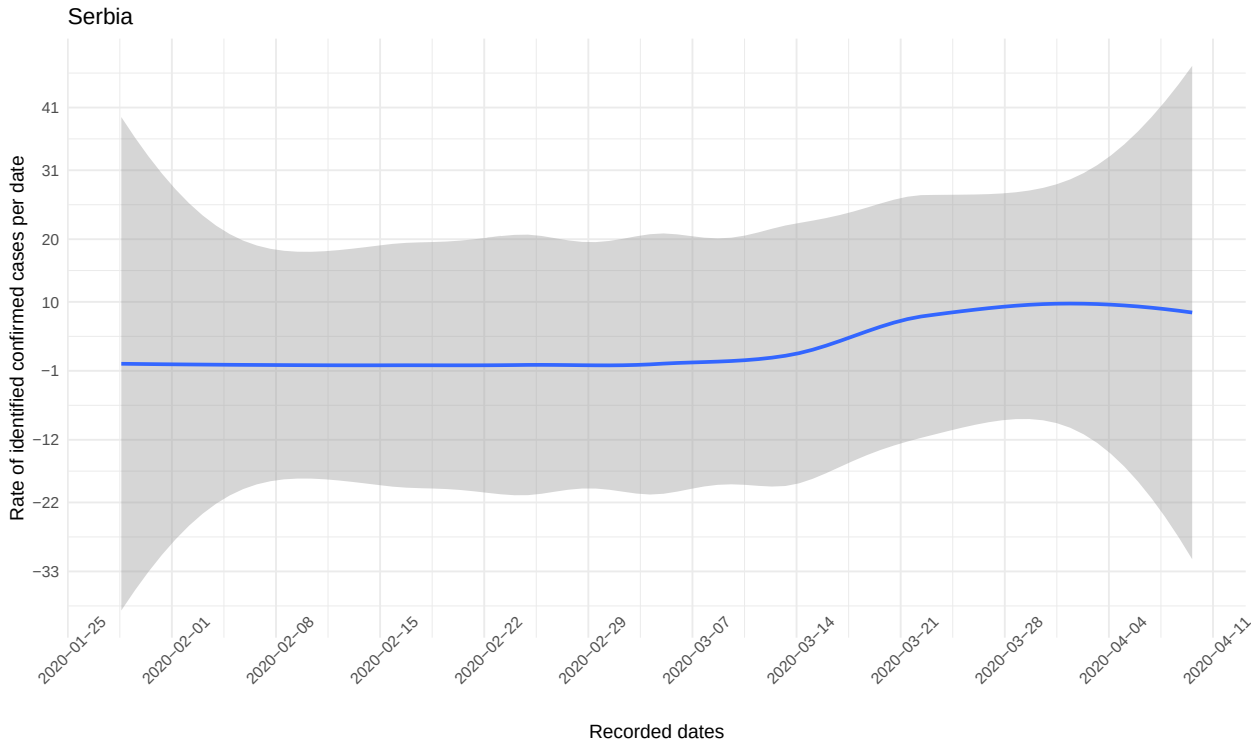


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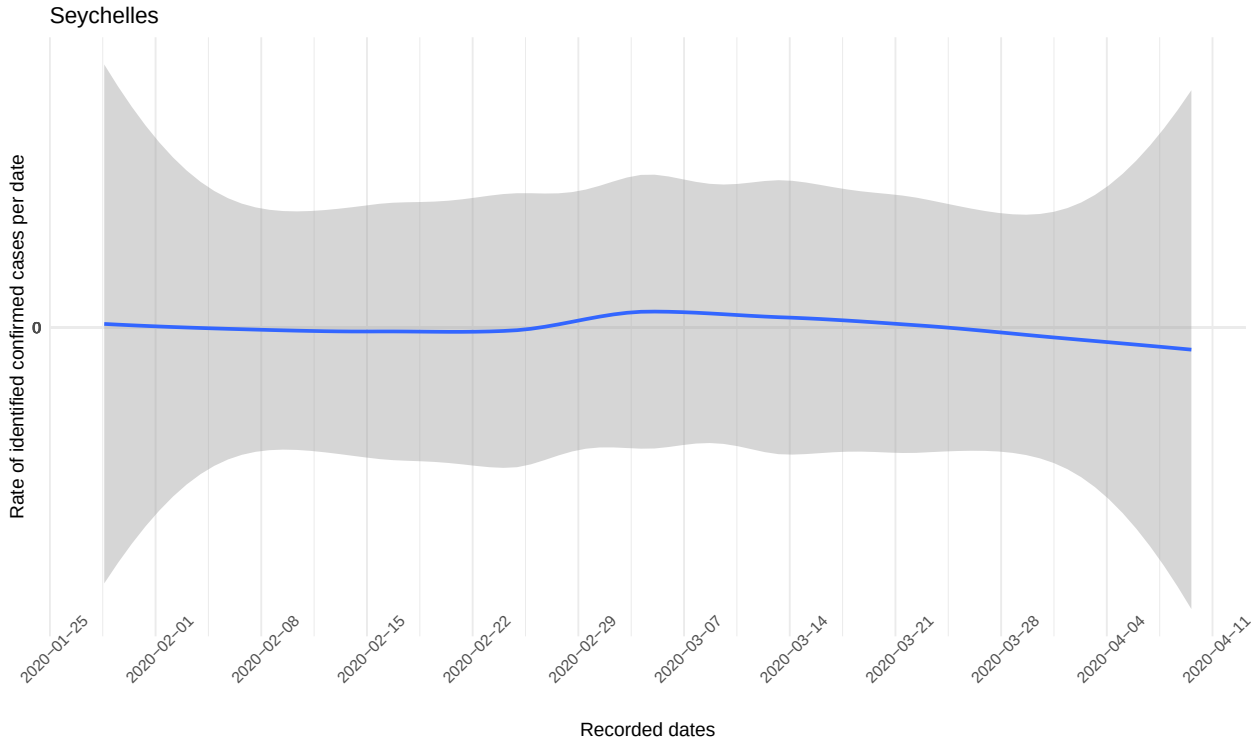


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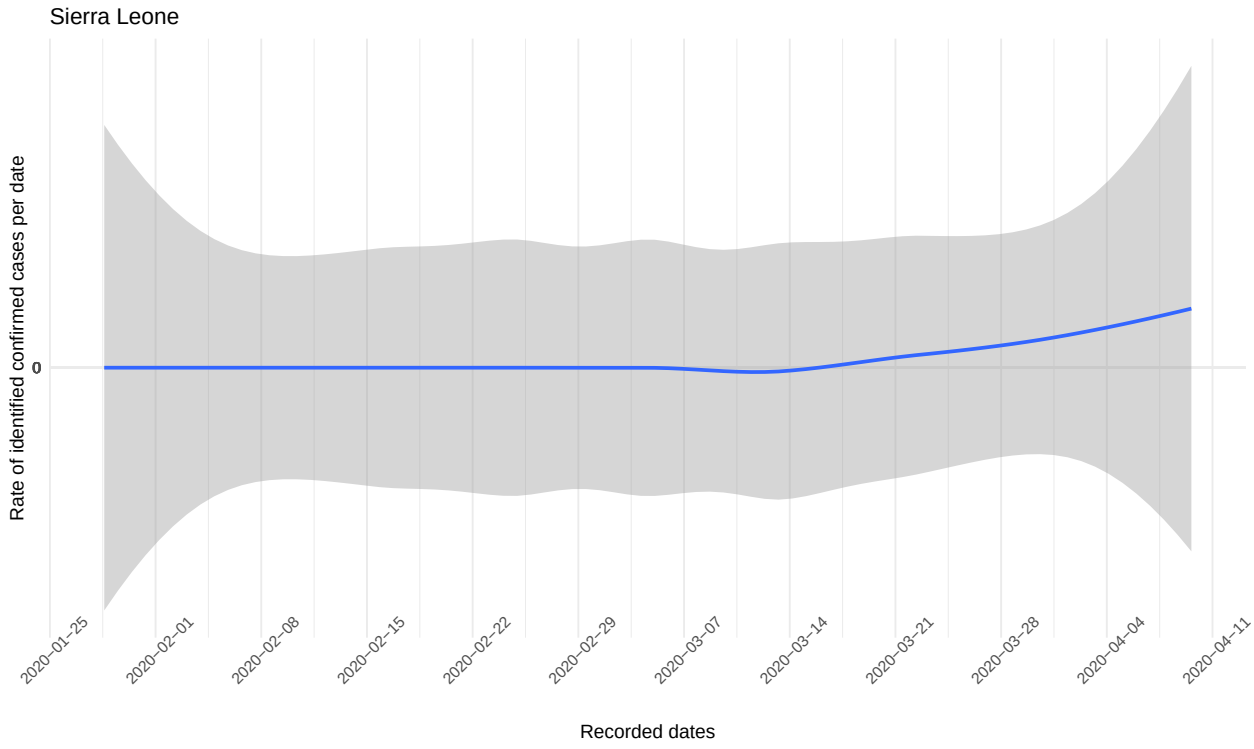


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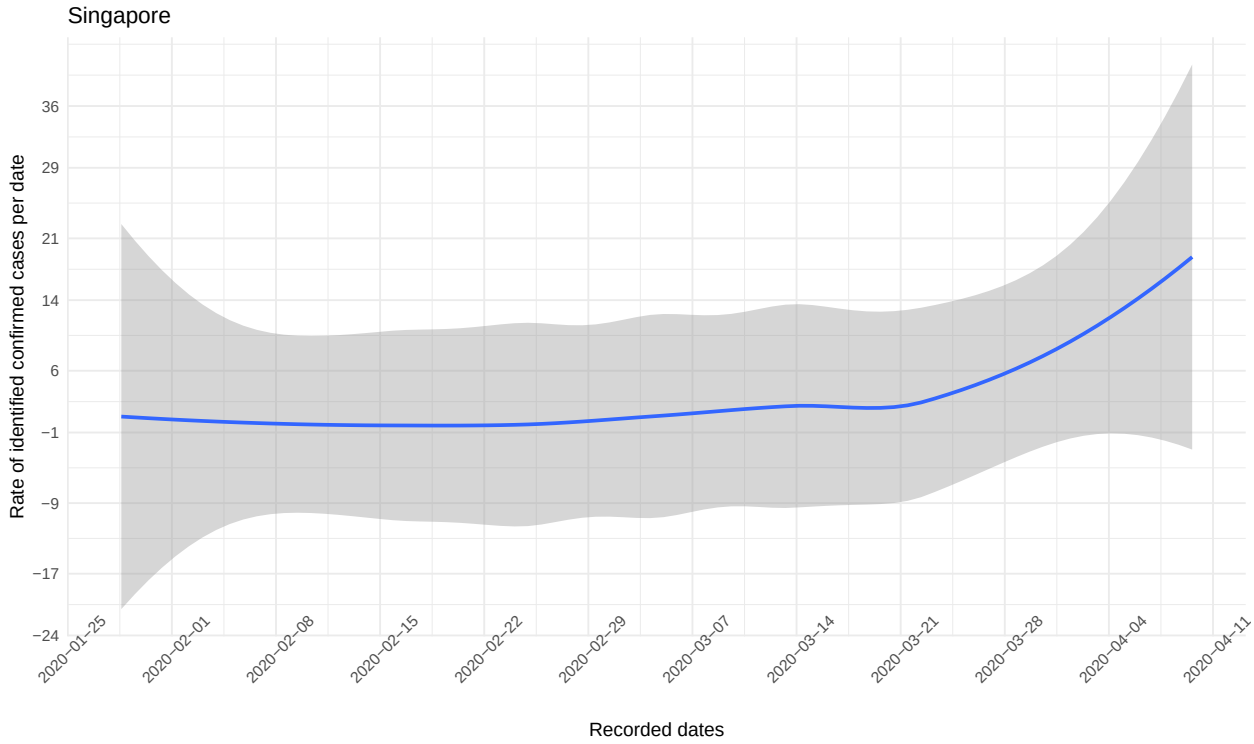


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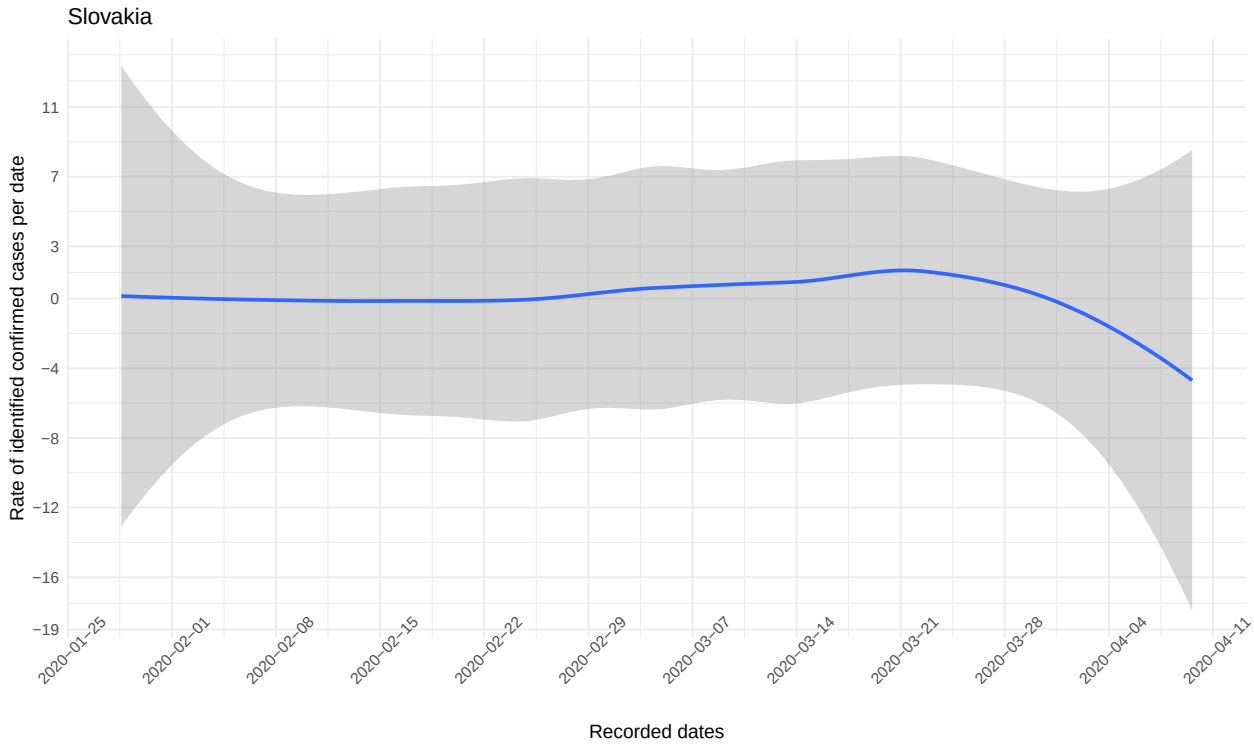


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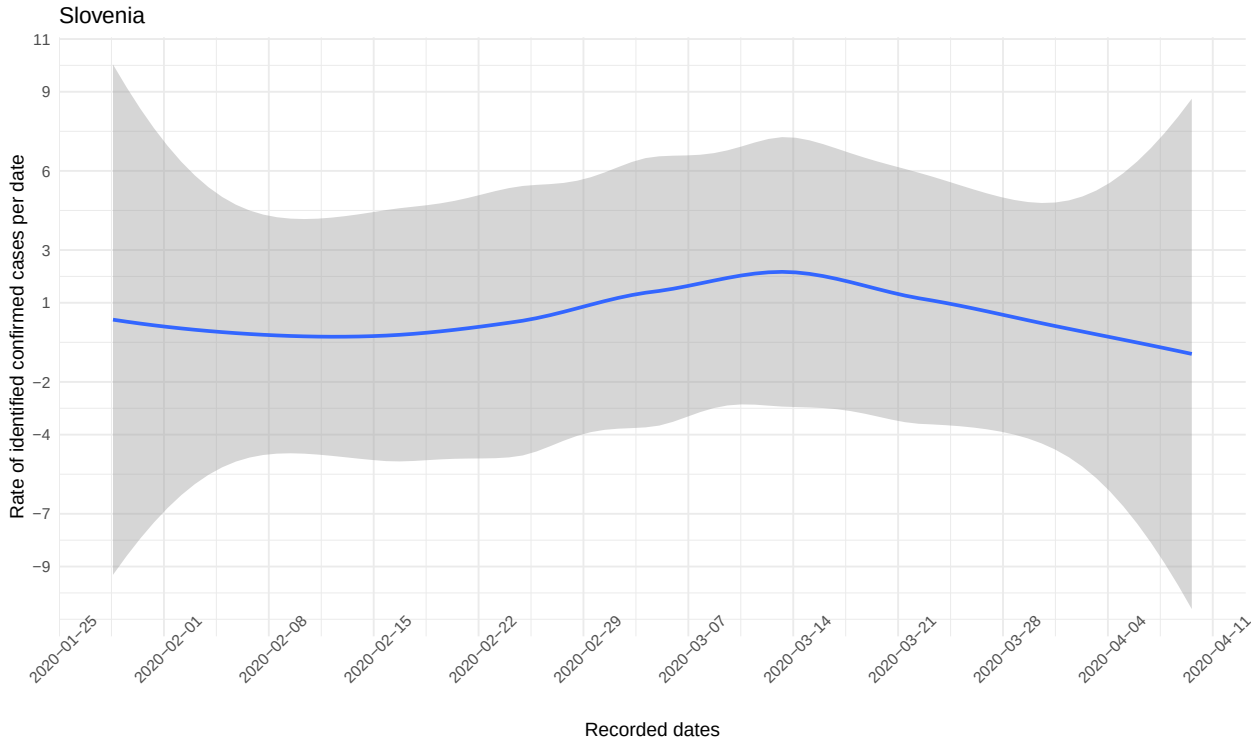


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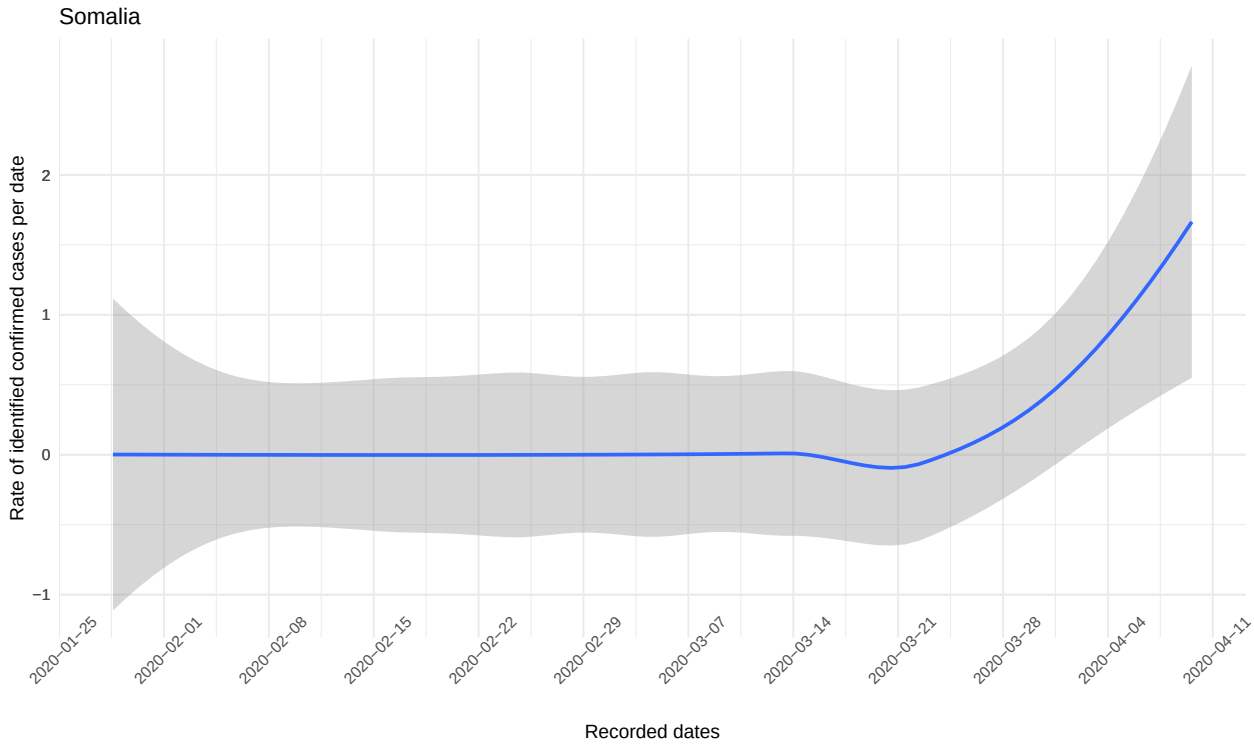


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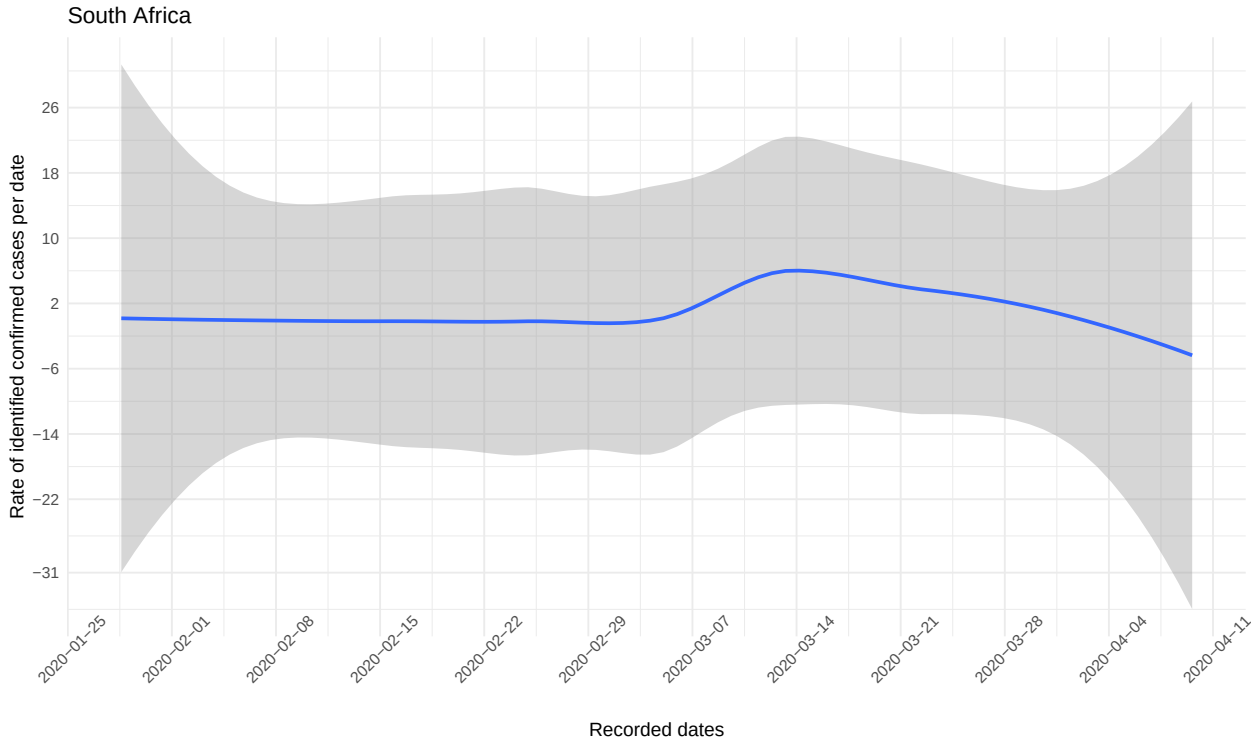


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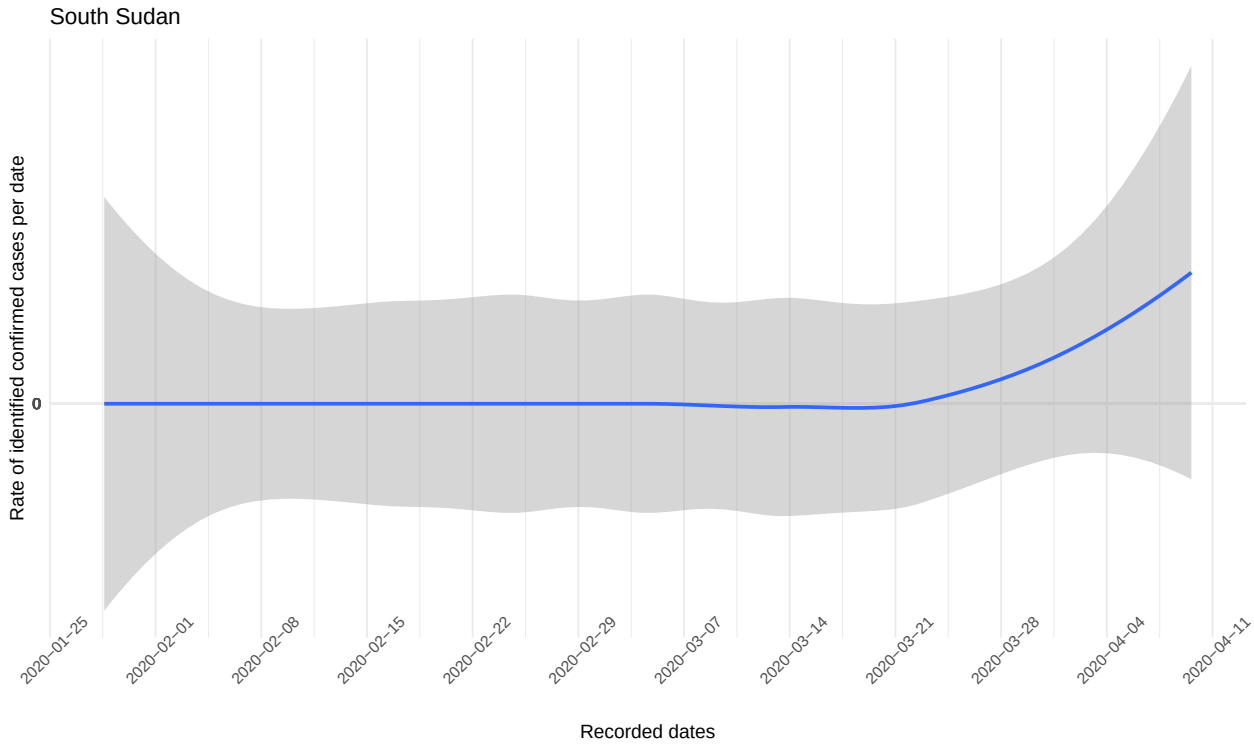


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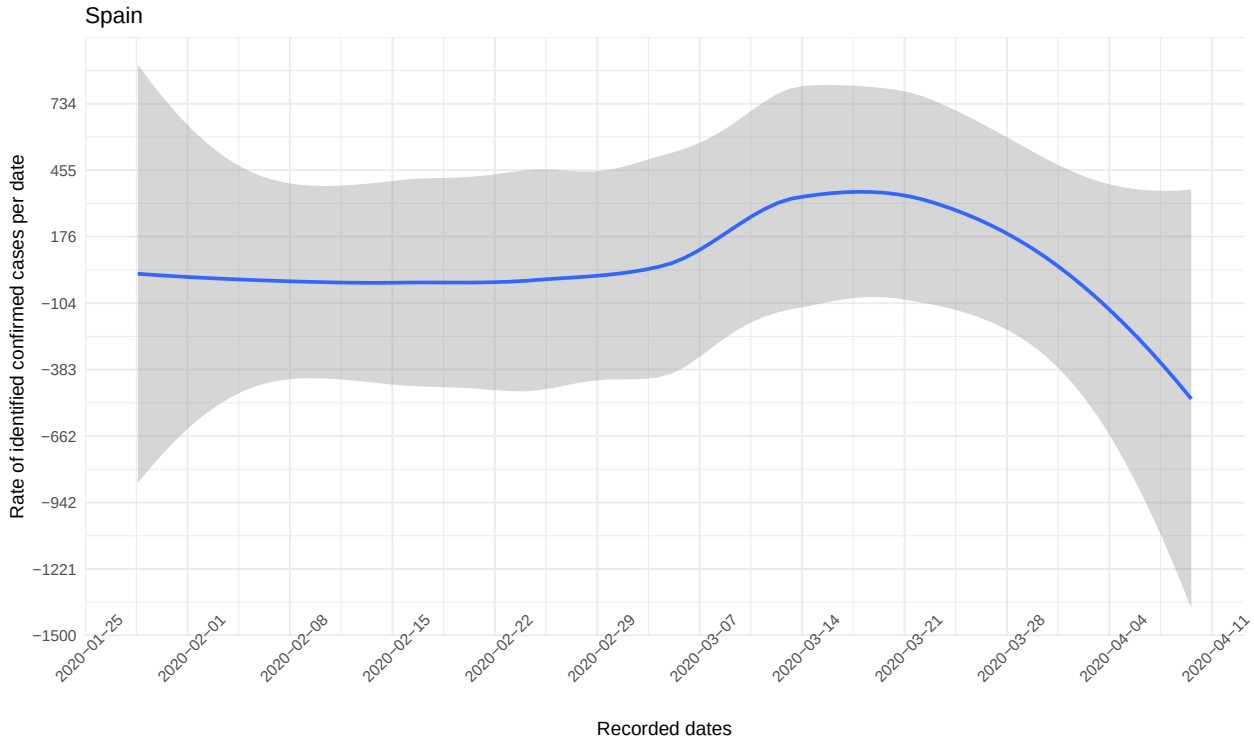


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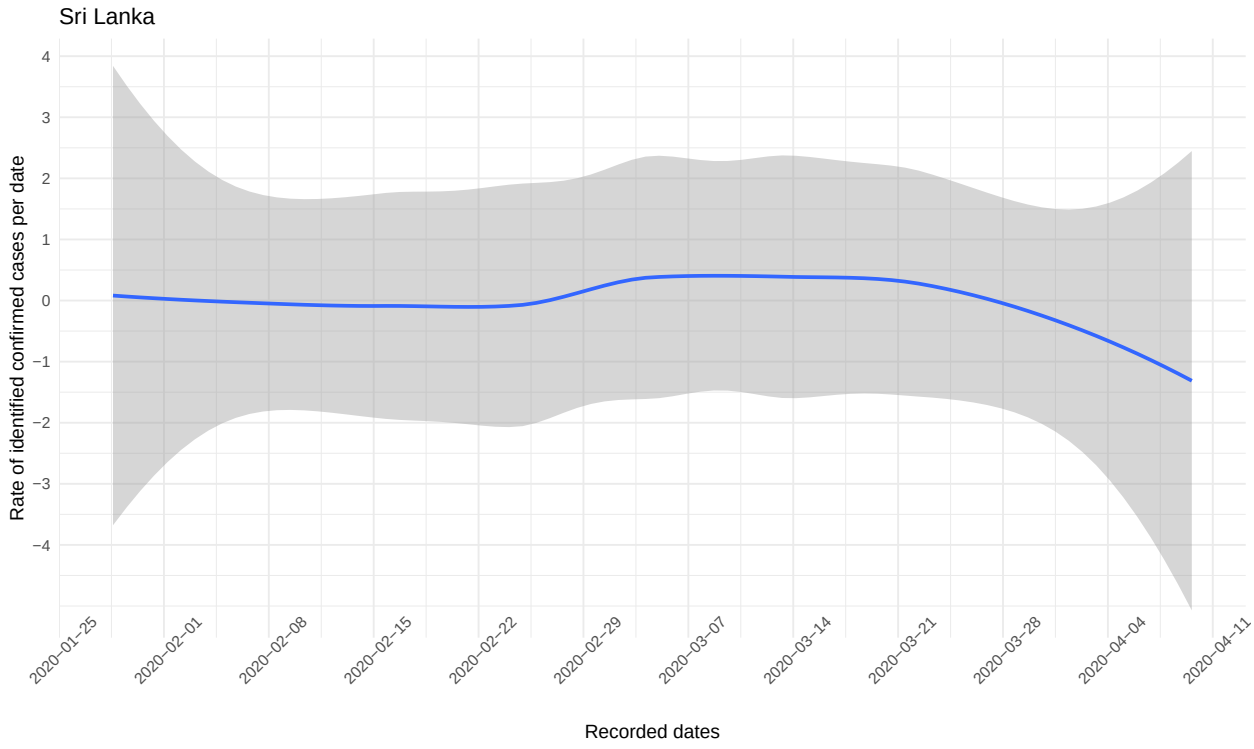


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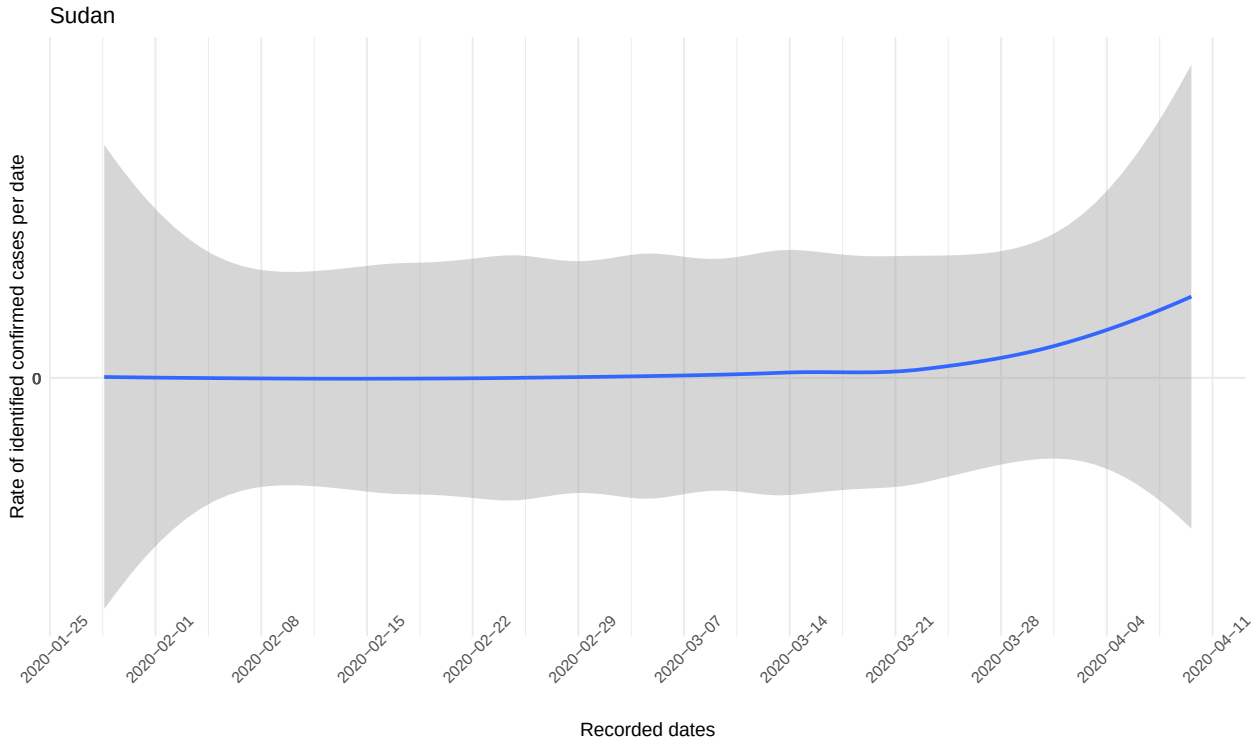


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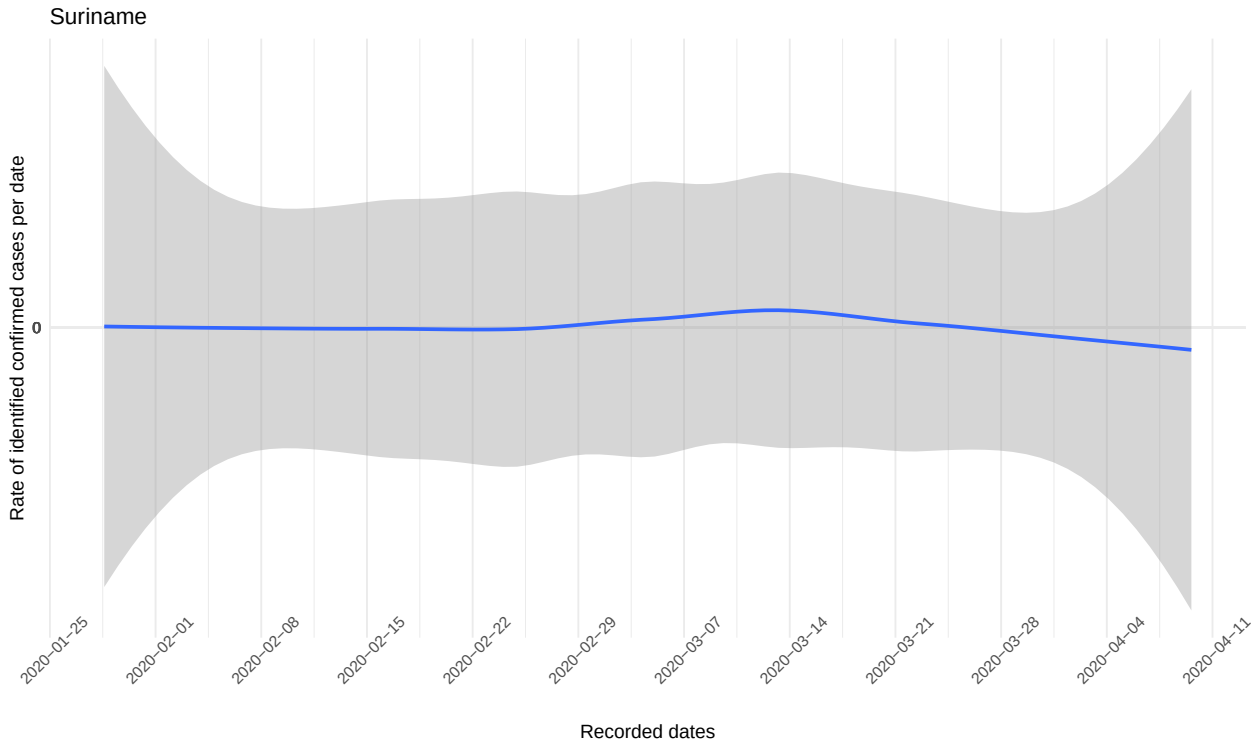


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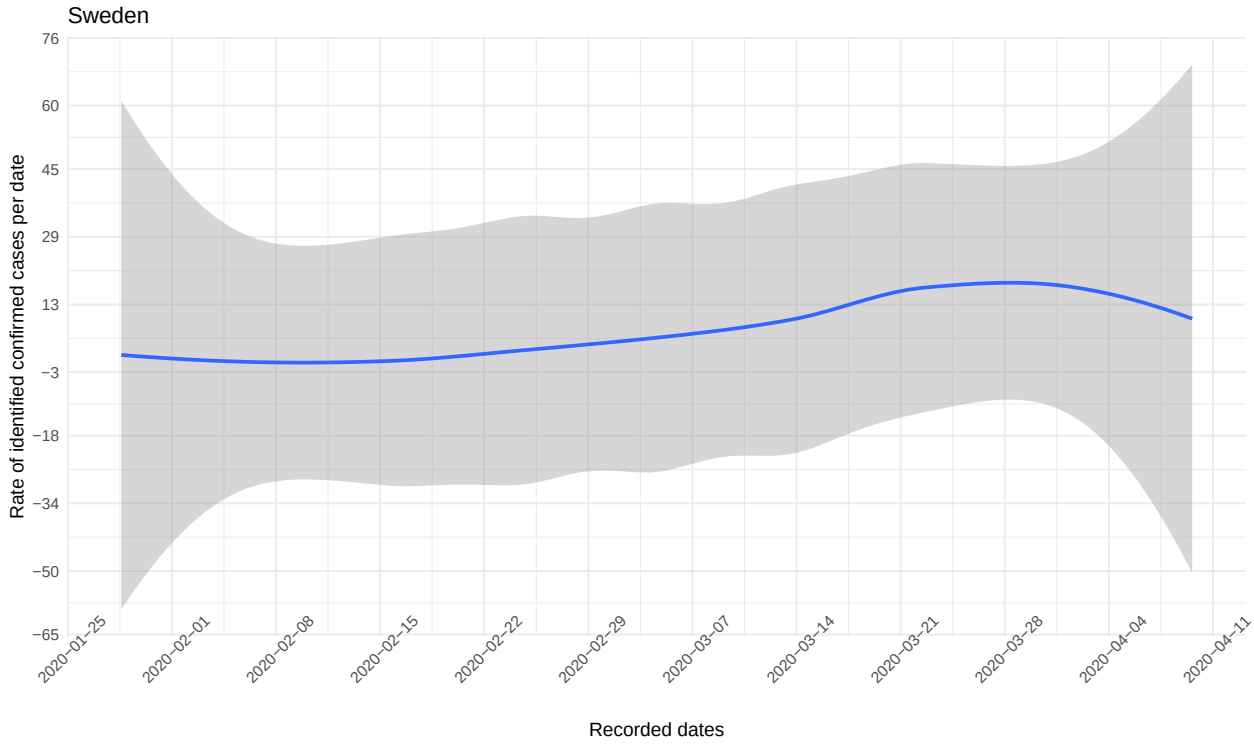


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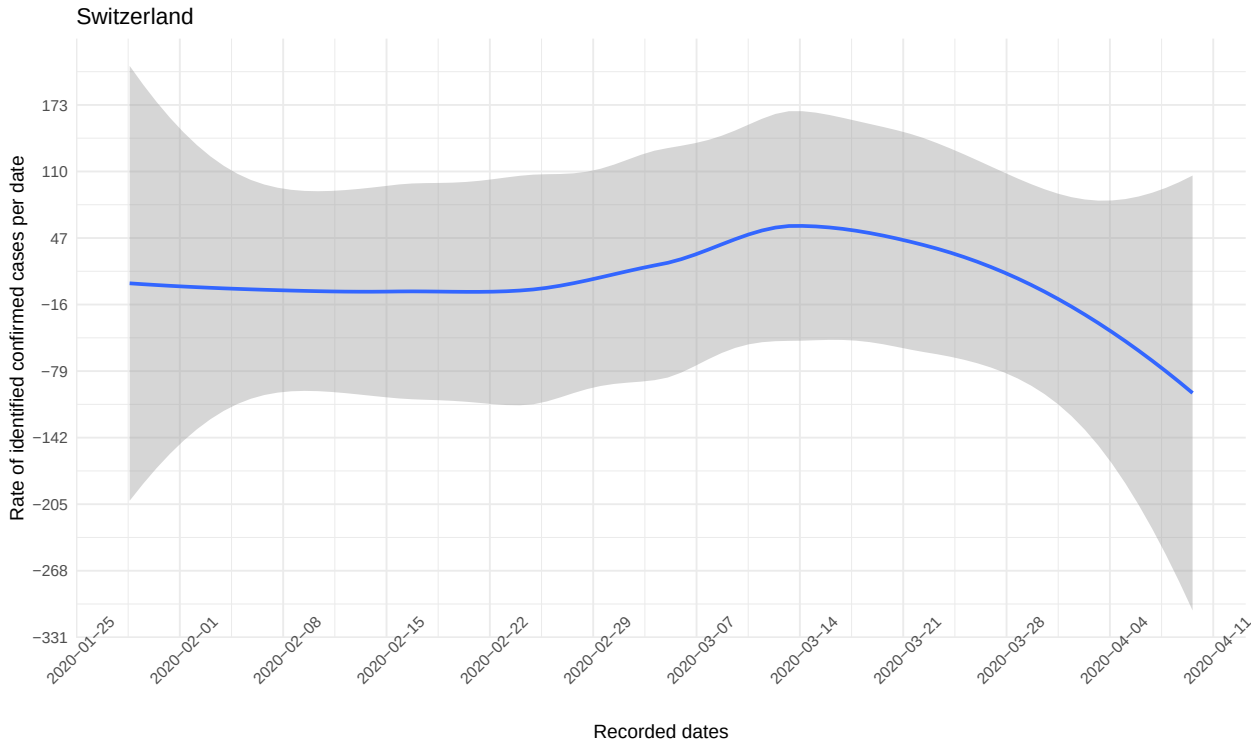


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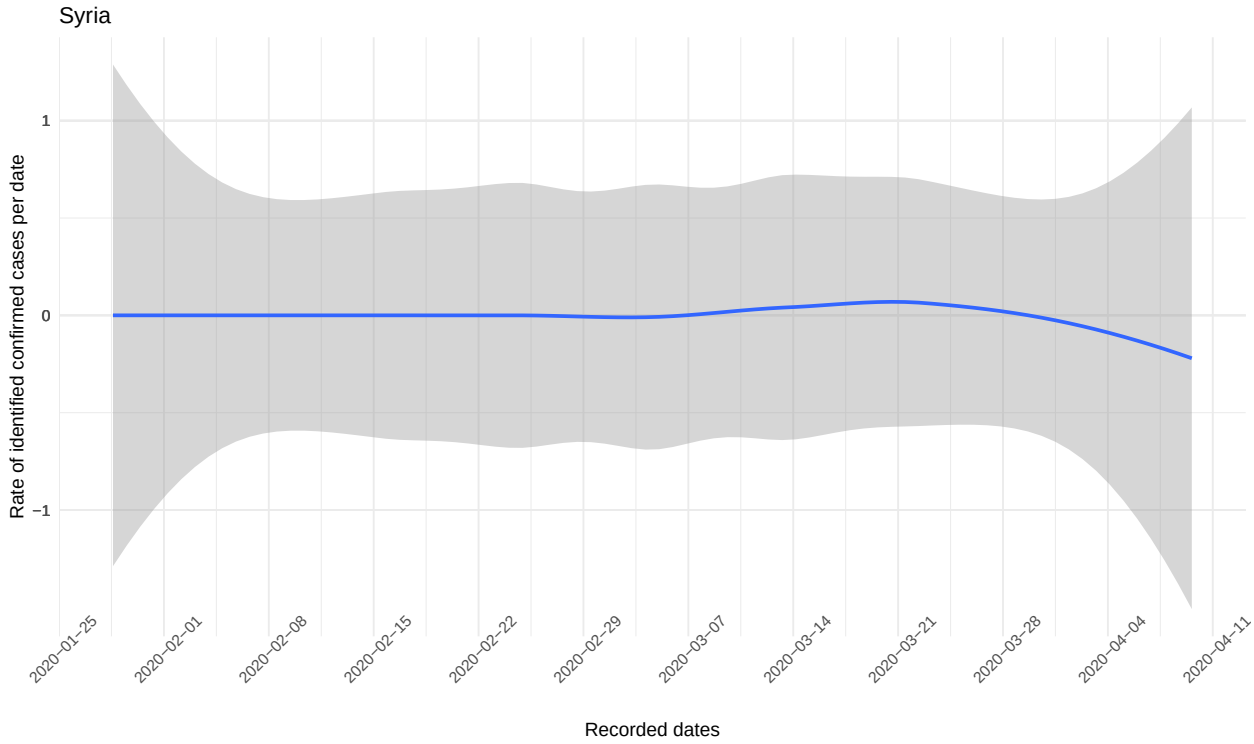


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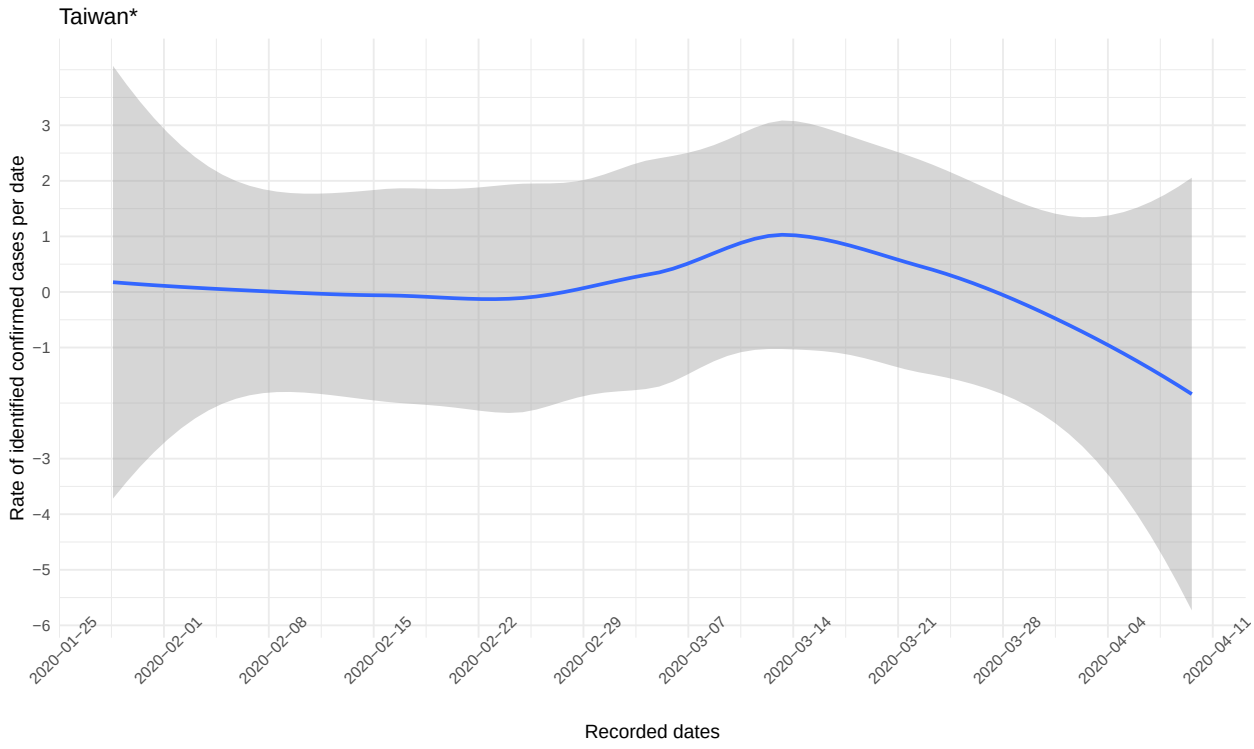


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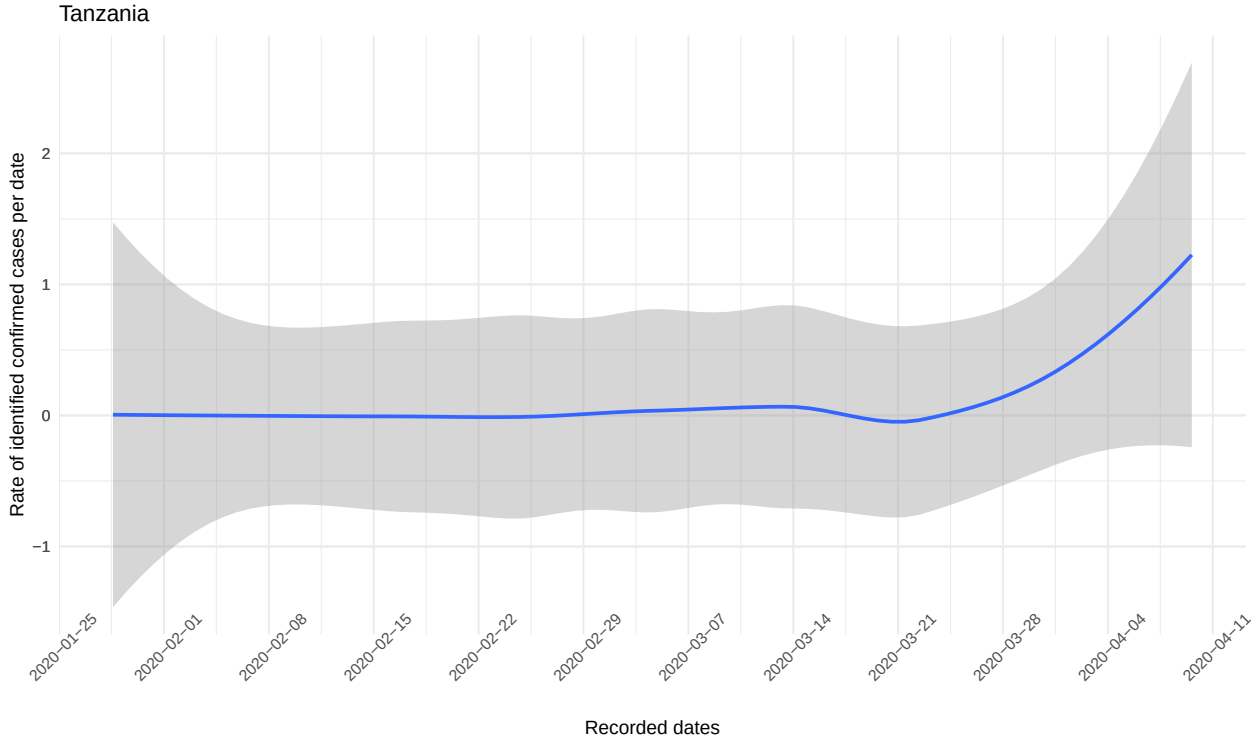


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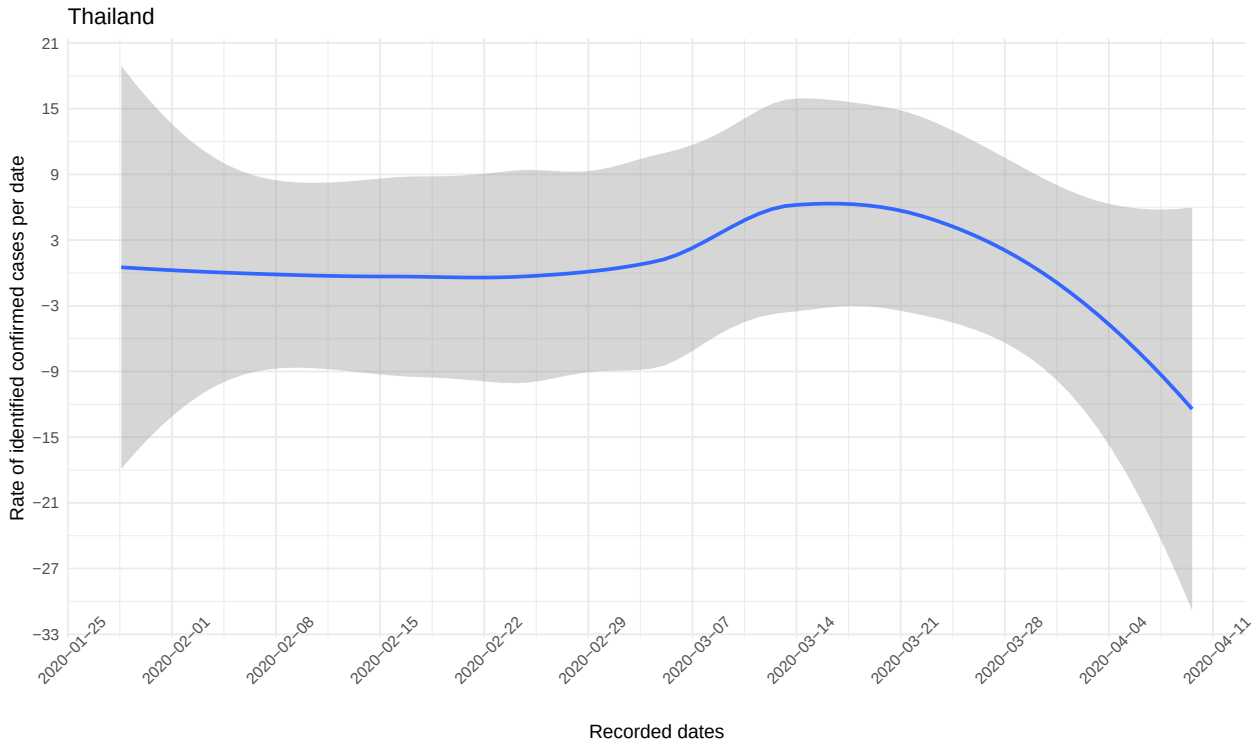


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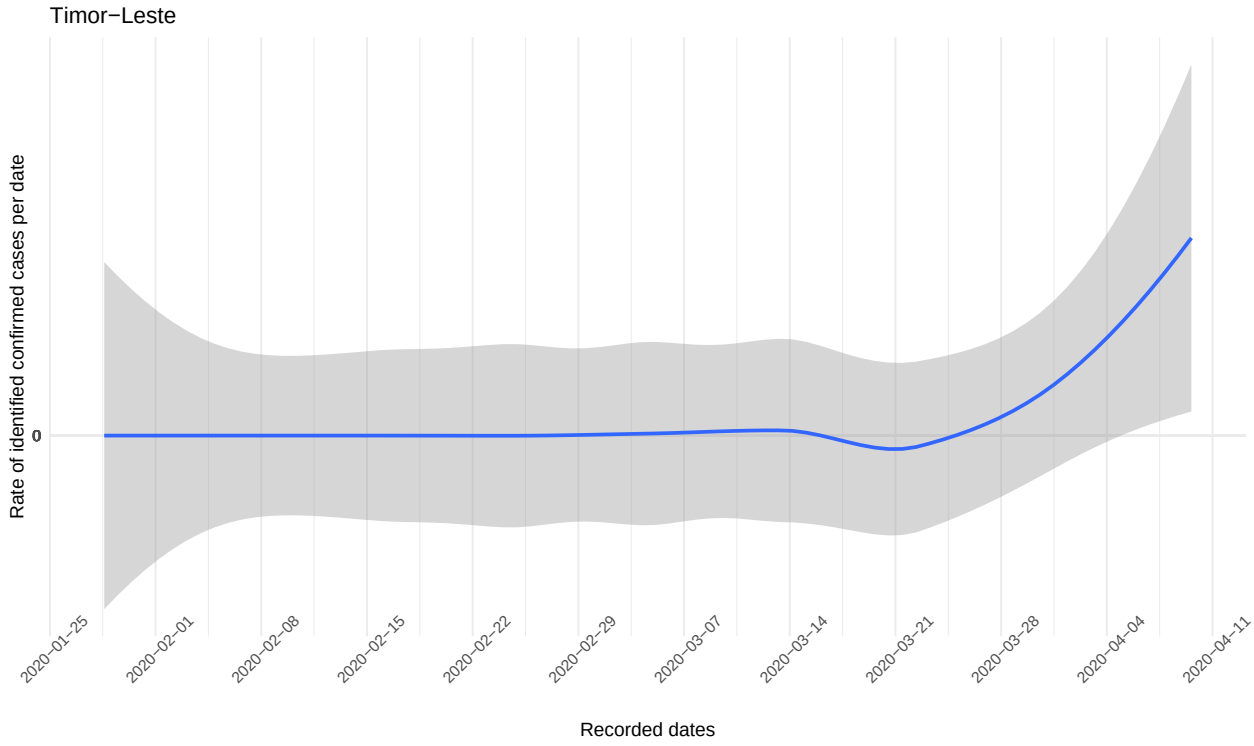


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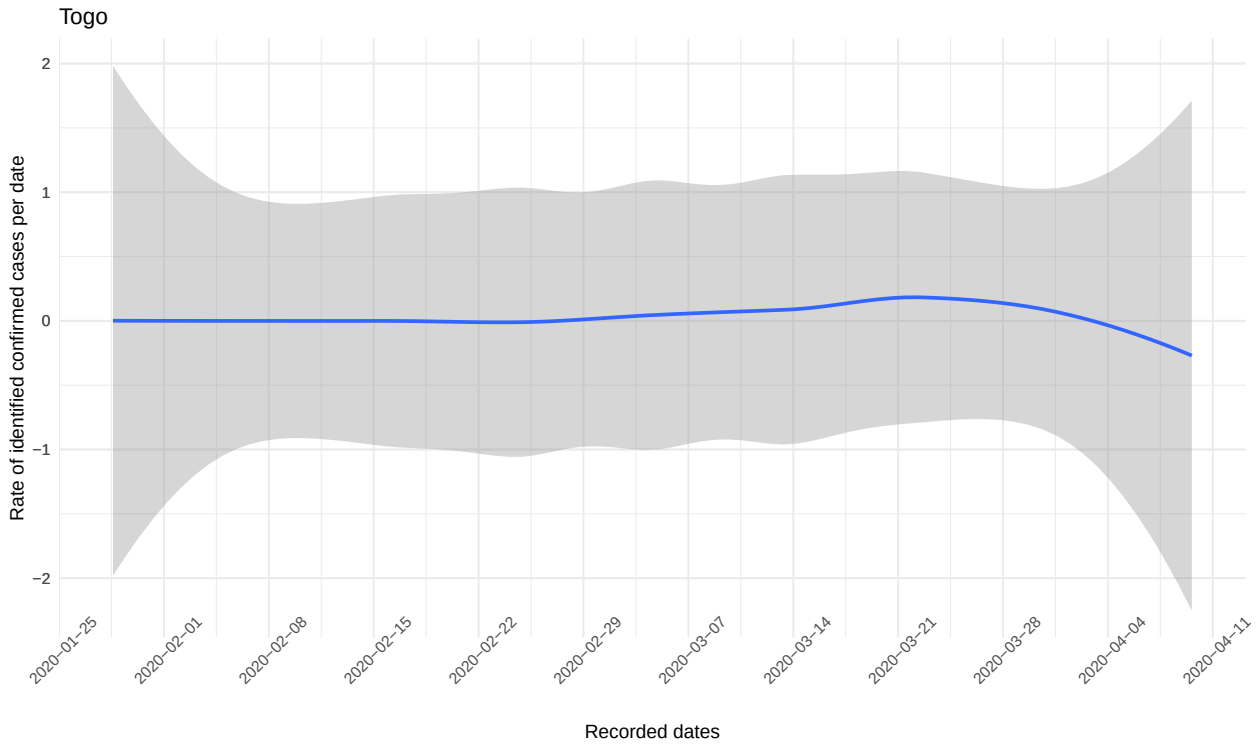


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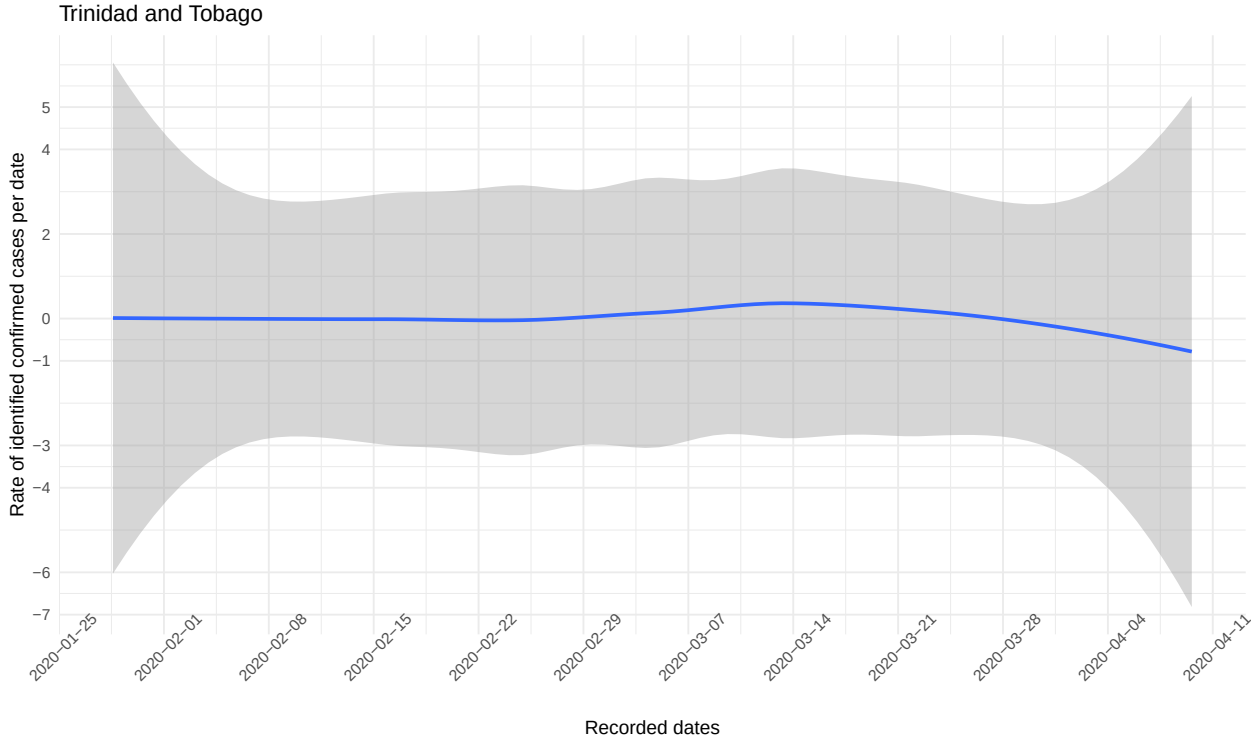


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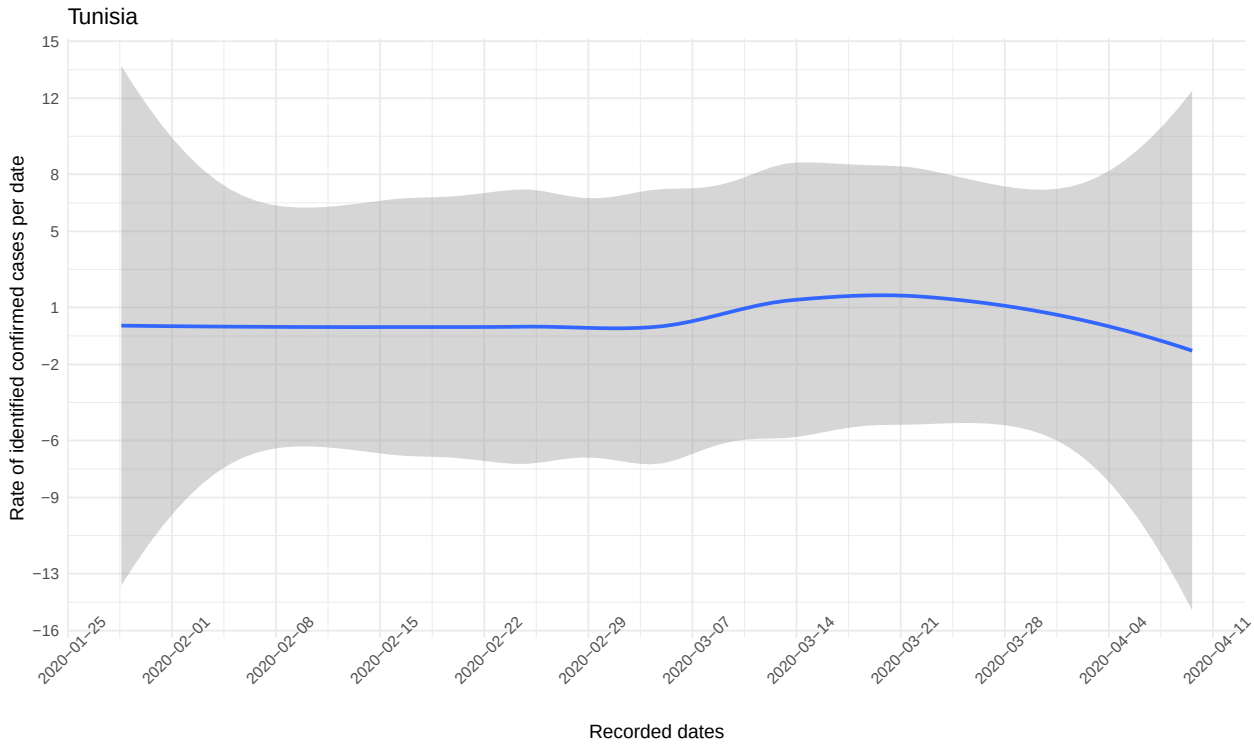


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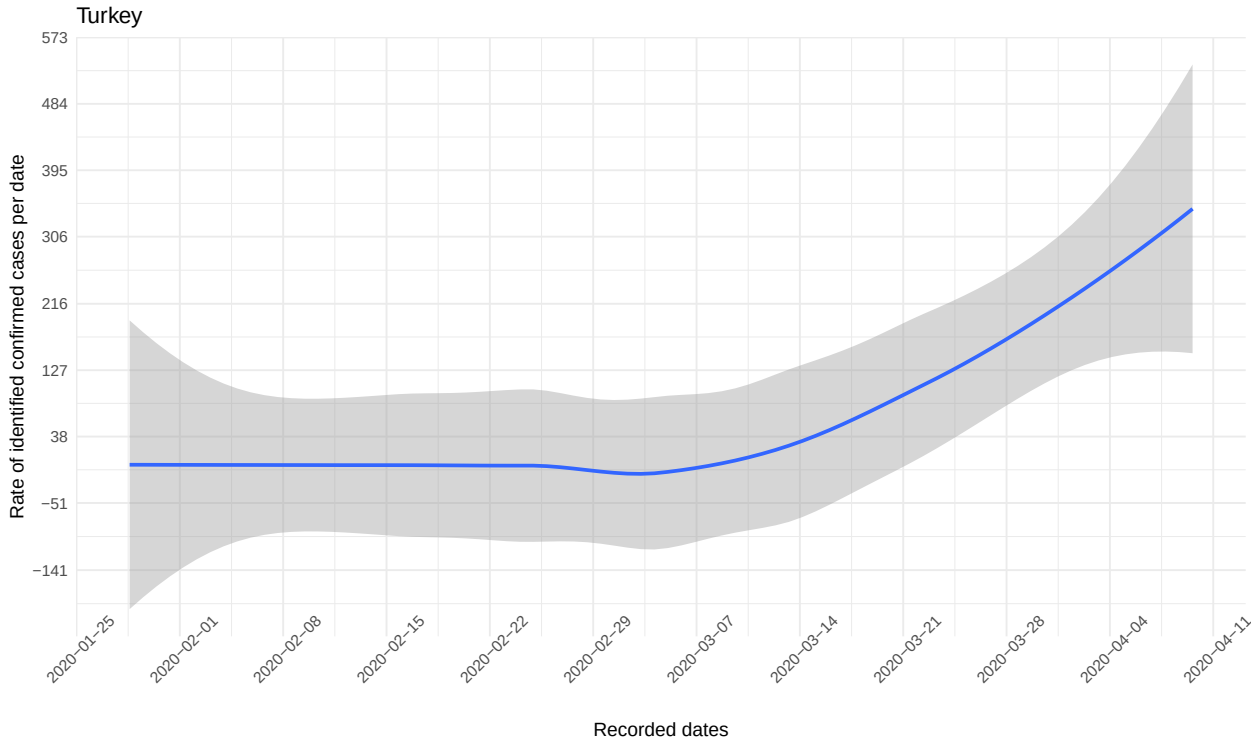


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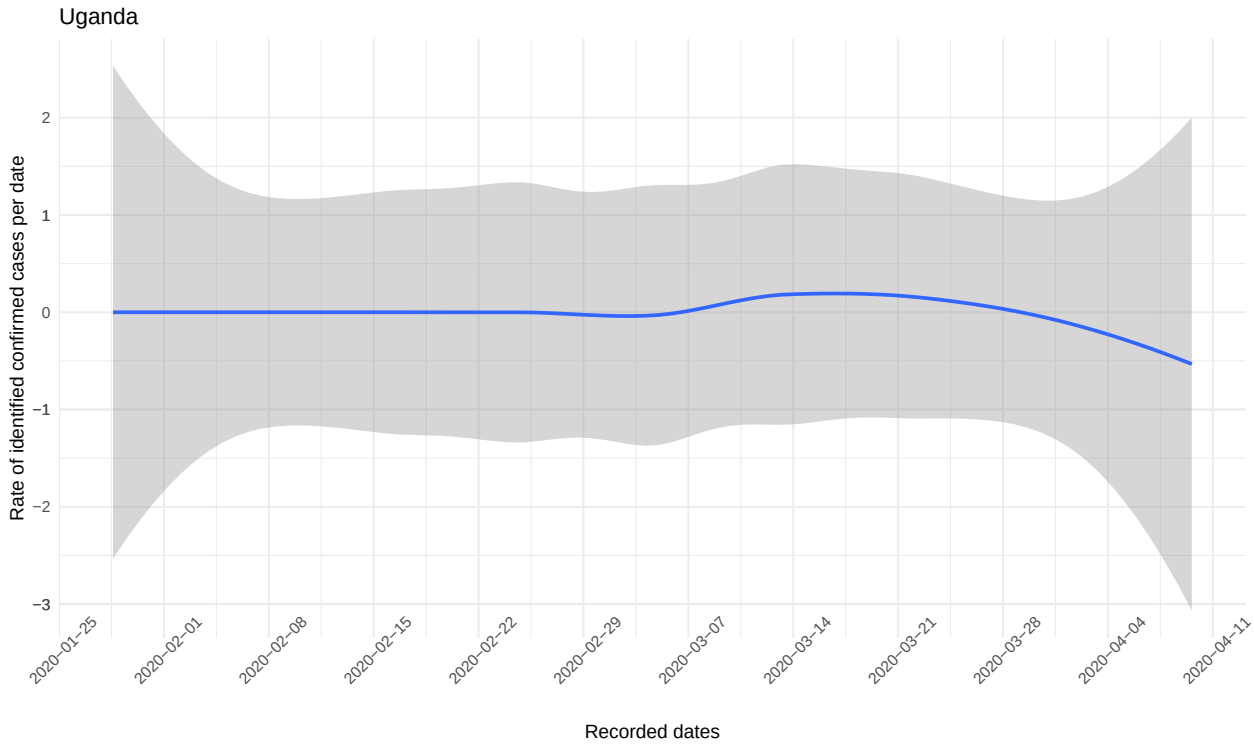


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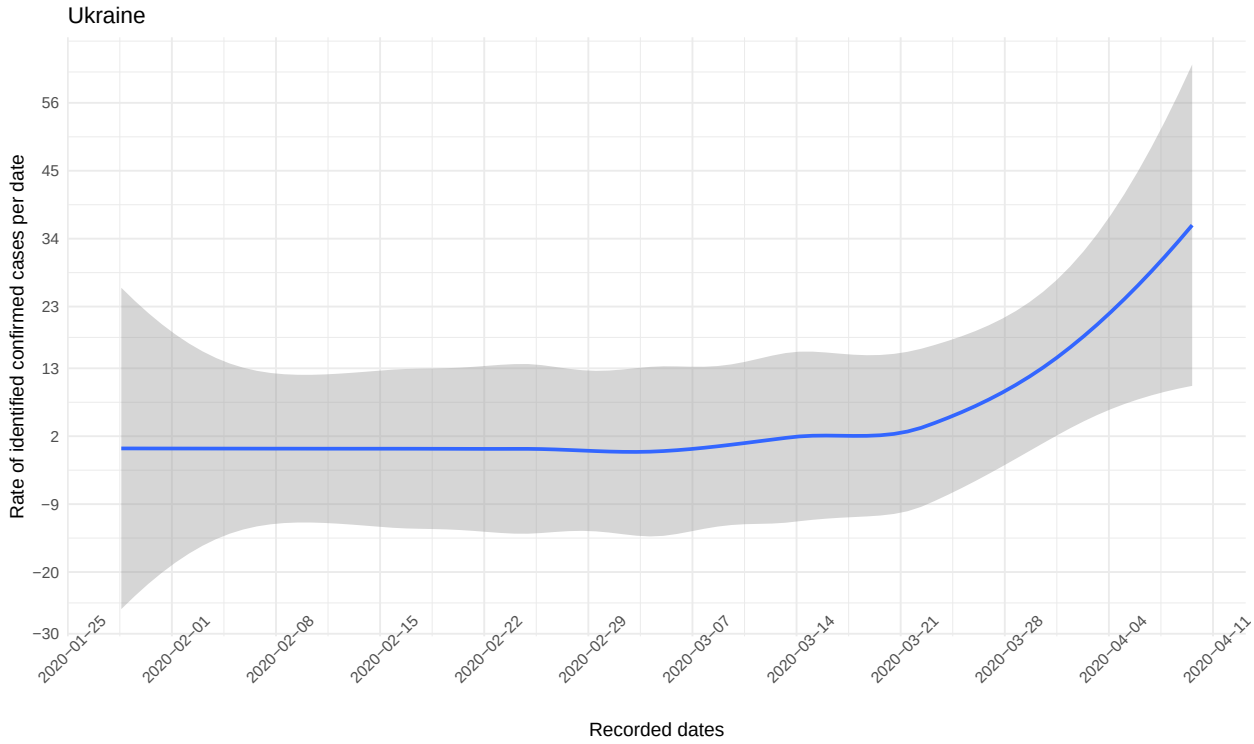


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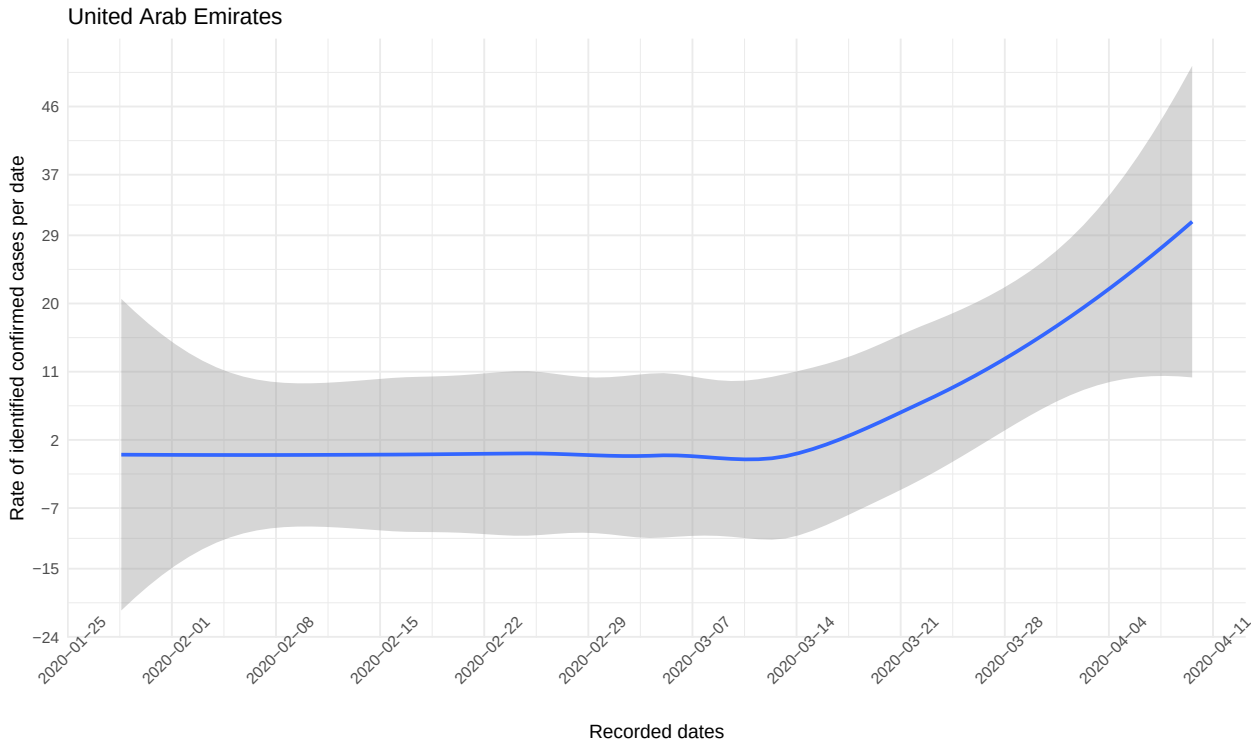


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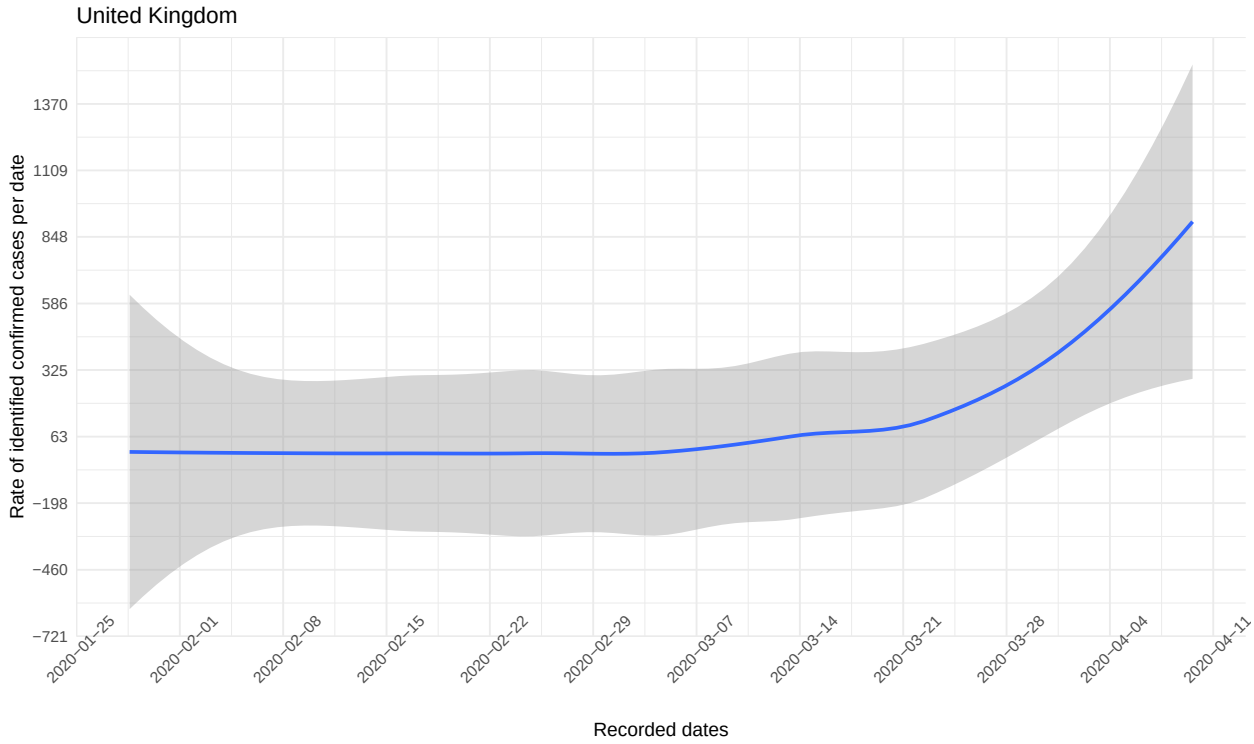


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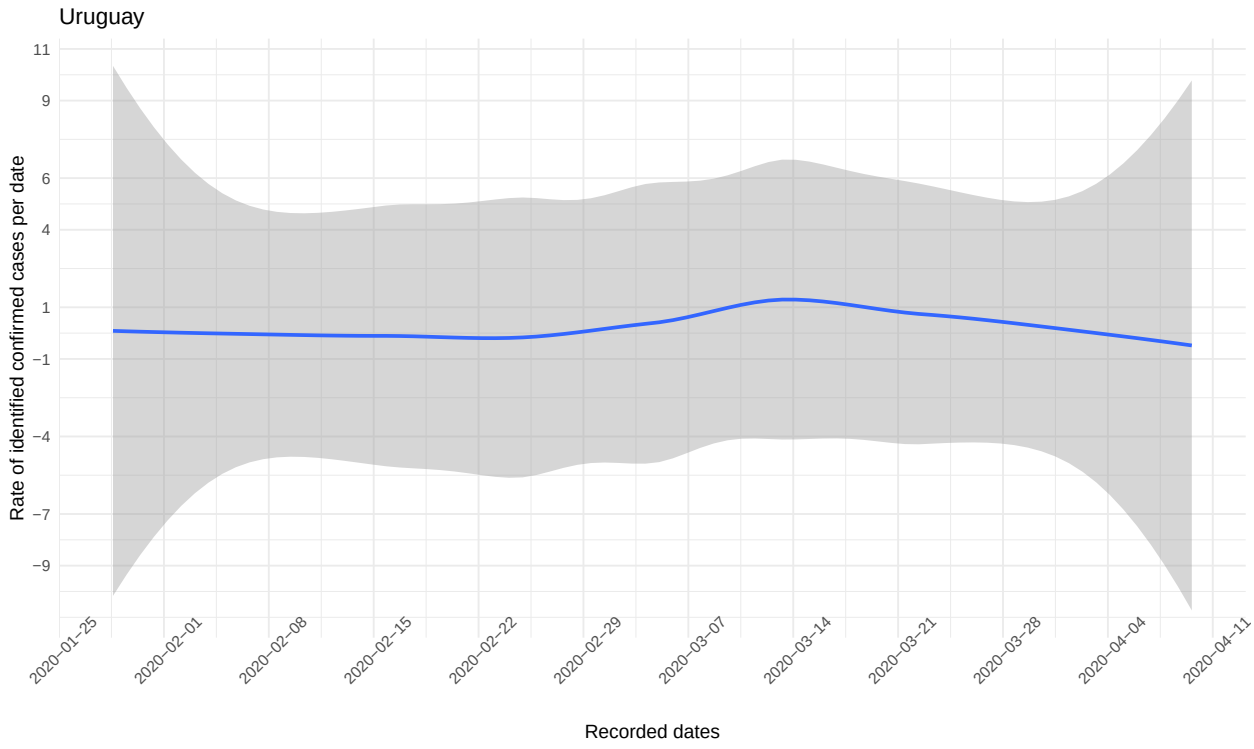


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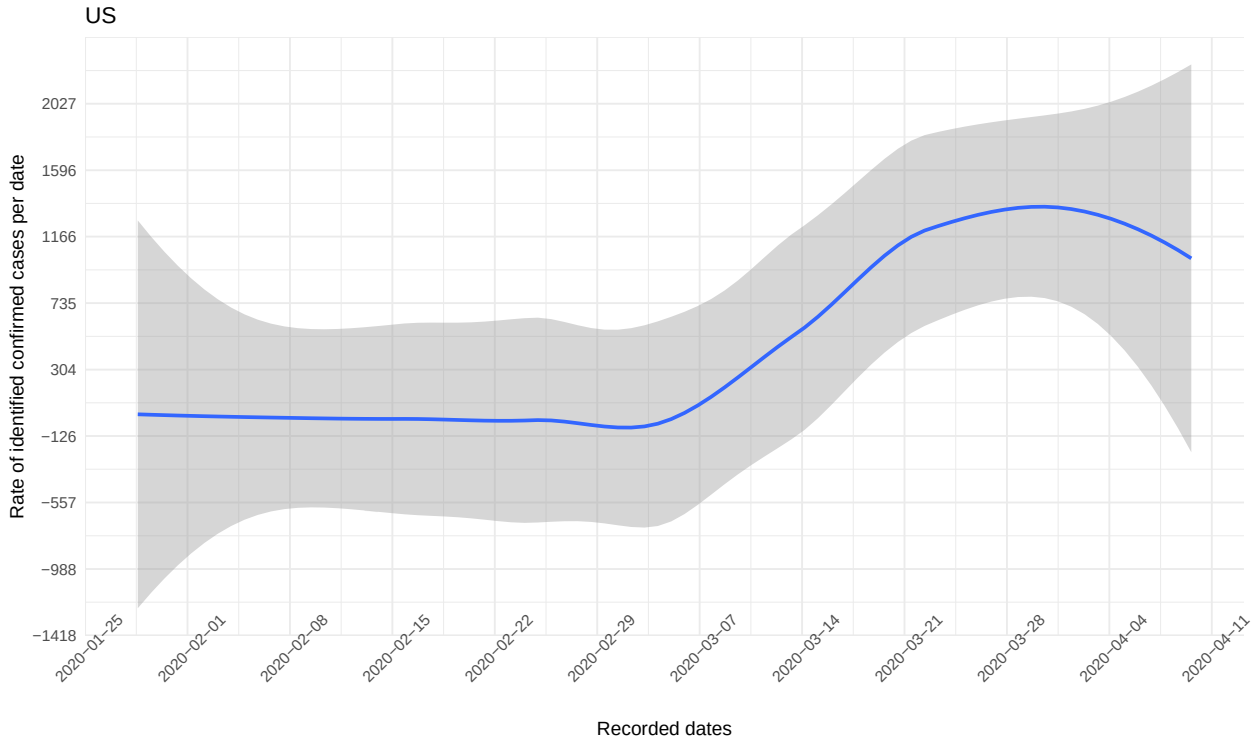


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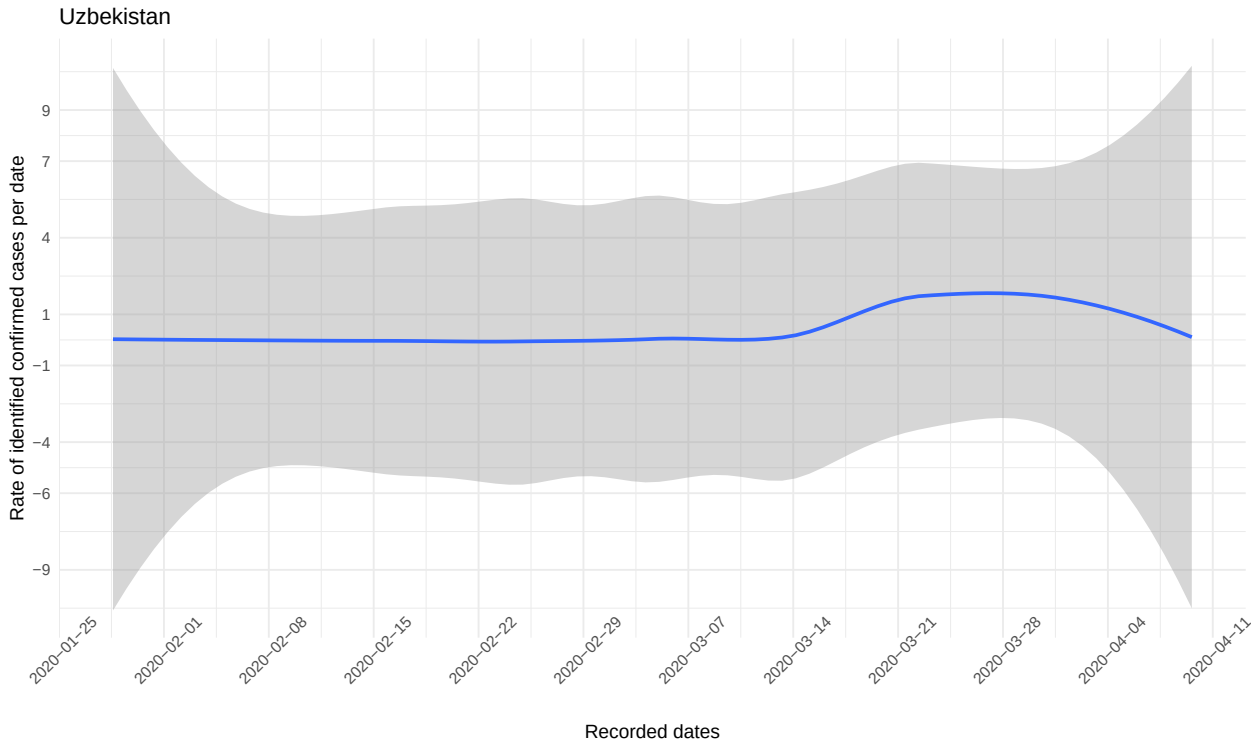


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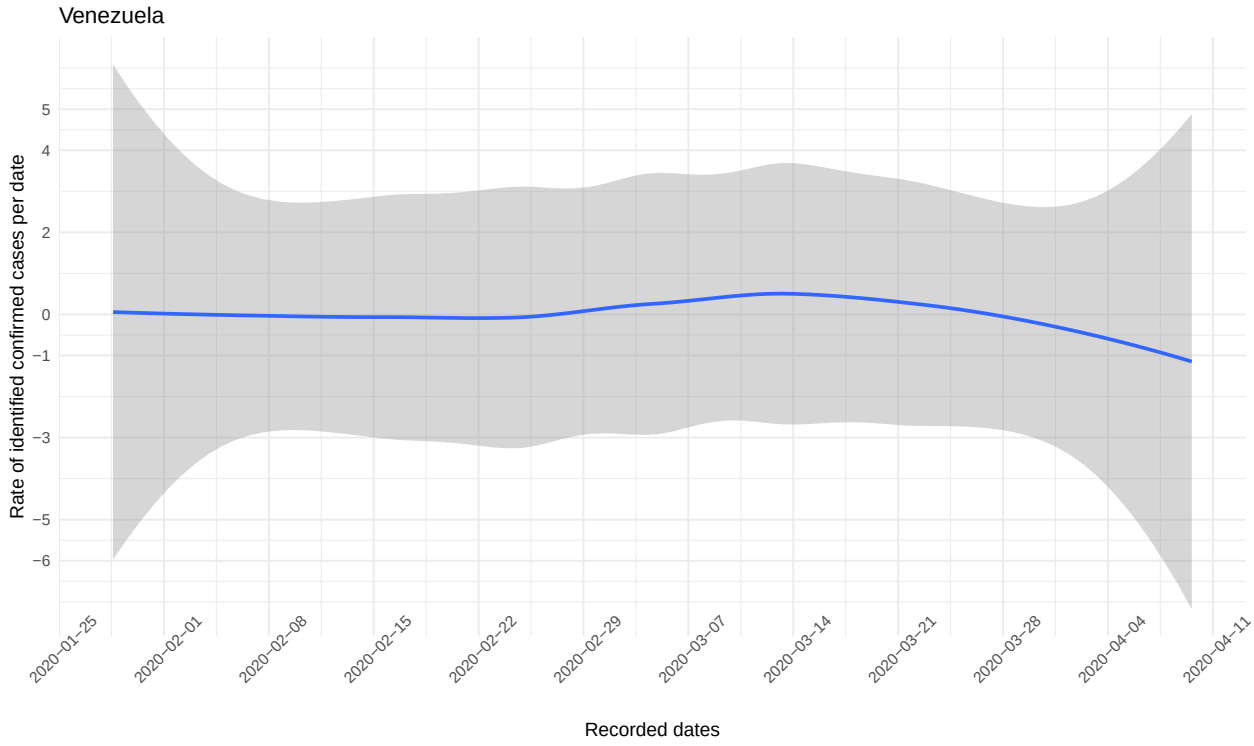


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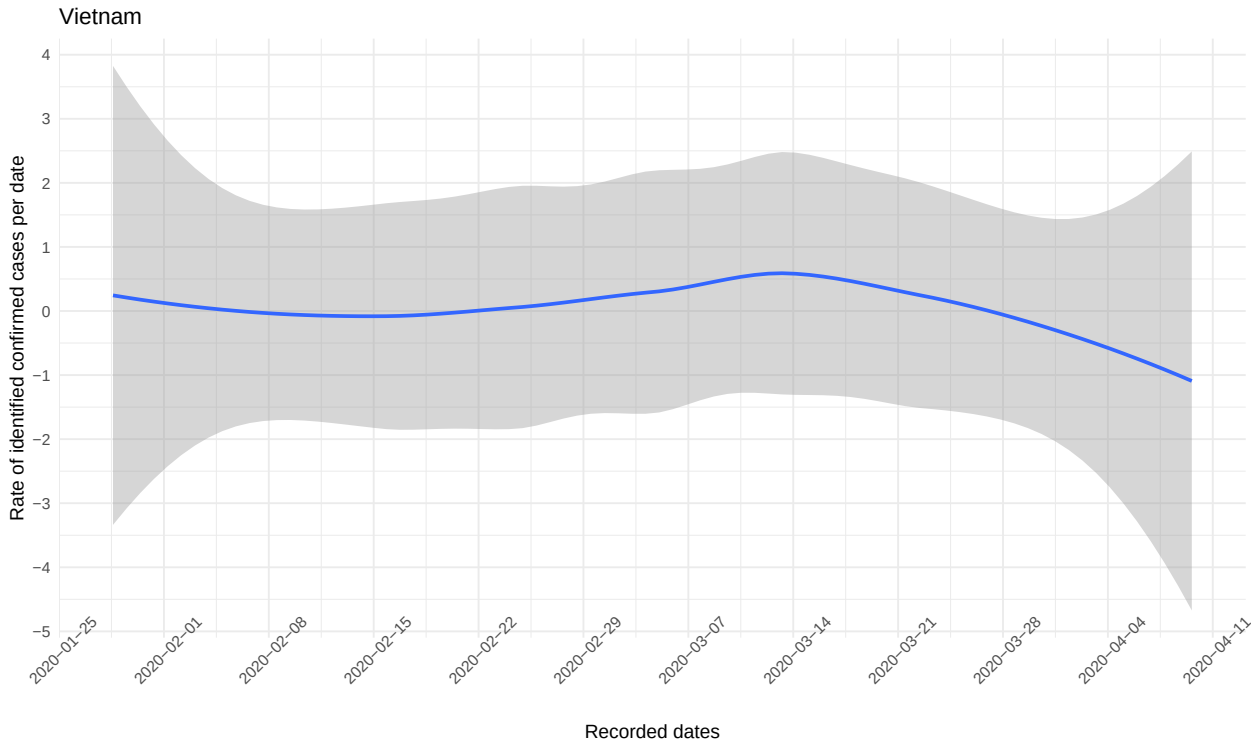


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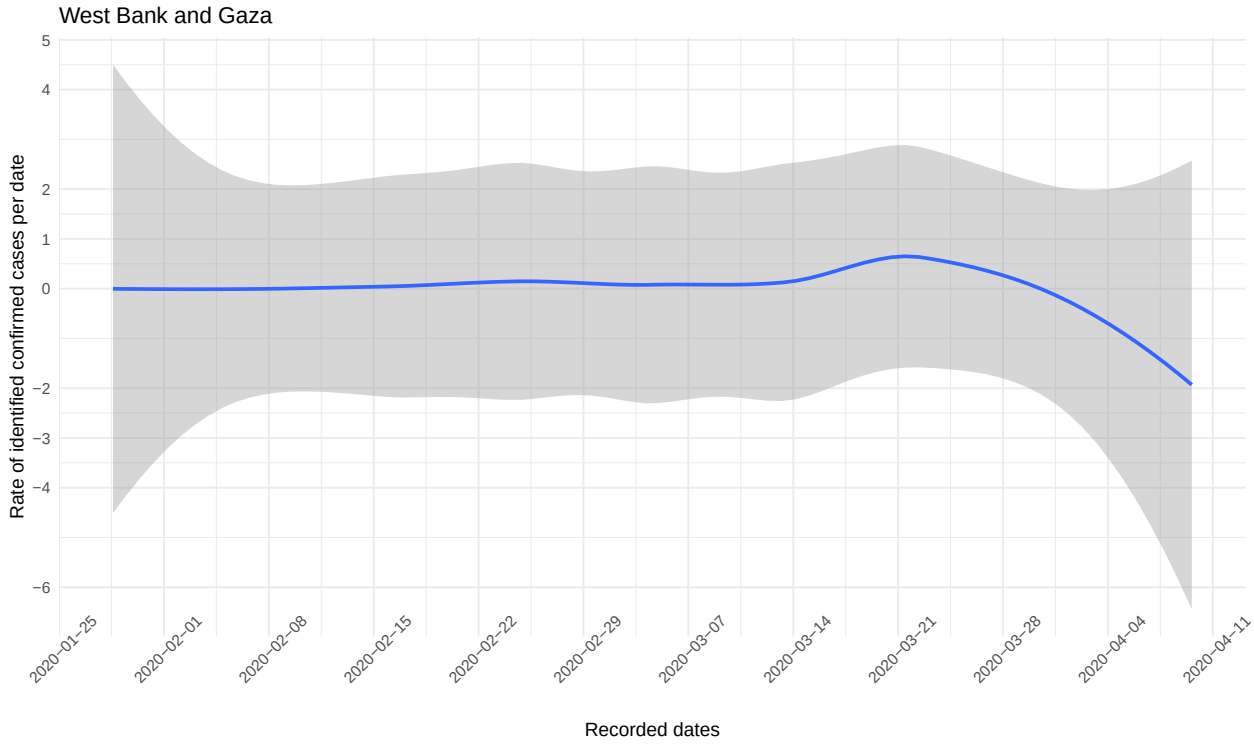


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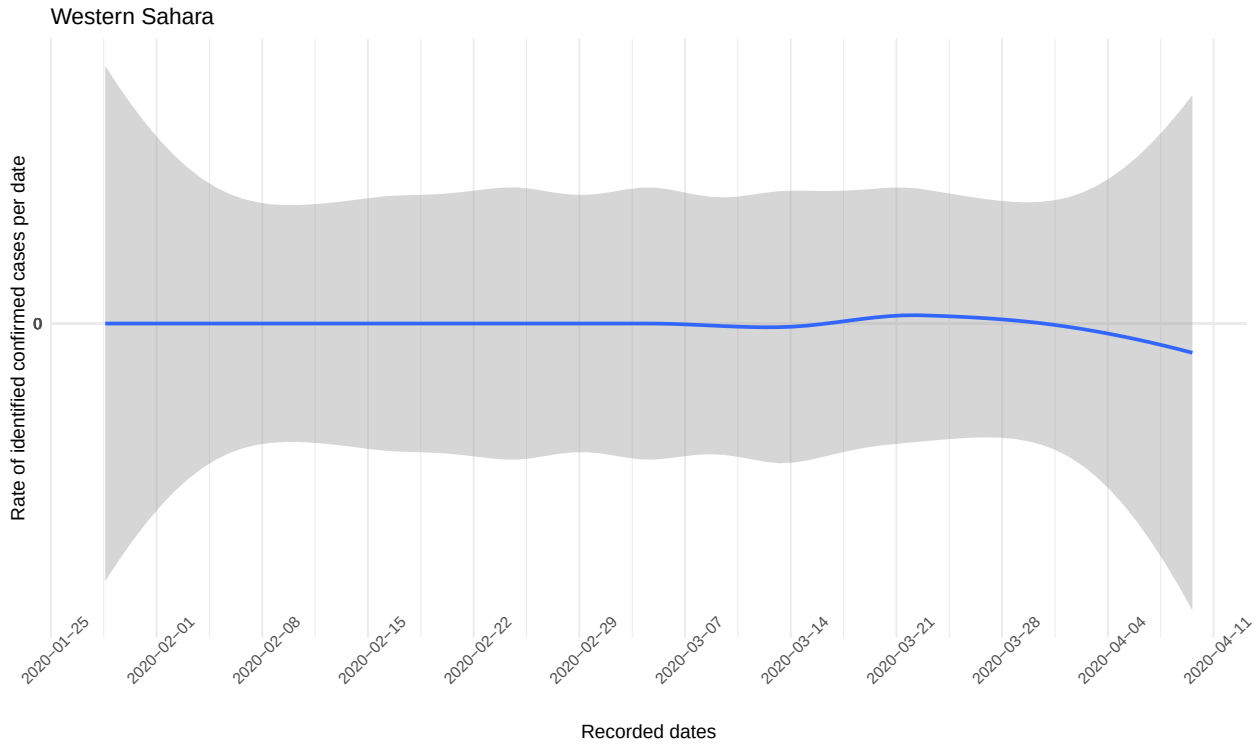


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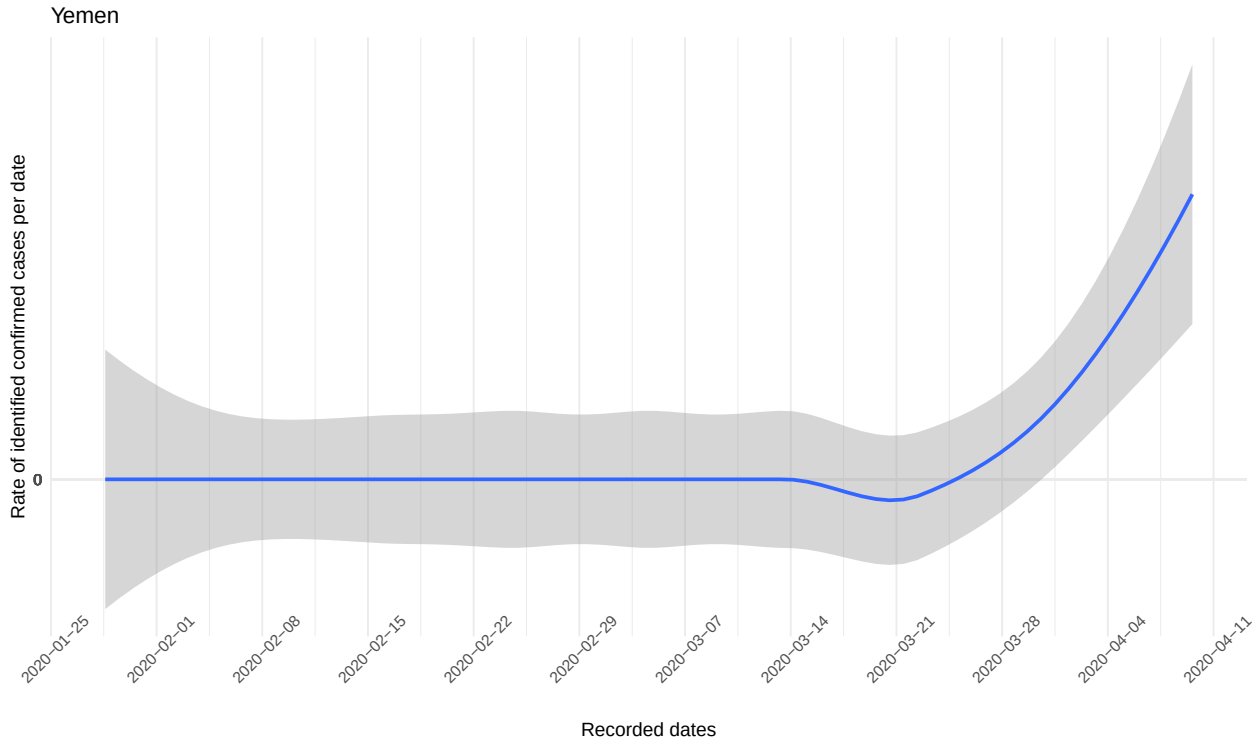


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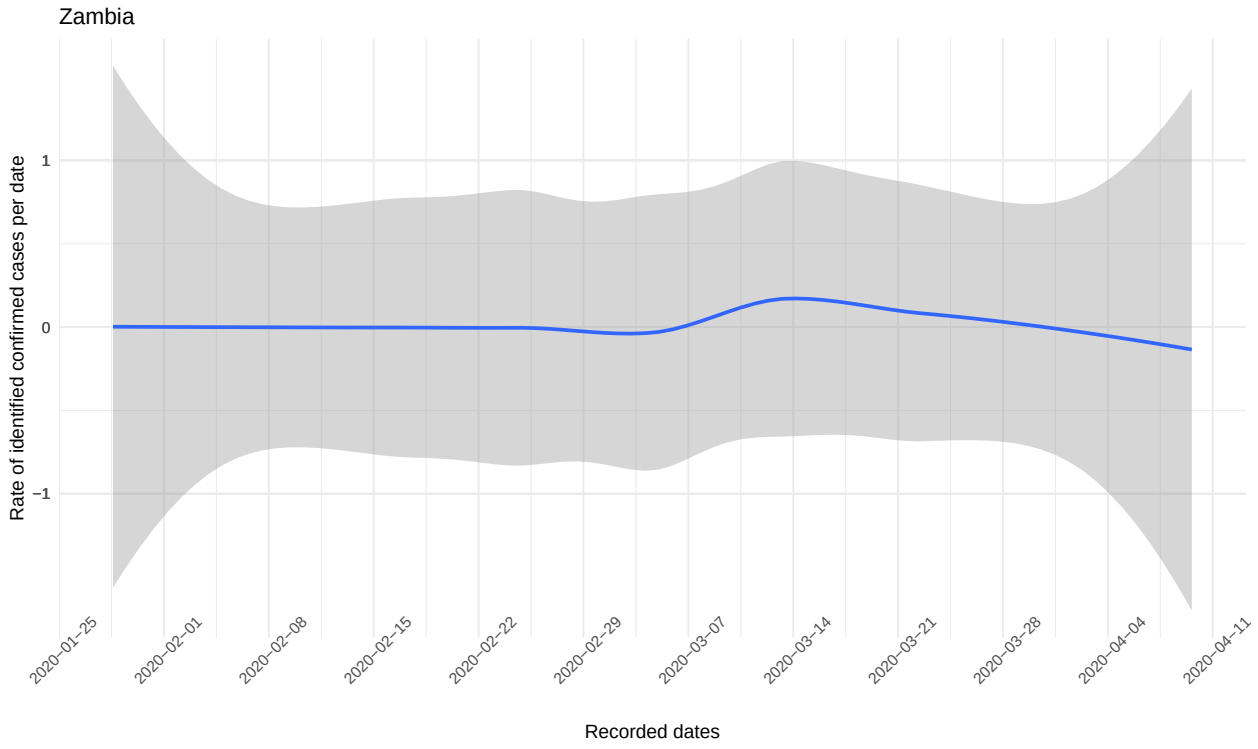


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