Wavelet coherence of COVID-19 pandemic variables in Japan

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Motivation

- Japan response to the COVID-19 has been in some aspects special
  - Non-pharmaceutical measures less stringent than in Europ
  - Pharmaceutical interventions still going on in 2023
- We were interested in studying the relation among main epidemiological variables
  - Our world in data
  - Synchronization of some variables in specific points of time
- Temporal correlations at multiple time scales
  - Wavelet coherence
  - Phase relations → potential causal relations

Motivation

- Focus on mortality results
  - Less prone to bias
  - Cases are extremely dependent on test reliability
    - FDA approved over a thousand brands with no formal validation
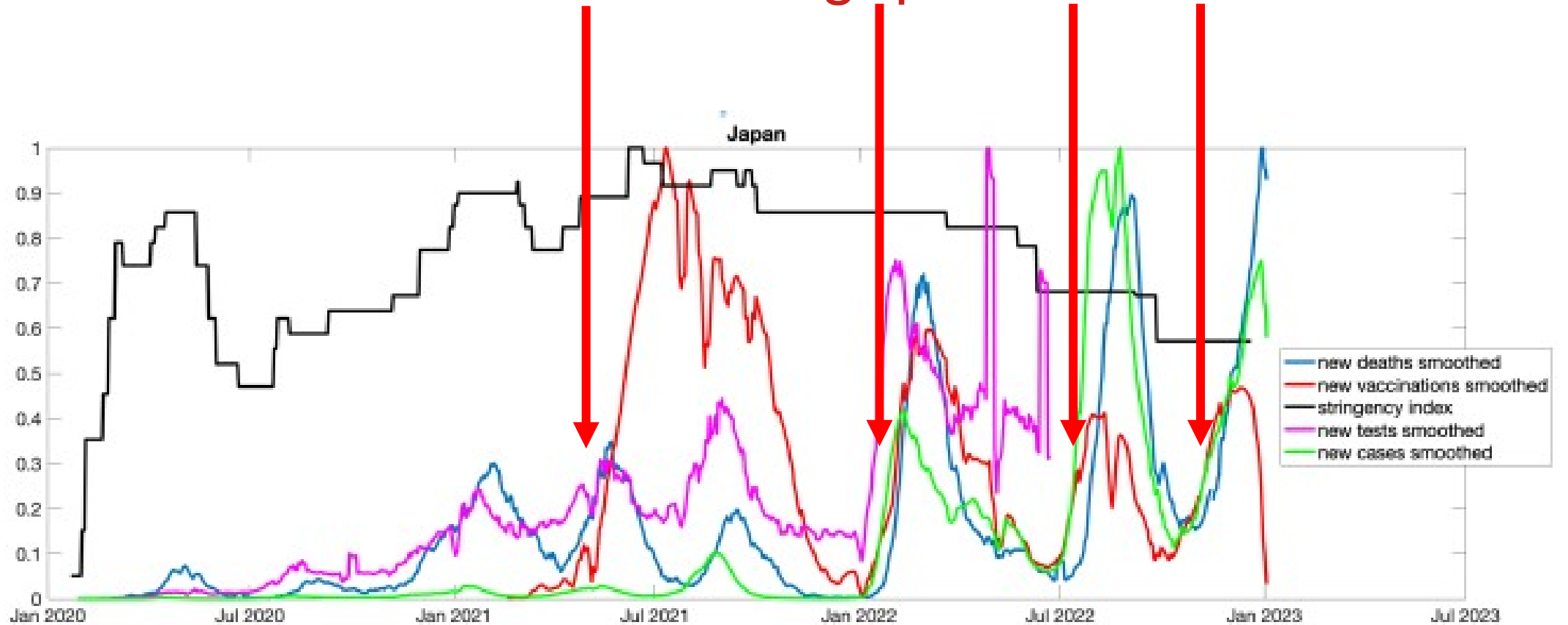 - False positives due to pressure to avoid false negatives

Fig. 1. Joint normalized plot of relevant variables for Japan since the beginning of the pharmaceutical interventions.

Time series normalized to the [0,1] interval to highlight pattern synchronization

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Wavelet coherence definitions

Morlett wavelet

$$\psi_0(\eta) = \pi^{-1/4} e^{iw_0\eta} e^{-\frac{1}{2}\eta^2}$$

ω_0 is frequency,

η is time,

Time series

$$X = \{x_n, n = 1, \ldots, N\}$$

Continuous wavelet transform (CWT)

$$W_n^X(s) = \sqrt{\frac{\delta t}{s}} \sum_{n'=1}^{N} x_{n'} \psi_0\left[(n'-n)\frac{\delta t}{s}\right].$$

$\left|W_n^X(s)\right|^2$ Wavelet power

scale s:

Crosswavelet transform (XWT)

$$W^{XY} = W^X W^{Y*}$$

Wavelet coherence (WC)

$$R_n^2 = \frac{\left|S\left(s^{-1}W_n^{XY}(s)\right)\right|^2}{S\left(s^{-1}\left|W_n^X(s)\right|^2\right) \cdot S\left(s^{-1}\left|W_n^Y(s)\right|^2\right)},$$

S is a smoothing operator

Materials

- Data downloaded from Our World in Data

- Variables: deaths, cases, tests, vaccine doses, stringency index, excess deaths, hospitaized patients, ICU patients

- Cut off date 01/january/2023

    - Most countries stopped mass testing in the summer of 2022

    - Same for other pandemic follow up observations and measures

    - By the end of 2022, considerations were dropped in practice

    - Spring 2023 the WHO declared the end of the emergency, after USA administration dropped all mandates and measures

Results

- We compute the wavelet coherence of various variables versus COVID_19 mortality

- Intensity (red) indicates strength of coherence (correlation)

- Arrows indicate phase between variables

  - Up: first variable precedes second variable

  - Right: variables are synchronized (positive correlation)

  - Down: second variable precedes first variable

  - Left: variables in oposition (negatively correlated)
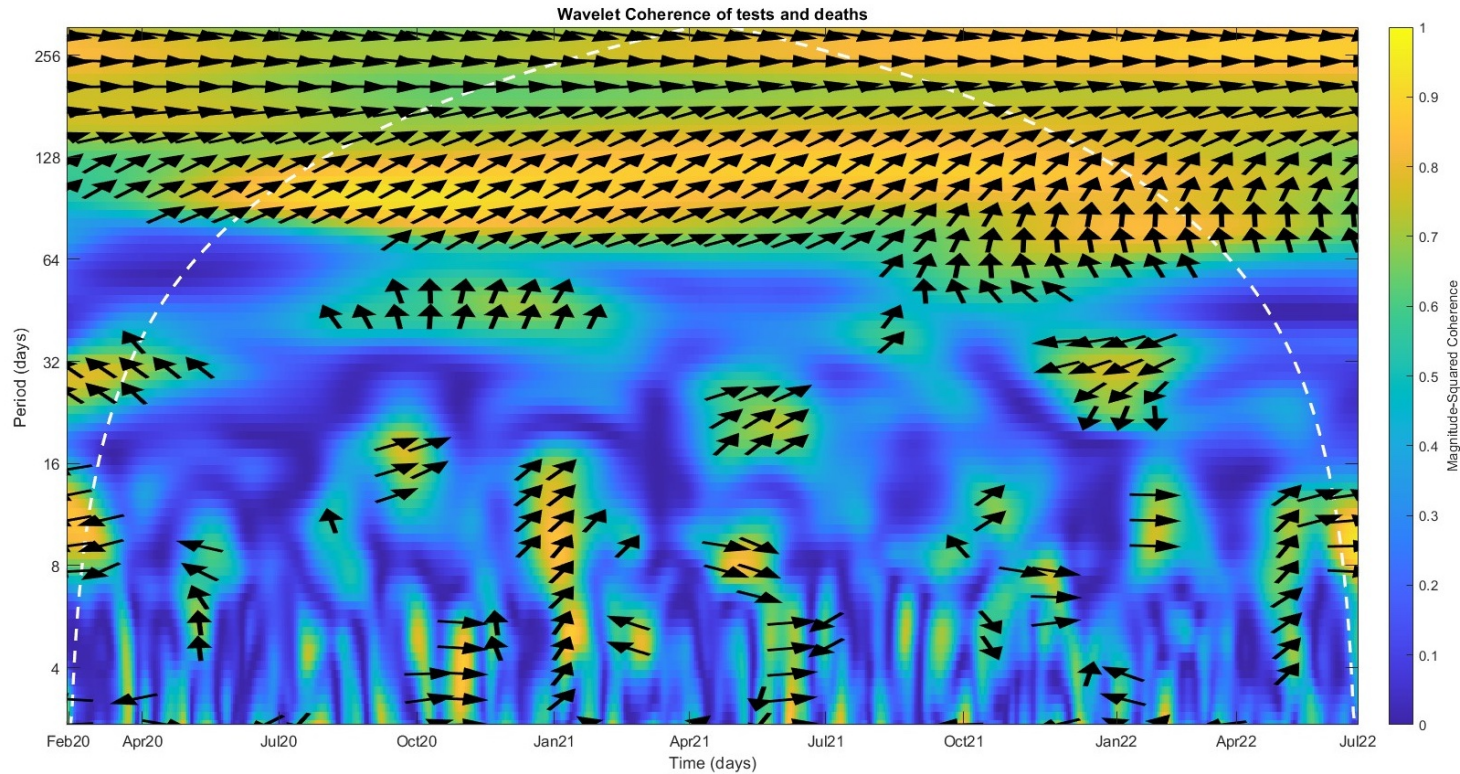
Cases vs deaths

Wavelet Coherence of cases and deaths
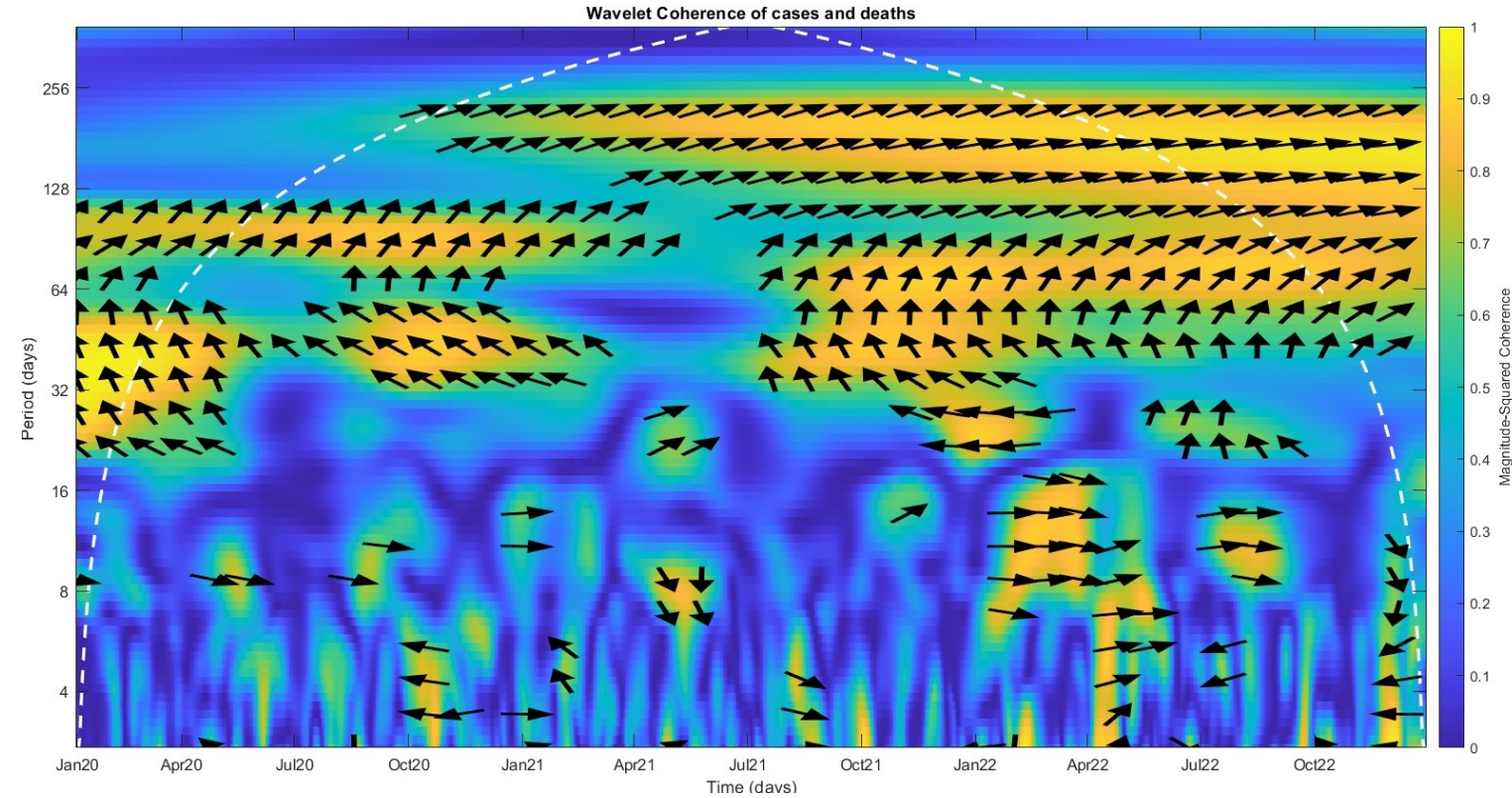
Long term coherence where cases precede deaths

Short term erratic relations: sometimes in phase, sometimes in opposed phase

Tests vs deaths

Wavelet Coherence of tests and deaths

Tests always are strongly correlated with deaths, in some scales are preceding deaths

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Hospital patients vs deaths

Wavelet Coherence of hospitalizations and deaths
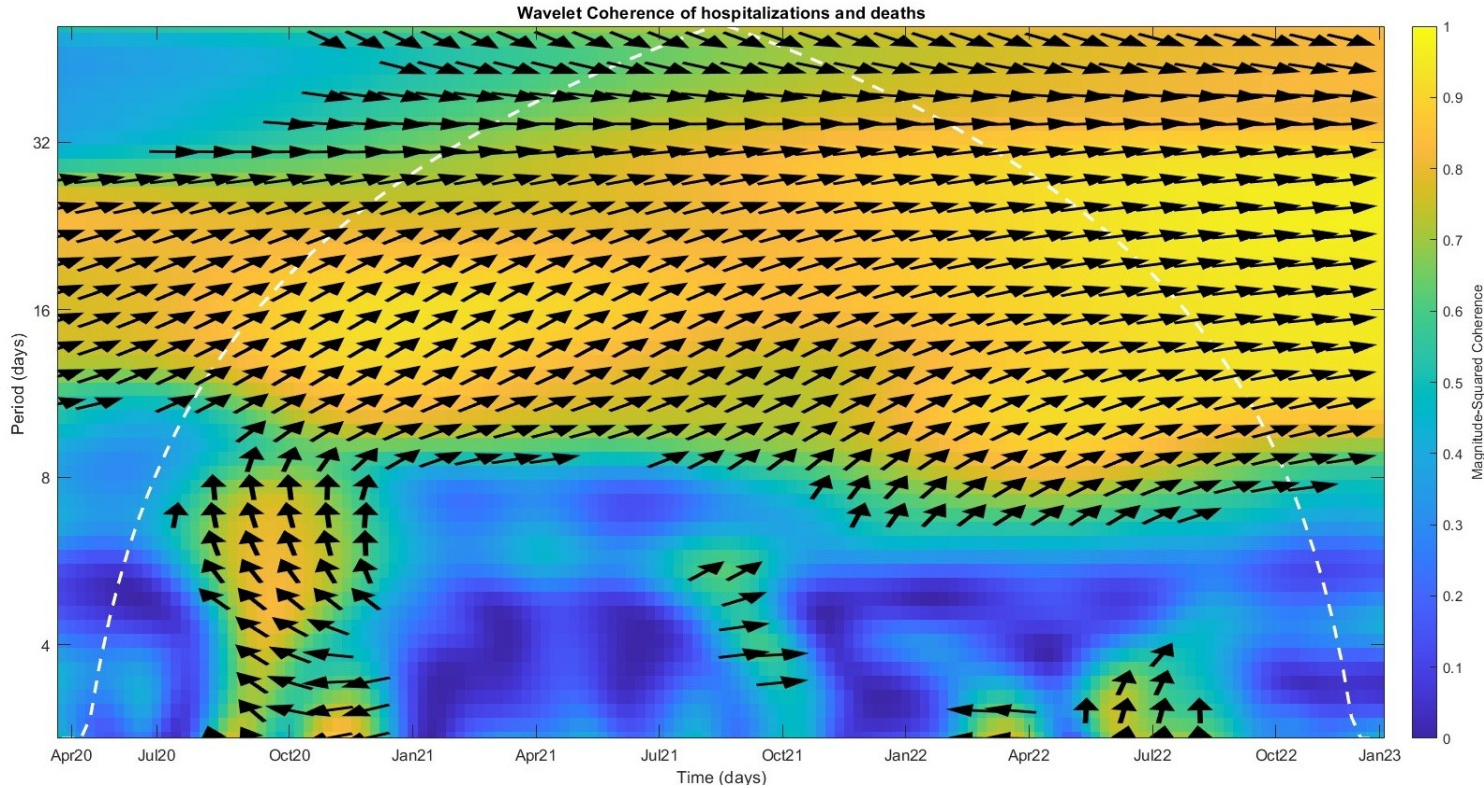
Strong coherence of hospitalizations preceding deaths at long term and medium term scales

At the end of the pandemic, they are in phase,

ICU patients vs deaths

Wavelet Coherence of ICU patients and deaths
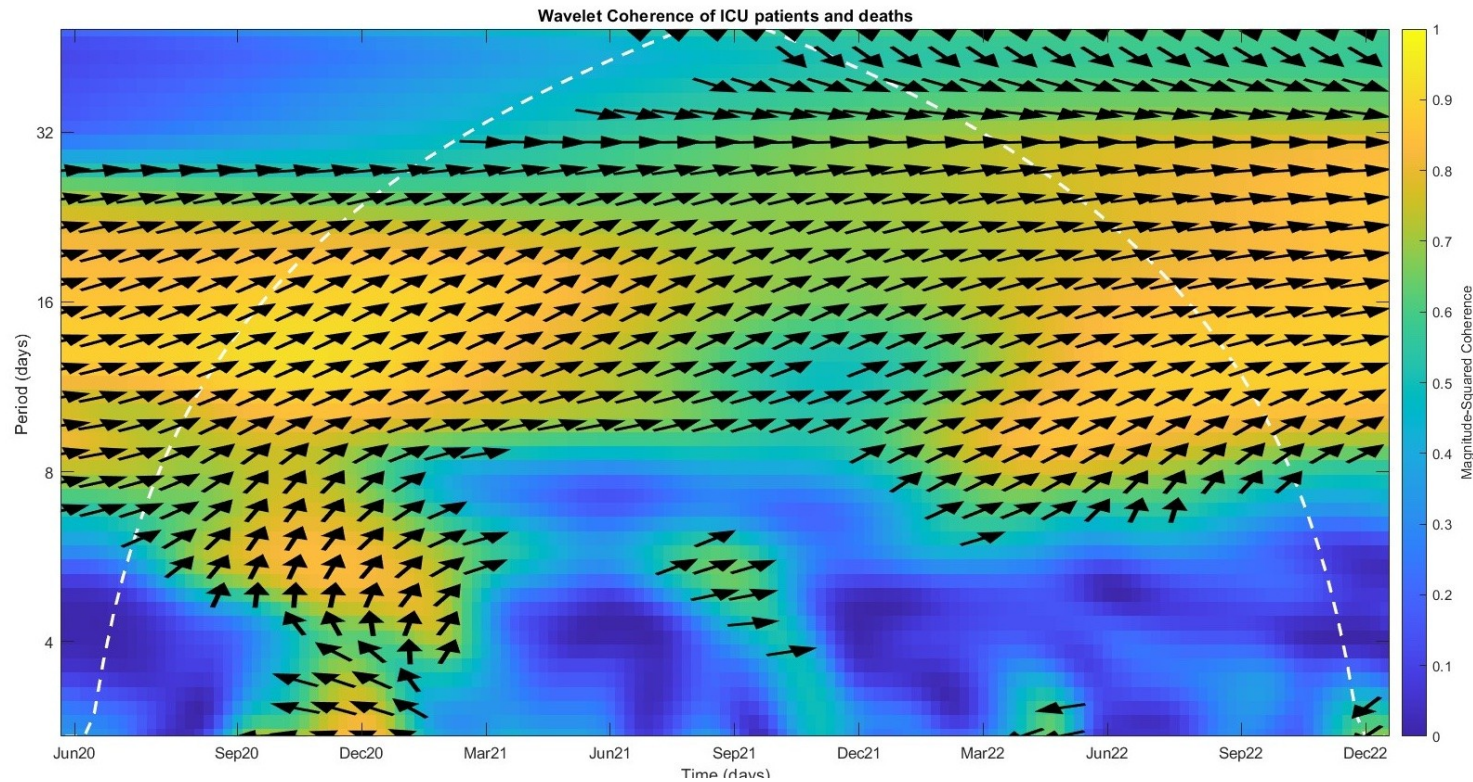
Strong coherence at the beginning and end of the pandemic
ICU patients preceding deaths

No short term coherences

Vaccine doses vs deaths

Wavelet Coherence of vaccinations and deaths
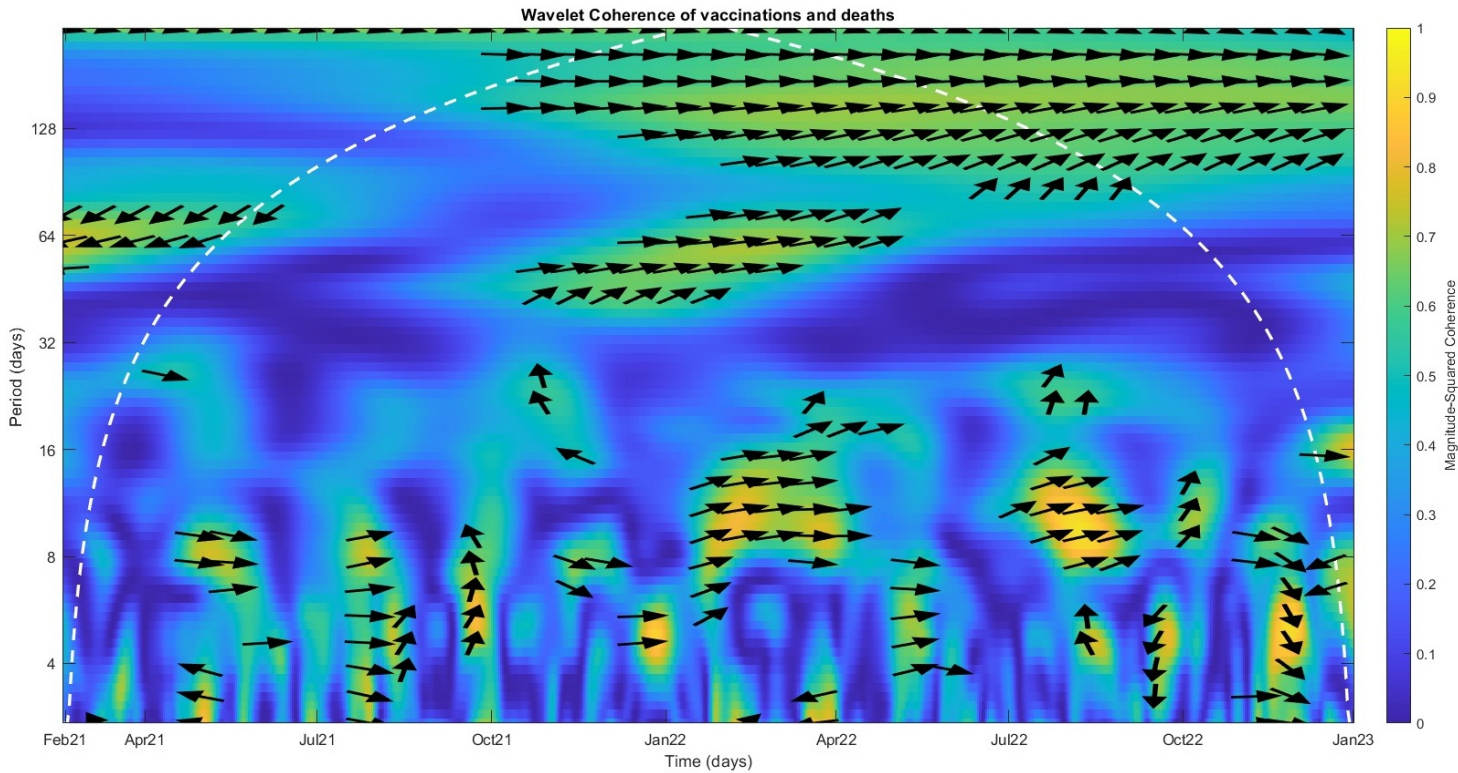
There is coherence between vaccine doses and deaths since the end of 2021 at large scales

Sometimes vaccines precede or are in phase with deaths in short term scales

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Stringency index vs deaths

Wavelet Coherence of stringency index and deaths
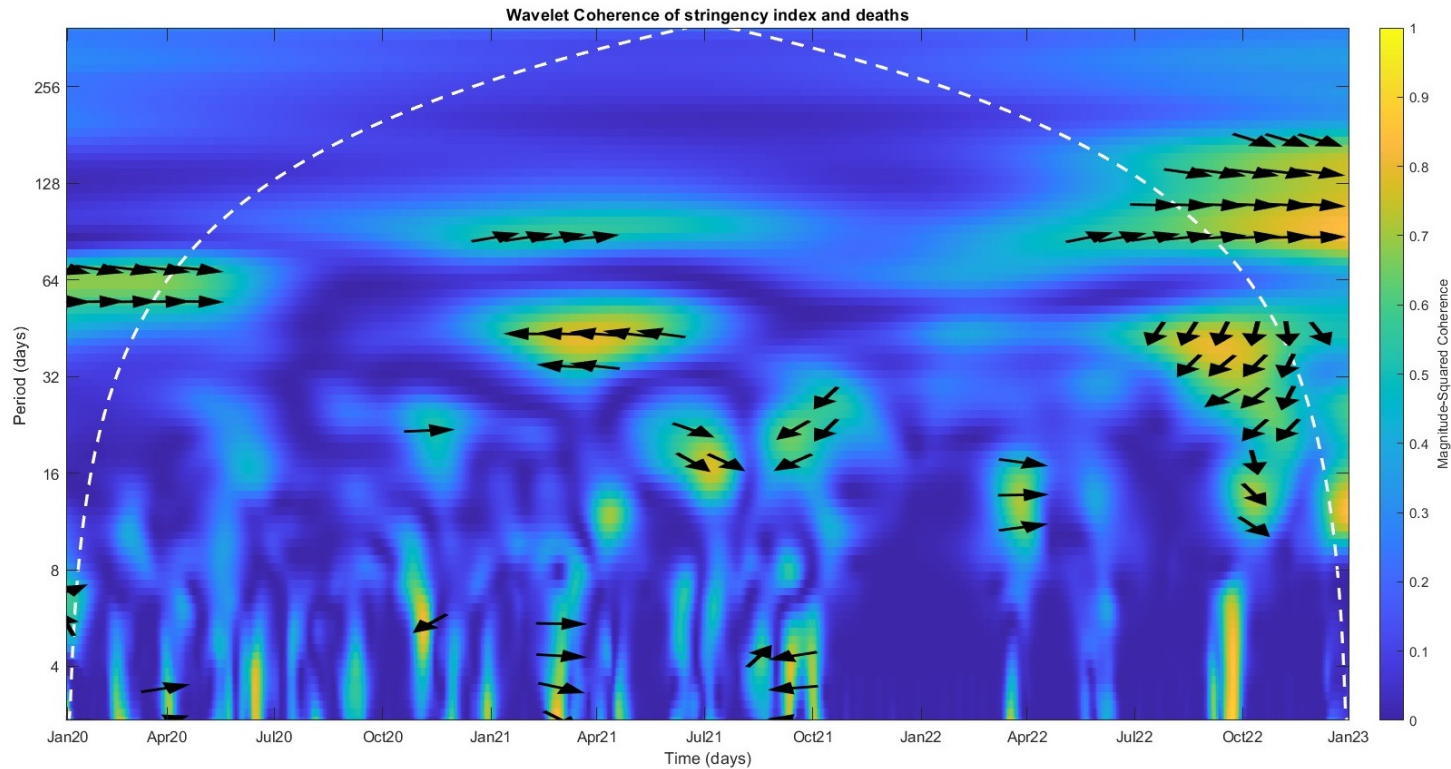
Stringency index is almost uncorrelated with the COVID-19 deaths

Excess deaths (all cause) vs deaths

Wavelet Coherence of excess mortality and deaths
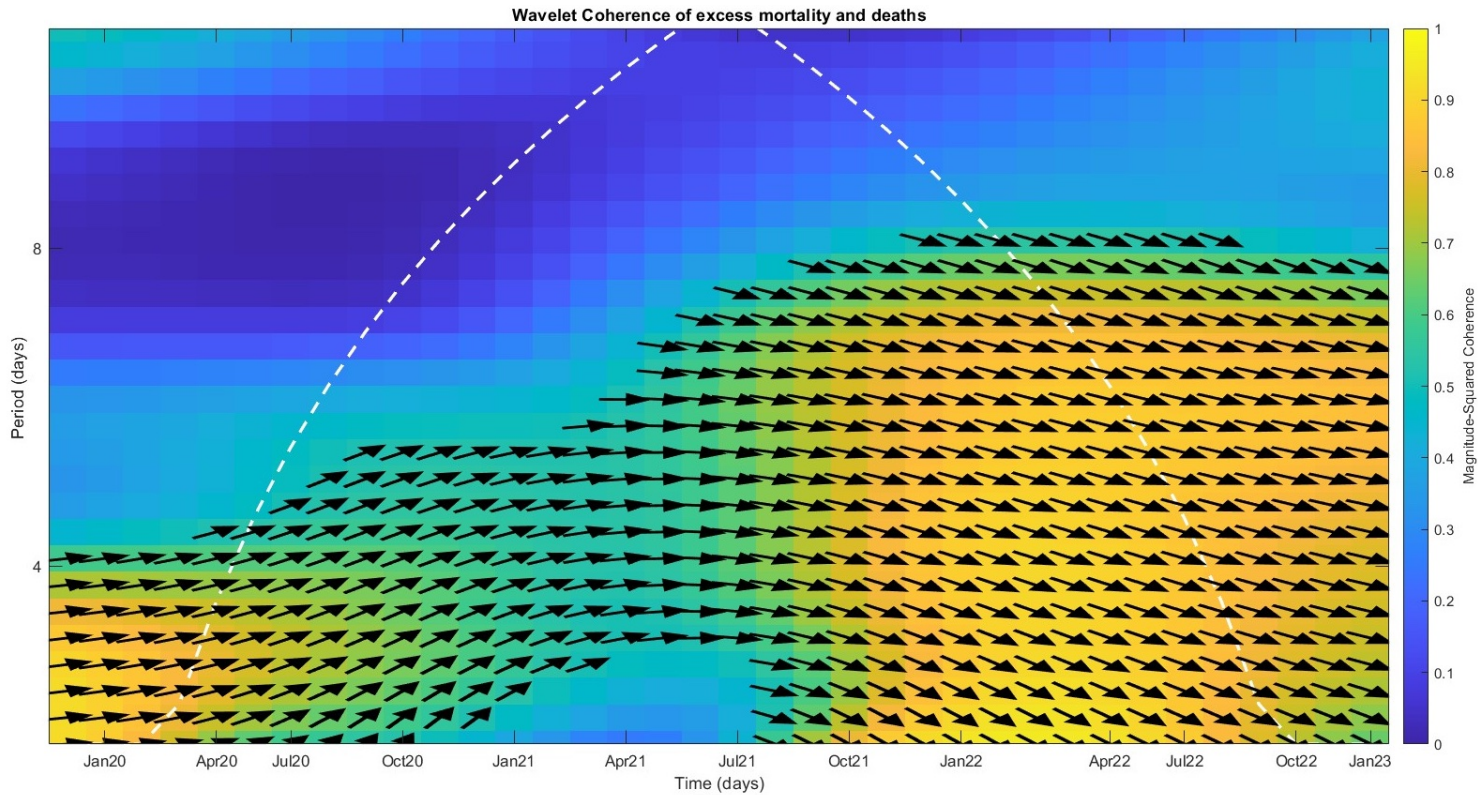
COVID-19 deaths as a major driver of excess deaths

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Some comparative visuals: Spain versus Japan

- Spain was one the European countries with the worst pandemic outcomes in 2020

- Japan was little affected by the pandemic in 2020

- Different non-pharmaceutical interventions and care of patients

- Similar vaccination policies in 2021

- Different policies in 2022

- Data from OWID until july 2023 (since March 2023 data source changes)

Spain (green) vs Japan (red) pandemic outcomes
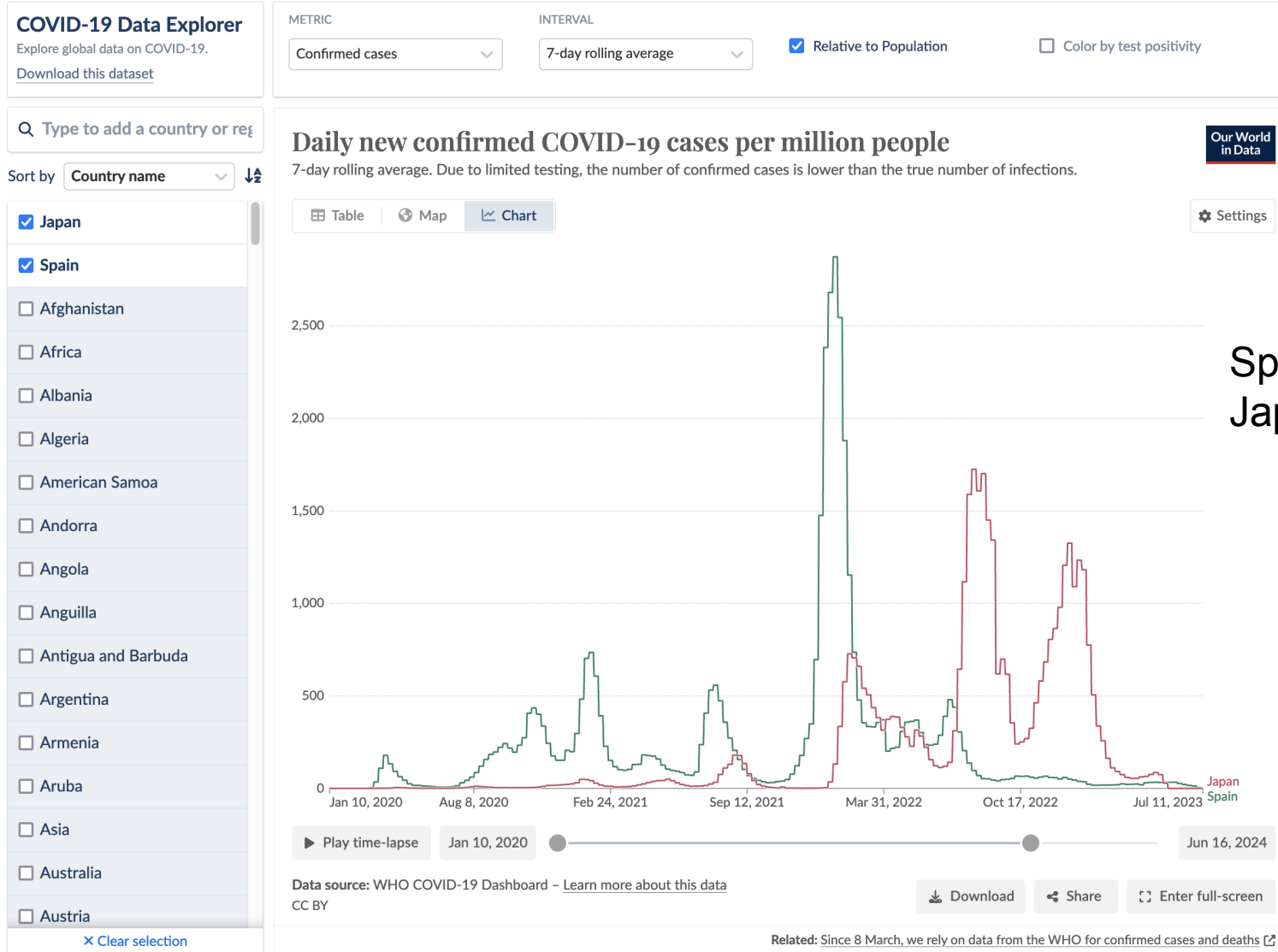
COVID-19 cases

Spain: omicron wave in january 2022
Japan: delayed big wave autumn 2022

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Spain (green) vs Japan (red) pandemic outcomes

COVID-19 Data Explorer
Explore global data on COVID-19.
Download this dataset

METRIC
Confirmed deaths

INTERVAL
7-day rolling average

☑ Relative to Population   ☐ Color by test positivity

Q Type to add a country or reg

Sort by Country name

☑ Japan
☑ Spain
☐ Afghanistan
☐ Africa
☐ Albania
☐ Algeria
☐ American Samoa
☐ Andorra
☐ Angola
☐ Anguilla
☐ Antigua and Barbuda
☐ Argentina
☐ Armenia
☐ Aruba
☐ Asia
☐ Australia
☐ Austria

✕ Clear selection

Daily new confirmed COVID-19 deaths per million people

Our World in Data

7-day rolling average. Due to varying protocols and challenges in the attribution of the cause of death, the number of confirmed deaths may not accurately represent the true number of deaths caused by COVID-19.

▦ Table   🌐 Map   📈 Chart   ⚙ Settings

▶ Play time-lapse   Jan 10, 2020   ●————————————●   Jun 16, 2024

Data source: WHO COVID-19 Dashboard – Learn more about this data
CC BY

⬇ Download   ⤴ Share   ⛶ Enter full-screen

Related: Since 8 March, we rely on data from the WHO for confirmed cases and deaths ↗

COVID-19 confirmed deaths

Spain: big first wave
Japan: worst results in 2022

19
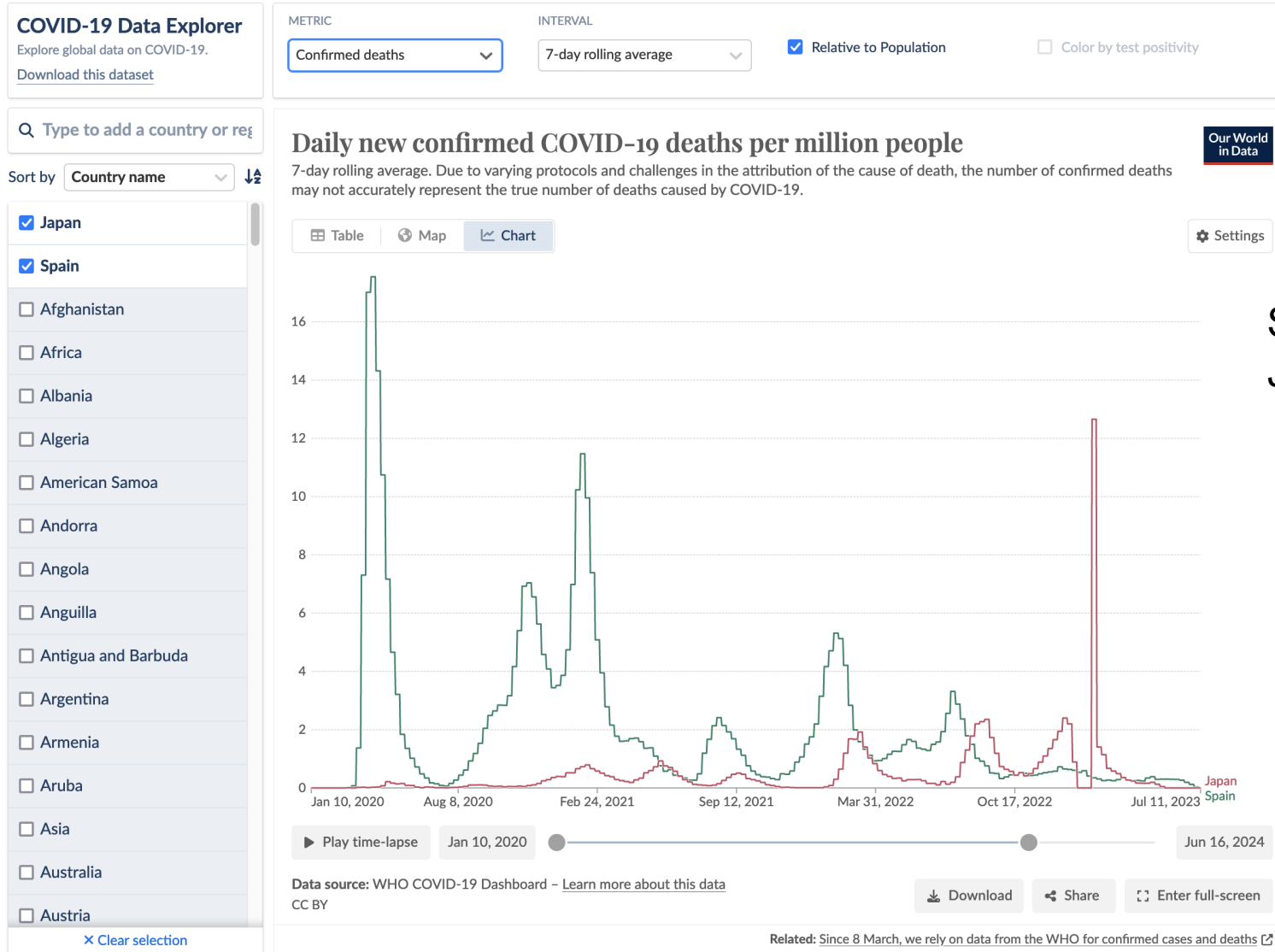
Spain (green) vs Japan (red) interventions
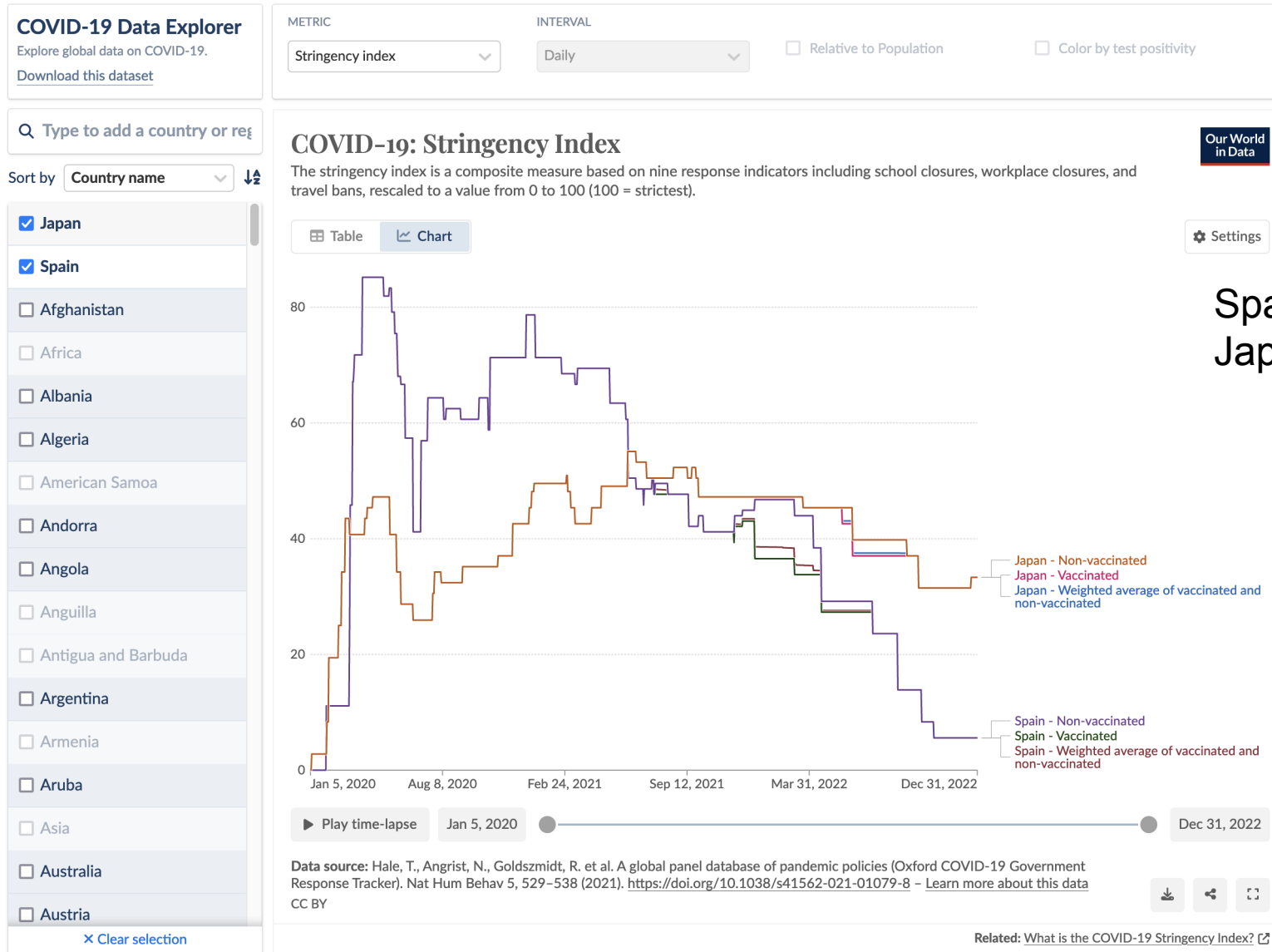
Stringency index

Spain: extreme stringency in 2020
Japan: sustained (low) stringency

Spain (green) vs Japan (red) interventions

Vaccine doses

both: large first mass vaccination

A bit delayed in Japan

Japan: sustained waves of vaccination

Spain (green) vs. Japan (red) interventions

Cumulative vaccine doses

Spain (below) vs. Japan (above) excess deaths outcomes

COVID-19 Data Explorer
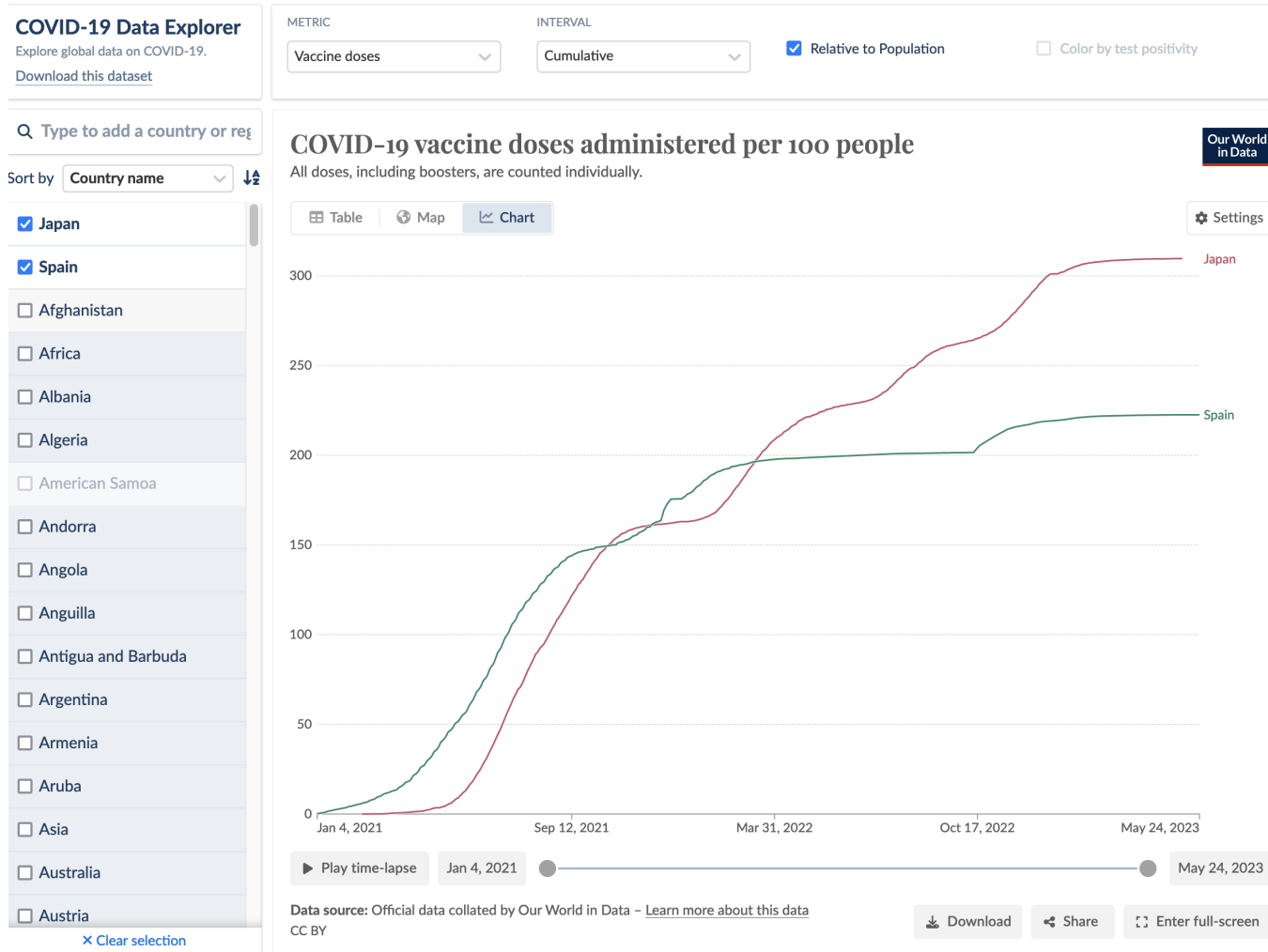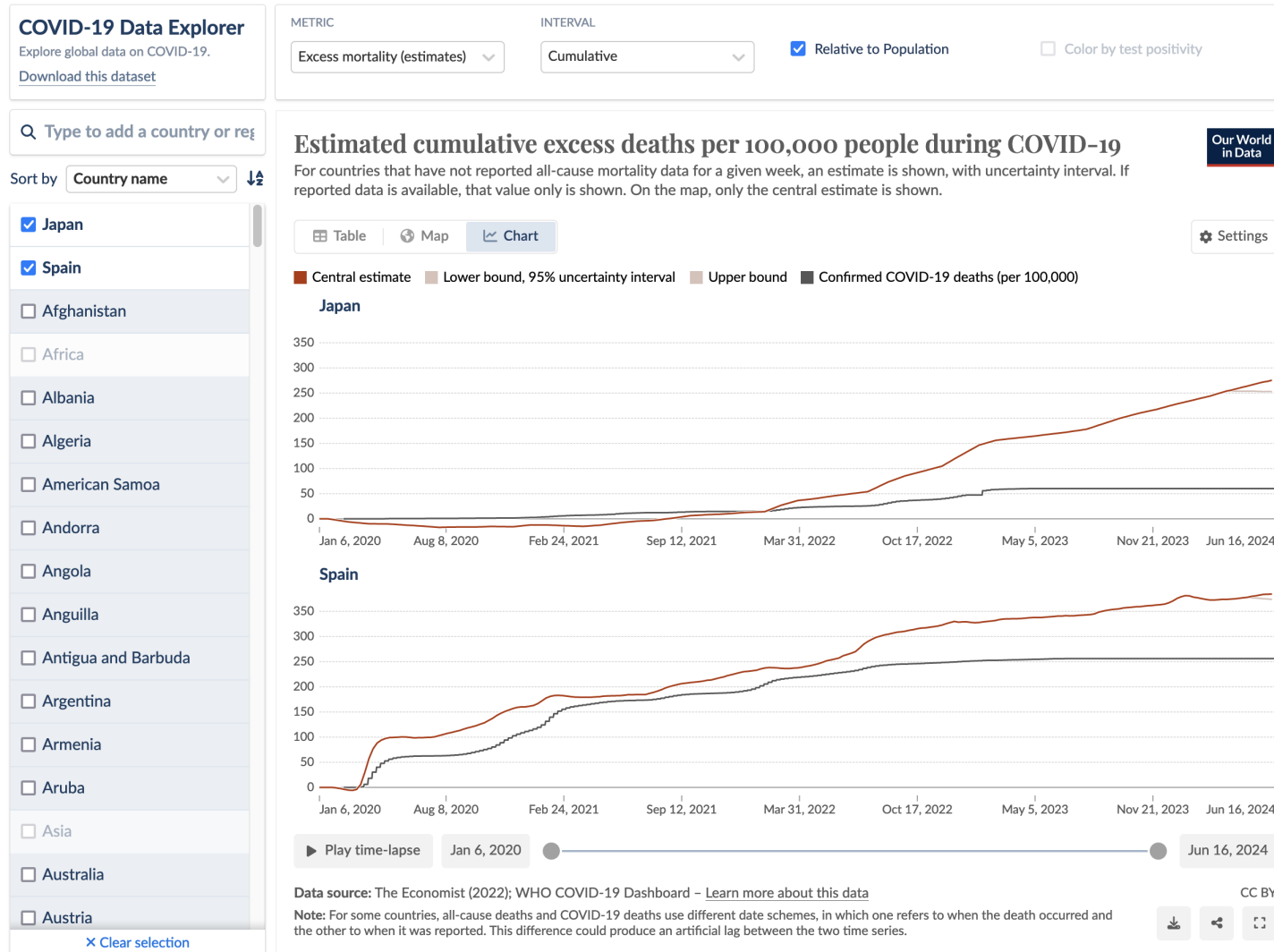Explore global data on COVID-19.
Download this dataset

METRIC
Excess mortality (estimates) ⌄

INTERVAL
Cumulative ⌄

☑ Relative to Population   ☐ Color by test positivity

🔍 Type to add a country or reg

Sort by Country name ⌄

☑ Japan
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☐ Antigua and Barbuda
☐ Argentina
☐ Armenia
☐ Aruba
☐ Asia
☐ Australia
☐ Austria
✕ Clear selection

Estimated cumulative excess deaths per 100,000 people during COVID-19
For countries that have not reported all-cause mortality data for a given week, an estimate is shown, with uncertainty interval. If reported data is available, that value only is shown. On the map, only the central estimate is shown.

Our World in Data

⊞ Table   ◉ Map   ⌁ Chart   ⚙ Settings

■ Central estimate ■ Lower bound, 95% uncertainty interval ■ Upper bound ■ Confirmed COVID-19 deaths (per 100,000)

Japan

Spain

▶ Play time-lapse   Jan 6, 2020 ⬤――――――――⬤ Jun 16, 2024

Data source: The Economist (2022); WHO COVID-19 Dashboard – Learn more about this data   CC BY
Note: For some countries, all-cause deaths and COVID-19 deaths use different date schemes, in which one refers to when the death occurred and the other to when it was reported. This difference could produce an artificial lag between the two time series.

Estimates of excess deahts (all-cause vs. COVID-19)

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Conclusions

- Major differences in pandemic outcome (deaths) may be due to cultural/healthcare system differences

    - In Spain's first wave was dealt with forbidding antibiotics, repurposed drugs, and treating old people with end-of-life treatments

    - Different administrative routines for COVID-19 death coding may have an influence on the outcomes

- In Japan, the non-pharmaceutical interventions seem to have little impact on the time evolution of COVID-19 deaths

- In Japan continued vaccination waves appear to have little impact in reducing the tail of the pandemic

- However, excess deaths appear to grow independently of COVID in 2023 and onwards