

# Some macroscopic observations about COVID-19 mortality in Israel

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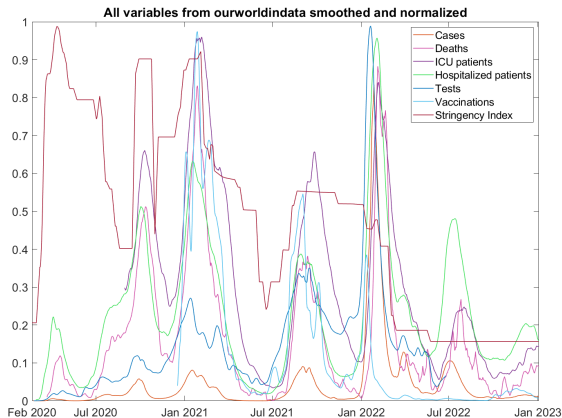
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# Introduction

## Why Israel?

- Israel has been like a testbed during the pandemic for several extreme measures
  - Strong lockdowns and social measures
  - Pioneering implementation of sanitary/vaccination pass
  - Monoculture of Pfizer Biontech vaccines until very late in the pandemic

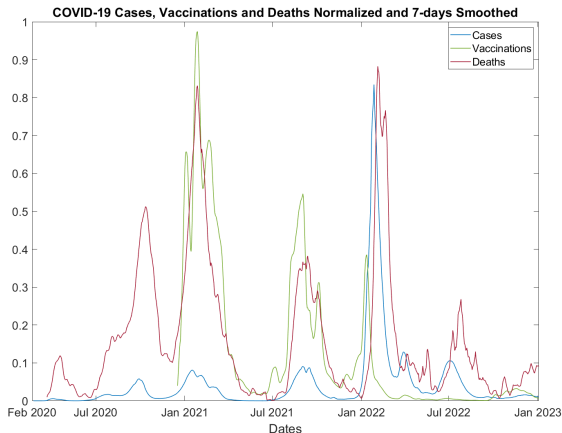
# Variables



**Figure:** All variables from ourworldindata.com smoothed and normalized

# Cases, vaccine doses, deaths

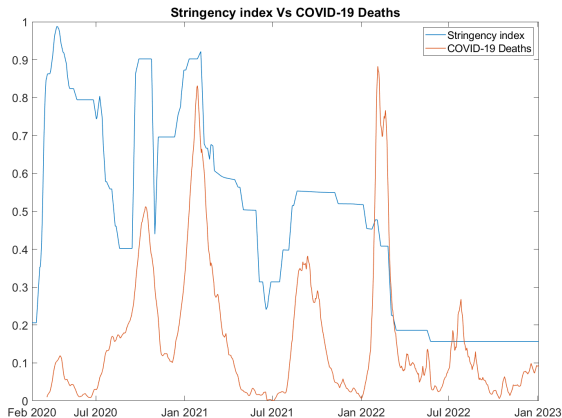
Normalized to [0,1]



**Figure:** COVID-19 cases, vaccinations and deaths normalized and smoothed with a 7-days window

# Stringency index, deaths

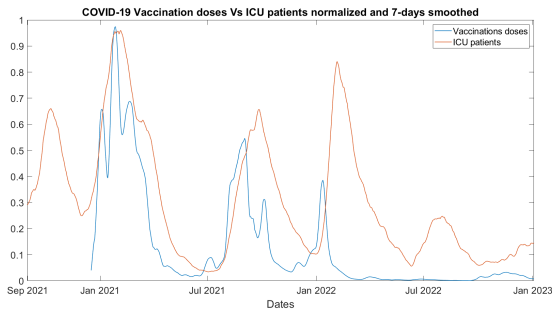
Normalized to [0,1]



**Figure:** Plot of Stringency index and COVID-19 deaths normalized and smoothed with a 7-day window

# Vaccination doses, ICU patients

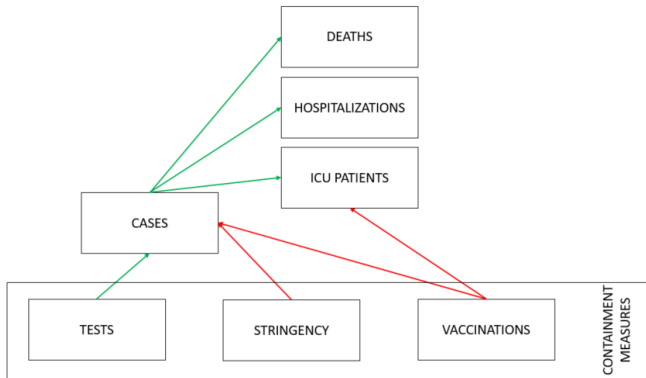
Normalized to [0,1]



**Figure:** Plot of COVID-19 vaccinations and ICU patients normalized and smoothed with a 7-day window

# Theoretical expectation

Anticipated assumption



**Figure:** Theoretical expectation of the congruence between variables and how each one affects the others positively or negatively



# Overall Signal Correlation

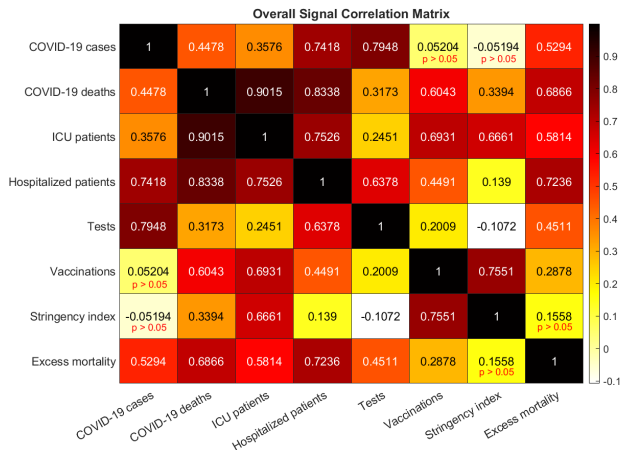


Figure: Overall Signal Correlation Matrix 2020-2022

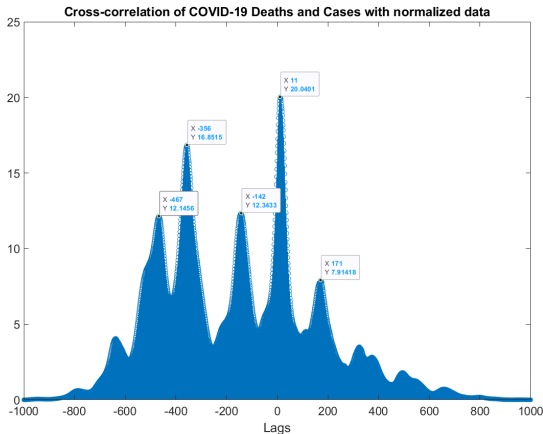
# Overall Signal Correlation

## Highlights

- Non-surprising positive correlations
  - Deaths – cases, Deaths – ICU patients
- Surprising positive correlation
  - Deaths – Vaccination
- Surprising null correlation
  - Stringency index – deaths and Stringency index – cases

# Cross-Correlation between deaths and cases

`xcorr(new deaths smoothed, new cases smoothed)`



**Figure:** tagged lags sorted by importance: [11, -356, -142, -467, 171]

# Cross-Correlation between deaths and vaccinations

`xcorr(new deaths smoothed,new vaccinations smoothed)`

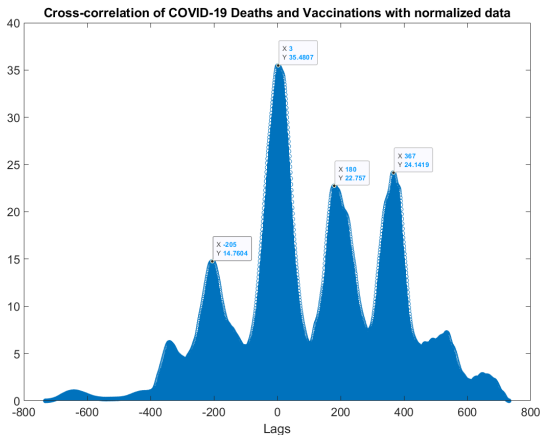


Figure: tagged lags sorted by importance: [3, 367, 180, -205]

# Cross-Correlation between cases and vaccinations

`xcorr(new cases smoothed,new vaccinations smoothed)`

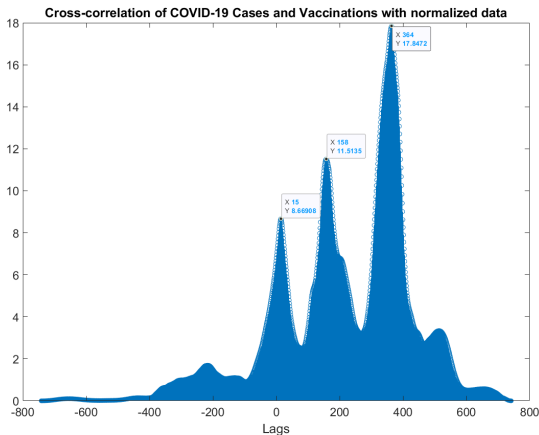


Figure: tagged lags sorted by importance: [364, 158, 15]

# Cross-Correlation between ICU patients and vaccinations

`xcorr(ICU patients, new vaccinations smoothed)`

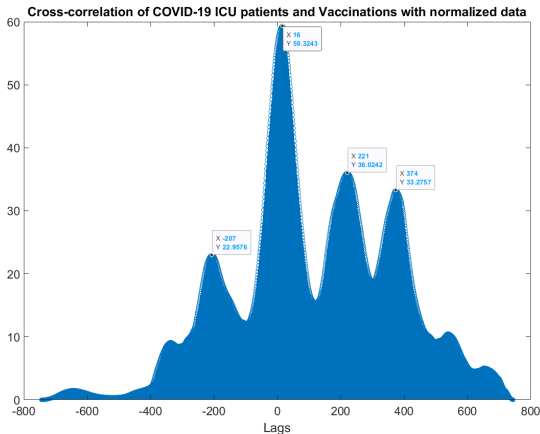


Figure: tagged lags sorted by importance: [16, 221, 374, -207]

# Cross-Correlation between deaths and Stringency index

`xcorr(new deaths smoothed,stringency index)`

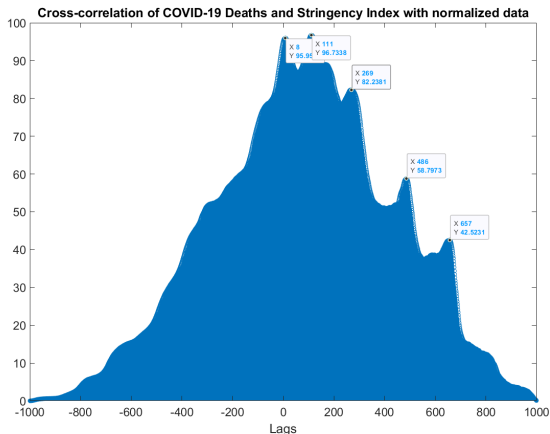


Figure: tagged lags sorted by importance: [8, 111, 269, 486, 657]

# Cross-Correlation between cases and Stringency index

`xcorr(new cases smoothed,stringency index)`

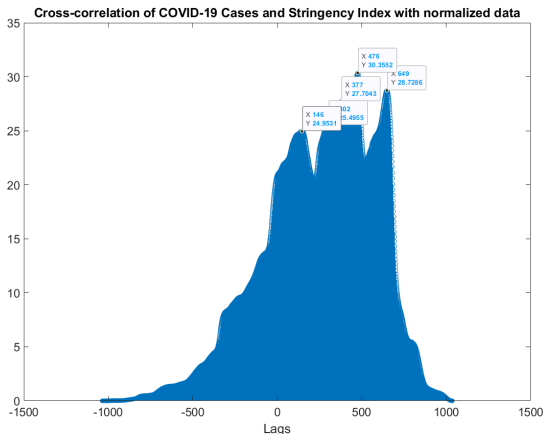


Figure: tagged lags sorted by importance: [476, 649, 377, 302, 146]



# Results from cross-correlation

## Highlights

- Non-surprising
  - Cases match/predict deaths after 11 days
- Surprising
  - Stringency doses match/predict deaths after 8 days
  - Stringency doses match/predict cases after 146, 302 days
  - Vaccination doses match/predict ICU after 16 days
  - Vaccination doses match/predict deaths after 3 days
  - Vaccination doses match/predict cases after 15, 158 days, and maximal at 364 days??

# Linear Regression Variable Importance

Regressing COVID-19 deaths from the other variables

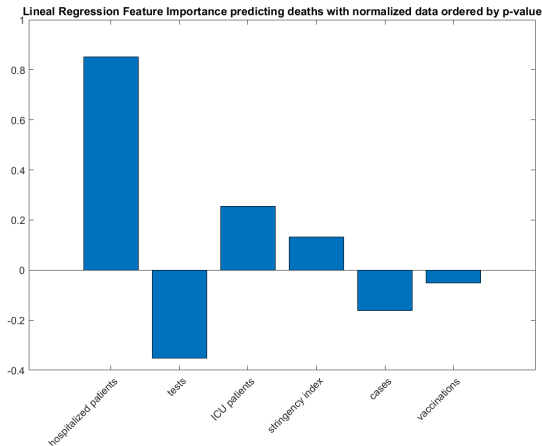


Figure: Plot of Estimate value ordered by p-Value

Variables	Estimate	SE	tStat	pValue
hospitalized patients	0.8572	0.0532	16.1011	8.3387e-48
tests	-0.3850	0.0356	-10.8178	8.6695e-25
ICU patients	0.2436	0.0308	7.9146	1.4502e-14
stringency index	0.1274	0.0263	4.8457	1.6576e-06
cases	-0.1201	0.0674	-1.7835	0.0751
vaccinations	-0.0314	0.0258	-1.2159	0.2246

**Table:** Results of the Linear Regression Variables Importance

# Observations

- Main effect comes from the hospitalized patients
- Stringency index has a positive coefficient highly significant  $p \ll 0.005$
- Vaccination doses has a minor negative effect with low significance ( $p=0.02$ )

# Linear Regression Variable Importance shifting lags from 1 to 31 days with normalized data

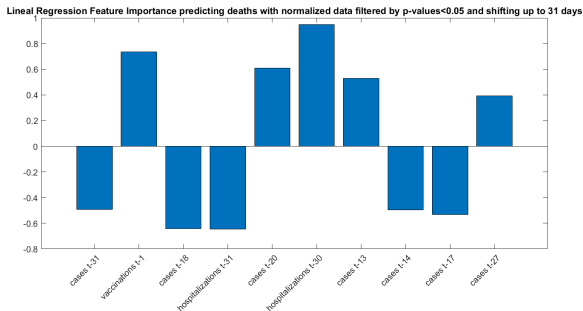


Figure: Plot of Estimate value ordered by p-Value

# Observations

- Past values of cases and hospitalization series have a large effect
- Vaccination doses appear among the most salient variables

# Random Forest Variable Importance

Regressing COVID-19 deaths from the other variables

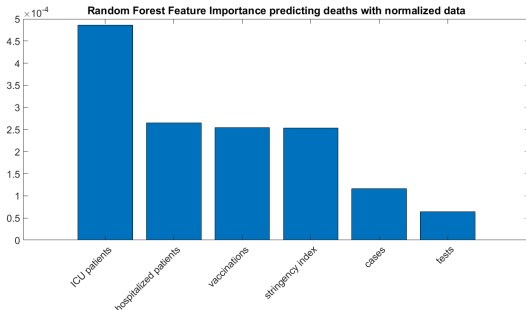


Figure: Plot of Feature Importance values

<b>Variables</b>	<b>importance</b>
ICU patients	4.8580e-04
hospitalized patients	2.6535e-04
vaccinations	2.5479e-04
stringency index	2.5368e-04
cases	1.1591e-04
tests	6.3907e-04

**Table:** Results of Random Forest Variables Importance



# Observations

- Stringency index and vaccine doses appear as more important variables than cases and tests
- The results do not provide the direction of causality

# Random Forest Variable Importance shifting lags from 1 to 31 days with normalized data

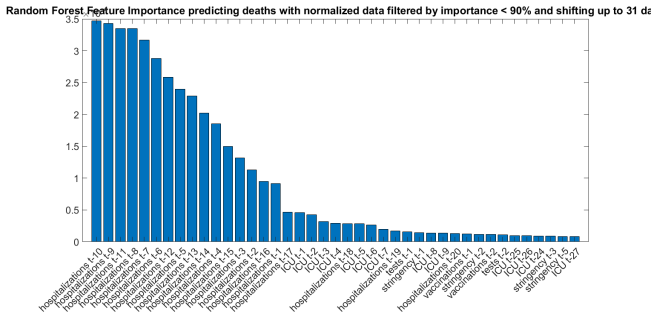


Figure: Plot of Feature Importance values

# Observations

- Past values of stringency index appear as more important variables than cases and tests
- The results do not provide the direction of causality

# Conclusions

- The relation of virus control measures (stringency + vaccination) shows some surprises that are not easy to characterize numerically
- There is no reference model of the expected response to control measures
- However, in COVID-19 after mass vaccination the peaking of omicron cases was strongly correlated stopped with the end of massive testing

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