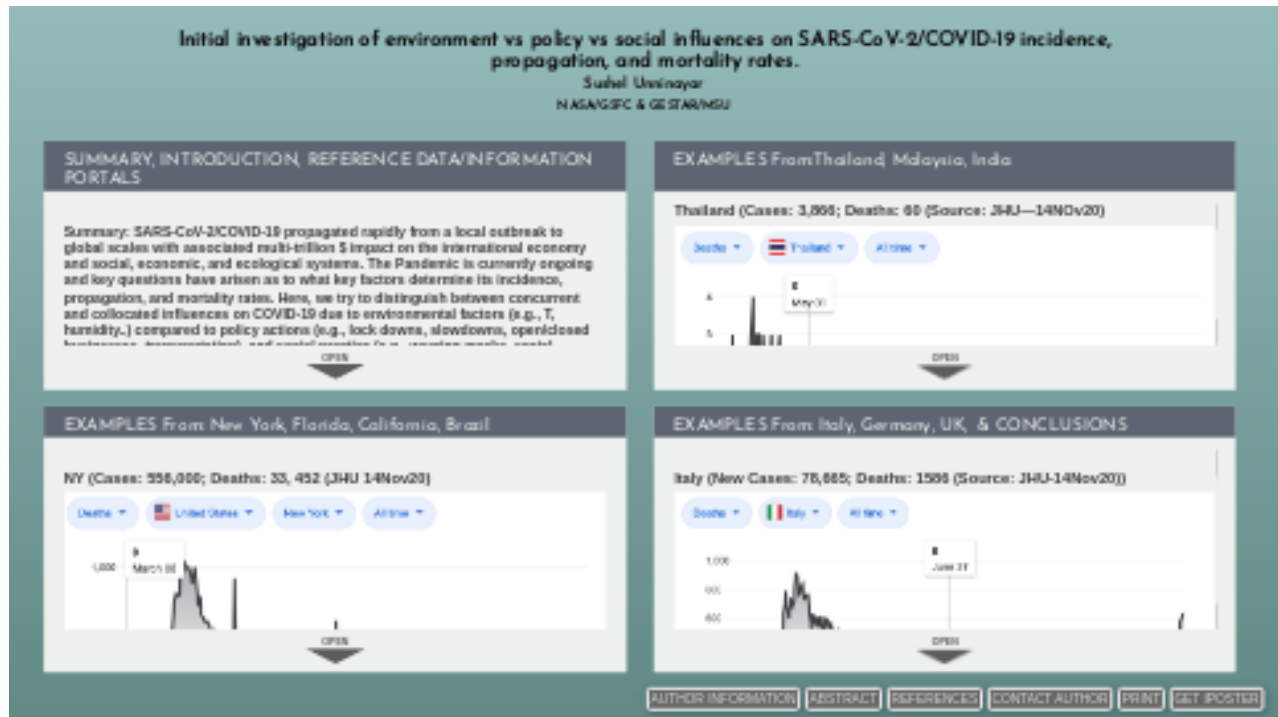


# Initial investigation of environment vs policy vs social influences on SARS-CoV-2/COVID-19 incidence, propagation, and mortality rates.



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NASA/GSFC & GESTAR/MSU

PRESENTED AT:



# SUMMARY, INTRODUCTION, REFERENCE DATA/INFORMATION PORTALS

**Summary:** SARS-CoV-2/COVID-19 propagated rapidly from a local outbreak to global scales with associated multi-trillion \$ impact on the international economy and social, economic, and ecological systems. The Pandemic is currently ongoing and key questions have arisen as to what key factors determine its incidence, propagation, and mortality rates. Here, we try to distinguish between concurrent and collocated influences on COVID-19 due to environmental factors (e.g., T, humidity..) compared to policy actions (e.g., lock downs, slowdowns, open/closed businesses, transportation), and social practice (e.g., wearing masks, social distancing). Publicly available data and information from selected countries/regions around the world are used in this initial analysis. Preliminary results suggest that policy actions and social practice have a dominating influence on the propagation and containment (or not) of COVID-19, possibly enabled by or associated with concomitant environmental factors.

**Case Examples from:** Group/Slide Set A: New York (USA), Florida (USA), California (USA), Brazil; Group/Slide Set B: Thailand, Malaysia, India; Group/Slide Set C: Italy, Germany, UK, South Africa. These three groups cover a range of climate, geographical, and cultural zones as well as N-Hemisphere vs S-Hemisphere seasonal timing differences.

**We submit that the data series for SARS-CoV-2/COVID-19 are not long enough to yield robust statistical analysis. Here we take the approach that if there are significant correlates, the data should speak for itself--namely it should become apparent upon even casual visual inspection.**

**Thus, we present all data in time series graphical form. All data are from publicly available sources as detailed in the references.**

**Sources: References:** JHU, EU-Copernicus/ECMWF, Wikipedia: COVID-19-Pandemic Data; Details in the References.

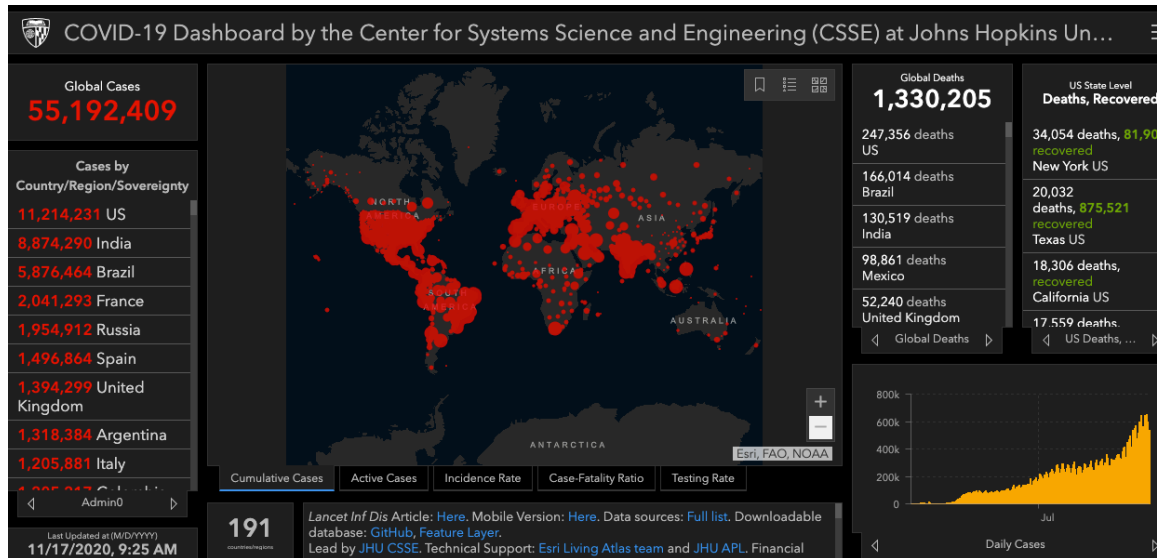
## INTRODUCTION:

**COVID-19-Global Environmental Context. Global Cases: 55,192,409; Deaths: 1,330,206 (JHU, 16Nov20)**

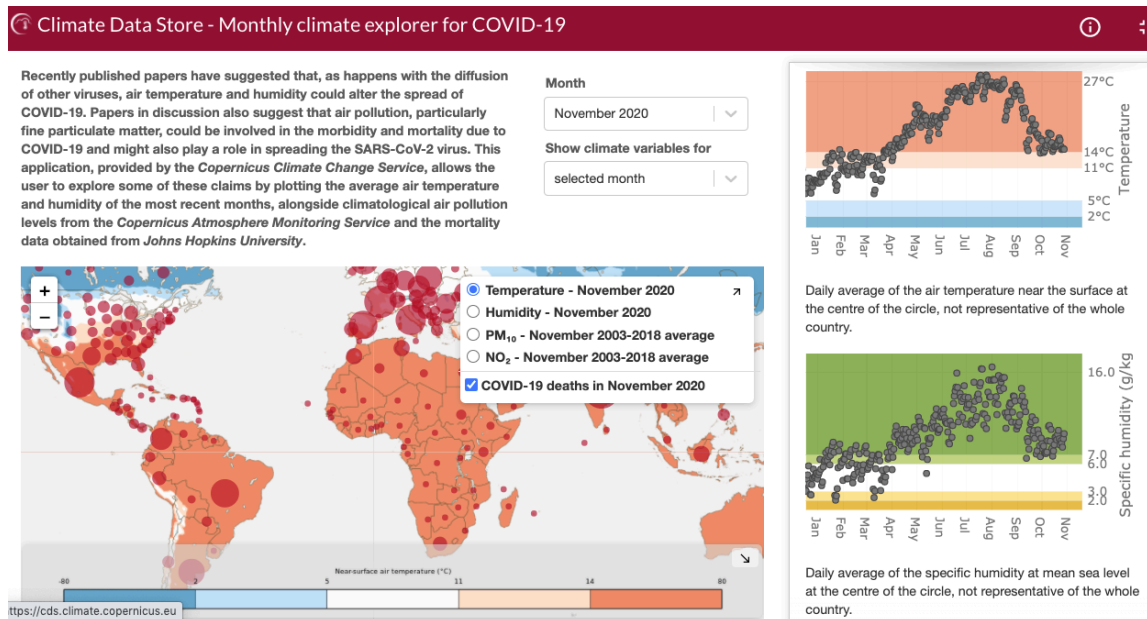
1. Most viral infections like influenzas or flu are seasonal and the common cold is more likely in winter. SARS-CoV-2 is hypothesized (based on these other Coronaviruses) to be (at least partially) environmentally (T/Humidity) sensitive. Some studies support that virus survives longer on surfaces in colder temperatures than higher temperatures, and lower specific humidity than higher. But, propagation was quick from Wuhan, China to the world (global) mainly via travel routes and contact between people to both tropical and mid-and-higher latitude countries with warm and cold climates.
2. Higher T could impact the virus survival directly by destabilizing its proteins and lipids and by providing more energy for evaporating (drying out) droplets?
3. Low H and colder T are more hospitable for the SARS-CoV-2 virus while warmer T and higher SH impacts how long it remains infectious on most surfaces.
4. Lower specific humidity could impact the airborne virus droplets by evaporatively decreasing droplet size leading to increased aerosolization and residence time, n tael distance?
5. Larger droplets are thought to be the main coronavirus carrier; tiny droplets dry out quickly. But the viruses can be still active. Some evidence that airborne virus particles can be infective. Hence air filters/purifiers.
6. UV radiation (Sun exposure) may also have an effect in inactivating the virus. Moisture (dissolves), sunlight (UV light) and heat (molecular motion) all make the virus less stable.
7. Soap dissolves the fat membrane and the virus falls apart. Disinfectants or liquids, wipes, gels containing alcohol have a similar effect but not as good as normal soap.
8. Primary infection is through the respiratory tract (both lower and upper) where the SARS-CoV-2 spike protein latches on to ACE-2 receptors, but external surfaces also offer intermediary transmission pathways. The ideal surface for the virus is organic and the proteins and fatty acids in the dead cells of the skin interact with the virus through both hydrogen bonds and fat-like hydrophilic interactions.
9. SARS-CoV-2 consists of a small set of genes enclosed by a sphere of fatty lipid molecules. Viruses don't survive too long by themselves—they need bodies to occupy and cells to control and replicate. The virus appears to be able to infect ACE-2 bearing cells in other organs, including the gut and blood vessels—Thus potentially causing damage to not just the lungs.
10. Since this paper was drafted in mid-November, SARS-CoV-2/COVID-19 rates have trended upwards in the USA and many other countries.

**Main Reference Data Portals (Details in References):**

**COVID-19 Dashboard by Center for Systems Science & Engineering (CSSE), Johns Hopkins University, Baltimore, MD, USA**

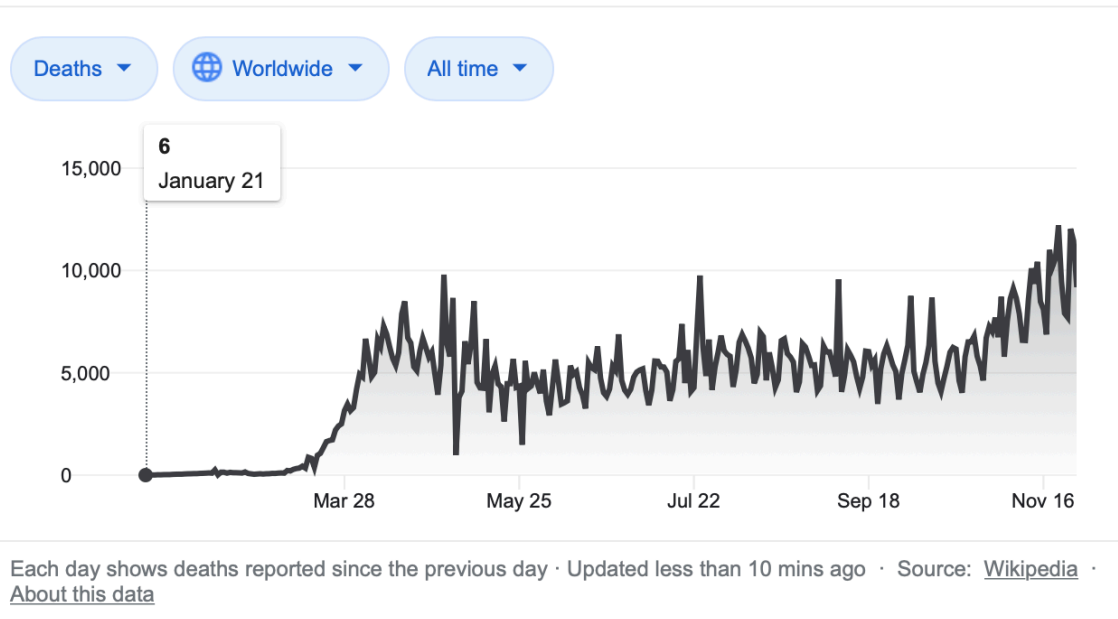


## EU-Copernicus Climate Data Services, Climate Data Store-Climate Explorer for COVID-19 (Met. Data From C3S ERA5 Reanalysis; COVID-19 data from JHU):



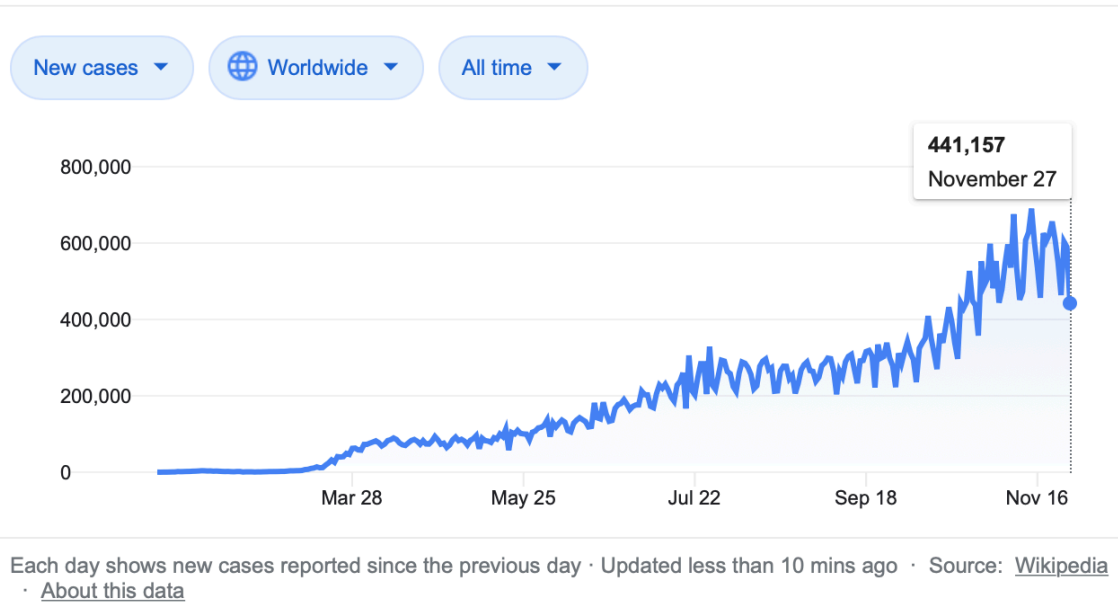
## Coronavirus (COVID-19) Statistics Data (from Wikipedia--data from multiple sources)

## Daily change



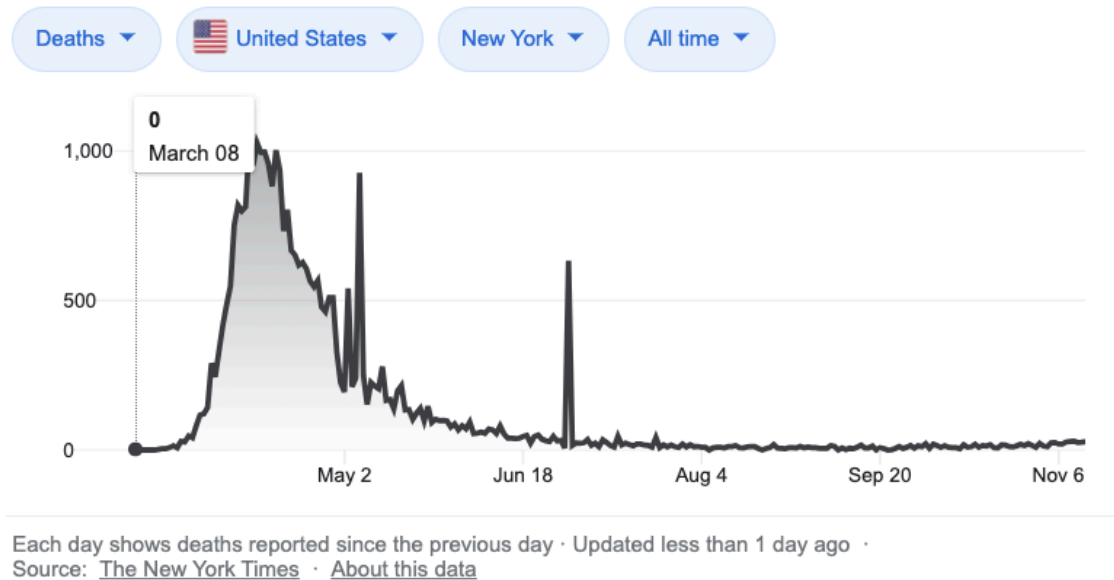
## Coronavirus (COVID-19) Statistics Data (from Wikipedia--data from multiple sources

## Daily change



# GROUP A: EXAMPLES FROM: NEW YORK, FLORIDA, CALIFORNIA, BRAZIL

**NY (Cases: 556,000; Deaths: 33,452 (JHU 14Nov20))**



## Policy/Social

**March: State of emergency declared, universities, theaters, closed, stay-at-home orders extended thru end April**

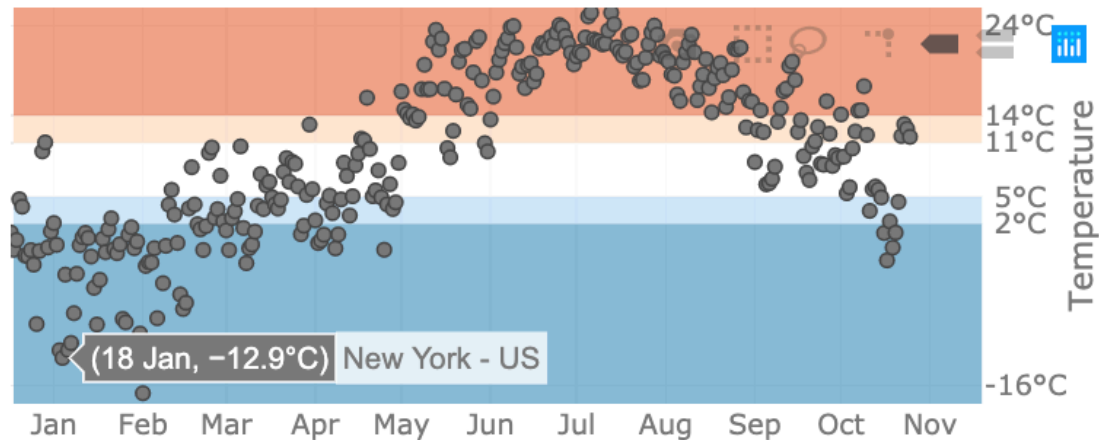
**June:** NY has lowest infection rate in USA—rate of increase less than 0.25% per day since 6 June.

**Sept:** Maintained infection rate below 1%

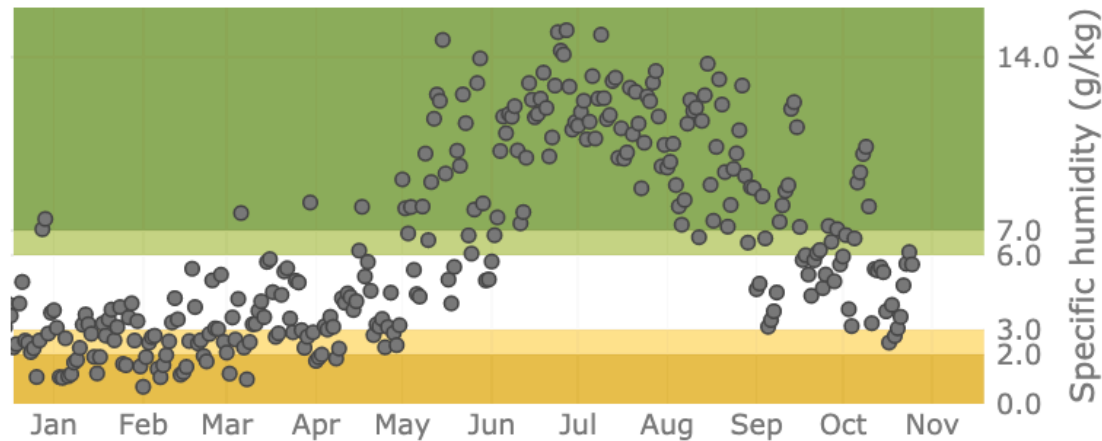
**Sept 26:** Increased infection rates in several neighborhoods in Brooklyn, Rockland county communities—Spring valley & Monsey

**Oct:** Cluster initiative action—restrictions in cluster areas

**Nov:** Statewide restrictions: Bars, gyms, businesses with liquor licenses close by 10.00pm, restaurants close by 10.00pm, non-essential gatherings limited to 10 people

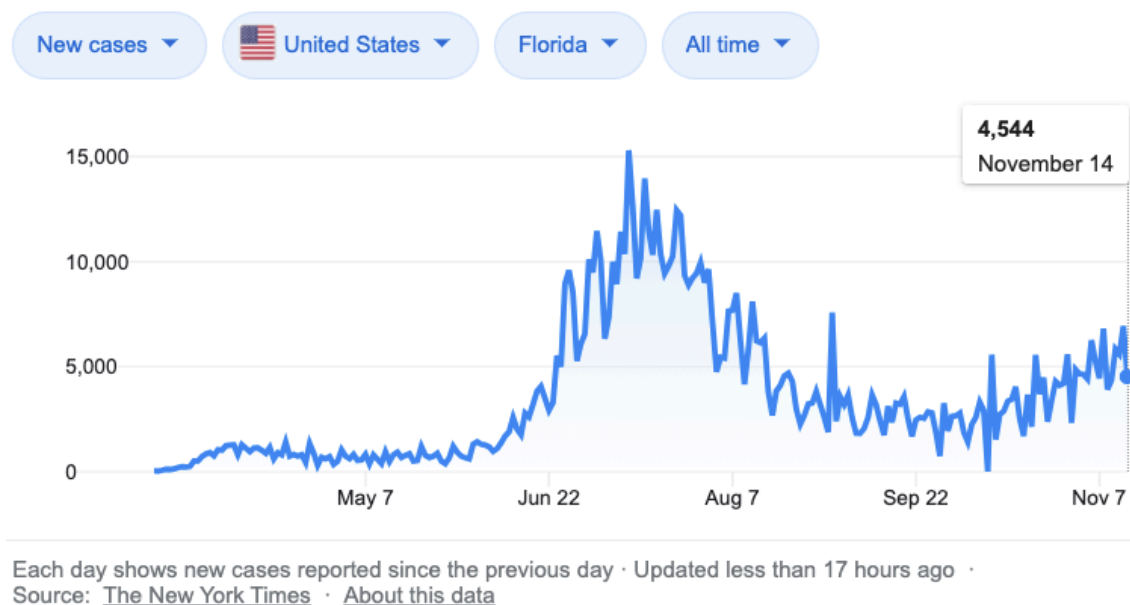
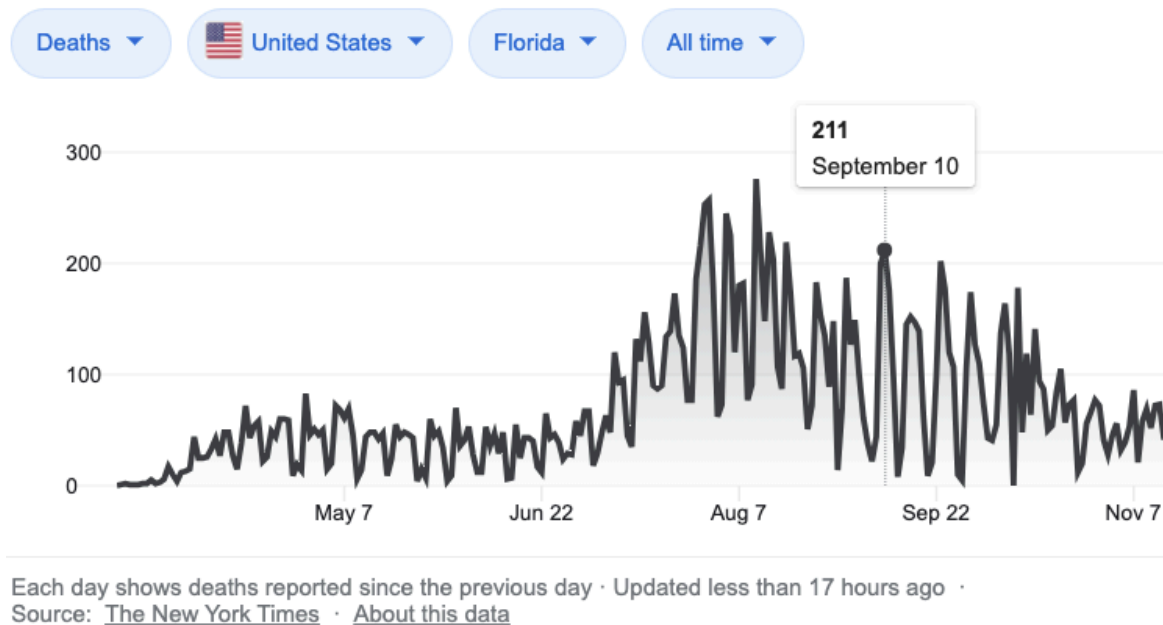


Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

**Florida (Cases: 875,096; Deaths: 17,469 (JHU: 15Nov20))**



## Social/Policy

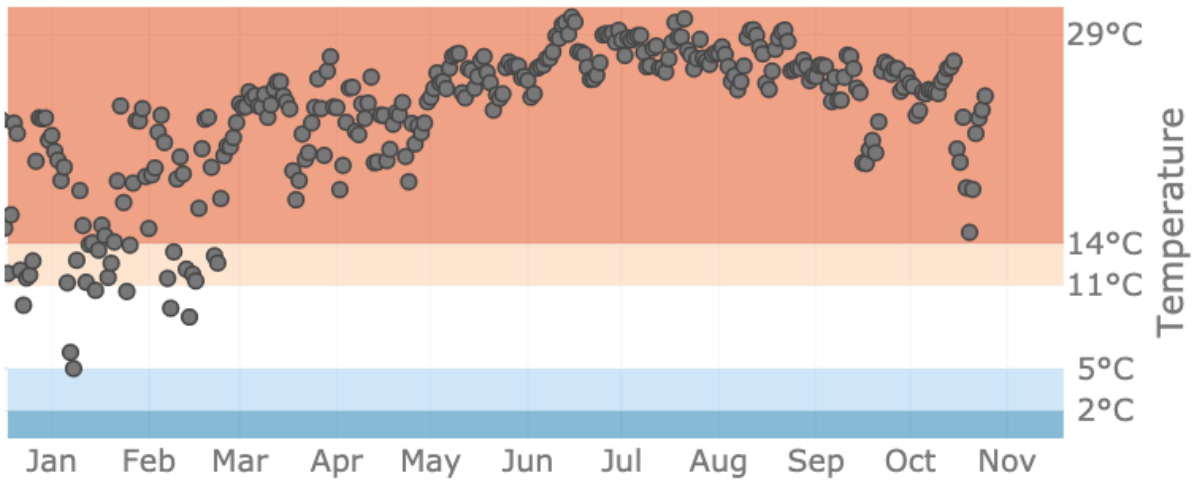
**March:** CDC evidence of community spread

**April:** Executive order to restrict activities within the state to essential services

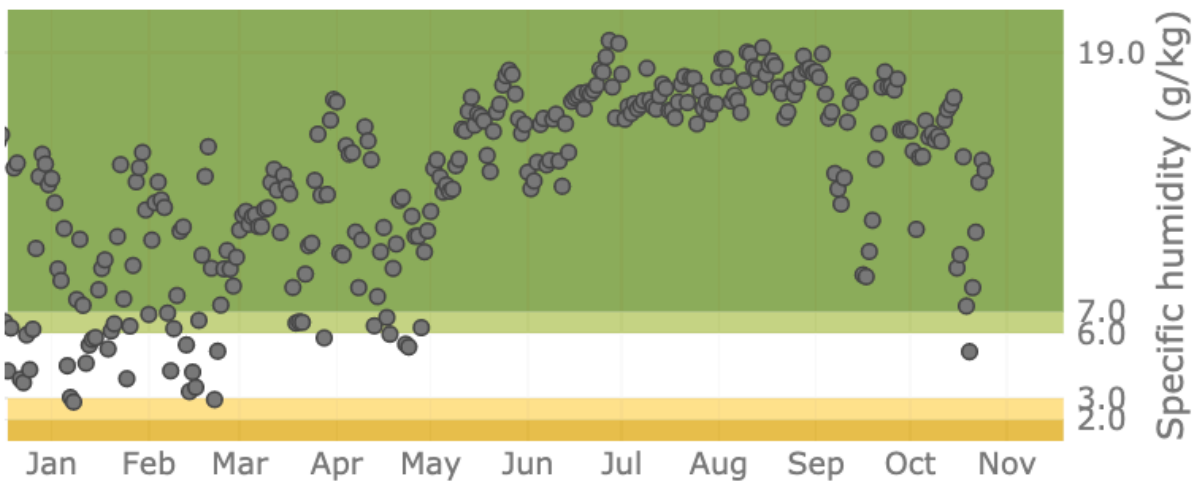
**Sept 25:** Executive order to begin reopening the state; prohibits local govt. from imposing fines or shutting down businesses, and from mask mandates

**November:** Florida has 3rd highest count of confirmed cases and 4th highest deaths in US



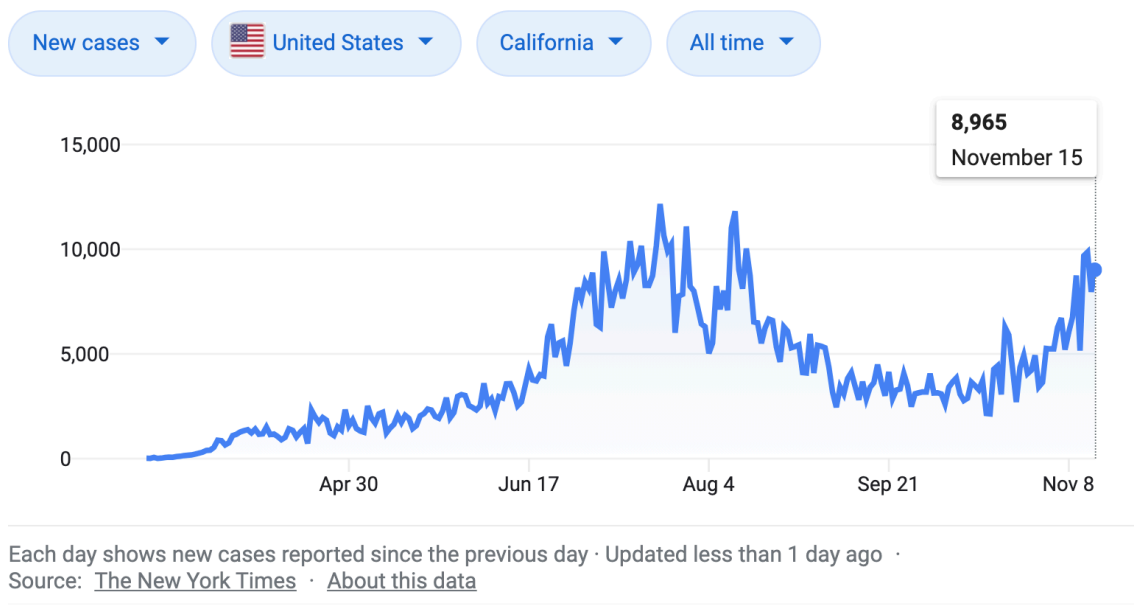
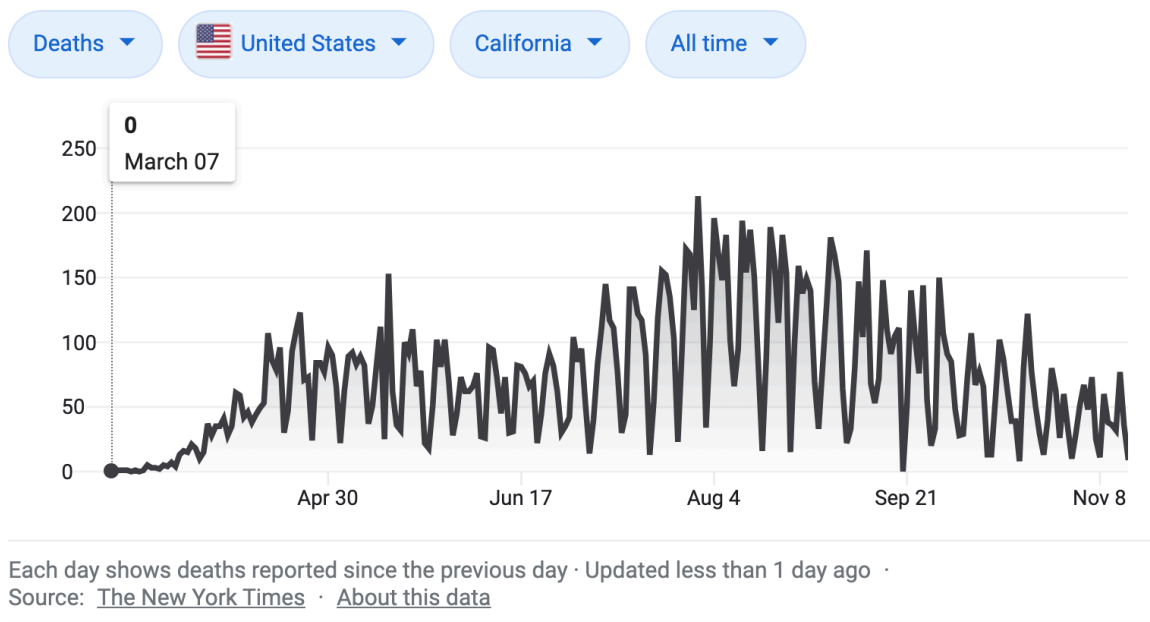


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Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

**CA (New Cases: 1,036,990; Deaths: 18,278 (JHU, 15Nov20))**



### Social/Policy

**Mach 12: Ban on public gatherings >250 people, social >10 people; schools closed March 13 through end March**

**March 19: Mandatory stay-at-home order issues**

**April 1: Closure all public and private schools**

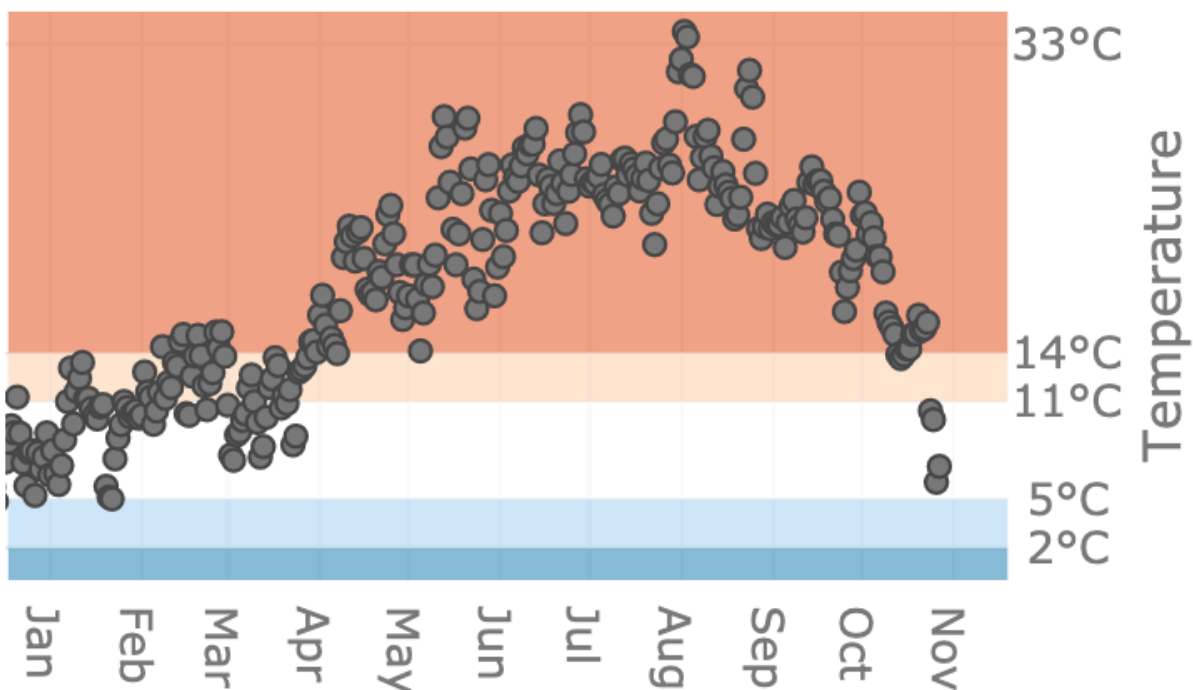
**April 13: Western States pact-Oregon, Washington, California**

**June 18: State-wide mask wearing mandate in most public spaces due to rising cases and deaths**

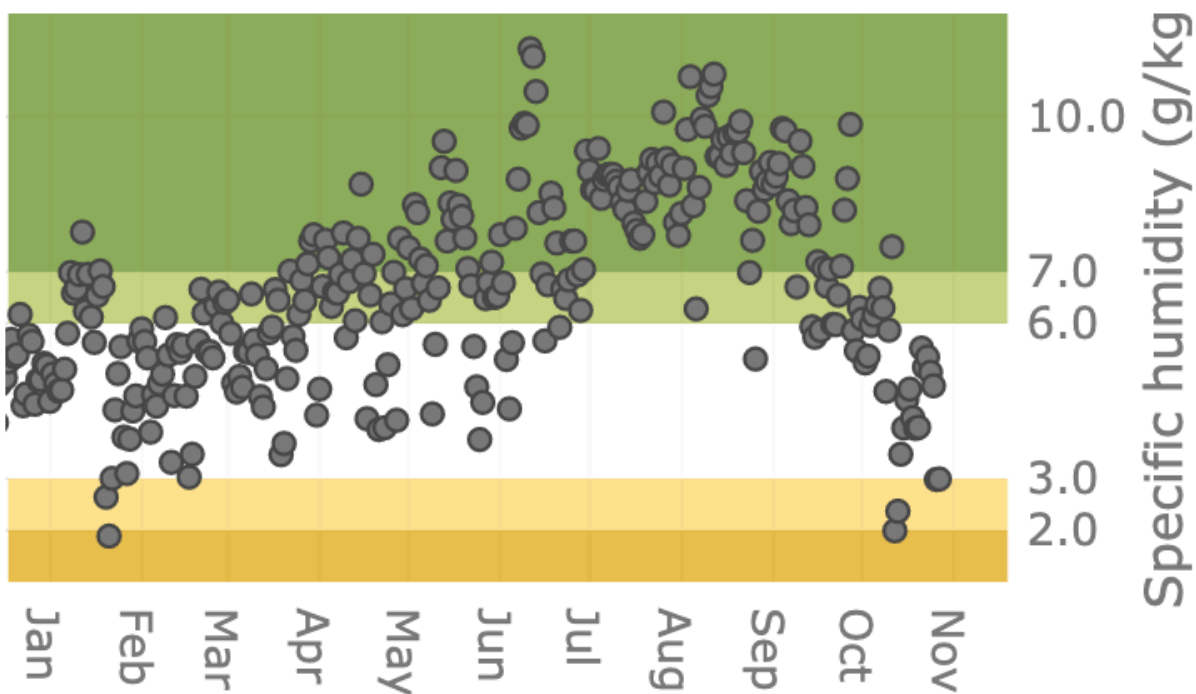
**July 1: Closure indoor businesses, gyms, movie theaters, gyms**

**Aug 28: Guidelines for lifting restrictions—Blueprint for safer economy**

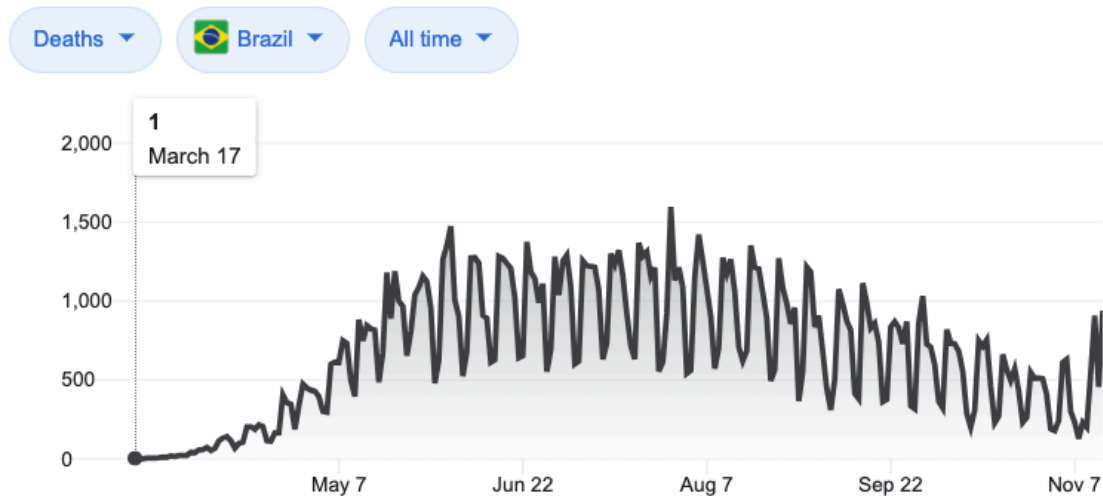
**Nov 13: Mandated requirements for all gatherings: > 3 households prohibited; gatherings must be outdoors; physical distancing; Wearing face masks**



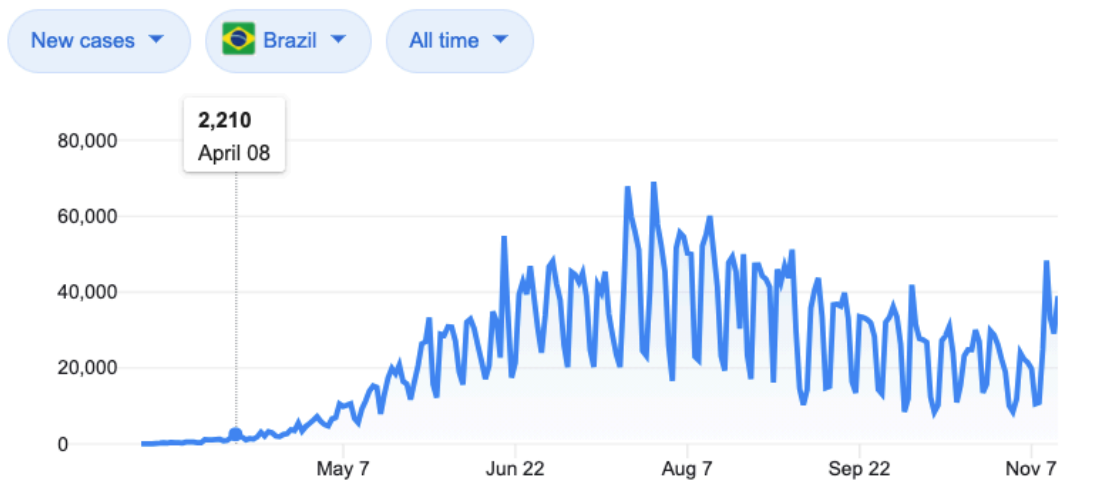
Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



## Brazil: (Cases: 5,848,959; Deaths: 165,658 (JHU: 15 Nov 20))



Each day shows deaths reported since the previous day · Updated less than 20 mins ago · Source: [Wikipedia](#)  
[About this data](#)



Each day shows new cases reported since the previous day · Updated less than 20 mins ago · Source: [Wikipedia](#)  
[About this data](#)

### Social/Policy

**March 13: Ministry health recommends travelers to Brazil self isolate for 7 days**

**March 27: Temporary ban on foreign travelers**

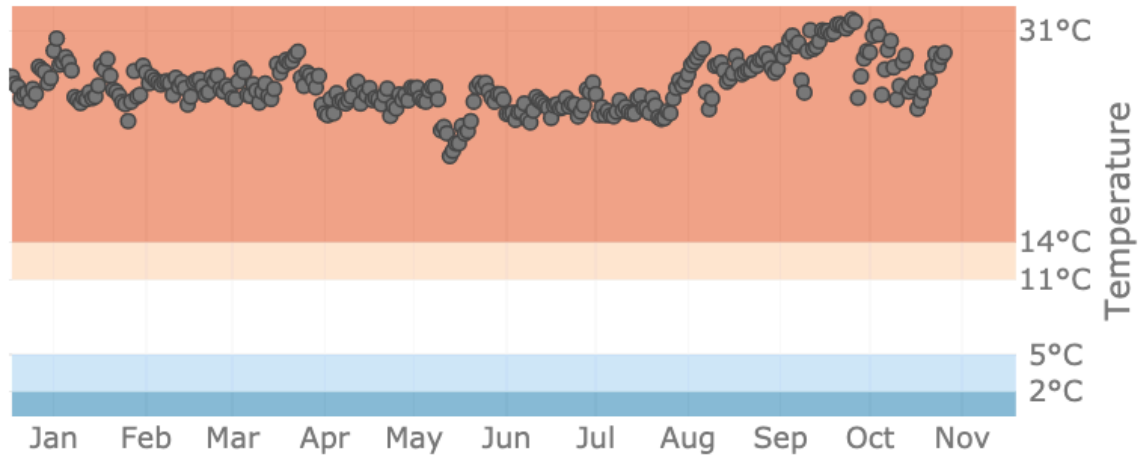
**March: National Govt Administration: Downplays COVID-19 as a common flu and critical of state directed lockdown measures**

**May 9: State Govt. of Rio Grande do Sol established new social distancing plan—ranked by sector from low risk to high**

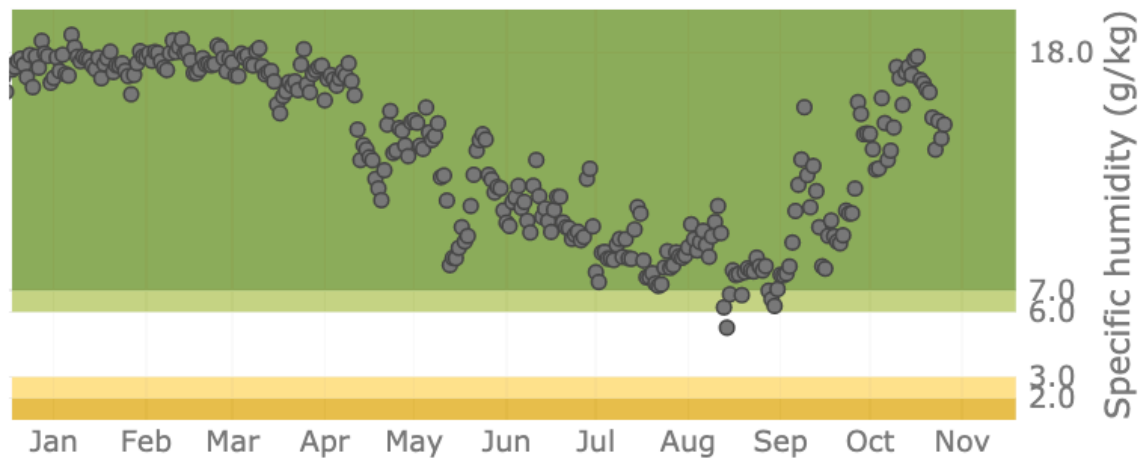
**June 19: Country reported 1.0 million cases**

**Aug: Three joint ventures began testing a new COVID-19 vaccine—debated by anti-vaccine groups**

**Sep: Brazil 3rd highest cases in world behind India and USA**



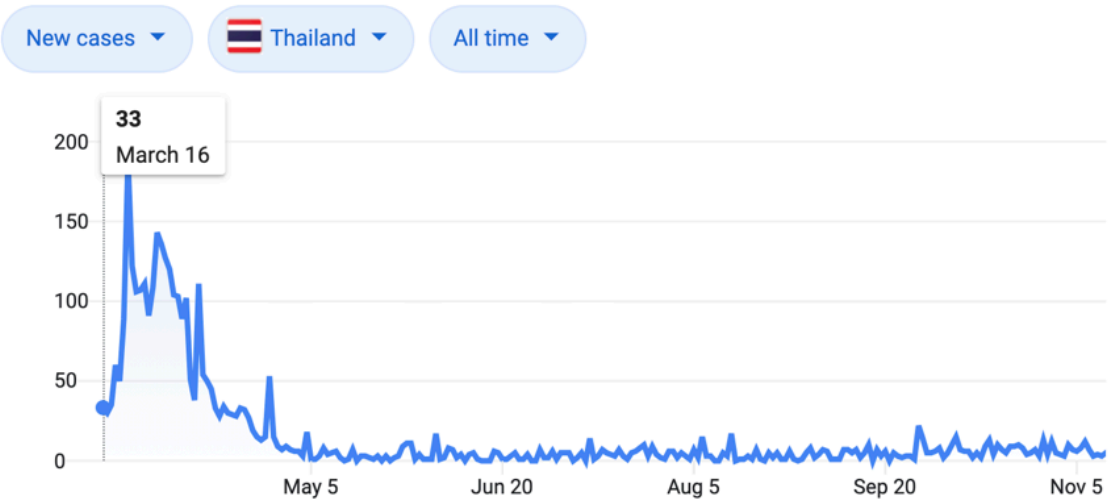
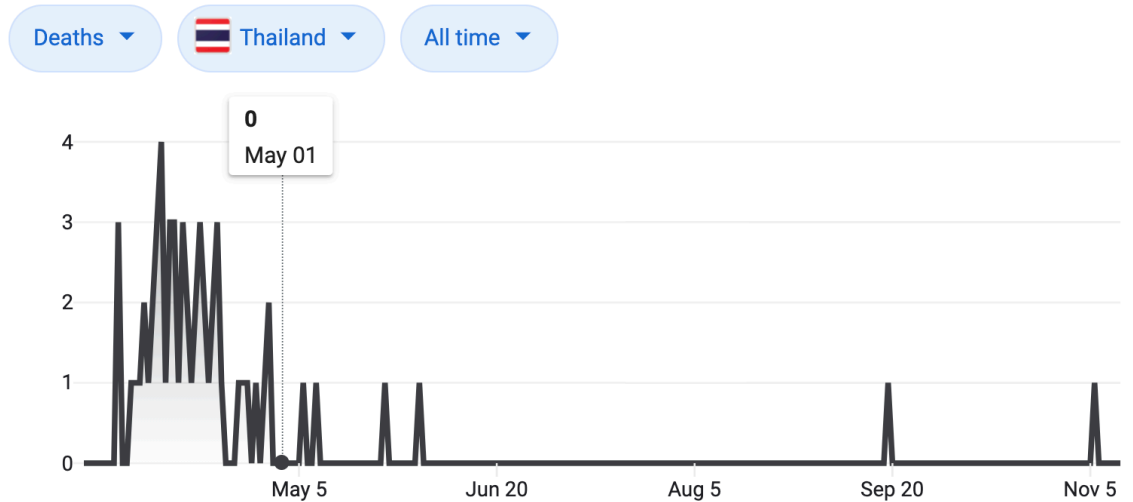
Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

## GROUP B: EXAMPLES FROM: THAILAND, MALAYSIA, INDIA

**Thailand (Cases: 3,866; Deaths: 60 (Source: JHU—14NOV20))**



### Policy/Social:

**13 Jan: First case outside China**

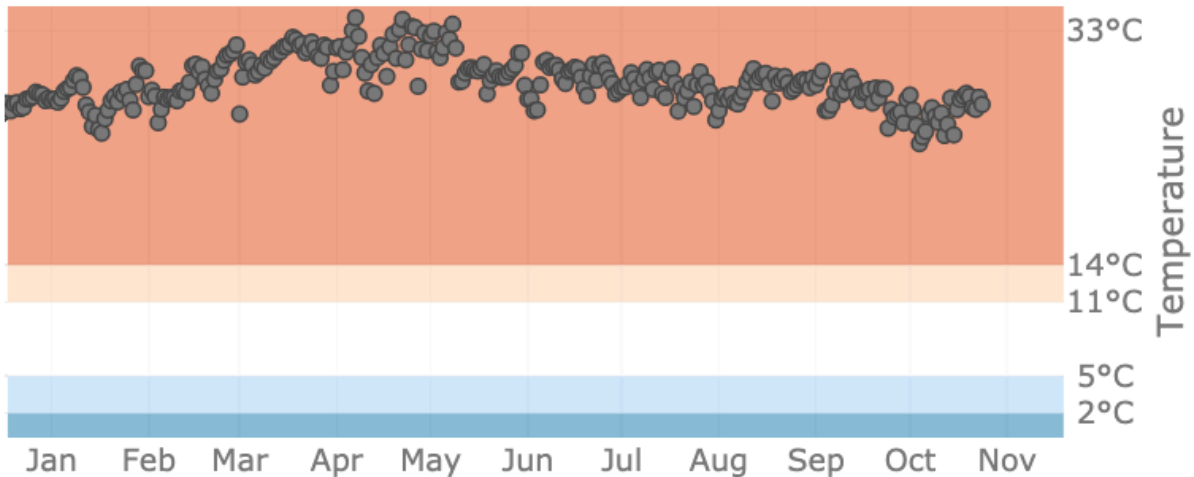
**26 March: Declaration of state of emergency**

**4 April: Lockdown—varying degree; international flights suspended**

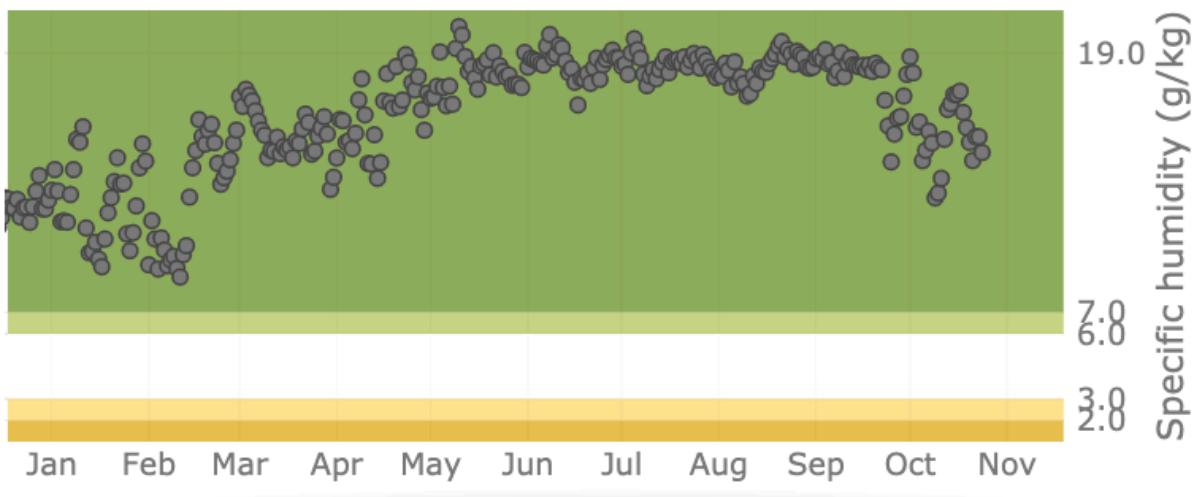
**Mid-May onwards: Locally transmitted infection rate near-zero—~ 100 days without local coronavirus transmission. Curfew lifted in July Nation mostly open: business, malls, gyms, restaurants**

**Aug: schools fully open**

**Oct--Current: Continued: 14-day mandatory quarantine for tourist travel except some provinces; if test positive on arrival, isolation. contact tracing and isolation ongoing**

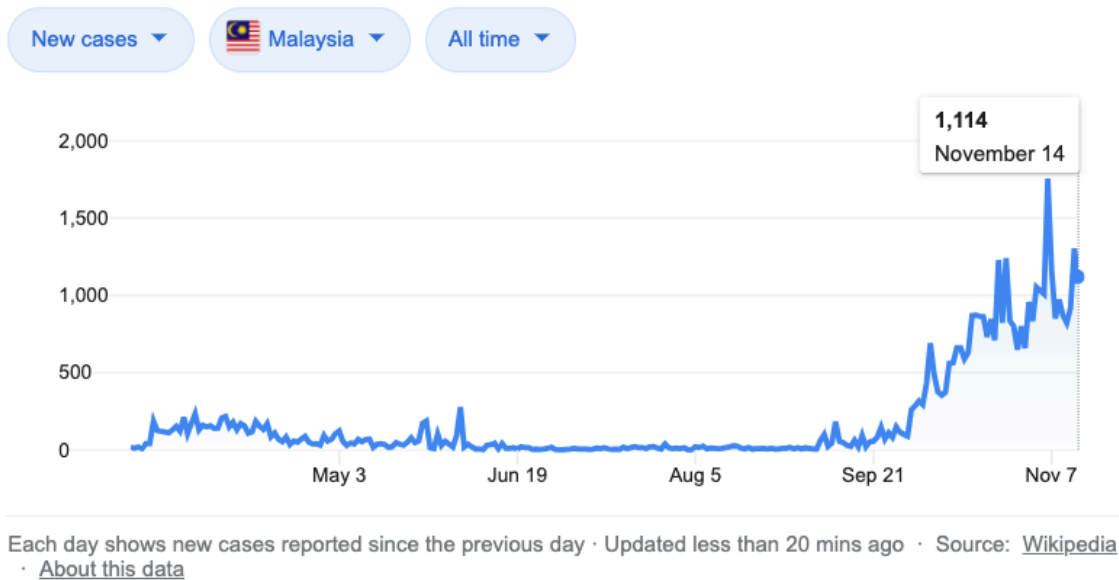
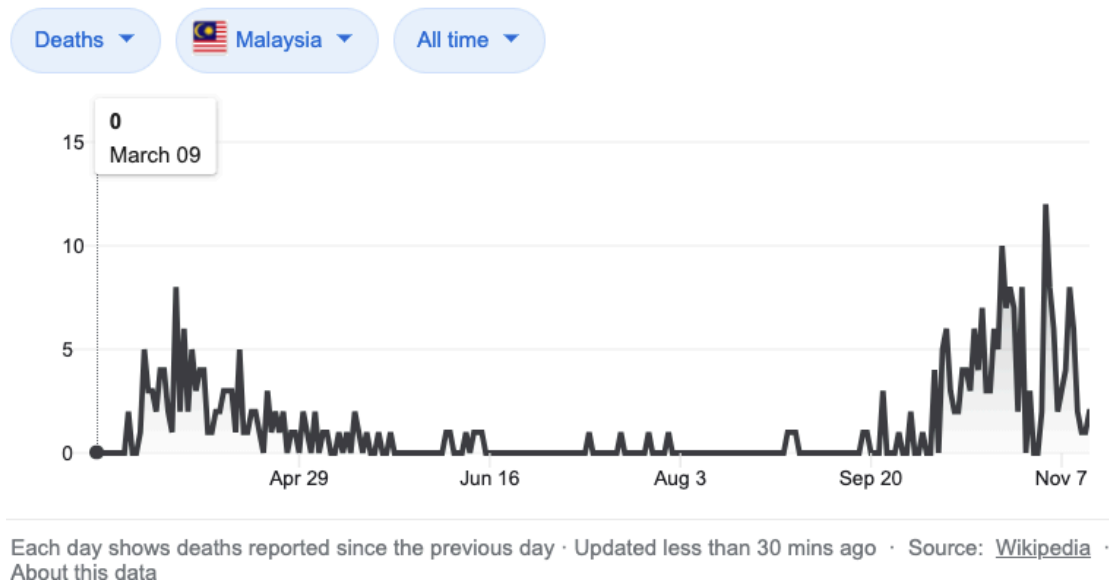


Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



**Malaysia (Cases: 46,209; Deaths: 306 (JHU, 15Nov20))**





## Social/Policy

**Late Jan: First cases—from China via Singapore**

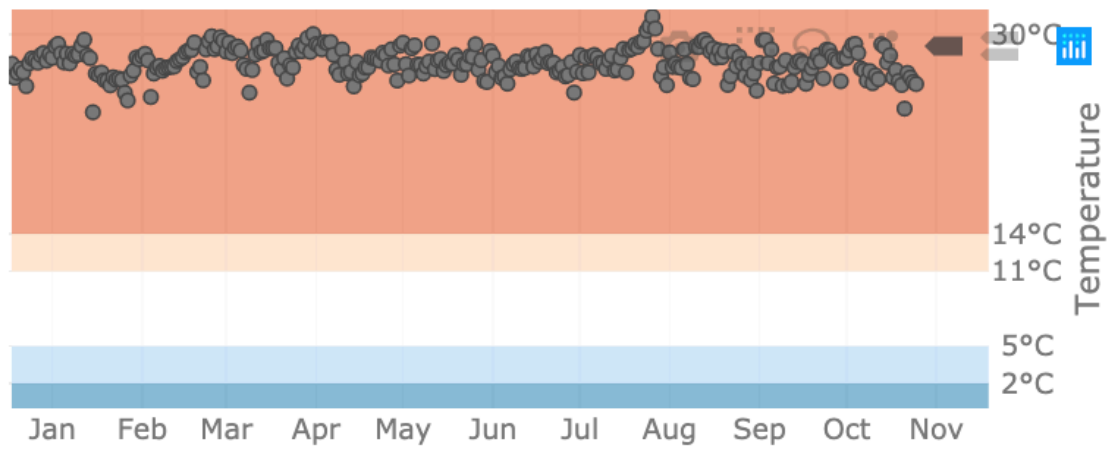
**March: Large clusters after religious gatherings in KL**

**16 March-mid-May: Nationwide movement control order & social distancing announced; travel restrictions**

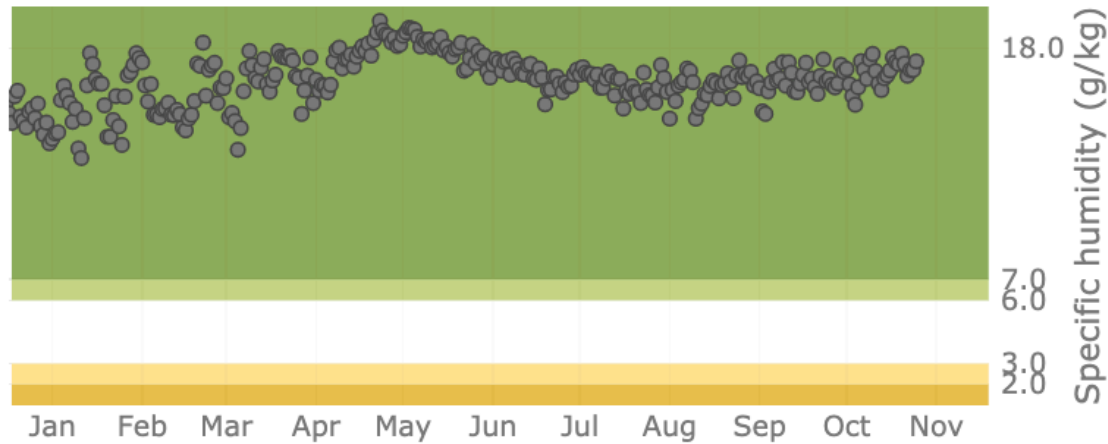
**12 May: Conditional movement control-Easing of restrictions—First phase after lockdown. Most businesses open**

**June: Schools, religious places of worship reopen,...**

**Through Nov: Periodic case spikes within local communities, immigrant enclaves, detention centers, prisons, , health facilities**

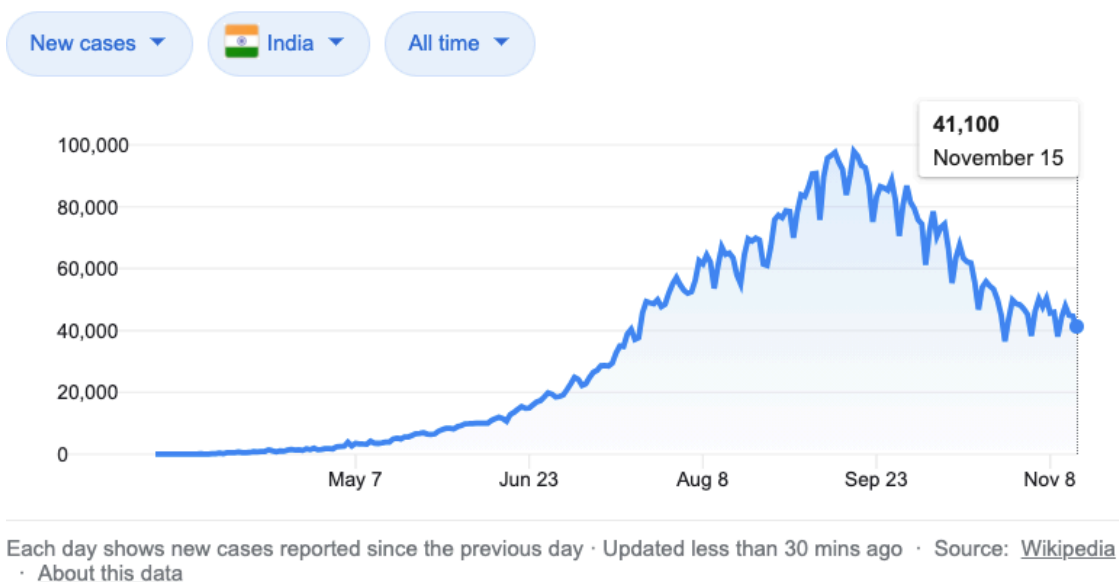
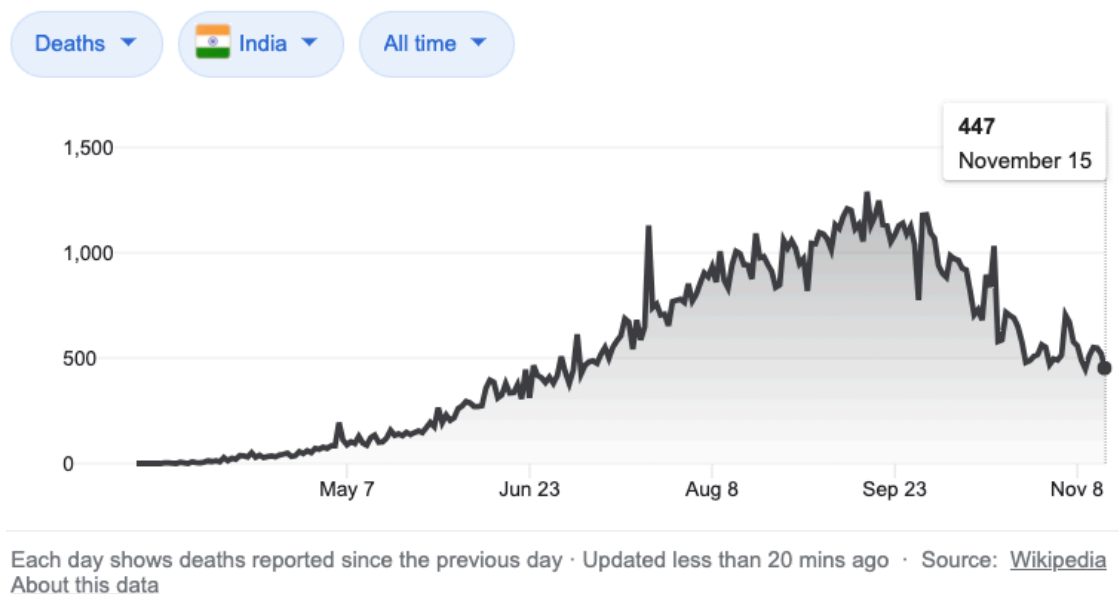


Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



Daily average of the specific humidity at mean sea level at the centre of the circle.

**India (Cases: 749,182; Deaths: 20,206 (JHU: 15Nov20))**



## Social/Policy

**January: First cases reported 30 January 2020**

**March 22: 14 day voluntary public curfew**

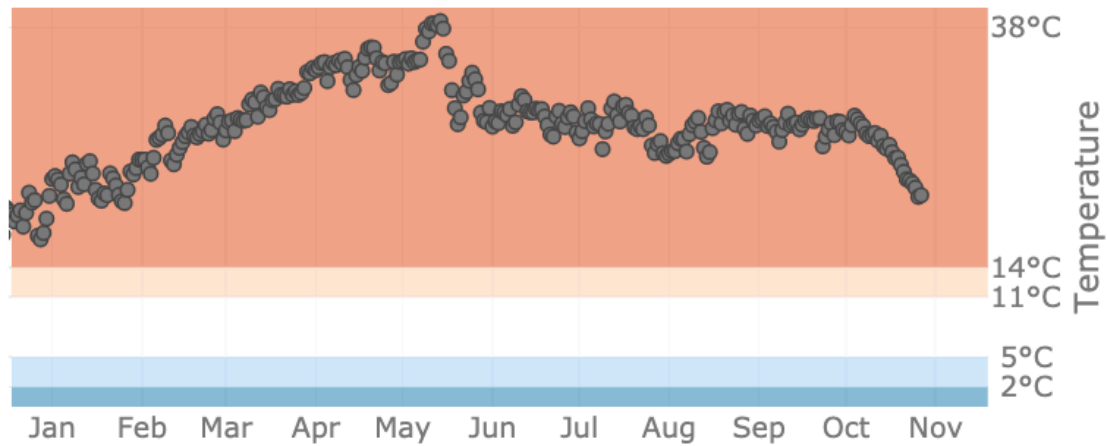
**March 24: Nationwide lockdown for 21 days**

**April 14: Lockdown extended thru 3 May**

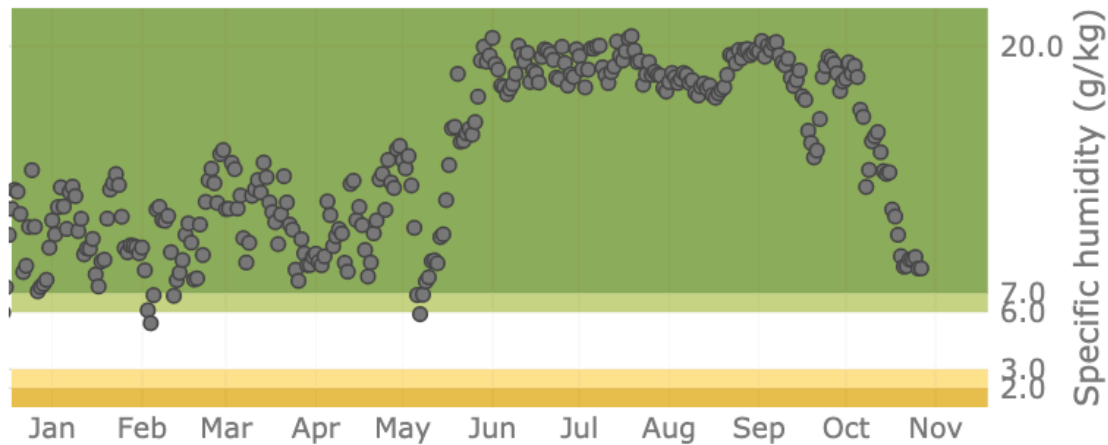
**June 1: Govt. started unlocking barring “containment” zones**

**July 20: Claim that fatality rate was among lowest in world with 2.41% and declining**

**October: Govt. announced that the pandemic had peaked and may come under control by Feb 2021. Has over 30 anti-COVID vaccines in various stages of development**



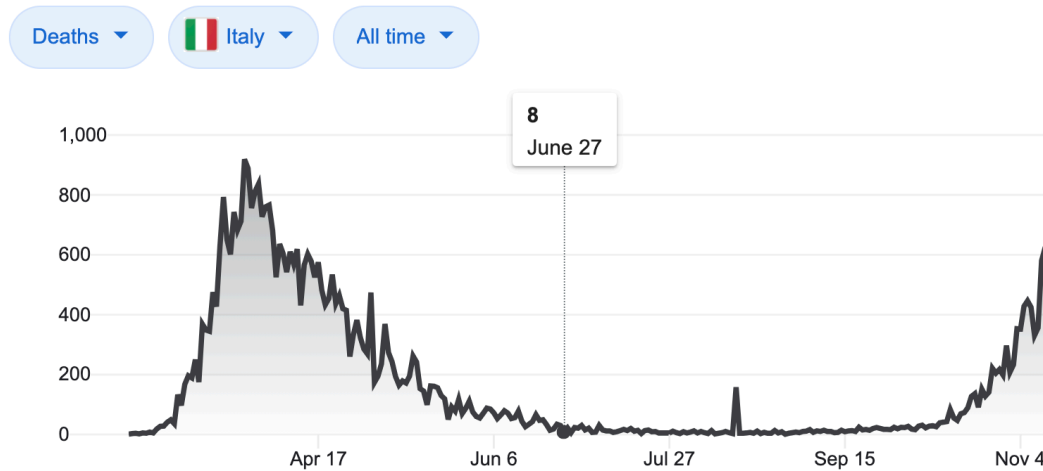
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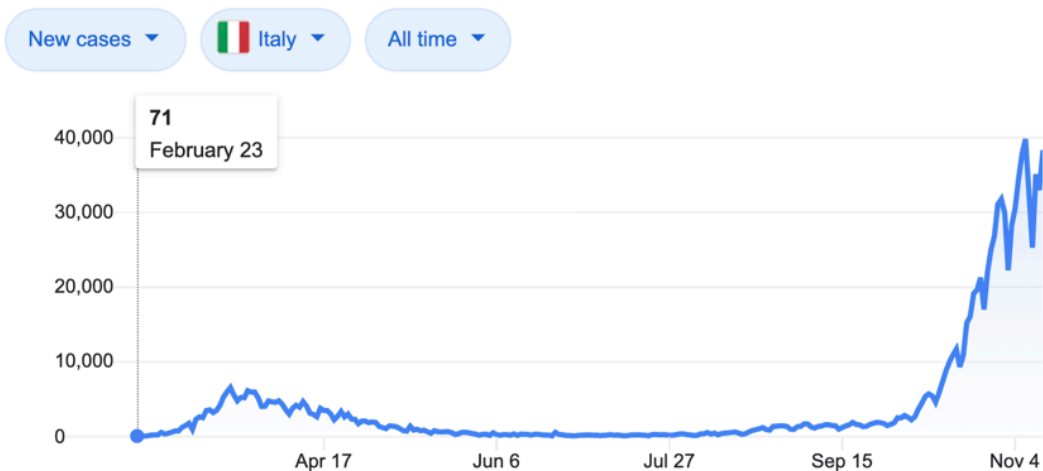
Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

## GROUP C: EXAMPLES FROM: ITALY, GERMANY, UK, SOUTH AFRICA; & CONCLUSIONS

**Italy (New Cases: 78,665; Deaths: 1586 (Source: JHU-14Nov20))**



Each day shows deaths reported since the previous day · Updated less than 20 mins ago · Source: [Wikipedia](#) · [About this data](#)



Each day shows new cases reported since the previous day · Updated less than 20 mins ago · Source: [Wikipedia](#) · [About this data](#)

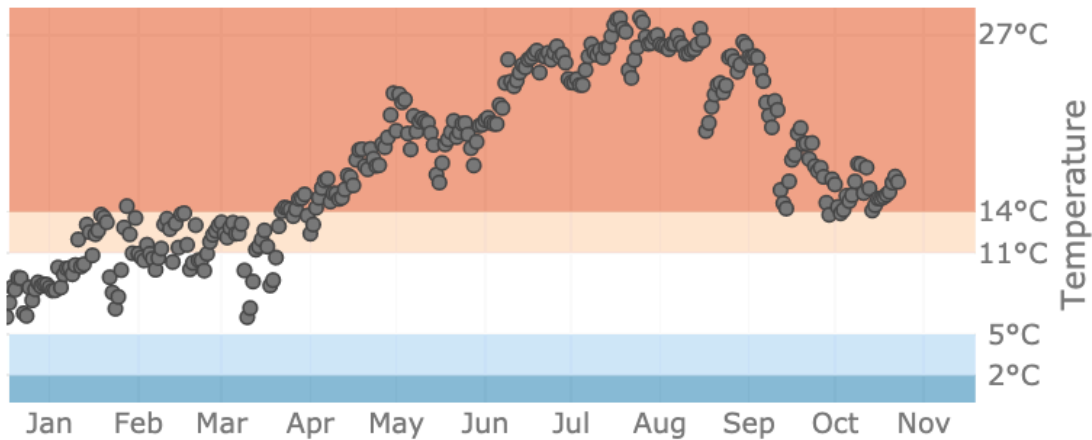
### Policy/Social:

**Jan/Feb: Unprepared; first country w/COVID in Europe; decentralized response; high impact**

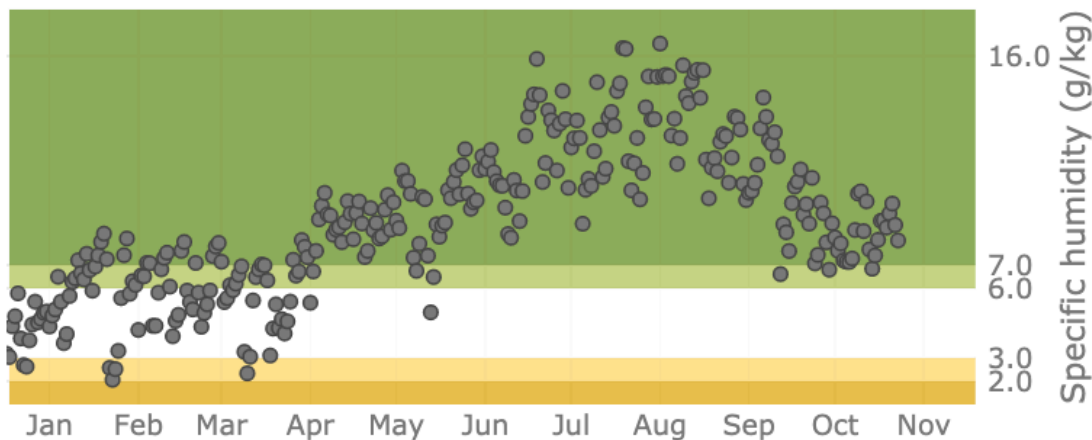
**March: National lockdown**

**May-Sept/Oct: Lockdown lifted--most activities reopened following specific rules. But state of emergency (preparedness) extended until 15 Oct 2020.**

**Nov 3: New restrictions nationwide: Curfew, masks required, closed gyms, museums, swimming, cinemas/theaters.**

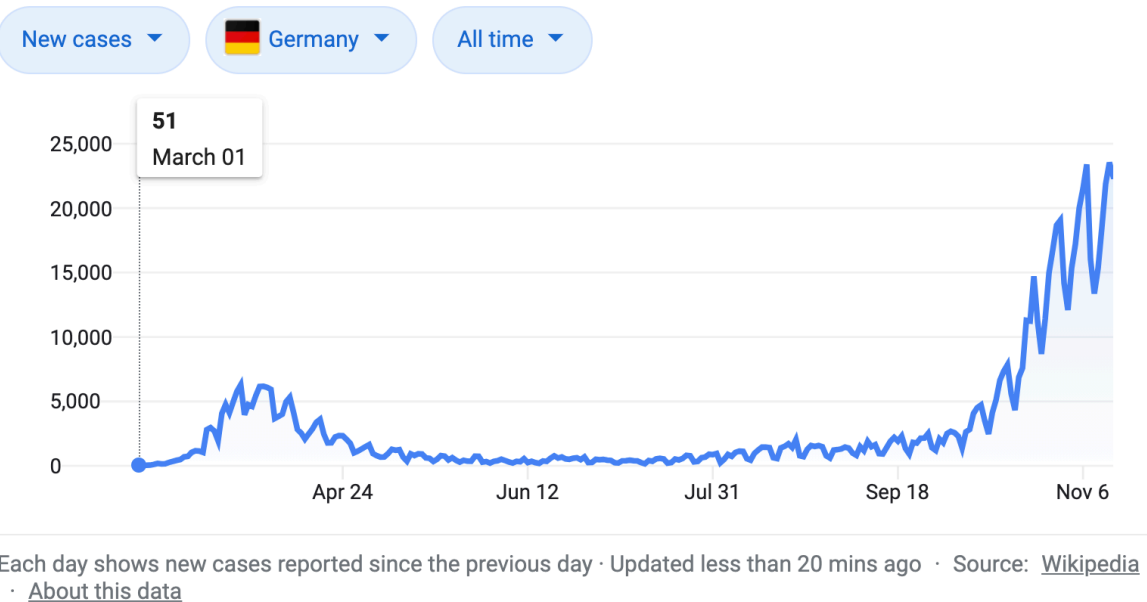
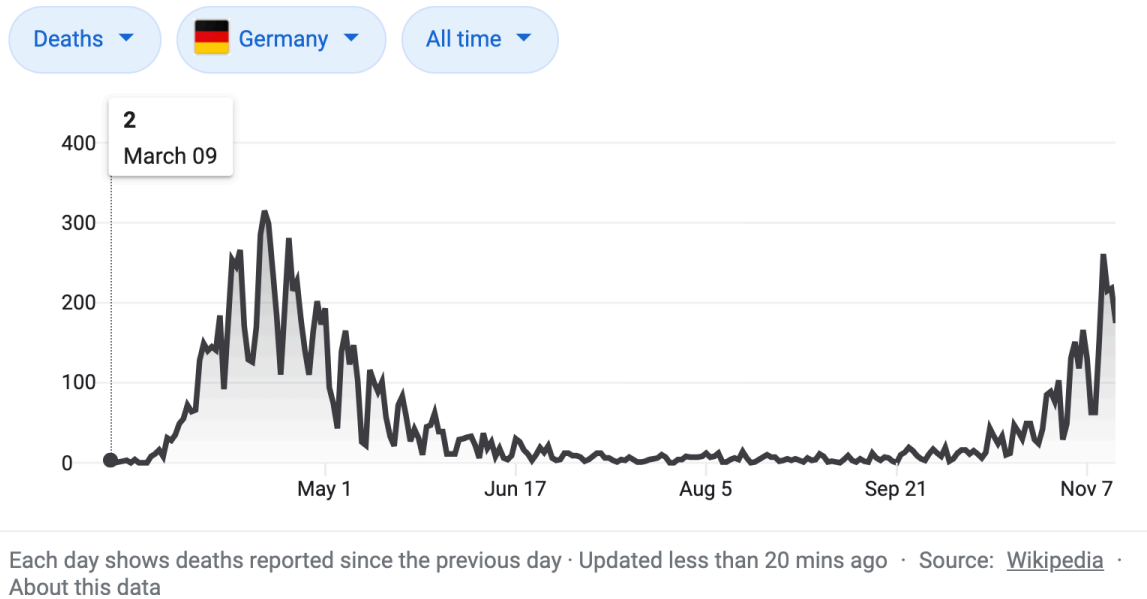


Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

**Germany (Cases: 746,945; Deaths: 12,453 (JHU—14Nov20))**



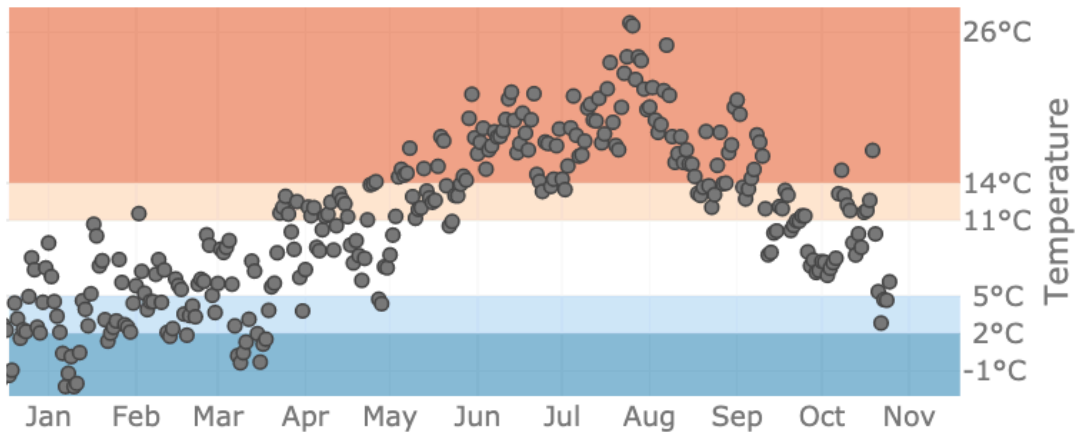
## Social/Policy

**Jan-early Feb: First cases near Munich; first large cluster March**

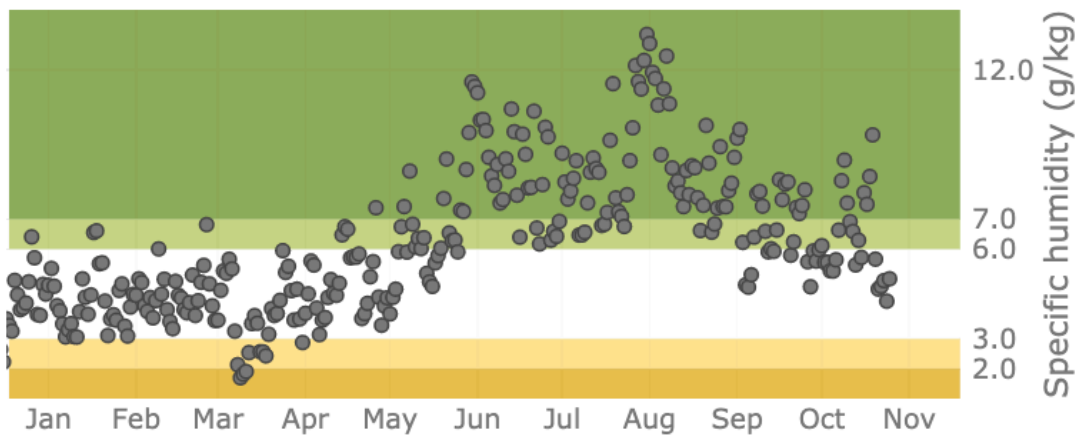
**Mid-March: Borders closed, curfews imposed in 6 states, other stats prohibited physical contact with >1 person outside household**

**April/May: Fragile intermediate success achieved, restrictions eased.**

**Nov: Partial lockdown due to sharp rise in infection numbers**



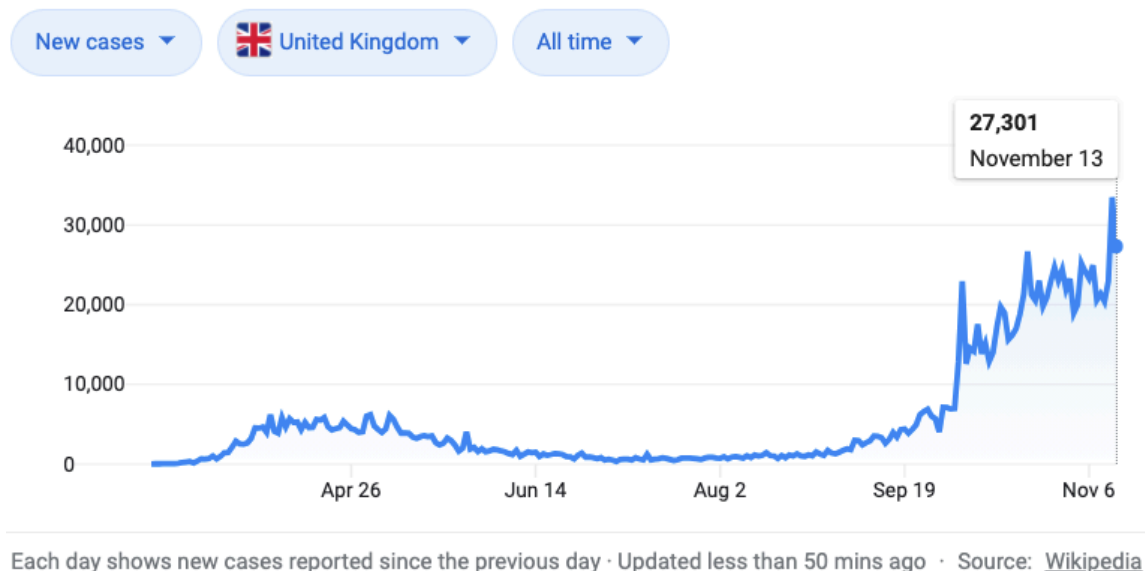
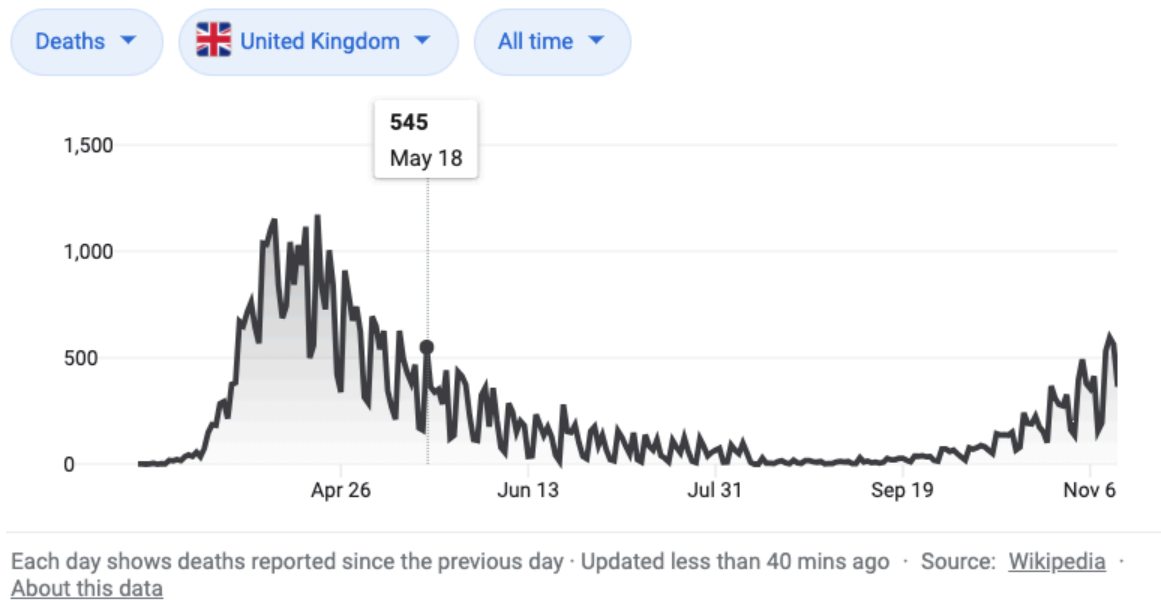
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Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

**UK (Cases: 1,128,6763; Deaths: 45,053 (Source: JHU, 14Nov20))**





### Policy/Social:

**Feb:** Launched info campaign to slow virus, drive thru' screening

**March:** Stay home orders issued; shut down schools, businesses, facilities, amenities, places of worship

**Mid-April:** Social distancing, masks, flattened curve; low daily cases thru Aug

**Mid-June:** Non-essential shops reopened; use of public transport increases

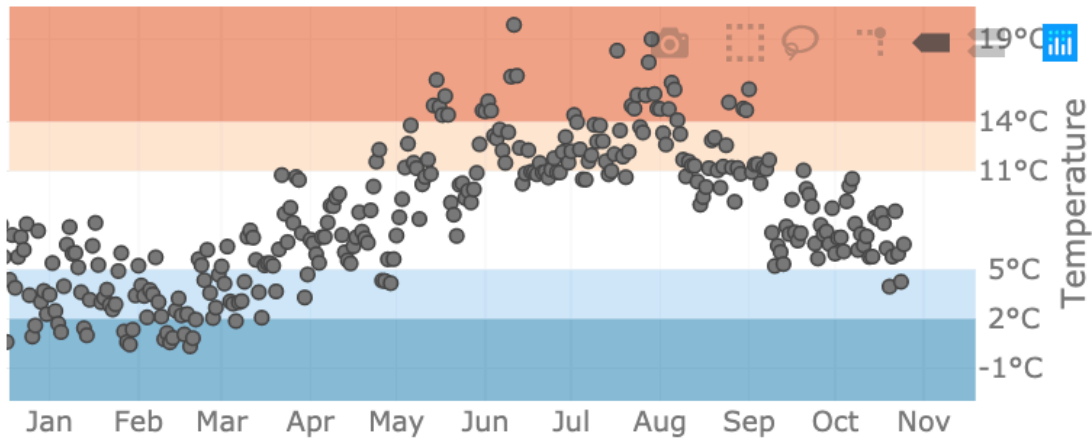
**Aug-onwards:** Resurgence

**Sept:** New restrictions on gatherings, social distancing

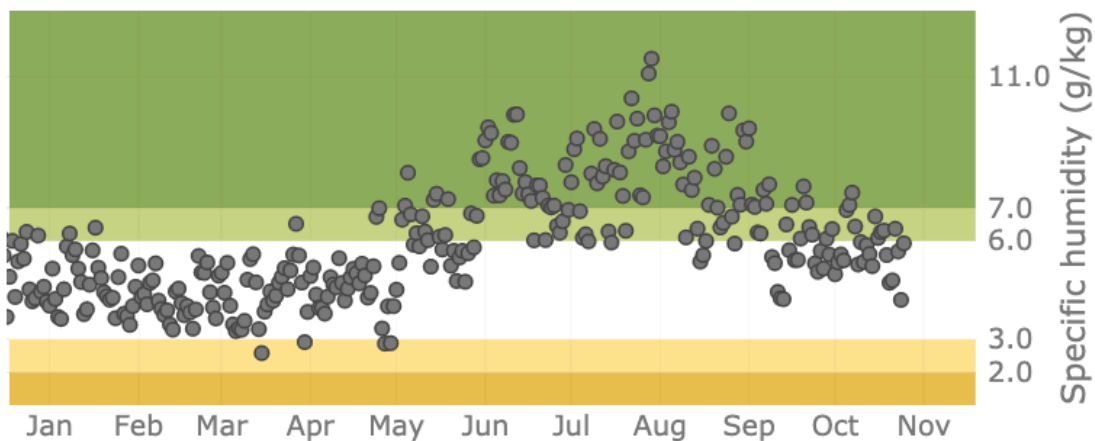
**Oct: Tier-3 lockdowns—close pubs; Tier-2 lockdowns London—banning people mixing indoors privately**

**Oct 31: National Lockdown**

**Nov 12/13: Test and release program introduced at airports with 7 day self isolating quarantine**



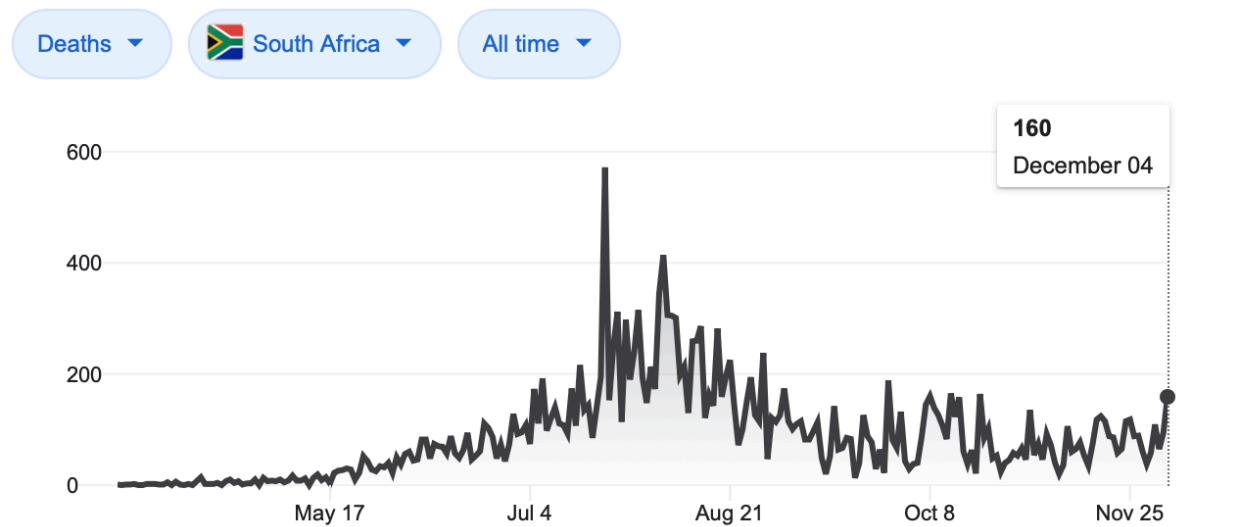
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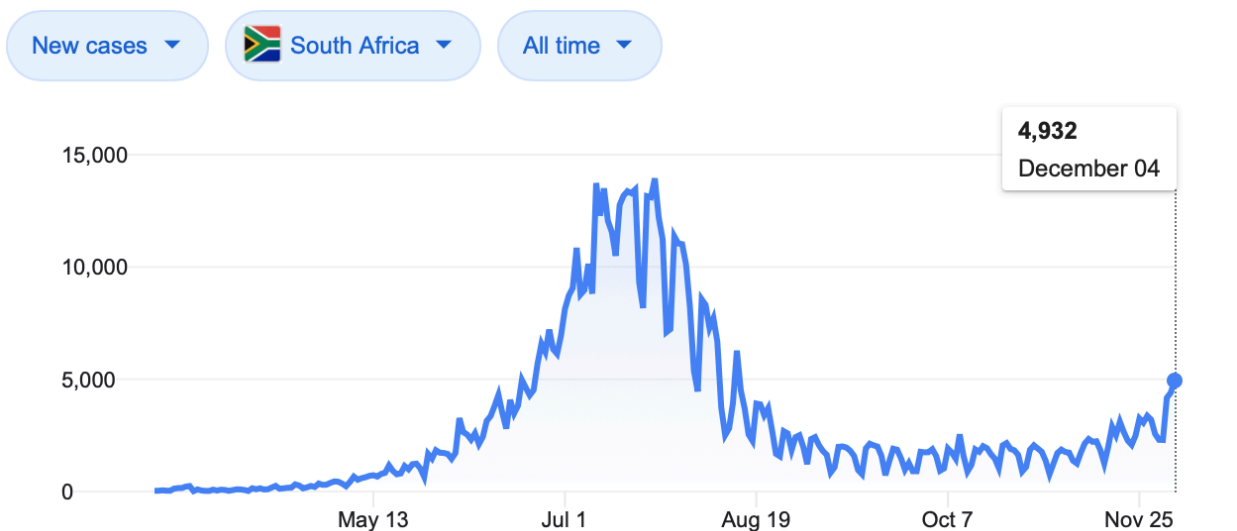
**South Africa (Cases: 749,182; Deaths: 20,206 (JHU, 16Nov20))**

## Daily change



Each day shows deaths reported since the previous day · Updated less than 40 mins ago · Source: [Wikipedia](#) · [About this data](#)

## Daily change



Each day shows new cases reported since the previous day · Updated less than 10 mins ago · Source: [Wikipedia](#) · [About this data](#)

## Social/Policy

### March 5: First case brought in from Italy

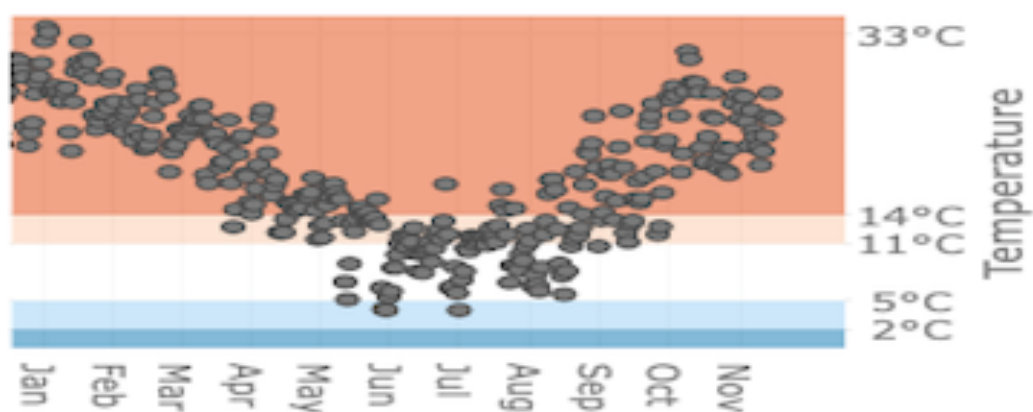
**March 15: Declaration of national state of disaster**

**March 27: National lockdown**

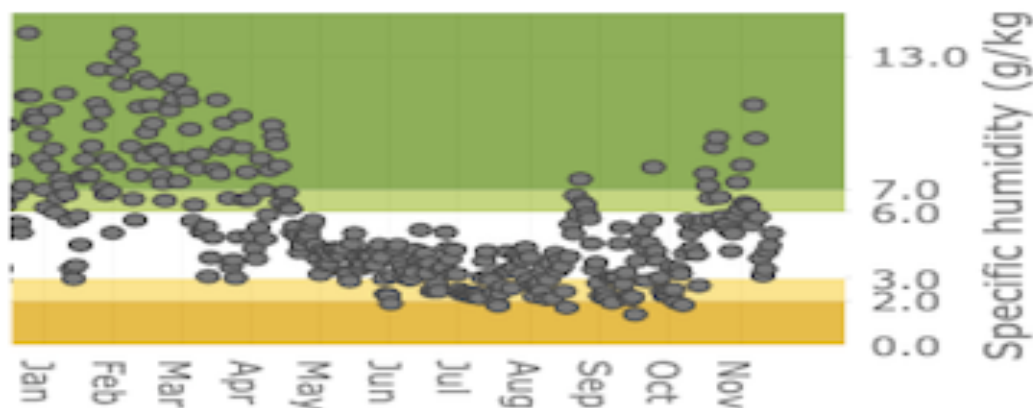
**May 1: Phased easing of lockdown restrictions**

**Sept 21: Restrictions lowered to alert level**

**(As of Nov 2020, SA has highest number COVID cases in Africa, with a relatively low death rate (fatality rate 3% as of Nov 15))**



Daily average of the air temperature near the surface at the centre of the circle, not representative of the whole country.



Daily average of the specific humidity at mean sea level at the centre of the circle, not representative of the whole country.

## CONCLUSIONS

**Viral infections like influenzas or flu are seasonal and the common cold is more likely in winter. SARS-CoV-2 is hypothesized (based on these other Coronaviruses) to be (at least partially) environmentally (T/Humidity) sensitive. Some studies support that virus survives longer on**

**surfaces in colder temperatures than higher temperatures, and lower specific humidity than higher.**

**Environmental factors (T, H, UV) may play a role directly in the survival of the virus on droplets and surfaces once expelled from an infected person, and indirectly by the human response to the environment and weather--e.g., open air vs indoor gatherings, social distancing...**

**Preliminary results suggest that policy actions and social practice have a dominating influence on the propagation and containment (or not) of COVID-19, possibly enabled by or associated with concomitant environmental factors**

**Policy actions appear to be non-uniform in many parts of the world. And varying controls divided between national and state governments. Better results in containment are seen where the policy and social response have been consistent and well managed**

**Well designed policy and social response together with unfavorable (to the Virus) climate conditions appear to be a positive contributor to the containment of the virus.**

**Until vaccines are available globally, relaxed social and policy responses together with favorable seasonal climate appears to be leading to expanded COVID-19 outbreaks**

**Since this paper was written in Mid-November, SARS-COV-2/COVID-19 rates have trended up in the USA and many other countries.**

## **AUTHOR INFORMATION**

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## ABSTRACT

**SARS-CoV-2/COVID-19 propagated rapidly from a local outbreak to global scales with associated multi-trillion \$ impact on the international economy and social, economic, and ecological systems. The Pandemic is currently ongoing and key questions have arisen as to what key factors determine its incidence, propagation, and mortality rates. Here, we try to distinguish between concurrent and collocated influences on COVID-19 due to environmental factors (e.g., T, humidity..) compared to policy actions (e.g., lock downs, slowdowns, open/closed businesses, transportation), and social practice (e.g., wearing masks, social distancing). Publicly available data and information from selected countries/regions around the world are used in this initial analysis. Preliminary results suggest that policy actions and social practice have a dominating influence on the propagation and containment (or not) of COVID-19, possibly enabled by or associated with concomitant environmental factors.**

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