OLIVER WYMAN

COVID-19 PRIMER SPECIAL EDITION

SEPTEMBER 2020

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INTRODUCTION

Oliver Wyman weekly COVID-19 primers

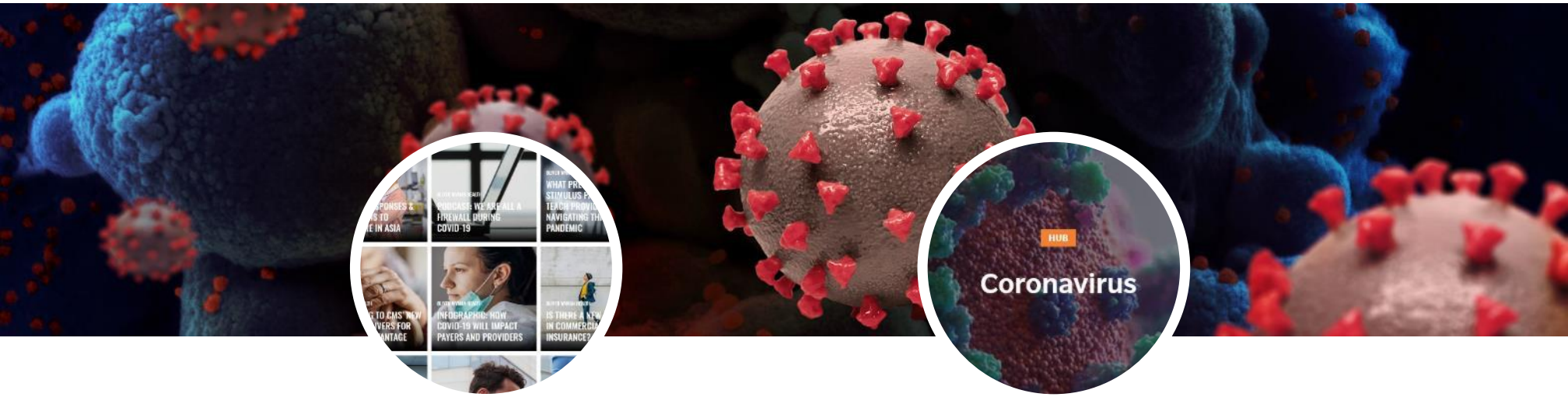
Since the very first COVID-19 cases in the region, **Oliver Wyman** has been issuing **weekly COVID primers for the GCC**, covering **country-specific infection forecasts, economic analyses, key research digests,** and **news round-ups from local media sources**.

This **special edition** is the **round-up of the 20+ weekly primers** issued to date, consolidating our **latest research and insights** on the topic.

Oliver Wyman team and tools

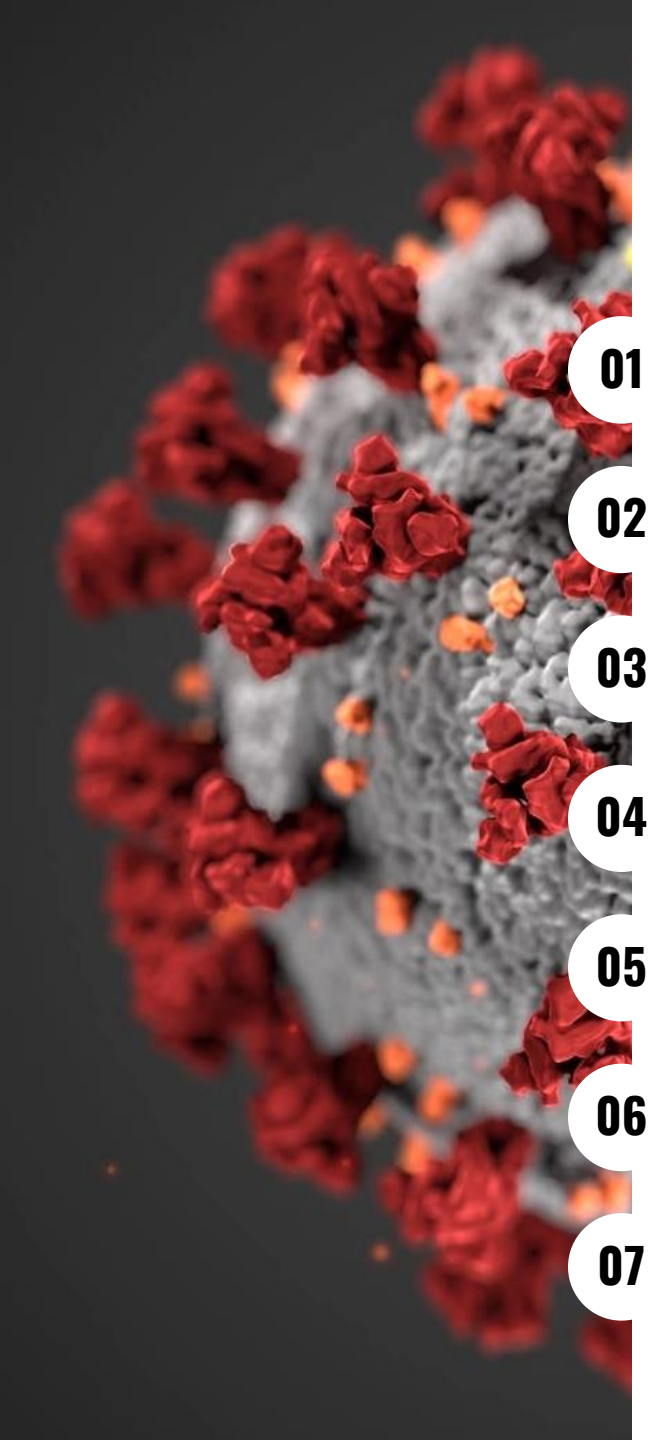
Oliver Wyman's dedicated team of specialists are constantly monitoring the latest developments to provide **actionable insights** for our clients.

In addition, Oliver Wyman has developed, hosts and continues to refine a suite of **proprietary tools** to address the pandemic, including the **Pandemic Navigator**, **COVID-19 Almanac**, **Scenario Sandbox and Generator,** and the **COVID-19 Risk Reporting dashboard**.



[Oliver Wyman Coronavirus Hub]

[MMC Coronavirus Hub]



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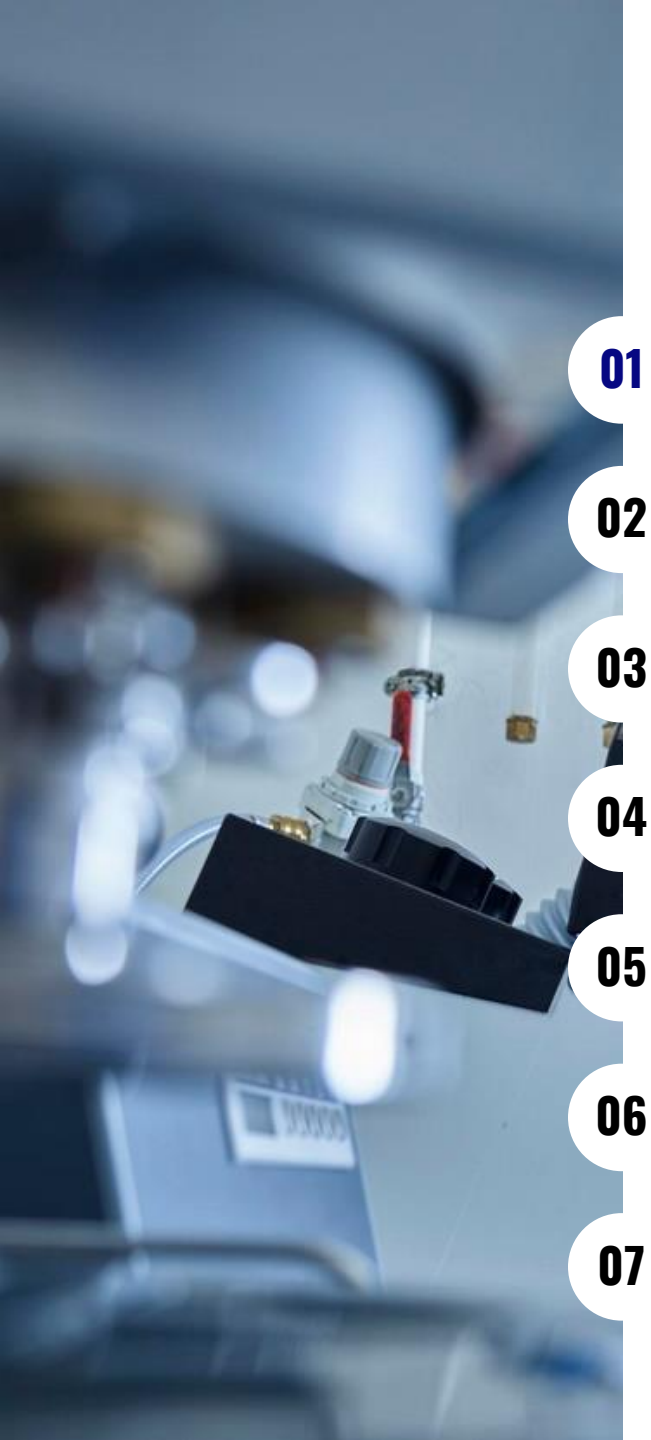


01. LATEST PANDEMIC DEVELOPMENTS

01 **Latest pandemic developments**

02 Viral mutations and comorbidities

03 Second wave prevention

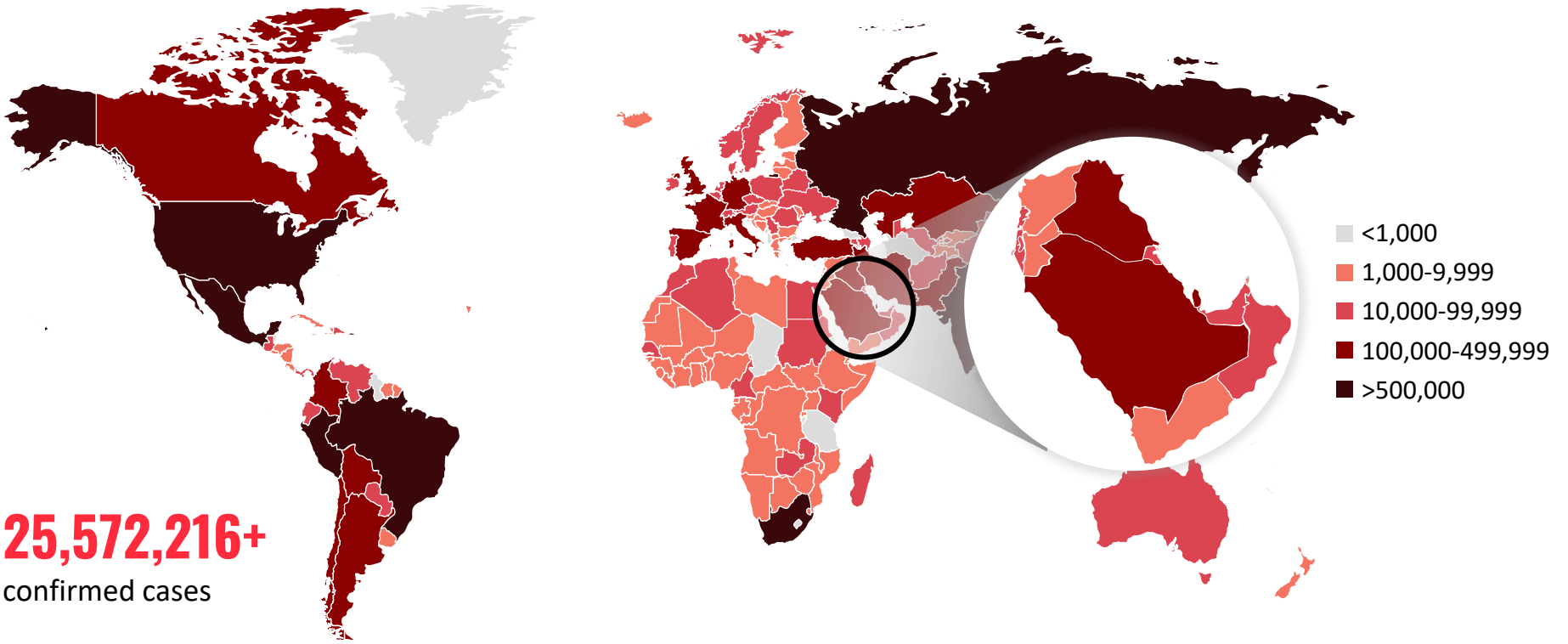
04 National testing policies

05 Governments policy response

06 Re-opening schools

07 Vaccine trials

COVID-19 HAS HAD A MAJOR IMPACT GLOBALLY



25,572,216+
confirmed cases

The **USA** accounts for **23.7%** of all confirmed cases, followed by **Brazil** (**15.3%**) and **India** (**14.4%**)

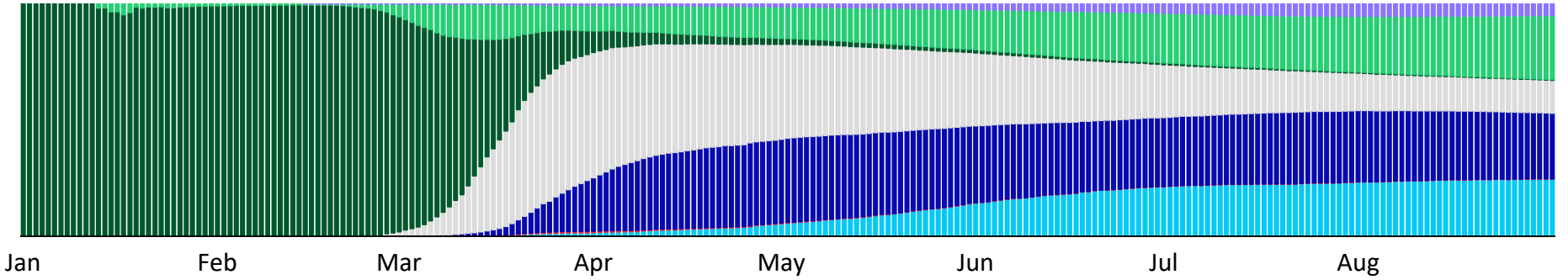
	Number of active cases	Number of deaths	Case fatality rate
GCC	**47,275**	**5,884**	**0.81%**
World	**6,913,637**	**852,710**	**3.33%**

Sources: Johns Hopkins University Center for Systems Science and Engineering (link) and Worldometer (link).

ALL REGIONS HAVE BEEN IMPACTED

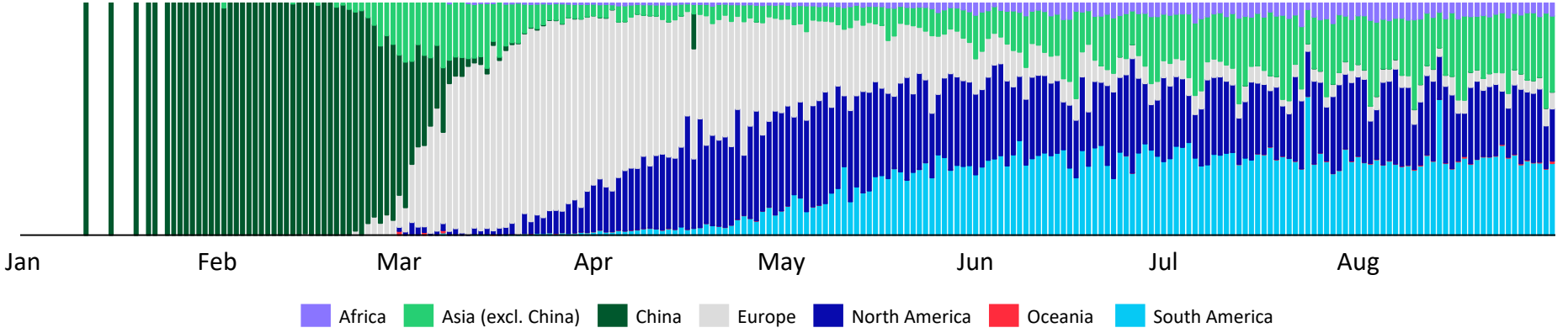
Total confirmed COVID-19 cases by region

% share, 1-Jan to 1-Sep



Daily COVID-19 deaths by region

% share, 1-Jan to 1-Sep

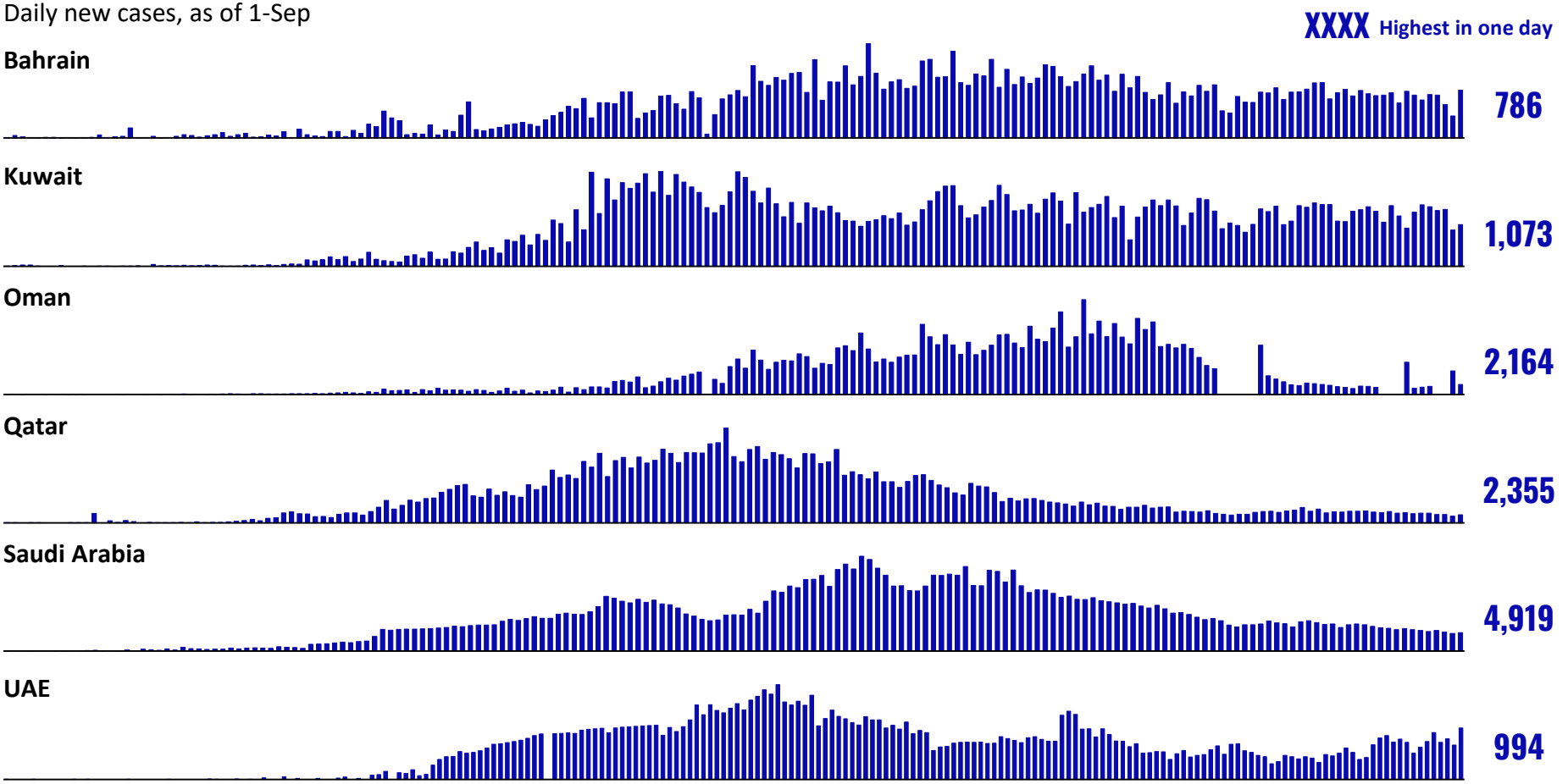


Source: Our World in Data (link).

THE GCC HAS ALSO BEEN IMPACTED

COVID-19 trajectories in the GCC

Daily new cases, as of 1-Sep

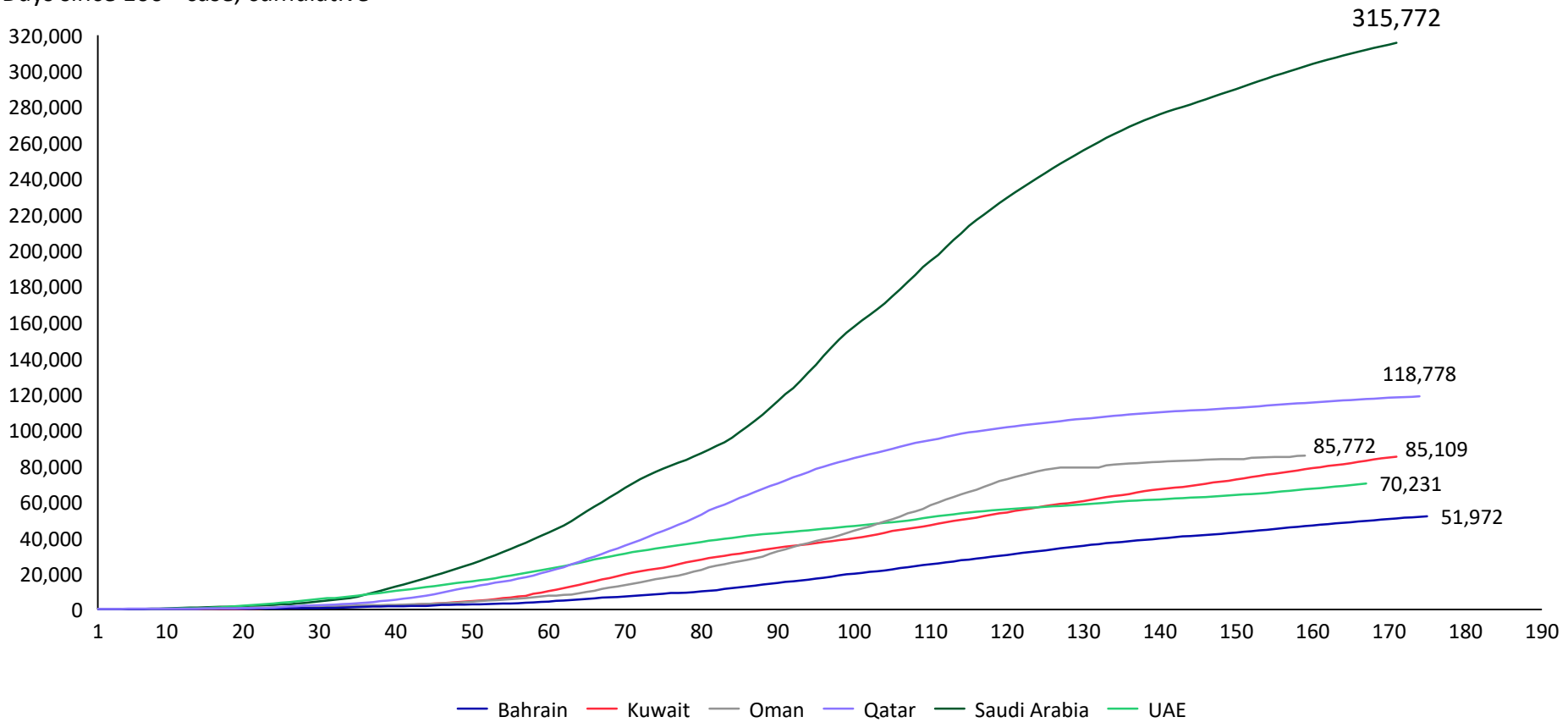


Sources: Johns Hopkins University Center for Systems Science and Engineering (link), Our World in Data (link), and health ministry press releases.

TO DATE THE GCC COUNTS 727,634 CONFIRMED CASES

Confirmed cases of COVID-19 in the GCC*

Days since 100th case, cumulative

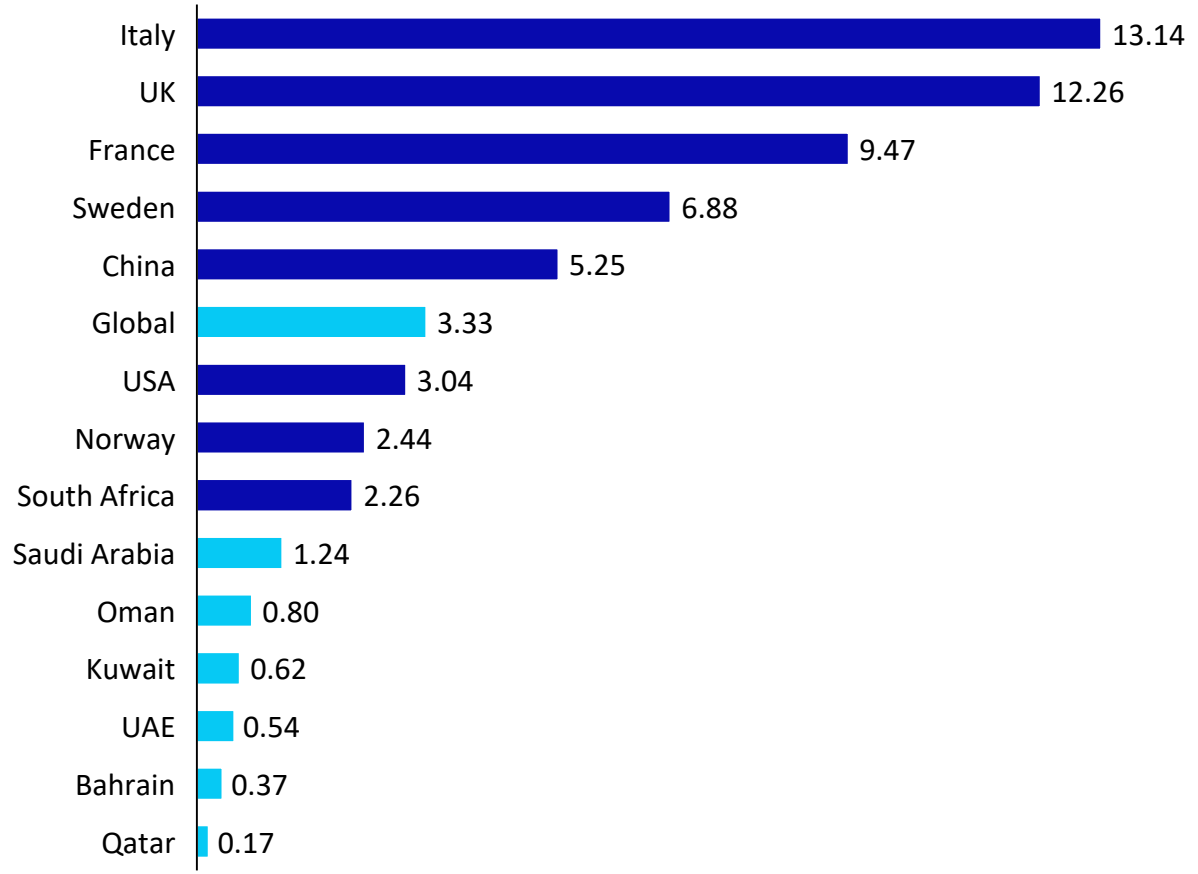


Note (*): Comparisons between countries should only serve as a guide, as reporting standards and testing measures vary across the GCC .
Source: Johns Hopkins University (link).

STILL, GCC CASE FATALITY RATES (CFR) HAVE BEEN MUCH LOWER THAN INTERNATIONAL PEERS

Case fatality rates by country

%



Sources: Johns Hopkins University Center for Systems Science and Engineering (link) and Vox (link).

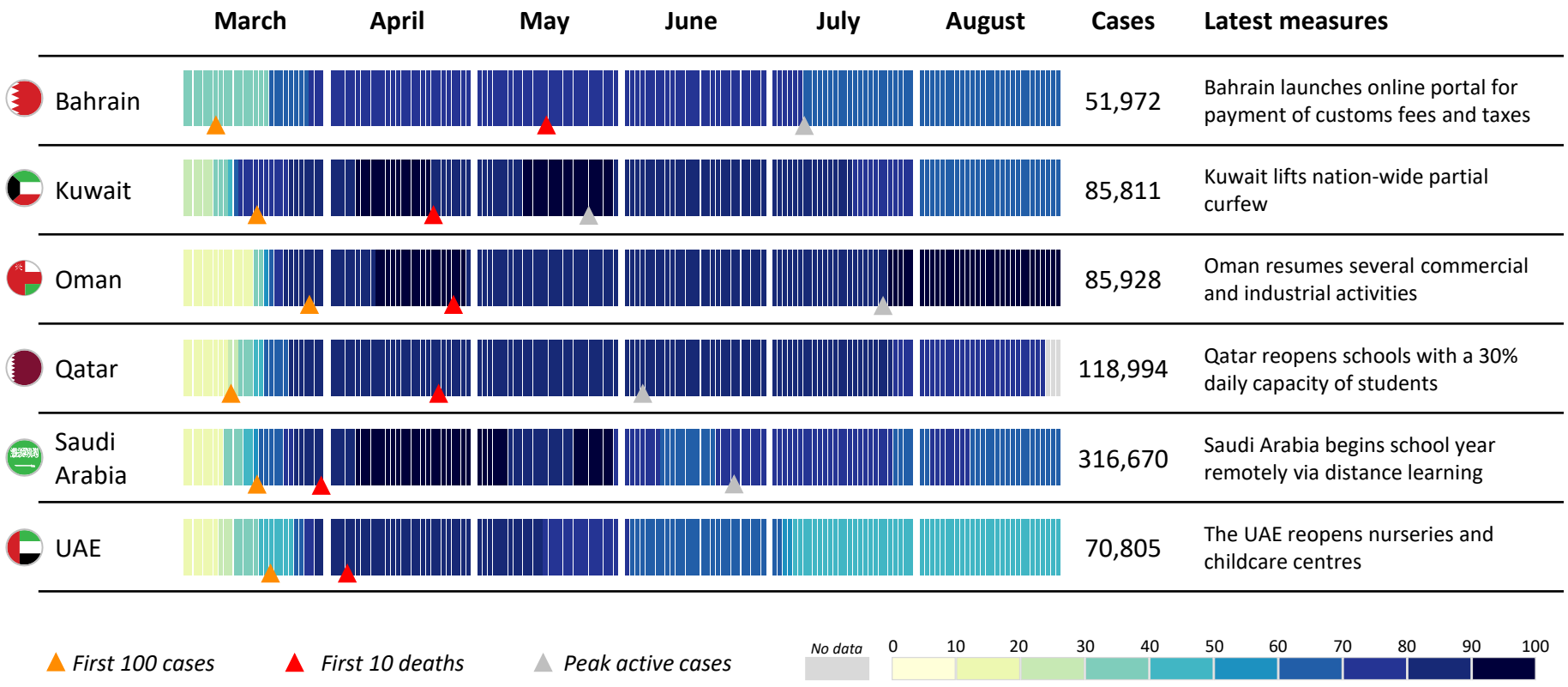
What is driving the variation?

- **Breadth of testing**: broader testing leads to a larger confirmed base of patients, leading to a decreased CFR
- **Government response**: the type of policy also affects CFR. For example, the decision to pursue a herd immunity scenario in the UK and Sweden dramatically increased their CFRs
- **Distribution of key risk factors**: age, gender and pre-existing conditions all affect CFR. For example, Italy has the second oldest population on Earth
- **Health system threshold**: every country has a health system capacity that, when exceeded, will result in a higher CFR due to inability to support all patients

GCC GOVERNMENTS HAVE RESPONDED WITH STRICT LOCKDOWNS AS THE COVID-19 CRISIS SPREAD

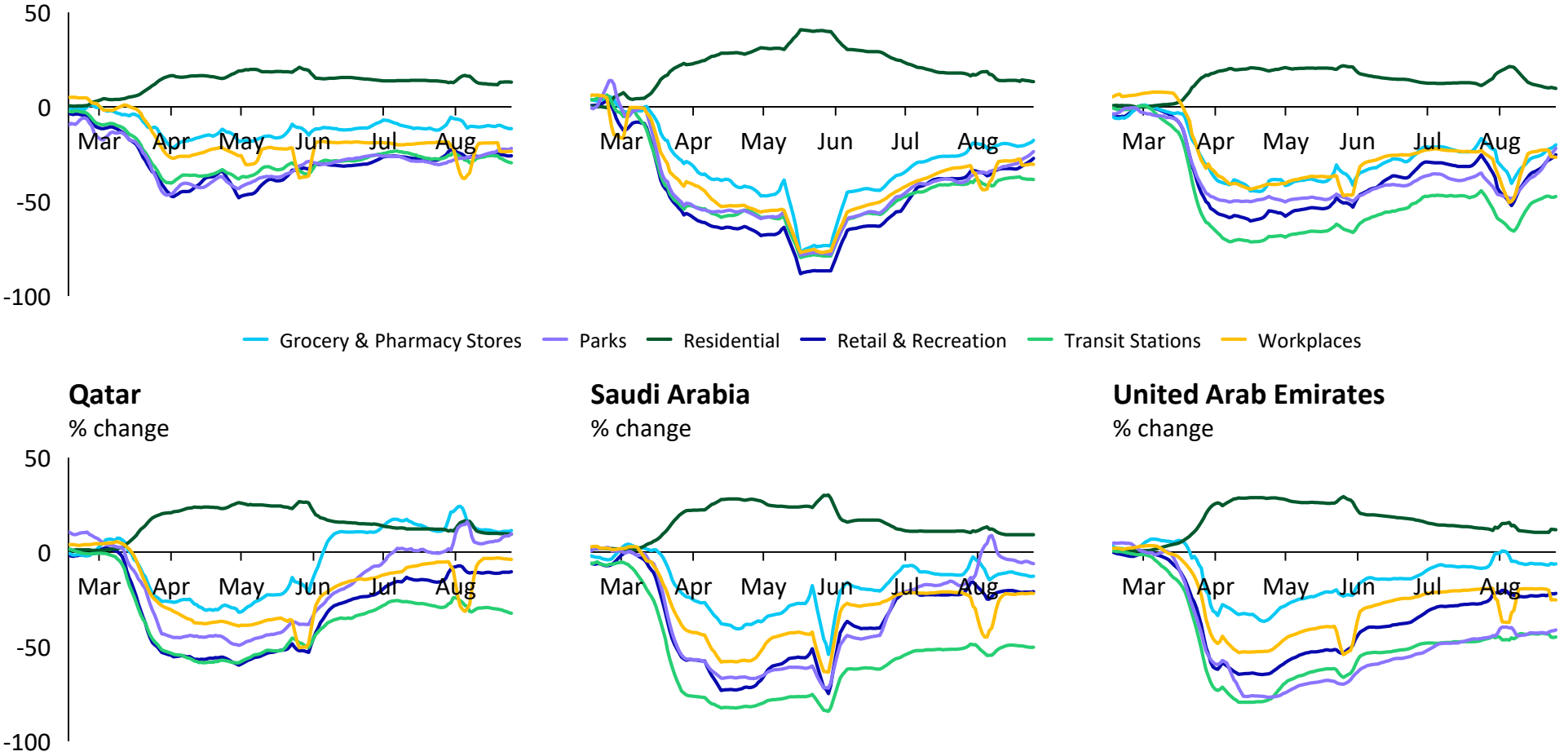
Historical development of lockdown measures based on the Government Response Stringency Index*

Since 1-March

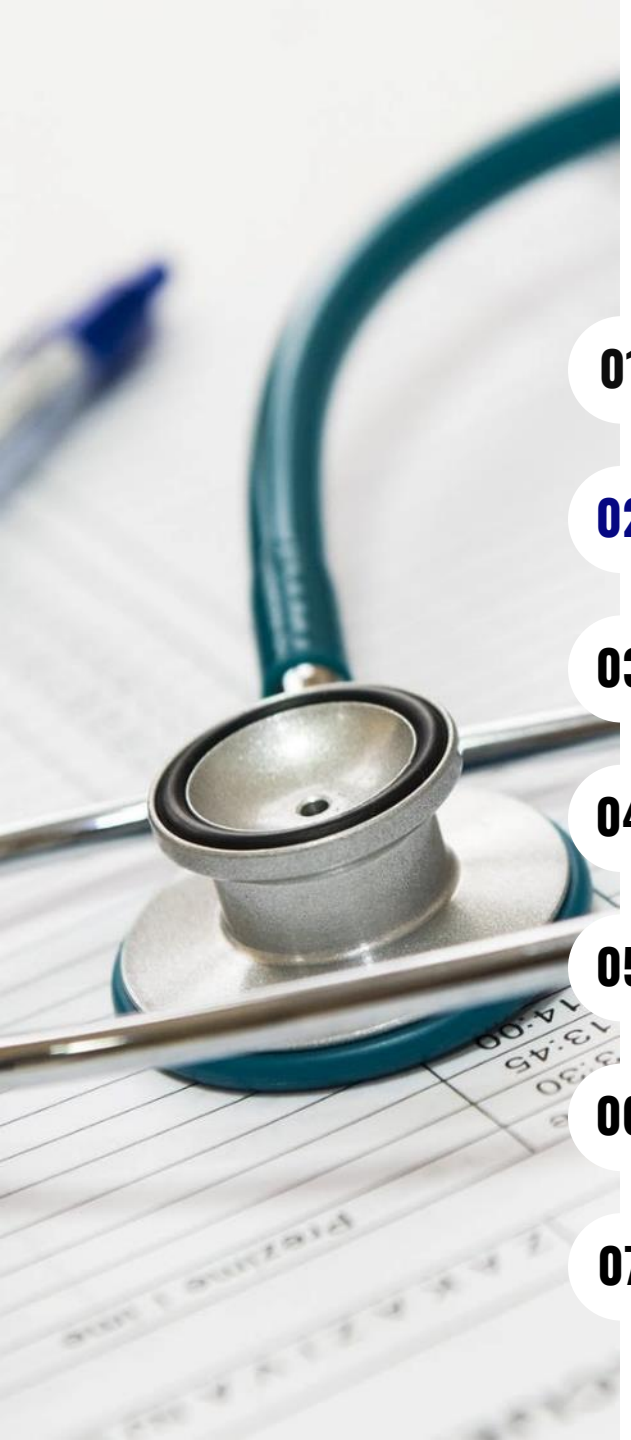


Note (*): The Stringency Index, developed by the University of Oxford, is a number from 1 to 100 that reflects the stringency of government response to COVID-19.
Sources: OW Pandemic Navigator Model, Our World in Data (link), and the University of Oxford (link).

THESE POLICIES HAD A MAJOR IMPACT ON MOBILITY



Sources: Google Community Mobility Reports (link) and Our World in Data (link).

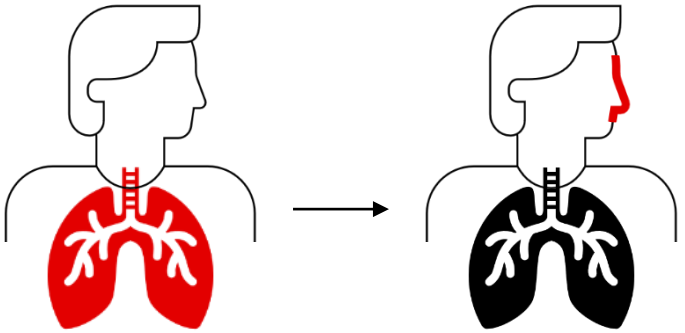


02. VIRAL MUTATIONS AND COMORBIDITIES

SARS-COV-2 MUTATIONS CAN WEAKEN OR STRENGTHEN VIRAL SPREAD

Mutations that <u>weaken</u> viral spread

- A mutation that allows the virus to **multiply primarily in the nasal areas rather than the lungs** would lead to the **epidemic becoming more harmless over time**[1]
- Such a mutation would lead to **people feeling much sicker with cold symptoms** and **staying at home**, making the mutated virus **less likely to spread**[1]



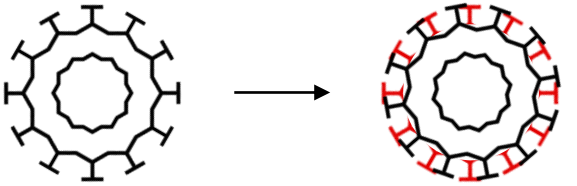
Virus multiplies in lungs
(no mutation)

Virus multiplies in nasal area
(mutation)

VS

Mutations that <u>strengthen</u> viral spread

- The **G variant strain of COVID-19 circulating in the USA and Europe** contains **a spike mutation** that made it **10 times more contagious** than the **original D variant strain** in China[2]
- Since March, the **G variant**, has **rapidly spread** to become the **dominant COVID-19 variant** around the world[2,3]
- It could potentially explain why the **COVID-19 outbreaks** in **Italy** and **New York quickly overwhelmed health systems**[3]



D variant
(no mutation)

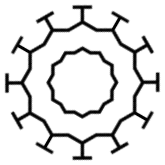
G variant
(spike mutation)

Sources: 1. Deutsche Welle (link); 2. Scripps Research (link); 3. The Washington Post (link).

SARS-COV-2 IS MUTATING AT A SLOWER PACE DUE TO THE STABILITY OF A NEW MUTATION

- The **genetic material** of **SARS-CoV-2** contains **29,903 nucleotides**, which are the **building blocks** that encode **all of the virus' genes**[1]
- A **change** in in **any one** of these building blocks results in a **mutation**, which could result in **one of three** outcomes:
    1. The virus becomes **more harmful**
    2. The virus becomes **less harmful**
    3. The **mutation has no effect** on the virus

- After an **initial period of rapid change**, the **mutation rate** of SARS-CoV-2 began to **slow down** in **April**[2]
- One reason for this slowdown is the **stability** of a new mutated variant, the **G variant**, which now accounts for the **majority of cases** in many regions, especially **Europe** and **North America**[2,3]
- Increasing evidence supports the idea that the **mutated G variant** is **more infectious**, but it is still **too early to say** whether it has other negative effects[4]



D variant
(no mutation)

G variant
(spike mutation)

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tttcgatctc ttgtagatct gttctctaaa cgaactttaa
aatctgtgtg gctgtcactc ggctgcatgc ttagtgcact
cacgcagtat aattaataac taattactgt cgttgacagg
acacgagtaa ctcgtctatc ttctgcaggc tgcttacggt
ttcgtccgtg ttgcagccga tcatcagcac atctaggttt
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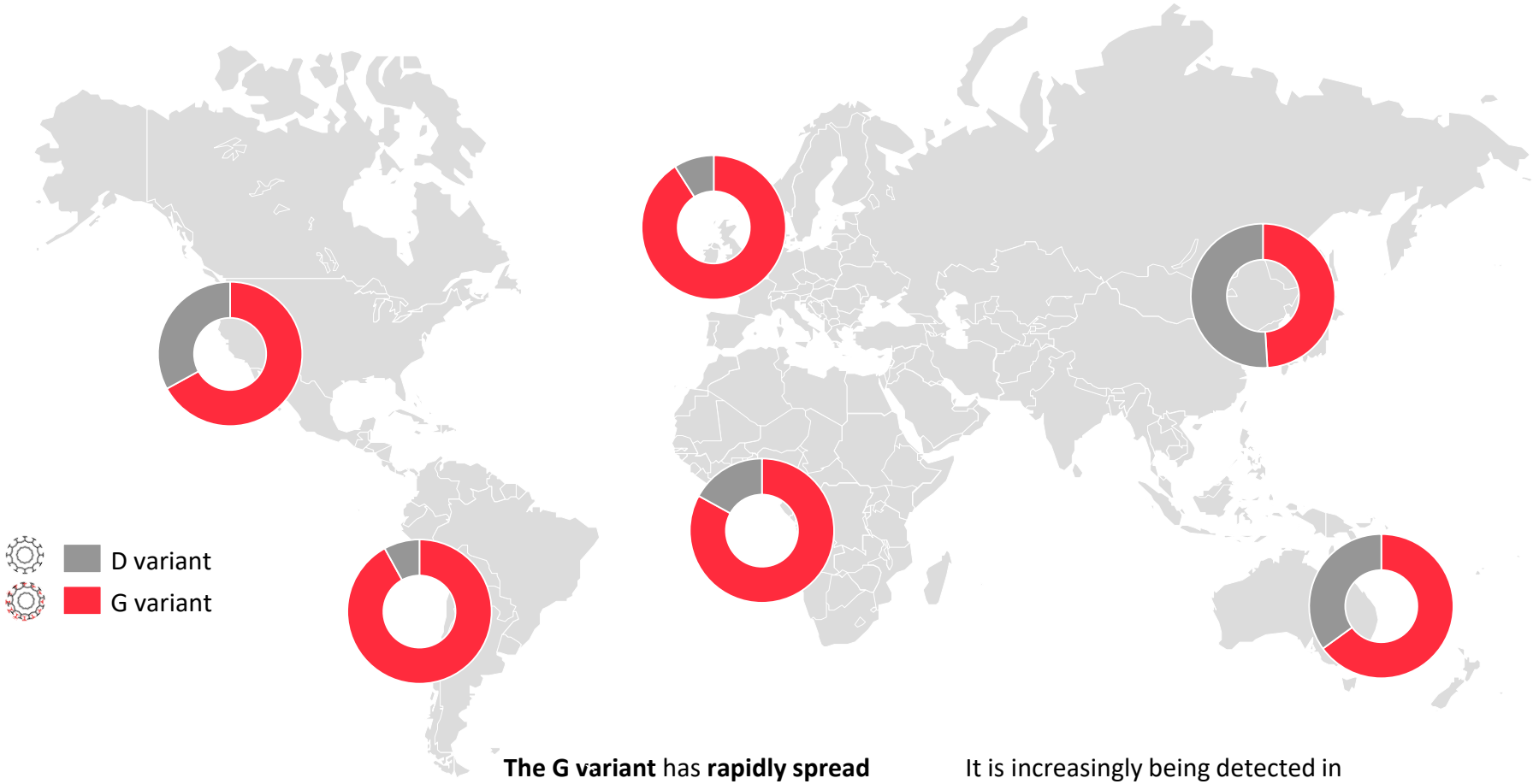
gacctgagca tagtcttgcc gaataccata atgaatctgg

Sources: 1. *Frontiers in Microbiology* (link); 2. bioRxiv (link); 3. The Washington Post (link); 4. Nextstrain (link).

AMONG 4,000+ STUDIED SAMPLES, THE G VARIANT WAS MORE COMMON IN EVERY CONTINENT EXCEPT ASIA



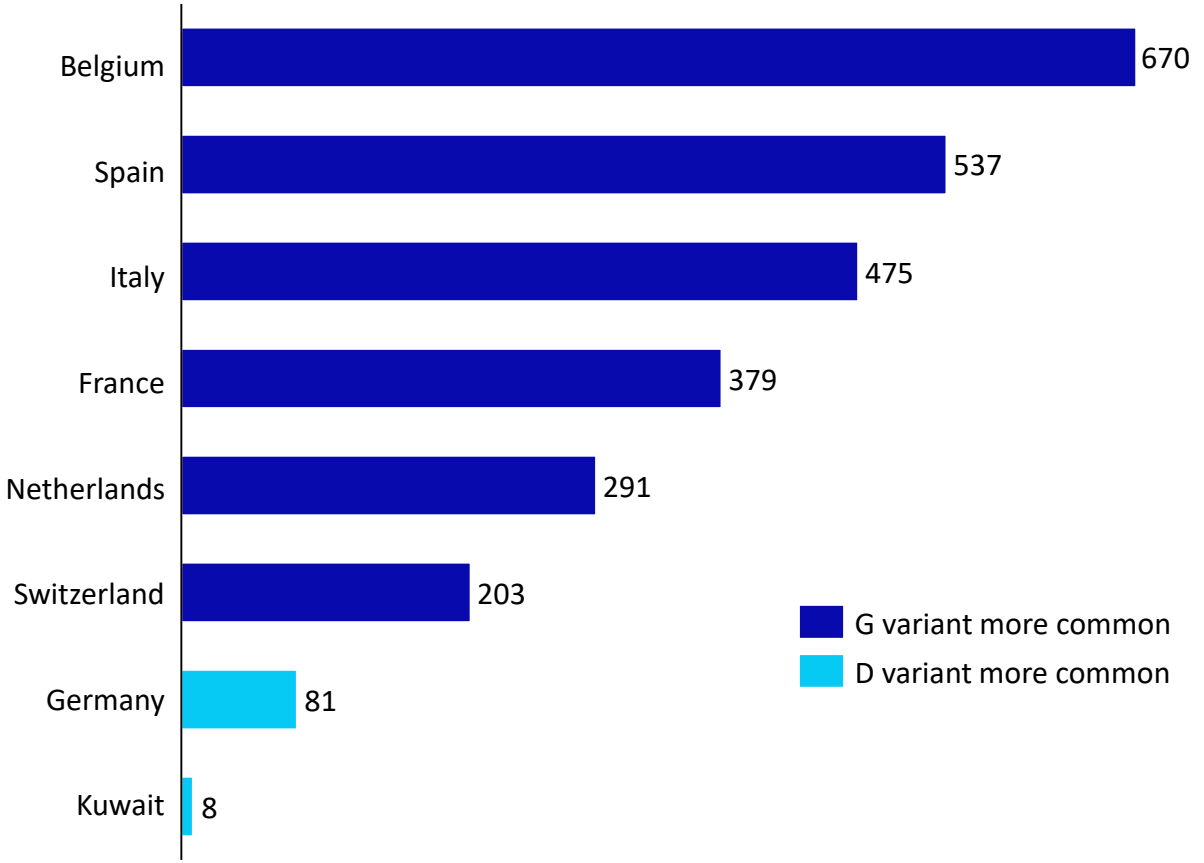
The G variant has **rapidly spread** across the world and has become the **predominant strain** in many countries[1]

It is increasingly being detected in Asia, with **Malaysia**[2] and **South Korea**[3] recently reporting **new outbreaks** caused by the **G variant**

Sources: 1. Nextstrain (link 1, link 2); 2. The Straits Times (link); 3. Yonhap News Agency (link).

SOME STUDIES REPORT THAT THE G VARIANT IS MORE COMMON IN REGIONS WITH HIGHER CFRS

Total number of deaths per million people[1]
Until 2-May



Association of G variant with CFR

- A study by the **Dasman Diabetes Institute** in Kuwait found that the **mutated G variant** was **commonly found in countries** with a **higher case fatality rate** (**Belgium**, **Spain**, and **Italy**), while the **non-mutated D variant** was found **more commonly in countries** with **lower death tolls** (**Germany** and **Kuwait**)[1]
- Another study from **NYU Langone Health** reported that the **G variant** could possibly be a **more pathogenic (disease-causing)** SARS-CoV-2 strain[2]
- In fact, an **increased case fatality rate was strongly correlated** with the **proportion of viruses containing the G variant mutation**[2]

Sources: 1. *International Journal of Infectious Diseases* (link); 2. *International Journal of Clinical Practice* (link).

COMORBIDITIES WERE ASSOCIATED WITH INCREASED RATES OF HOSPITALIZATION AMONG COVID-19 PATIENTS

Impact of COVID-19 on the lungs and other organs[1,2]

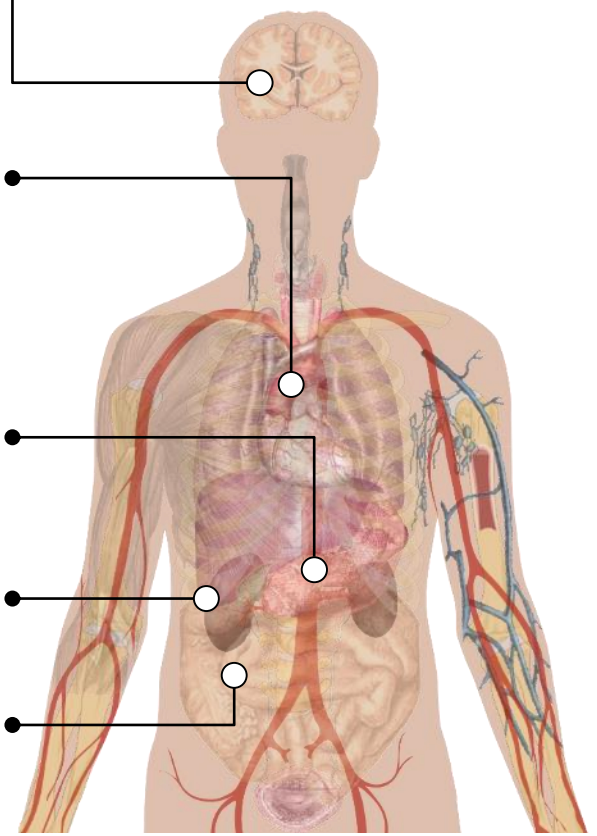
Brain and eyes
Altered mental state, headaches, dizziness, fatigue, & conjunctivitis

Heart
Irregular heartbeat, inflammation of heart muscle, blockage of blood flow to heart muscle, & inability to pump blood to organs

Pancreas
Worsened blood glucose levels & pH

Kidneys
Acute kidney injury

Stomach and intestines
Abdominal pain, anorexia, diarrhoea, nausea, & vomiting



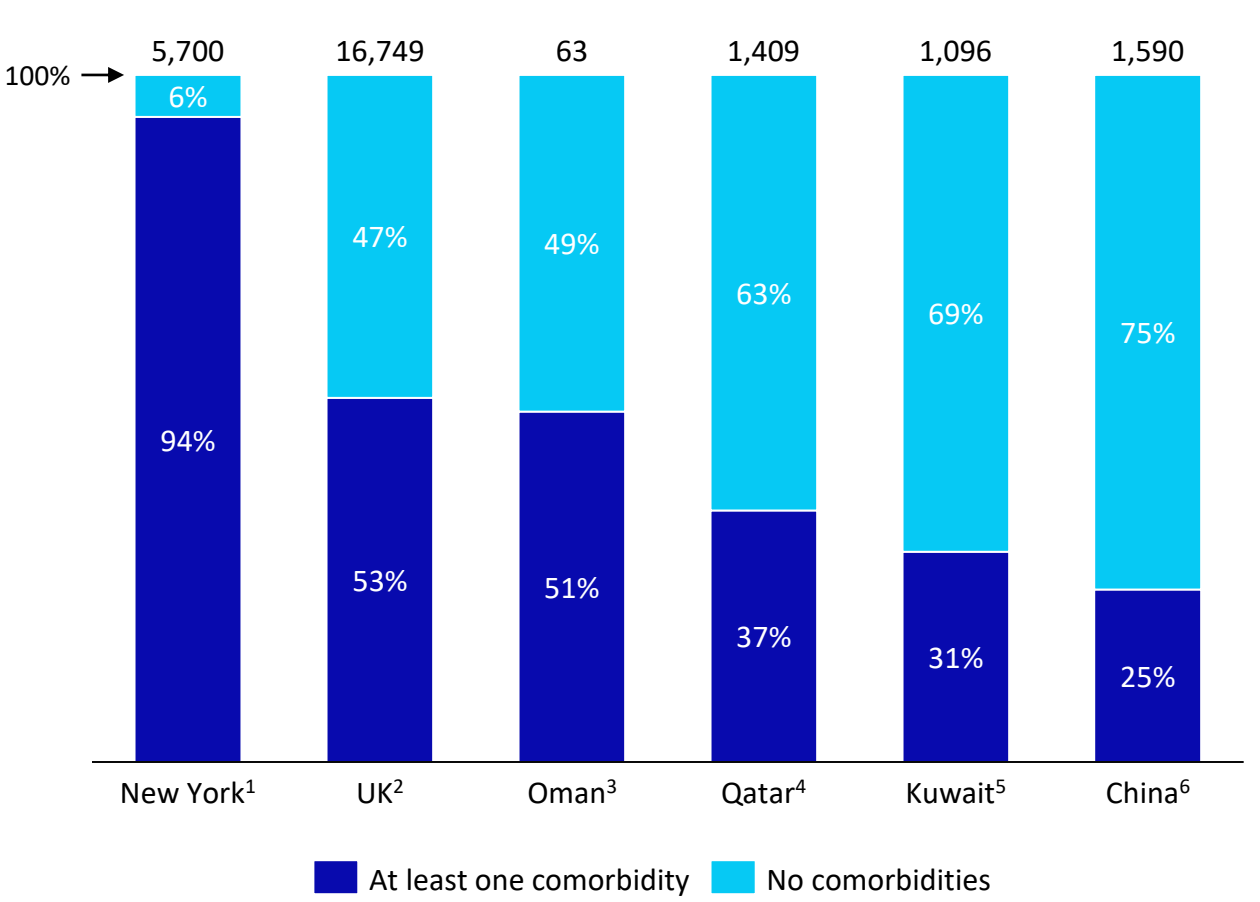
Developments

- The list of **known symptoms of COVID-19** has **continued to expand** as more is discovered about the disease
- This suggests that **COVID-19** should be thought of as a **multi-system disease rather than a purely respiratory one,** which carries **certain implications** for those with **comorbidities**[1]
- **Comorbidity** is the **presence of one or more additional health conditions** that co-occur with a **primary condition**
- Certain **comorbidities**, namely **hypertension**, **diabetes** and **obesity**, were over-represented in hospitalized COVID-19 patients[3]

Sources: 1. *Nature Medicine* (link); 2. Public domain image from the *Wikijournal of Medicine* (link); 3. *JAMA* (link).

RATE OF HOSPITALIZED COVID-19 PATIENTS CAN REACH AS HIGH AS 94%

Prevalence of comorbidities among hospitalized COVID-19 cases



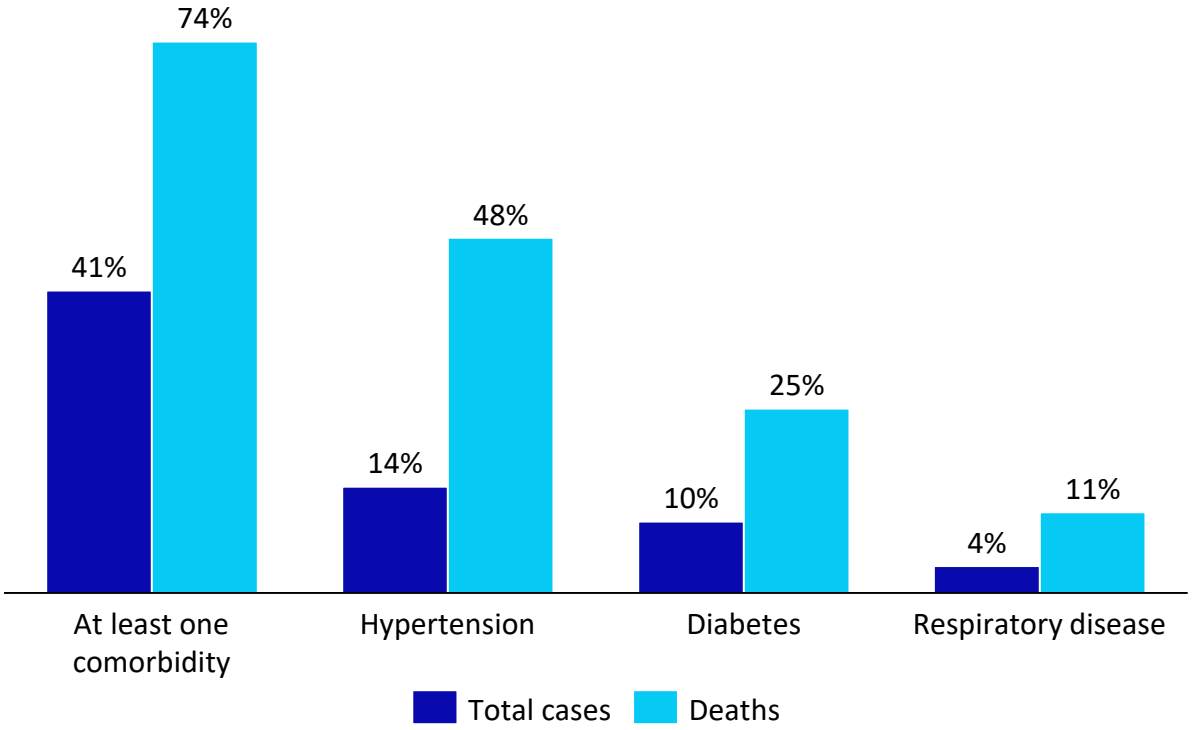
Developments

- The **prevalence of comorbidities differed among hospitalized COVID-19** cases from **different countries**
- However, in all studies mentioned, having a **greater number of comorbidities** was associated with a **worsened clinical outcome**
- The most common **underlying chronic diseases** included **diabetes, hypertension** and **obesity**
- In fact, the CDC reports that **hospitalization was 6 times more likely** among COVID-19 patients with a comorbidity[7]

Sources: 1. *JAMA* (link); 2. *BMJ* (link); 3. *Journal of Infection and Public Health* (link); 4. medRxiv (link); 5. *The Lancet* (link); 6. *European Respiratory Journal* (link); 7. *Morbidity and Mortality Weekly Report* (link).

COMORBIDITIES HAVE ALSO BEEN ASSOCIATED WITH A HIGHER CASE FATALITY RATE

Prevalence of comorbidities among confirmed COVID-19 cases and deaths[1]
%



Developments

- **Hypertension** was **more significantly associated** with both **severe COVID-19 cases** as well as associated **deaths**[1]
- Similarly, both **diabetes** and **respiratory diseases** were **more prevalent among deaths** compared to total cases[1]
- In an analysis of **287,320 COVID-19 cases** in the US, the CDC found that **death was 12 times more likely** for COVID-19 patients if they suffered from a comorbidity[2]

Sources: 1. *Postgraduate Medicine* (link); 2. *Morbidity and Mortality Weekly Report* (link).

EXAMPLE: VITAMIN D DEFICIENCY MAY BE ASSOCIATED WITH COVID-19 INFECTION

abc *subject of next slides*

Vitamin D is associated with COVID-19 infection

- **Vitamin D levels** have been observed to be **lower in COVID-19 patients**[1]
- **Vitamin D supplements** were found to have a **protective effect** against **acute respiratory infections**[2,3,4]
- **Vitamin D increases** the **conversion from ACE2** (the receptor through which SARS-CoV-2 enters the cell) **to ACE**, potentially **inhibiting COVID-19-induced multi-organ damage**[5,6]
- The **higher COVID-19 mortality rates** observed in **northern latitudes** could be attributed to the **higher levels of vitamin D deficiency**[6]
- A **highly significant, positive correlation** was found between **lower COVID-19 mortality rates** and a **country's distance from the equator**[7]

VS

Vitamin D is not associated with COVID-19 infection

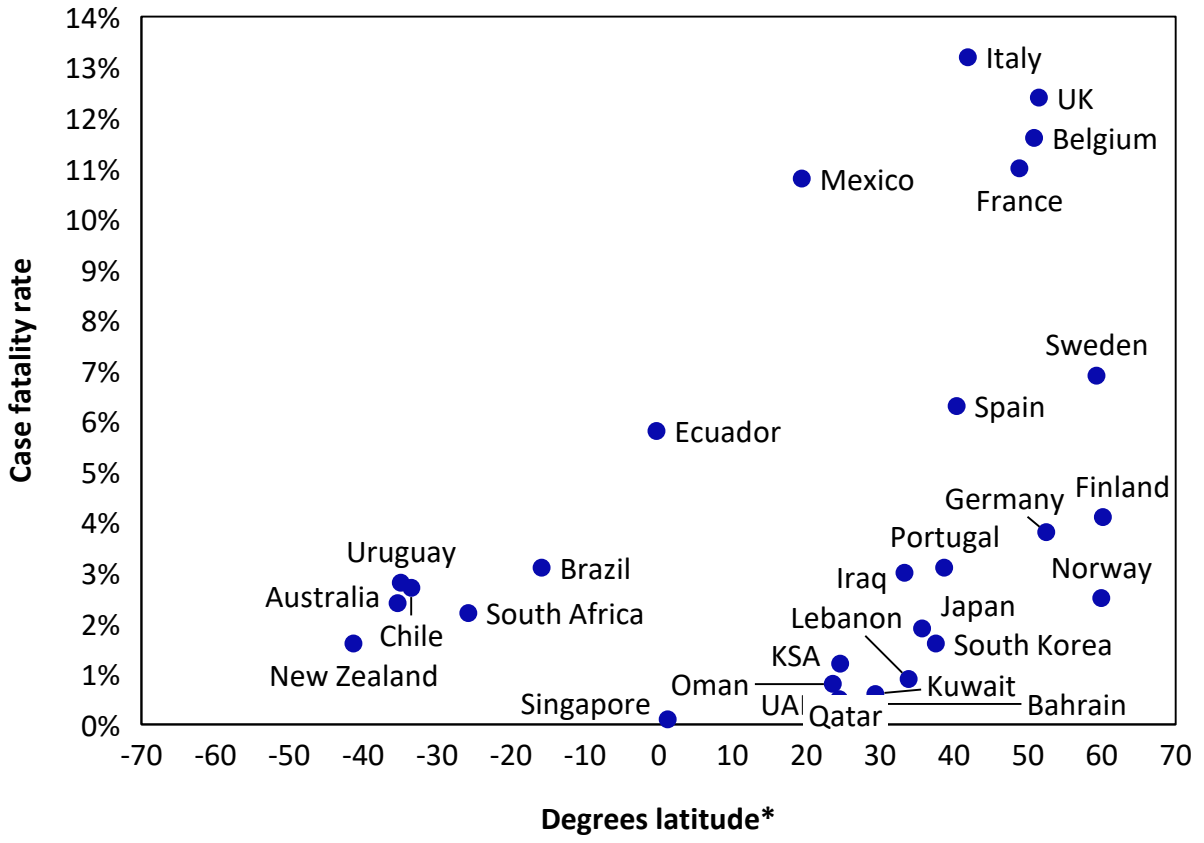
- In a study of **449 patients**, **vitamin D was not associated with COVID-19 infection** nor could it explain the ethnic differences in COVID-19 infection[8]
- **England's Department of Health** found **no evidence** to **support taking vitamin D supplements** to prevent or treat COVID-19[9]
- A lead researcher at the **University Hospital of Würzburg disputes findings** that **link COVID-19 to vitamin D deficiency**, stating that it is a **mere observation** and not a correlation[10]
- In a study of **144 geopolitical areas**, **latitude was not associated** with **epidemic growth of COVID-19**[11]

Sources: 1. *Nutrients* (link); 2. *PLoS ONE* (link); 3. *BMJ* (link); 4.*Nutrients* (link); 5. *Naunyn-Schmiedeberg's Archives of Pharmacology* (link); 6. *Journal of Internal Medicine* (link); 7. *American Journal of Infection Control* (link); 8. *Diabetes & Metabolic Syndrome* (link); 9. National Institute for Health and Care Excellence (link); 10. *Canadian Medical Association Journal* (link); 11. DW (link).

THIS MAY EXPLAIN THE HIGHER CFR IN NORTHERN LATITUDES

COVID-19 mortality by country and latitude

As of 1-Sep



Developments

- **Latitude** has been found to have a **significant effect on vitamin D deficiency**, with populations in **northern latitudes** at **higher risk**[1,2]
- Findings suggest that **countries in northern latitudes**, e.g. UK, Sweden, Spain, and France, had **higher COVID-19 mortality** due to vitamin D deficiency[3,4,5]
- However, this hypothesis is **not supported** by the fact that **Arab countries** have **low COVID-19 mortality rates** despite **high rates of vitamin D deficiency**
- In contrast, **vitamin D levels** are **severely low** among the **aging populations of Europe**, who were also the **most vulnerable age group to COVID-19**[6]

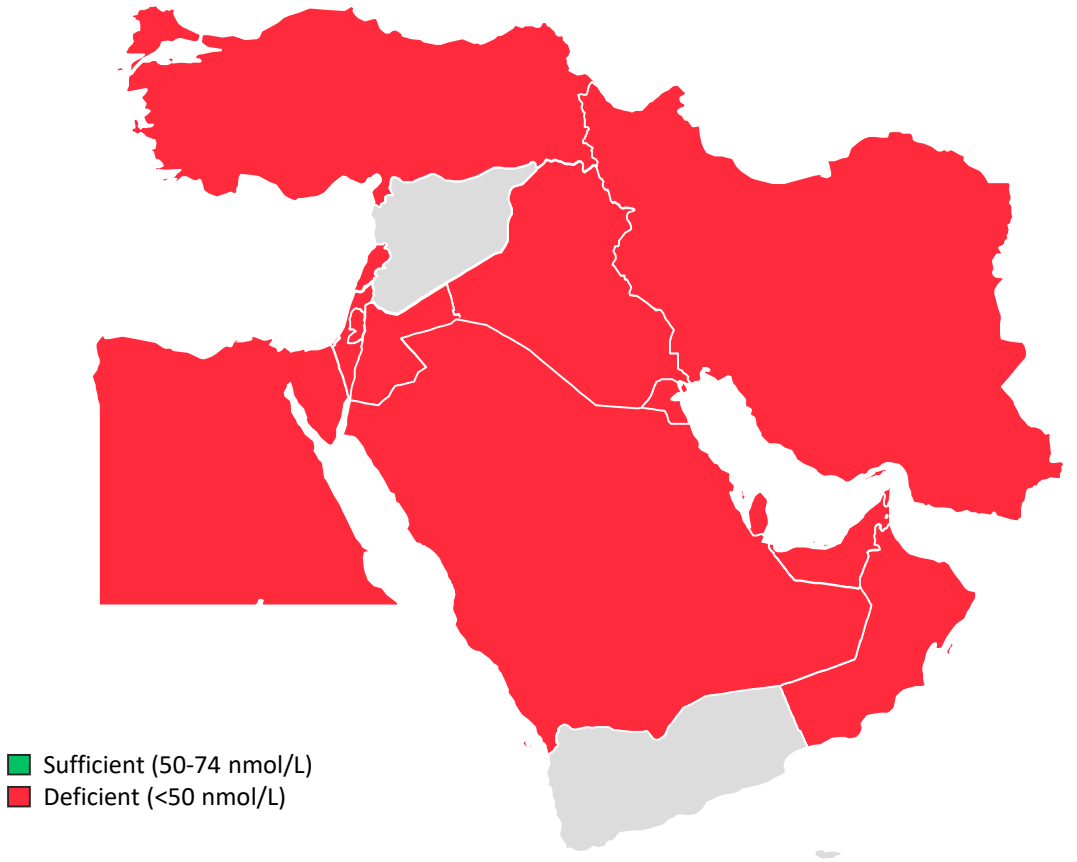
Note (*): degrees latitude is for capital cities.

Sources: 1. *International Journal of Circumpolar Health* (link); 2. *The Journal of the American Osteopathic Association* (link); 3. *Social Science Research Network* (link); 4. Centre for Evidence-Based Medicine (link); 5. *Alimentary Pharmacology and Therapeutics* (link); 6. *Aging Clinical and Experimental Research* (link).

THIS COULD BECOME AN ISSUE FOR THE GCC AS VITAMIN D DEFICIENCY IS COMMON

Vitamin D deficiency in adults in the Middle East[1-8]

Measured in serum 25(OH)D levels (nmol/L)

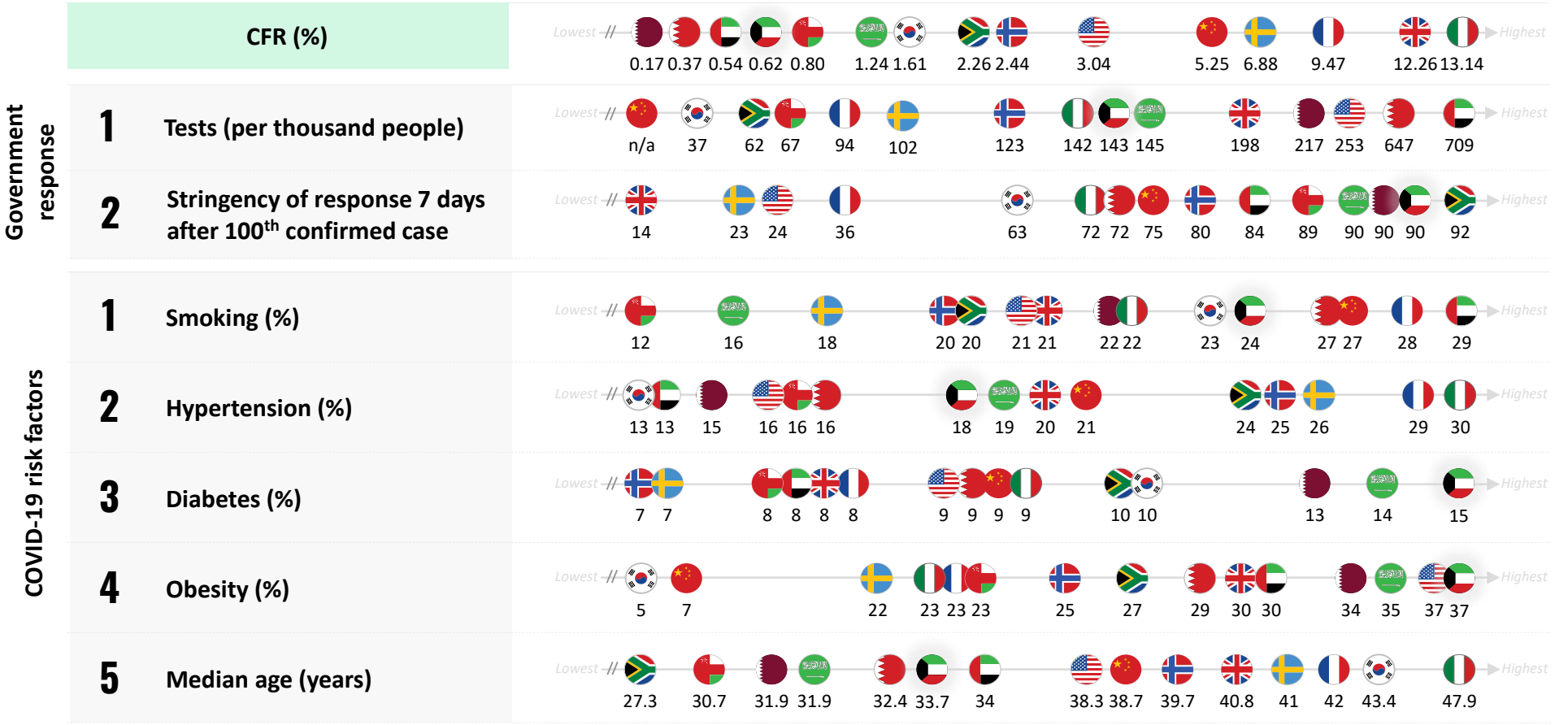


Developments

- The **major source of vitamin D** for children and adults is **exposure to natural sunlight**[9]
- Despite the plentiful sunshine, **vitamin D deficiency is prevalent in the Middle East**, reaching **epidemic proportions** in certain populations
- The **extended curfews**, **quarantines**, and **stay-at-home measures** may have exacerbated this issue, as individuals are **less exposed to the sunlight**, **less physically active**, and **more likely to have an unhealthy diet**[10]
- Of concern to public health is the association of vitamin D deficiency **with increased risk** and **severity of chronic diseases** and **viral infections,** including HIV[11,12]

Sources: 1. *Dermato-Endocrinology* (link); 2. *Journal of Public Health Research* (link); 3. *Sultan Qaboos University Medical Journal* (link); 4. *Endocrine Abstracts* (link); 5. *Journal of Obesity & Weight Loss Therapy* (link); 6. *European Journal of Clinical Investigation* (link); 7. *Bahrain Medical Bulletin* (link); 8. *International Journal of Medical Biochemistry* (link); 9. *Journal of Pharmacology & Pharmacotherapeutics* (link); 10. *Nutrition, Metabolism and Cardiovascular Diseases* (link); 11. *Journal of Clinical Virology* (link); 12. *Topics in Antiviral Medicine* (link).

DESPITE A HIGHER SHARE OF COMORBIDITIES, THE GCC HAS A RELATIVELY LOW CFR



The lower CFR in the GCC region could be due to a **wider breadth of testing**, a **more stringent government response early on in the epidemic**, and a **lower median age** compared to international peers.

Sources: Johns Hopkins University Center for Systems Science and Engineering (link), WHO noncommunicable diseases country profiles (link), University of Oxford (link), and health ministry press releases.

03. SECOND WAVE PREVENTION

01 Latest pandemic developments

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06 Re-opening schools

07 Vaccine trials

THERE ARE THREE MAJOR TRANSMISSION ROUTES FOR SARS-COV-2 TO BE SPREAD

abc *focus of next slides*

Respiratory viruses have three major transmission routes[1,2]

01 Contact transmission

- Direct contact with an infected person
- Indirect contact with a SARS-CoV-2-contaminated object or surface (fomites)

02 Droplet transmission

- Occurs when a person is in **close proximity** (within 1 meter) with a **symptomatic** person, which risks the exposure of the mouth, nose, and eyes to infected **respiratory droplets** (particles >5 µm in diameter)
- Both the **U.S. Centers for Disease Control and Prevention** and the **WHO** consider this to be the **most frequent mode of COVID-19 transmission**[3]

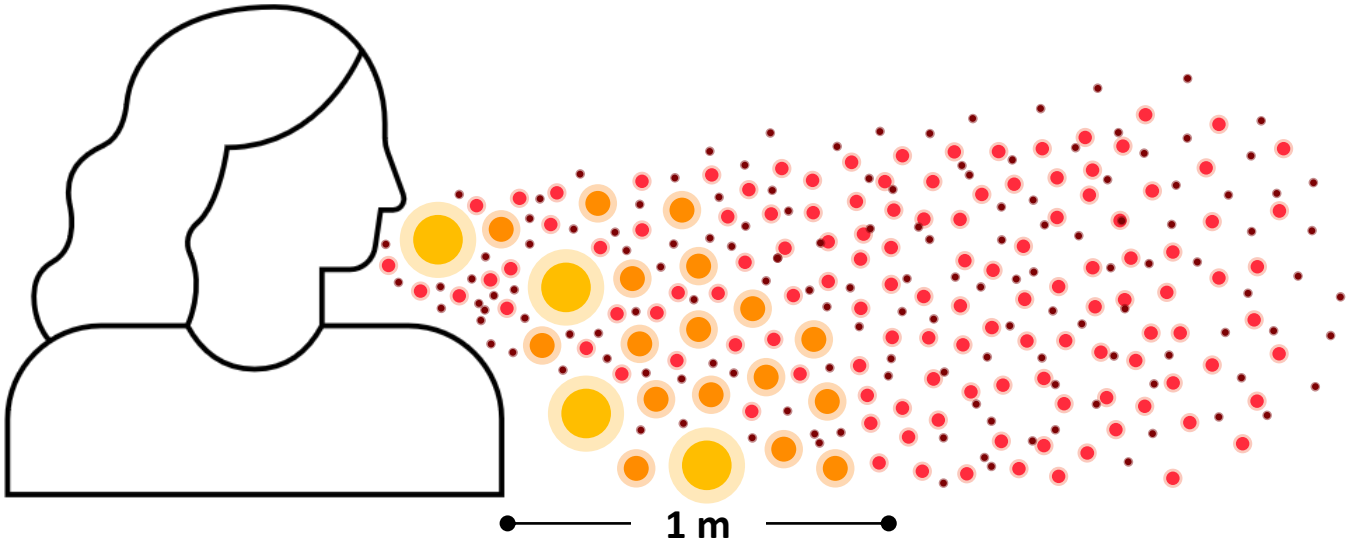
03 Airborne transmission

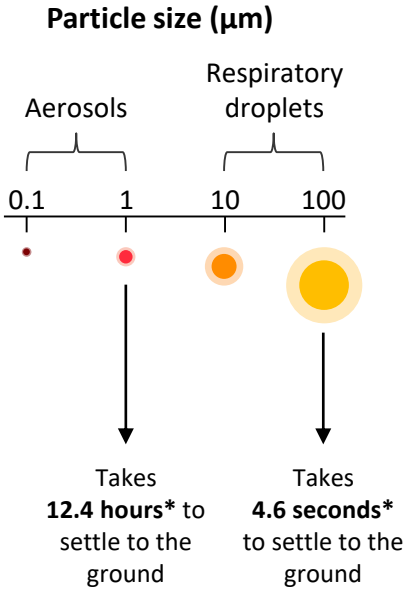
- Occurs when **aerosols** (particles <5 µm in diameter) are generated
- A current point of contention is how much airborne transmission contributes to COVID-19 spread
- The **WHO** maintains that **airborne transmission of COVID-19 is only significant in medical settings**, i.e. during the performance of procedures such as **resuscitation** and **disconnection from ventilators**

Sources: 1. WHO Scientific Brief (link); 2. European Centre for Disease Prevention and Control (link); 3. NPR (link).

THE SARS-COV-2 PARTICLE SIZE MAYBE SMALLER THAN ORIGINALLY THOUGHT

Particles of different sizes can be released by individuals while breathing, speaking, sneezing, or coughing[1]





Respiratory droplets fall to the ground faster than they can evaporate, **contaminating surfaces** and **objects**. They generally **do not travel further than 1 meter** from an individual[1]

Aerosols evaporate faster than they can fall to the ground, allowing them to **float in the air** and **be carried by air currents** over distances **greater than 1 meter**. The distances that aerosols can travel are **significantly increased** by **sneezing** and **coughing**[1]

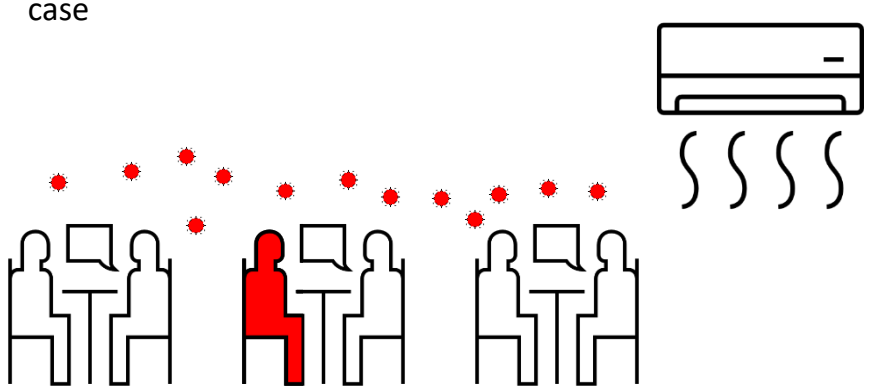
The **WHO** currently maintains that **aerosols carrying viable SARS-CoV-2 cannot be generated** by normal human cough conditions[2]. However, on 6-July, an **open letter signed by 239 scientists** challenged the **WHO** on this assumption[3]

Note (*): in still air and from a height of 8 feet (2.44 meters).
Sources: 1. *Science* (link); 2. WHO Scientific Brief (link); 3. *Clinical Infectious Diseases* (link).

CURRENT VIEW IS AIRBORNE TRANSMISSION INCREASES SUBSTANTIALLY INDOORS

Exhibit A: Chinese restaurant[1,2]

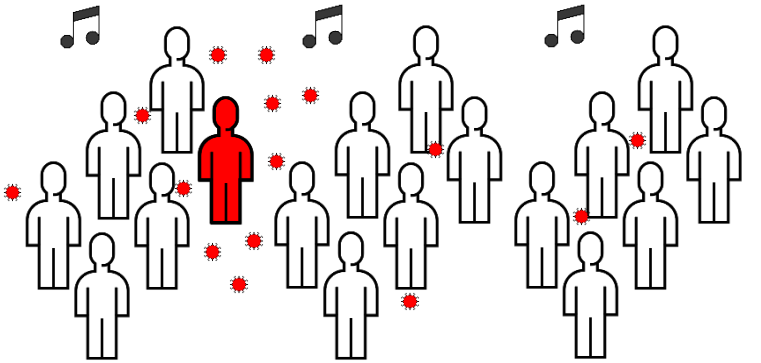
- A COVID-19 outbreak occurred among 10 persons from 3 families who had eaten in a restaurant in Guangzhou
- One individual (who was asymptomatic during the lunch) had infected all the others, despite camera footage showing no contact between them
- It later became apparent that all three families were seated in the path of airflow from an air conditioner, which had likely spread the aerosols from the index case



VS

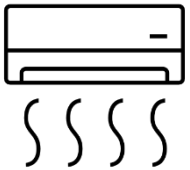
Exhibit B: Washington choir[3,4]

- Despite observing physical distancing and bringing their own sheet music, 52 out of a total of 61 choir members were infected by a single symptomatic individual during a rehearsal
- Two of the singers later died, and the median age of the choir members who attended that practice was 69 years old
- The outbreak was later attributed to the act of singing in a confined setting, which caused a large amount of infectious aerosols to accumulate



Sources: 1. U.S. Centers for Disease Control and Prevention (link); 2. medRxiv (link); 3. The Los Angeles Times (link); 4. The New York Times (link).

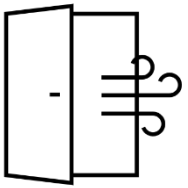
IF SO, SEVERAL FACTORS MIGHT INCREASE THE RISK OF AIRBORNE TRANSMISSION IN THE GCC



Air conditioning

It has been suggested that **air conditioning may play a role** in COVID-19 transmission, as individuals rebreathe more air when in an air-conditioned indoors environment[1]

The use of **air conditioning is widespread among the GCC** countries due to the harsh climate, which also forces people to rebreathe more air as they spend more time in air-conditioned spaces[2]



Indoor building ventilation

Poor indoor ventilation can cause SARS-CoV-2 **particles to accumulate in the air**, potentially increasing the indoor spread of COVID-19[2]

The harsh climate of the GCC countries make it near impossible to make use of natural ventilation, especially in the hot summer months[3]

As a result, **most household, public, and office settings in the GCC suffer** from poor indoor ventilation levels due to architectural designs that rely on air-conditioning systems[3]

Incense burning

The habitual burning of incense is a major source of airborne particles, and **incense smoke may facilitate the transmission** of COVID-19 in an indoors environment[3]

Burning **incense is widespread among households** and certain public spaces in the GCC, which could be a potential cause for concern for public health officials[4]

Cigarette smoking

SARS-CoV-2 may attach to aerosols and respiratory droplets in secondhand smoke, which can **increase the reach and transmission of COVID-19** from infected smokers[5]

Smoking is common among males in the GCC, with an average of 28.5% of the male population being smokers compared to just 3.0% of the female population[6]

Sources: 1. The Harvard Gazette (link); 2. *City and Environment Interactions* (link); 3. *Science of the Total Environment* (link); 4. *BMC Pulmonary Medicine* (link); 5. American Chemical Society (link); 6. *Tobacco Induced Diseases* (link).

THE OECD PREDICTS SEVERE AND LONG-LASTING ECONOMIC CONSEQUENCES, ESPECIALLY IF ANOTHER WAVE OF INFECTIONS OCCURS

Double-hit scenario: a second wave of infections occurs before the end of 2020

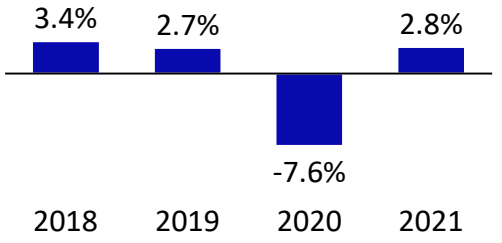
- Another wave of infections would trigger **new lockdown measures**
- **World economic output** would **fall by -7.6% in 2020** and **climb to 2.8% in 2021**
- **OECD unemployment rate** would **nearly double** from 5.4% in 2019 to 10% in 2020, with **insignificant job recovery** by 2021

VS

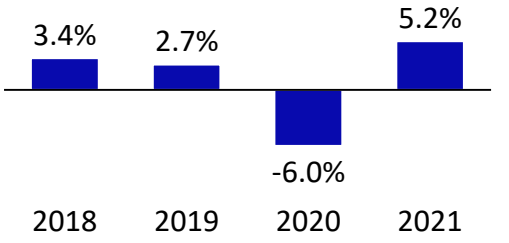
Single-hit scenario: a second wave of infections is prevented

- **Current lockdowns are lifted**, and business activity is not frozen by future lockdowns
- **World economic output** would **fall by -6% in 2020** and **climb to 5.2% in 2021**
- **OECD unemployment rate** would increase from 5.4% in 2019 to 9.2% in 2020

Real GDP growth in double-hit scenario



Real GDP growth in single-hit scenario



To **prevent a second wave**, governments must **strengthen health care systems**, **ensure global cooperation on vaccine development**, and **utilize testing, tracing, and distancing strategies.**

Source: OECD Economic Outlook, June 2020 (link).

PHYSICAL DISTANCING, FACE MASKS AND EYE PROTECTION CAN SIGNIFICANTLY REDUCE COVID-19 TRANSMISSION AND PREVENT A SECOND WAVE

Physical distancing

- Current policies of at **least 1 m physical distancing** result in a **large reduction in risk** of infection (from **12.8%** to **2.6%**)
- However, **distances of 2 m** might be **more effective in reducing risk** of infection (from **12.8%** to **1.5%**)

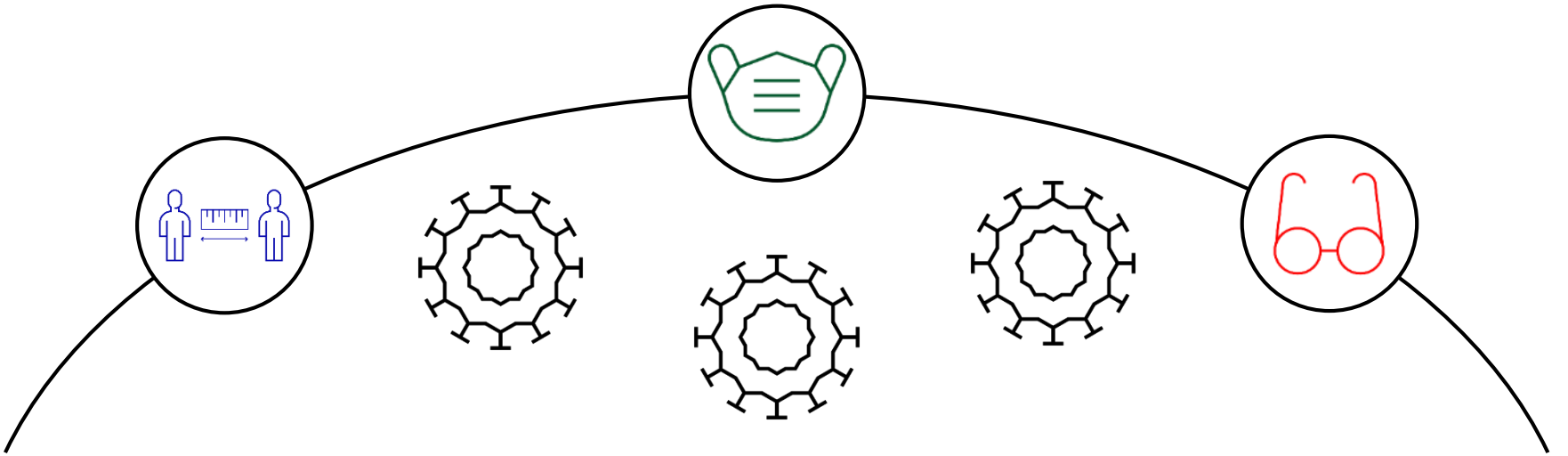
Face mask use

- Wearing a **face mask** can also **reduce the risk of infection** from **17.4%** to **3.1%**
- **Multi-layer cloth masks** offer **better protection** for the **general public** than **single-layer masks**

Eye protection

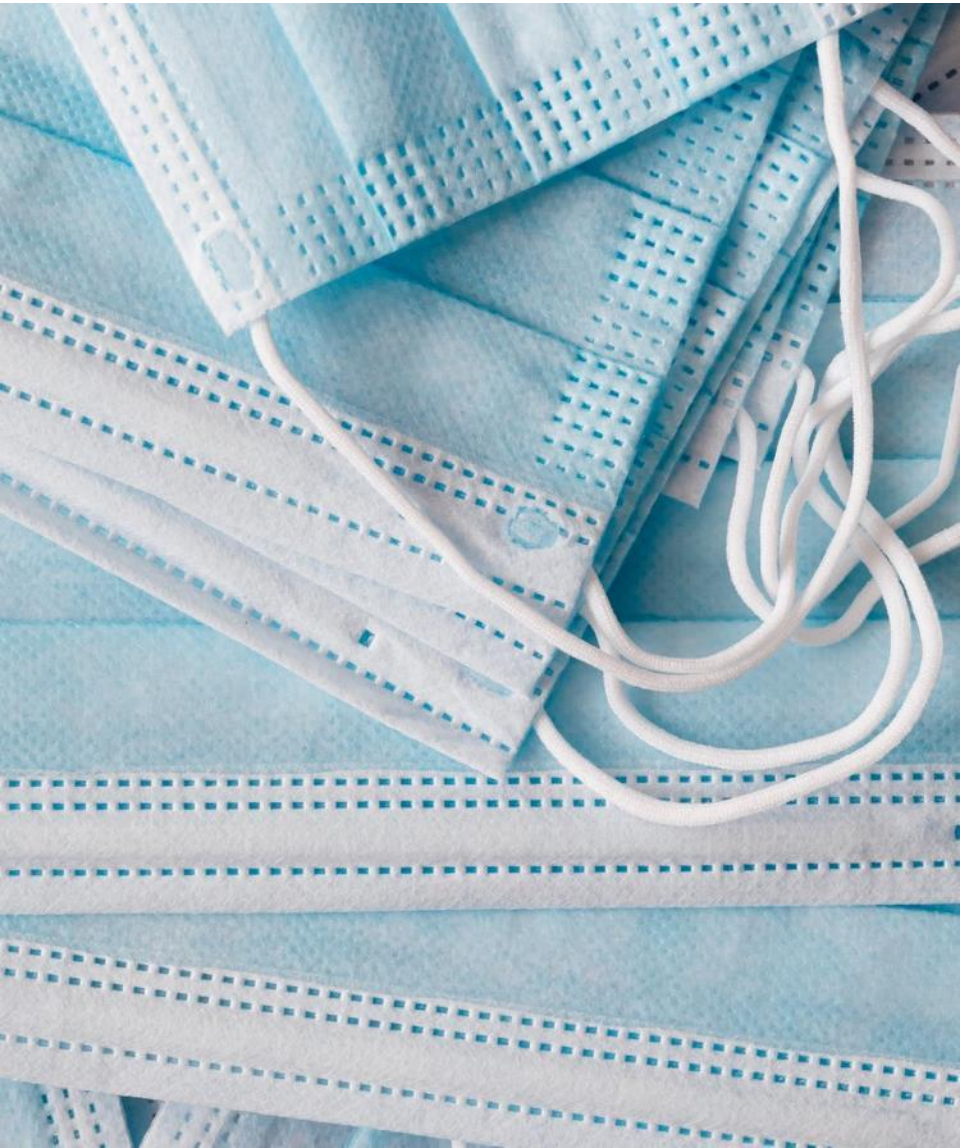
- Wearing **eye protection**, such as **goggles**, **face shields** or even **large eye glasses**, can **reduce the risk of infection** from **16%** to **5.5%**

However, even when properly used and combined, **none of these interventions offers complete protection against COVID-19**. Basic protective measures, such as **hand hygiene**, are still essential to reduce transmission.



Sources: ABC News (link) and *The Lancet* (link).

EFFECTIVE COMMUNICATION IS CRITICAL. FOR EXAMPLE, MASKS WERE NOT IMMEDIATELY ADOPTED DUE TO MIXED GUIDELINES



Why have masks been the subject of such mixed guidelines?

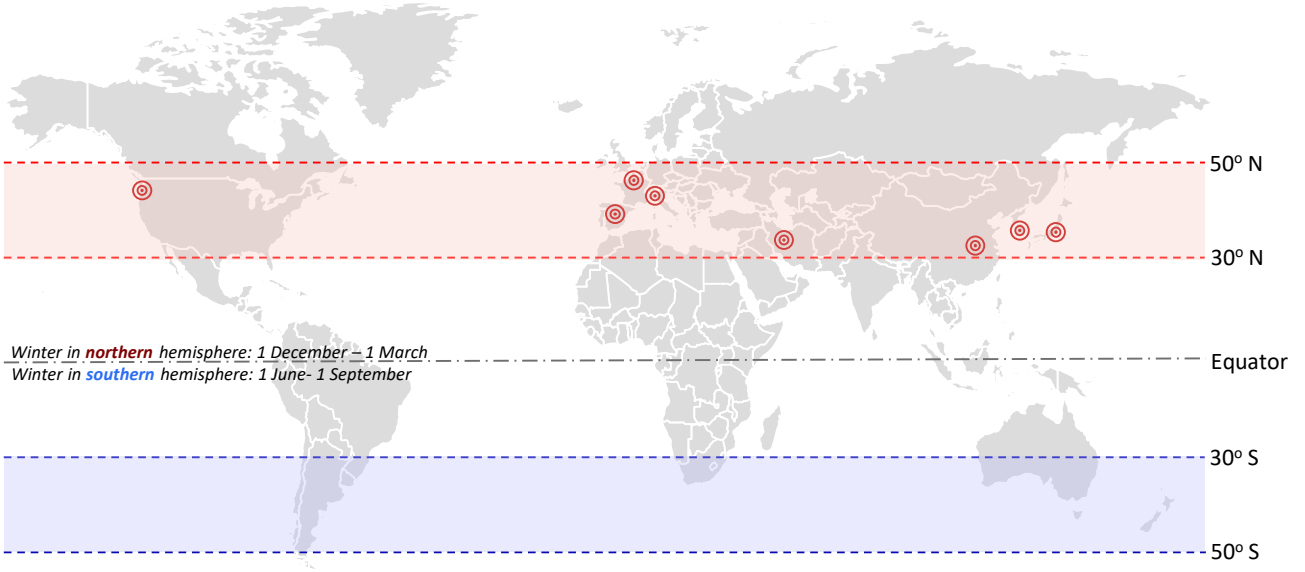
- Initially, the **WHO** did not recommend the usage of masks except for those who were sick and showing symptoms
- However, what was not known then was the significance of asymptomatic and pre-symptomatic transmission of COVID-19
- In its updated guidance (6-Apr), the **WHO** stated that, while masks could limit the spread of the disease, there was no evidence that they would prevent healthy people from contracting COVID-19
- In contrast, the **US Centers for Disease Control and Prevention** urged the American public to wear masks or face cloth coverings in public places
- As of May, more than 85% of the global population lived in countries where the use of masks in public places was recommended or mandated

Sources: Health ministry press releases, Centers for Disease Control and Prevention (link), The Guardian (link), and Masks4All (link).

EMERGING EVIDENCE ALSO SUGGESTS THAT CLIMATE COULD MODULATE THE SPREAD IN MORE SUBSTANTIAL WAYS THAN PREVIOUSLY THOUGHT

In a study of **50 cities with** and **without COVID-19**, those with **significant community transmission** were **distributed** within a **defined latitude corridor** (30° N to 50° N)[1]

Cities in this latitude corridor (including **Seattle, Madrid, Paris, Milan, Qom, Wuhan, Daegu**, and **Tokyo**) displayed **consistently similar weather patterns**, **mean temperatures of 5 to 11 °C** and **low humidity**[1]



This **distribution is consistent** with the **behaviour of a seasonal respiratory virus**, which **might suggest** the **potential for seasonal outbreaks** in the upcoming months[1]

The **decrease in humidity** during winter is especially worrisome, as **a 1% decrease in humidity** can **increase COVID-19 cases by 6%**[2]

As **winter begins** in the **southern hemisphere**, a **surge in respiratory cases** have been observed in **Brazil**[3], while a **leading Australian microbiologist** warned that **winter could raise the risk for COVID-19 spread** in the southern hemisphere[4]

Sources: 1. *JAMA Network Open* (link); 2. *Transboundary and Emerging Diseases* (link); 3. Bloomberg (link); 4. Xinhua News Agency (link).

04. NATIONAL TESTING POLICIES

THE WHO HAS ISSUED RECOMMENDATIONS ON TESTING POLICIES AND BENCHMARKS FOR REOPENING THE ECONOMY

Recommendations for testing policy

Testing policy

- The WHO recommends to **test all suspect cases**
- However, **if diagnostic capacity is insufficient**, countries should implement **prioritized testing** that targets **vulnerable populations**, **health workers**, and the **first symptomatic individuals in a closed setting** (e.g. prisons, schools)

Recommendations for testing rates

Testing rate

- The WHO suggests that a general benchmark of adequate testing involves **at least 10 daily tests per newly confirmed case**

Recommendations for reopening

Positivity rate

- The WHO advises governments that rates of positive cases **should remain at 5% or lower for at least 14 days** before they reopen, with an adequate positivity rate **ranging between 3% and 12%**

Sources: Johns Hopkins University Coronavirus Resource Center (link), Our World in Data (link), WHO interim guidance (link), and the WHO virtual press conference (link).

NOT ALL COUNTRIES FOLLOW THE SAME TESTING POLICY, WHICH CAN CAUSE A DISCREPANCY BETWEEN THE REPORTED AND TRUE NUMBERS OF CASES

The University of Oxford divides current government testing policies* into four main groups:

No testing policy

- Testing is not guided by any government policy
- Only two countries, Tanzania and Yemen, do not have a testing policy currently in place

Could lead to a **low testing capacity**, **uneven access to testing**, and **supply bottlenecks**

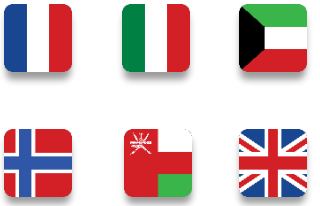
Symptoms & key groups

- Testing is limited to those who both (a) have symptoms and (b) meet specific criteria, e.g. key workers, came into contact with a known case, or returned from overseas

Could **miss out on asymptomatic cases**, which can **account for up to 45%** of active cases in the **overall population** and **more than 60%** of active cases in **younger individuals**

Anyone with symptoms

- Testing includes anyone showing COVID-19 symptoms, e.g. fever, dry cough, and tiredness



Open public testing

- Testing is open and available to the public, e.g. "drive-thru" testing is available to asymptomatic people

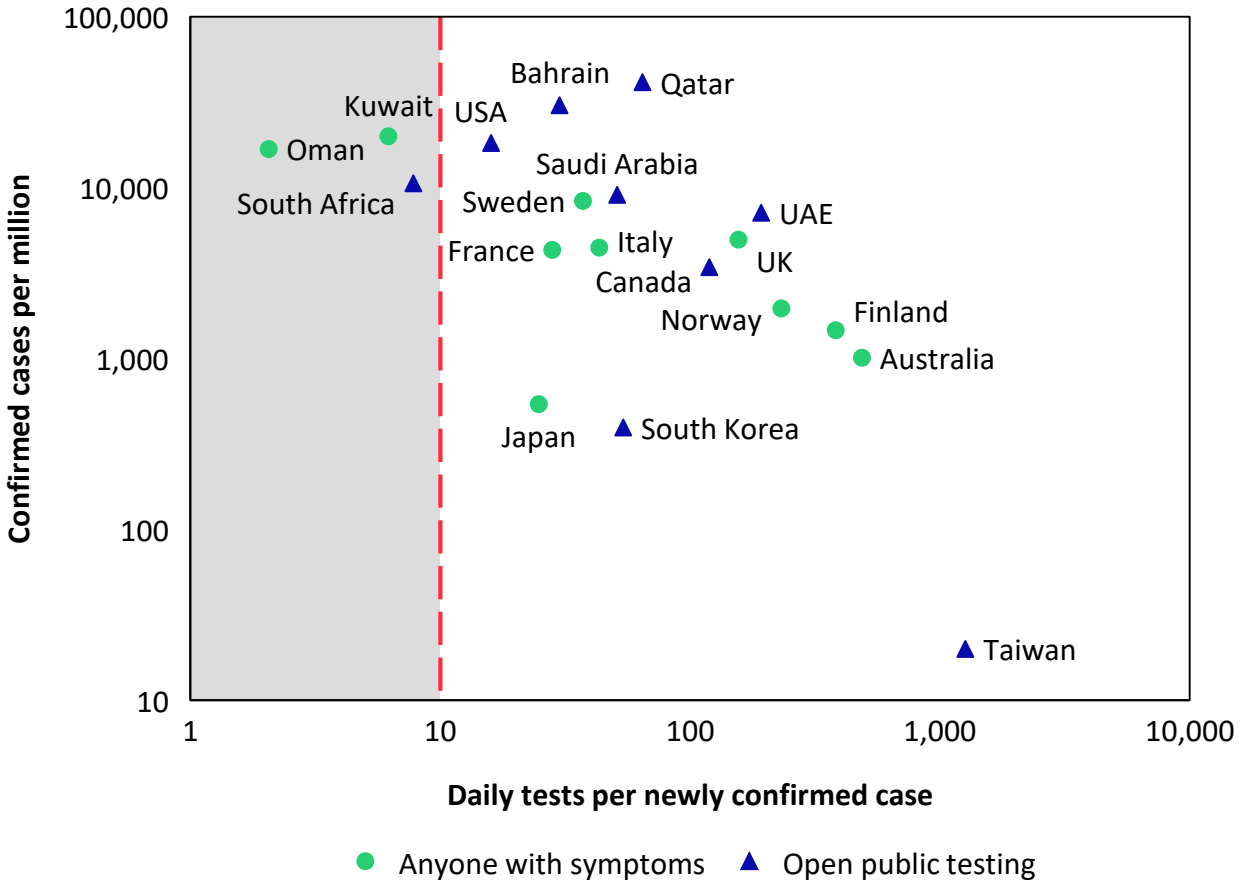
Allows **detection asymptomatic cases**, ensuring reported active cases is **closer to the true number**

Note (*): testing policy only includes PCR testing and not antibody testing.
Sources: *Annals of Internal Medicine* (link), Bloomberg (link), and the Oxford COVID-19 Government Response Tracker (link).

SIGNIFICANT VARIATION EXISTS WITH REGARD TO THE NUMBER OF DAILY TESTS, WHICH FLUCTUATES BETWEEN COUNTRIES AND ON DIFFERENT DAYS

Number of daily tests conducted per newly confirmed case

As of 1-Sep, logarithmic scale



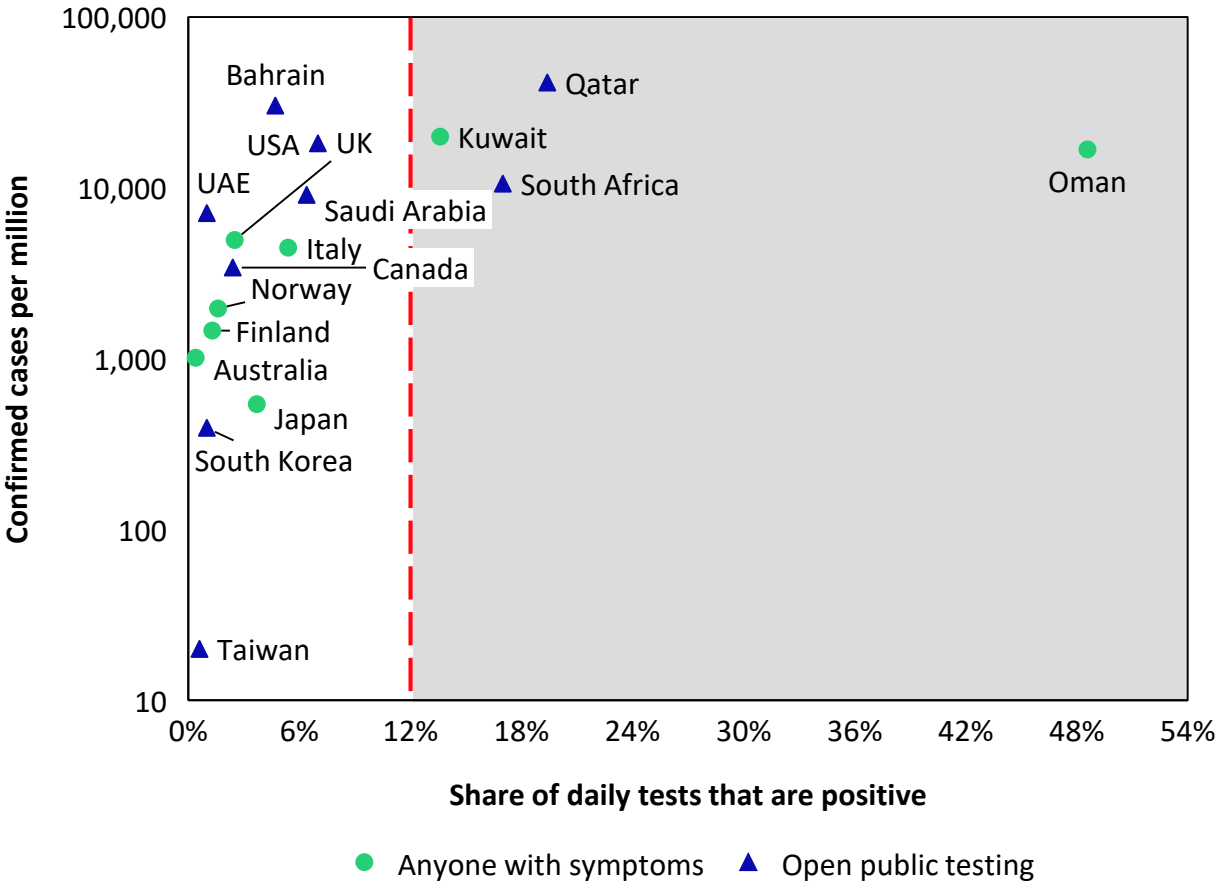
Note: the Omani MoH stopped releasing testing data after 6-Aug.
Sources: Our World in Data (link) and the WHO virtual press conference (link).

Developments

- Following the WHO's suggestion, a **general benchmark of adequate testing rates** involves at least **10 daily tests per newly confirmed case**
- A **testing rate lower than 10 daily tests per newly confirmed case** suggests that there might be many undetected cases
- Among the GCC, **Bahrain, Qatar, Saudi Arabia and the UAE meet the WHO recommendation** for an adequate testing rate

FOR A SAFE REOPENING, THE WHO HAS ADVISED THAT THE SHARE OF DAILY TESTS THAT ARE POSITIVE SHOULD REMAIN AT 5% OR LOWER FOR AT LEAST 14 DAYS

Share of daily tests that are positive
As of 1-Sep, logarithmic scale for y-axis



Note: the Omani MoH stopped releasing testing data after 6-Aug.
Sources: Johns Hopkins University Coronavirus Resource Center (link), Our World in Data (link), and the WHO virtual press conference (link).

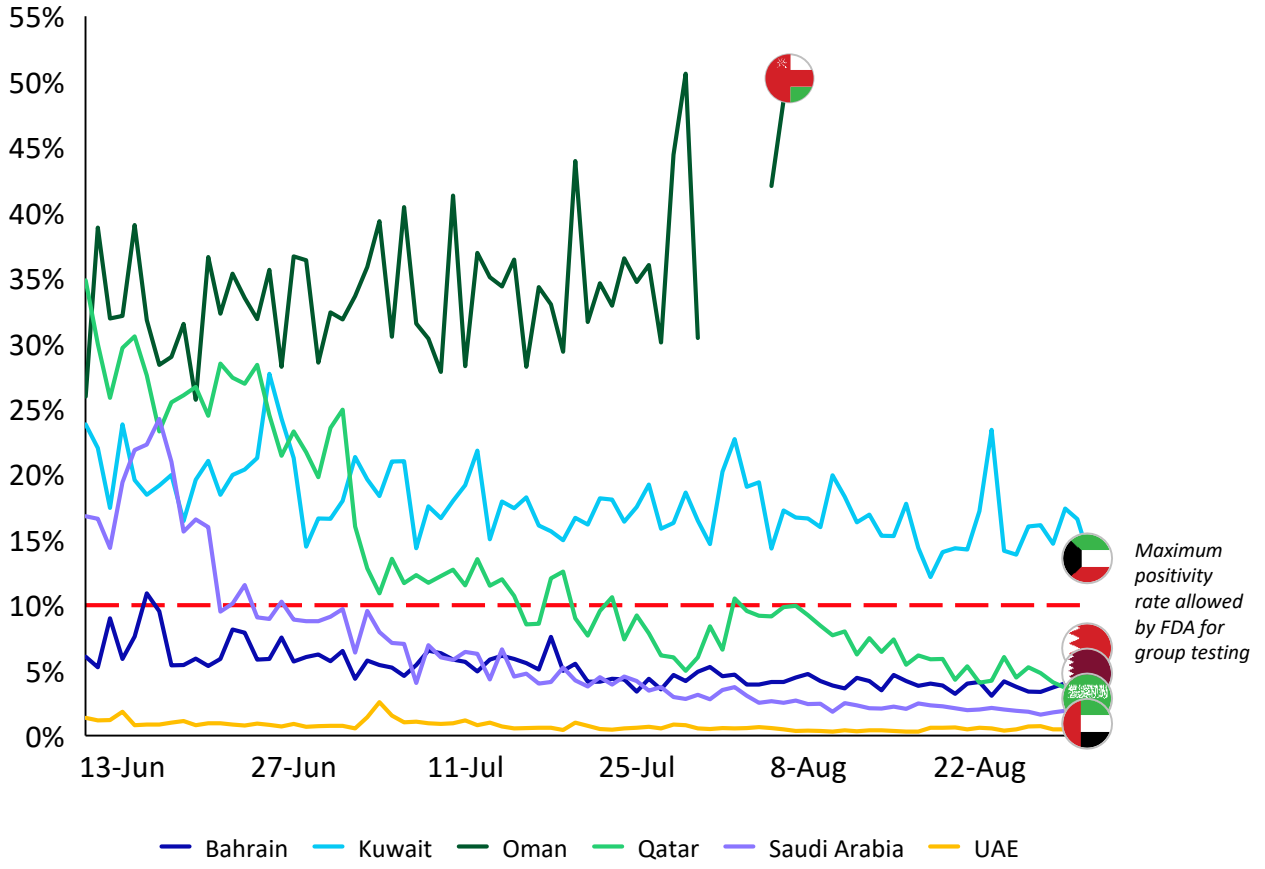
Developments

- Following the WHO's suggestion, a **general benchmark of adequate positivity rates** involves a **positivity rate** that lies between **3%** and **12%**
- A **positivity rate higher than 12%** indicates that **insufficient testing** is being carried out, which impedes the ability of the government to adequately monitor the outbreak
- Among the GCC, **Bahrain, Saudi Arabia and the UAE meet the WHO recommendation** for an adequate positivity rate

GROUP TESTING IS A COST-EFFECTIVE WAY OF TESTING INDIVIDUALS

Percentage of daily tests that are positive (positivity rate) in the GCC[1,2]

10-June to 1-Sep



High positivity rates can prevent effective group testing

- Group testing can prevent testing from becoming prohibitively expensive for employers and school administrators[3]
- However, group testing of up to 5 samples at a time is recommended by the US Food and Drug Administration (FDA) only when the positivity rate is less than 10%[4]
- For instance, Nebraskan health authorities were forced to stop group testing when their positivity rates increased to 17%[5]
- Among the GCC, group testing on the population level would currently be recommended for the UAE, Bahrain, and Saudi Arabia
- However, the high positivity rates of Oman and Kuwait could be due to their policy of testing those with symptoms only[6]

Note: the Omani MoH stopped releasing testing data after 6-Aug.

Sources: 1. Our World in Data (link); 2. Health ministries' infographics; 3. University of Southern California (link); 4. The Washington Post (link); 5. Los Angeles Times (link); 6. Our World in Data (link).

THIS TYPE OF TESTING COULD HELP SUPPRESS POTENTIAL SECOND WAVES

Current testing focuses on testing each suspect case individually

- For example, if there are 27 suspect cases, then 27 tests are performed to rule out COVID-19

- This uses up a **large amount of finite testing resources**, causing some authorities to restrict testing those showing symptoms
- Such restrictions are counter-productive as **bypass asymptomatic and pre-symptomatic cases** and inflate the positivity rate

By utilizing group testing, health authorities could vastly increase their testing capacities, allowing greater access to testing

- In a group testing approach, samples are grouped together and tested as one. Individual testing is only carried out if the group test comes up as positive[1]
  - However, test groups **must not be too large** to avoid the risk of diluting positive samples and obtaining false negatives[1]
  - The **most efficient group size** was reported to be **5 samples**, with a maximum of 30 samples per group to allow for confident identification[2,3]
- Several governments have utilized group testing, which **can save chemical reagents**, **money**, and **time**[4]
  - **Germany** and **Singapore** utilize group testing in **nursing homes**[4]
  - In **India**, the protocol for testing **migrant workers** and **returnees from abroad** involves combining 25 samples in a single group to be tested as one[5]
  - Health authorities in the state of **Nebraska** turned to group testing when they **began to run out of testing reagents**[6]
- Group testing is also useful in group settings such as schools and offices, where they can become a recurring feature of back-to-school and back-to-work programs[4]

Sources: 1. Bloomberg (link); 2. *American Journal of Clinical Pathology* (link); 3. *The Lancet Infectious Diseases* (link); 4. The Washington Post (link); 5. Ministry of Health & Family Welfare (link); 6. NPR (link).

THERE ARE SEVERAL SCIENTIFIC METHODS OF GROUP TESTING THAT COULD BE UTILIZED

------- *positive result*
------- *negative result*

Group testing method A

Samples are distributed into equal groups, and each group is tested. If a group's test result is positive, then each sample in that group is re-tested individually

1st round = 3 tests for 27 people

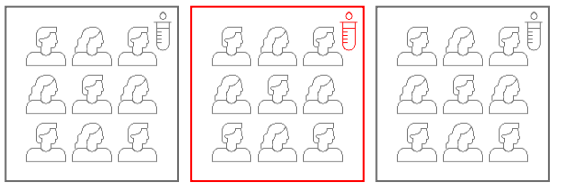
2nd round = 9 tests for 9 people

This method was used to test the vast majority of **Wuhan's** population, allowing officials to group **test 2.3 million people** (with up to **5 samples in each group**) and **identify 56 cases** in a little over **two weeks**

Group testing method B

Similar to method A, but it adds an extra round of group testing before testing individually, which reduces the total number of people that need to be tested

1st round = 3 tests for 27 people



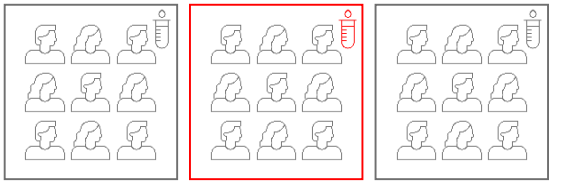
2nd round = 3 tests for 9 people

3rd round = 3 tests for 3 people

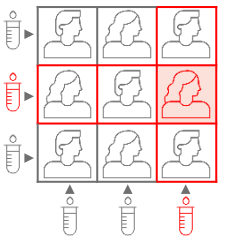
Group testing method C

Method C involves two rounds of testing, Samples are arranged in a square matrix in the second round, where each row and column is treated as a group and tested

1st round = 3 tests for 27 people



2nd round = 6 tests for 9 people



This method is being trialled by the **Rwandan government**, potentially **cutting the cost** of testing each person **from USD 9** to **USD 0.75**

Sources: *Nature* (link) and medRxiv (link).

05. GOVERNMENTS POLICY RESPONSE

01 Latest pandemic developments

02 Viral mutations and comorbidities

03 Second wave prevention

04 National testing policies

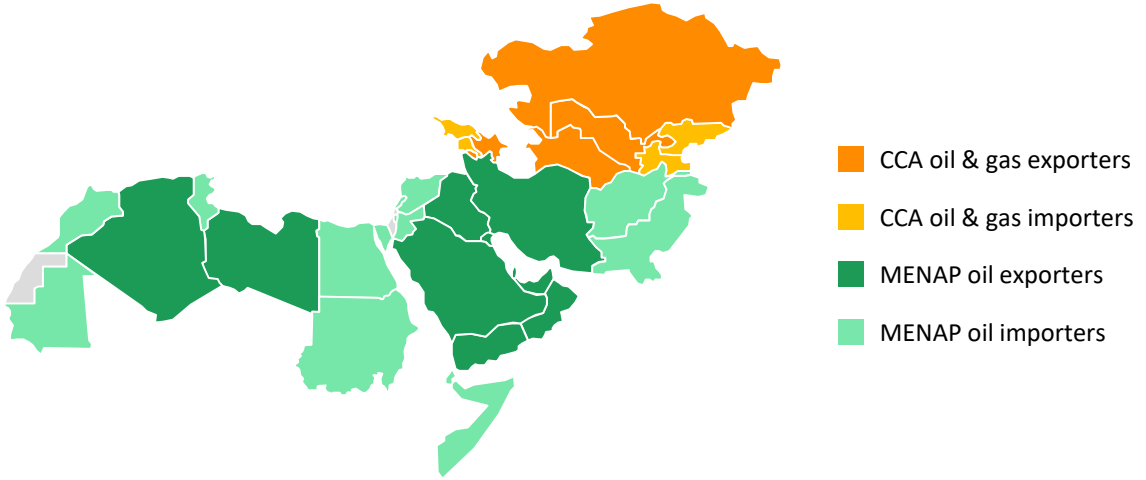
05 **Governments policy response**

06 Re-opening schools

07 Vaccine trials

THE IMF DOWNWARDLY REVISES ITS ECONOMIC OUTLOOK FOR THE ECONOMIES OF THE MIDDLE EAST AND CENTRAL ASIA

IMF grouping system of Middle Eastern and Central Asian economies



Projected annual growth in real GDP across the MENAP region

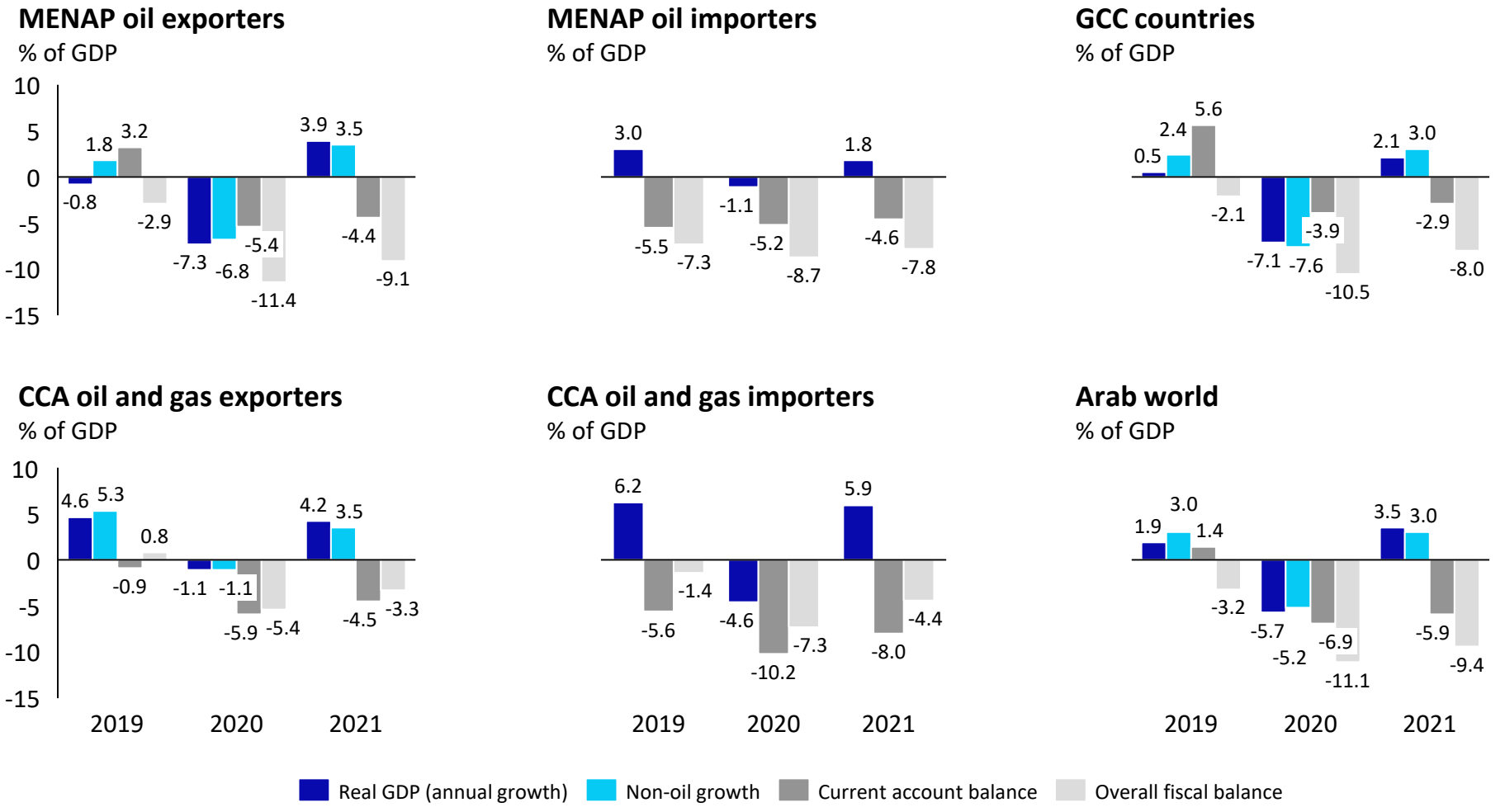
% of GDP

CCA: Caucasus and Central Asia; GCC: Gulf Cooperation Council; MENA: Middle East & North Africa; MENAP: Middle East, North Africa, & Pakistan.
Sources: IMF Regional Economic Outlook Update (July 2020) (link).

Developments

- The IMF has revised its growth forecast for the MENAP region, expecting it to contract by 5.1% in 2020 compared to a 0.5% contraction in 2019
- The IMF's negative outlook for the region was influenced by two major factors:
  - Uncertainty around the length of the pandemic and the associated economic shutdown
  - Potential for renewed volatility in global oil markets
- Across the MENAP region, oil exporters will experience the most contraction (-7.3%) in 2020, while MENAP oil importers will see the least contraction (-1.1%)
- A higher economic contraction is projected for the GCC (-7.1%) in 2020 compared to the Arab World (-5.7%)

FURTHER DETERIORATION OF NON-OIL GROWTH AND FISCAL BALANCES IS EXPECTED IN 2020



CCA: Caucasus and Central Asia; GCC: Gulf Cooperation Council; MENAP: Middle East, North Africa, & Pakistan.

Sources: IMF Regional Economic Outlook Update (July 2020) (link).

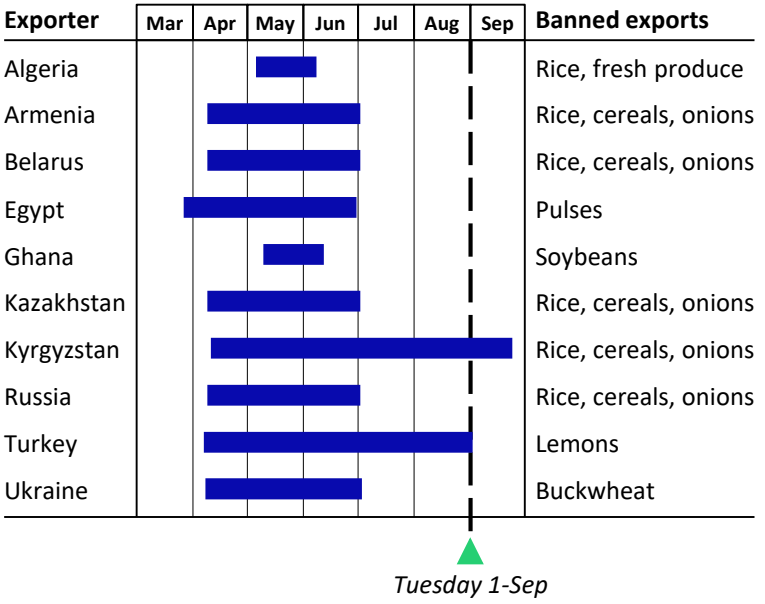
THE CRISIS HAS HEAVILY IMPACTED THE GCC COUNTRIES, MOST OF WHOM ARE MAJOR FOOD IMPORTERS

Bans on food exports

- To protect their domestic food supplies, several major food exporters have **introduced temporary bans on food exports**, including **basic staples** such as **maize**, **rice**, and **wheat**

Restrictions on food exports linked to COVID-19

Select exporters, from Mar-20 to Sep-20

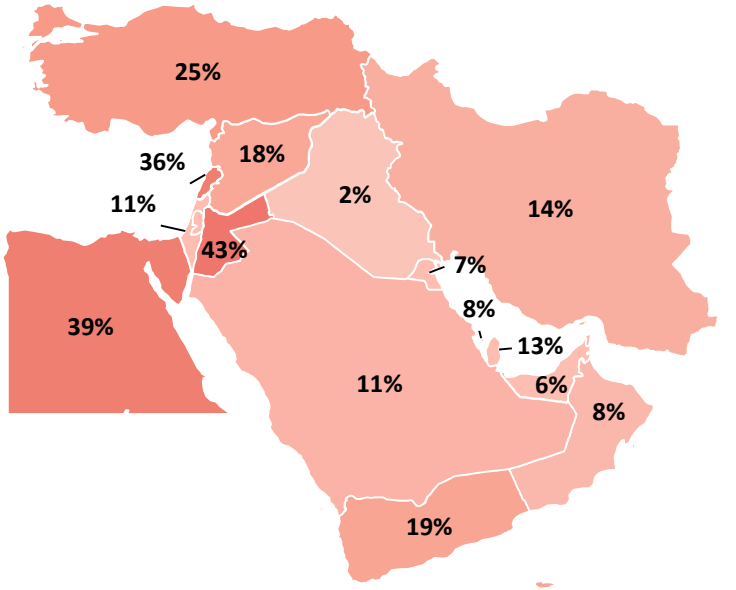


Impact of bans on food importers

- Such trade restrictions are a **threat to the food security** of major food importers, and the **share of restricted flows in food imports** was **significantly higher** in the Middle East

Disruption of food imports among major importers

% share, cumulative



Sources: CGIAR (link) and the International Food Policy Research Institute (link).

POLICY RESPONSES TO COVID-19

Key policy responses

1-Jan to 28-Aug

Country	Area of response: Fiscal	Monetary	Exchange rate	Stated amount
Bahrain[1]	✓	✓		**$11.5 BN** BHD 4.3 BN
Kuwait[1,2]	✓	✓		**$18.1 BN** KWD 5.5 BN
Oman[1]	✓	✓		**$20.8 BN** OR 8 BN
Qatar[1,3]	✓	✓		**$20.6 BN** QAR 75 BN
Saudi Arabia[1]	✓	✓		**$35.8 BN** SAR 134 BN
UAE[1]	✓	✓		**$77.6 BN** AED 284 BN
China[1]	✓	✓	✓	**$995 BN** ¥6.84 TR
France[1]	✓	✓		**$552 BN** €462 BN
Italy[1,4]	✓	✓		**$962 BN** €805 BN
Singapore[1]	✓	✓		**$118 BN** S$161 BN
South Korea[1,5]	✓	✓	✓	**$230 BN** ₩270 TR
UK[1,6]	✓	✓		**$972 BN** £726 BN
USA[1,7]	✓	✓		**$2.96 TR**

Examples of key policy responses

Fiscal

- Personal expense relief
- Tax exemption
- Mortgage loan flexibility
- Reduced government spending

Monetary and macro-financial

- Reduced interest rates
- Reduced capital & liquidity requirements
- Purchase of treasuries
- Private sector debt relief

Exchange rate and balance of payments

- Adjusted exchange rate
- Raised ceiling on cross-border financing
- Removed restrictions on investment quota
- Opened bilateral swap line

Sources: 1. IMF Policy Tracker (link); 2. Kuwait News Agency (link 1, link 2); 3. Qatar e-Government (link); 4. Bloomberg (link 1, link 2); 5. Reuters (link); 6. Business Insider (link); 7. Financial Times (link).

COMPENSATION AND BENEFITS (C&B) PROGRAMS ACROSS THE GCC ARE BEING REEVALUATED TO ENSURE MAXIMUM VALUE-FOR-MONEY

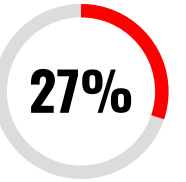
MERCER
OLIVER WYMAN

- **C&B program adjustments** were **more prevalent** among **local organizations (81%)** compared to **their international peers (53%)**
- The **Life Sciences** sector was the **most resilient** to COVID-19, as **87%** of organizations in this sector **report no changes** to their C&B programs
- The **Engineering, Construction, & Real Estate** sector was the **least resilient** to COVID-19, as **90%** of organizations in this sector **report taking actions** across one or more C&B programs
- In terms of **changes already made**, the most prevalent actions involved **reductions to the base salary**, **suspension of salary increases**, and **reduction of employee headcount**
- With regard to **changes planned**, the most prevalent actions involve **reduction of employee headcount**, **suspension of salary increases**, and **changes to leave policy**

Expect a **moderate to high impact** on financial performance

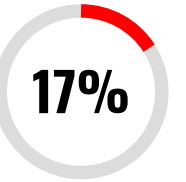
Plan to or have already **adjusted one or more C&B** elements

Have considered or taken actions involving **terminations**, **hiring freezes**, and **employee furloughs**



Have already made **reductions to the base salary**, with a **20-25% median reduction** on allowances

Have taken action on **2020 salary increases**



Have made changes to their **leave policy**

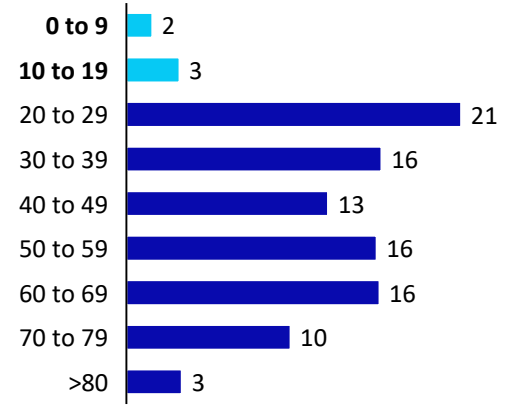
Note: Survey sample comprised 522 subsidiaries, belonging to 168 groups, across various industries and operating in the GCC.
Source: Mercer (link).

06. RE-OPENING SCHOOLS

CONFIRMED CASES ARE UNEQUALLY DISTRIBUTED AMONG AGE GROUPS ACROSS COUNTRIES, WITH CHILDREN UNDER 19 LESS AFFECTED THAN OTHER AGE GROUPS

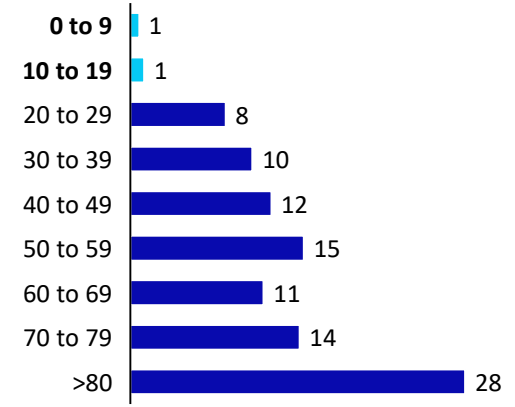
Australia[1]

% share of confirmed cases



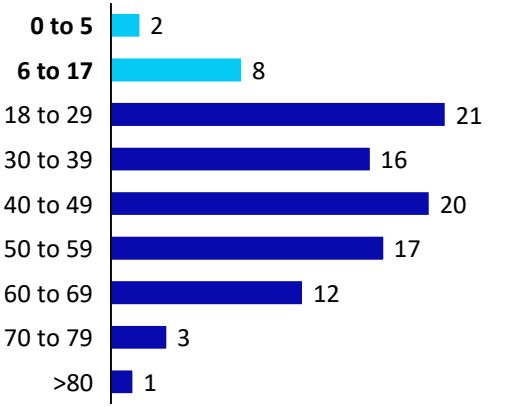
England[2]

% share of confirmed cases



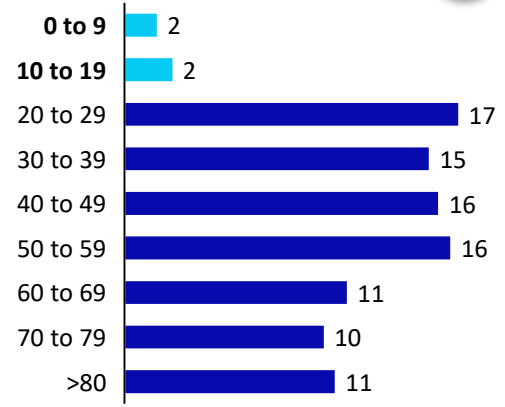
Iceland[3]

% share of confirmed cases



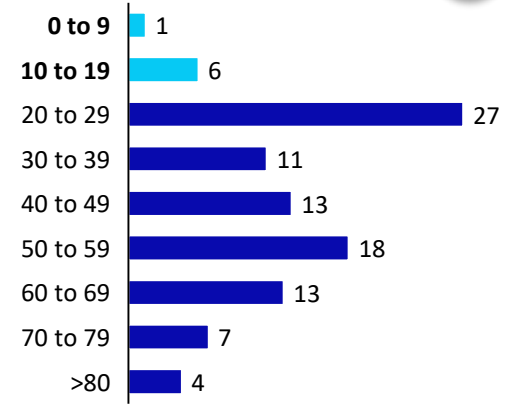
Japan[4]

% share of confirmed cases



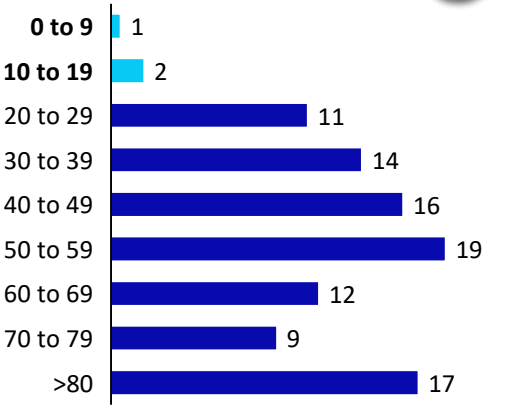
South Korea[5]

% share of confirmed cases



Sweden[6]

% share of confirmed cases



Sources: 1. Department of Health (link), 2. Government Digital Service (link), 3. Directorate of Health (link), 4. Toyo Keizai Online (link), 5. COVID-19 Dashboard (link), 6. Public Health Agency of Sweden (link).

CHILDREN APPEAR BE LESS SUSCEPTIBLE TO INFECTION AND TRANSMISSION COMPARED TO ADULTS

COVID-19 infection in children

- **Children** consistently make up **less than 2% of total reported case numbers** despite making up **nearly a quarter** of the world's population[1]
- Although children are less likely to be tested as their **symptoms are less severe than those in adults**, this finding that children are less susceptible has been confirmed in countries with **widespread community testing** such as **Australia**, **Iceland** and **South Korea**[1,2,3]

	Children (0-19) comprised less than 5.2% of the first 7,755 laboratory confirmed cases (link)
	Children (0-18) comprised less than 0.8% of 4,695 confirmed cases in the Madrid region (link)
	Children (0-18) comprised 1.2% of the 22,512 confirmed cases reported as of 17-Mar (link)
	Children (0-18) comprised 1.7% of 142,082 cases reported between 12-Feb to 2-Apr (link)
	Children (0-19) comprised 1.3% of 72,314 cases reported until 11-Feb (link)

COVID-19 transmission in children

- Children are **unlikely to transmit** COVID-19[4]
- Evidence cited by the Dutch government suggests that **children play a minor role in the transmission of COVID-19**, as it is mainly **spread between adults** and **from adults to children**[5]

	A COVID-19-positive child in the French Alps did not transmit the virus to anyone despite coming into contact with 172 people (link)
	No cases of secondary transmission among 735 students and 128 staff who came into contact with 9 COVID-19-positive students in school (link)
	No cases of secondary transmission occurred from 3 COVID-19-positive children in school, even during high-risk activities such as music lessons and choir practice (link)

Sources: 1. Royal College of Paediatrics and Child Health (link), 2. CDC (link), 3. medRxiv (link), 4. National Institute for Public Health and the Environment (link).

THE TYPE OF SOCIAL SETTING HAS A SIGNFICANT IMPACT ON TRANSMISSION PATTERNS

Age-specific social contacts differed across settings

- In Wuhan, COVID-19 transmission in the early stages mainly took place **within households** and **public/community places**
- According to a study[1] of six representative Chinese cities (including Wuhan), this could be explained by both households and public/ community spaces **involve intensive contacts between individuals of different age groups**
- In contrast, the majority of social contacts in **schools** and **workplaces** occur **between individuals of the same age group**
- Another study[2] of transmission patterns in China, found that **children 0-14 years old were less susceptible** to SARS-CoV-2 infection than all other age groups, with **individuals over the age of 65 most susceptible to infection**

In **households**, the majority of social contacts occur between individuals from different age groups

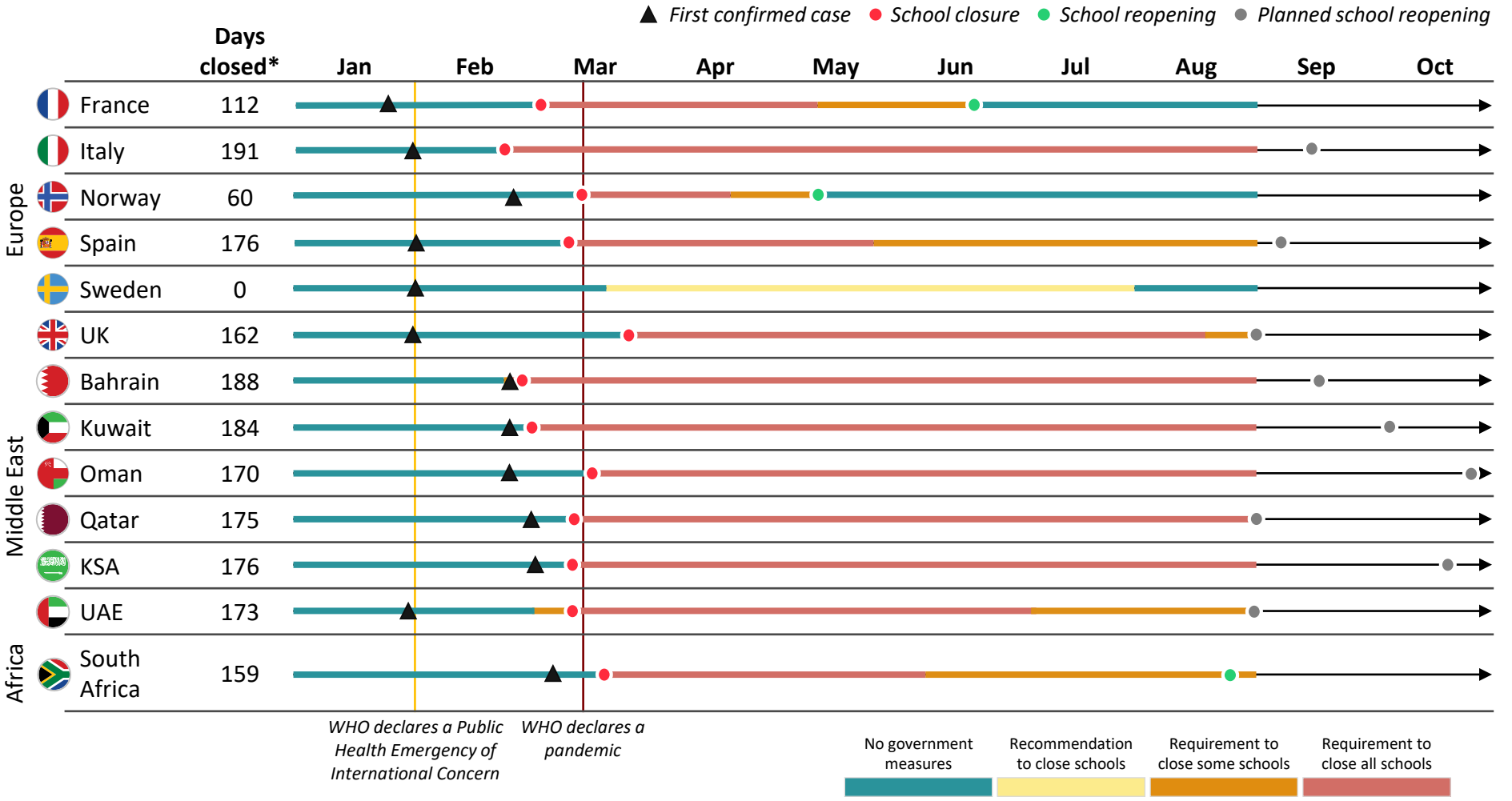
In the **workplace**, social contacts were dominated by young and middle-aged adults (23-44 years old)

In **schools**, the majority of social contacts occurred between children in the same age group

In **public/community spaces**, social contacts occur between individuals from different age groups

Sources: 1. *The Lancet* (link), 2. *Science* (link).

SCHOOL CLOSURE POLICIES HAVE VARIED THROUGHOUT THE LOCKDOWN, BUT MOST COUNTRIES ARE PLANNING TO REOPEN SCHOOLS IN SEPTEMBER



Note (*): number of days from school closure to 31-Aug or school reopening (for France, Norway and South Africa).
Sources: Our World in Data (link) and the University of Oxford (link).

THE SAFE REOPENING OF SCHOOLS HIGHLY DEPENDS ON THE LEVELS OF COVID-19 SPREAD IN THE COMMUNITY

Early on in the pandemic, it appeared that SARS-CoV-2 **might behave differently** in **children**, and they were thought to be less infectious due to their milder symptoms. However, several studies show that, **once children become infected**, they are **no less infectious than adults**. In places with **ongoing community spread**, spillover of infections to schools is a serious threat that could further increase community transmission.[1]

Reopening schools in areas with low community spread

- In **South Korea** and **Australia**, schools reopened when community spread was low[1]
- An analysis of **11,000 school-aged children** in **Seoul** found **no sudden increase** in pediatric cases after school reopening[2]
- Similarly, an analysis of school reopenings in **New South Wales** found that **only 25 out of 7,700 schools** reported an initial COVID-19 infection[3]
- The **success of school reopenings** in both countries can be attributed to the **strong public health response** that involved **high levels of testing** and **effective contact tracing**[1]

VS

Reopening schools in areas with high community spread

- In **Jerusalem**, schools reopened when community spread was high[1]
- 10 days after reopening, a **major COVID-19 outbreak** occurred in a single high school that resulted in the infection of **153 students** and **25 staff members**[4]
- **87 additional infections** occurred **outside the school** due to contact with infected students[4]
- A leading factor in the mass outbreak was an **extreme heat wave** (above 40 °C), during which the school **exempted students from wearing masks indoors** and **continuously operated indoor air-conditioning**[4]

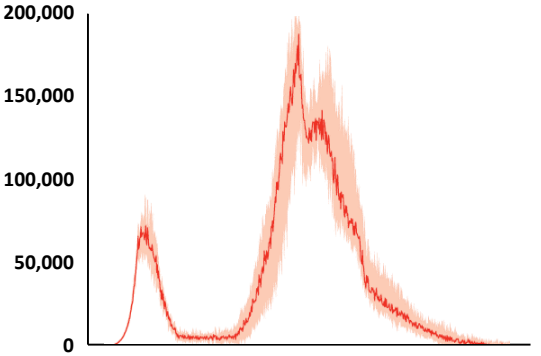
Sources: 1. *Nature* (link); 2. medRxiv (link); 3. *The Lancet Child and Adolescent Health* (link); 4. *Eurosurveillance* (link).

SAFE SCHOOL REOPENING REQUIRES A WELL-COORDINATED STRATEGY FOR LARGE-SCALE TESTING, EFFECTIVE CONTACT-TRACING, AND ENFORCED ISOLATION

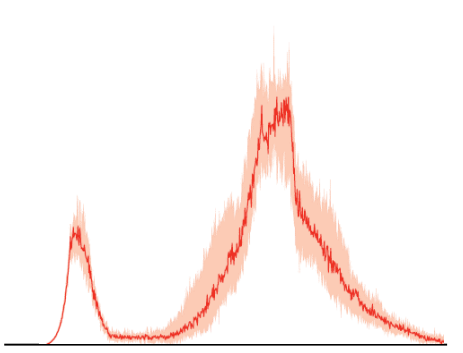
A study in *The Lancet* focused on the optimal strategy for school reopening

- **Mathematical modelling** was used to **estimate the impact** of different **school reopening scenarios** in the **UK**
- Results showed that **increased levels of testing** combined with **effective contact tracing** and **isolation** was **crucial** to **prevent a second wave**
- If British schools are reopened in September **without sufficient levels of testing and contact tracing**, a **second wave** is likely to occur in **December 2020**
- This **second wave** would be **2 to 2.3 times** the size of the first COVID-19 wave in the UK
- In the **absence of sufficient testing and contact tracing**, a **second wave** would **still occur even if school children were assumed to be only half as infectious as adults**

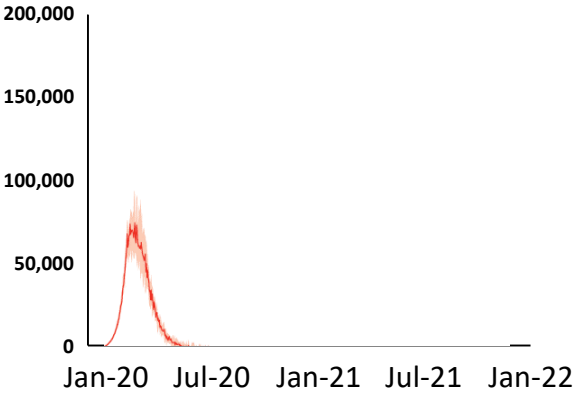
Model estimates at **68% tracing** and **18% testing** in a **full reopening** scenario



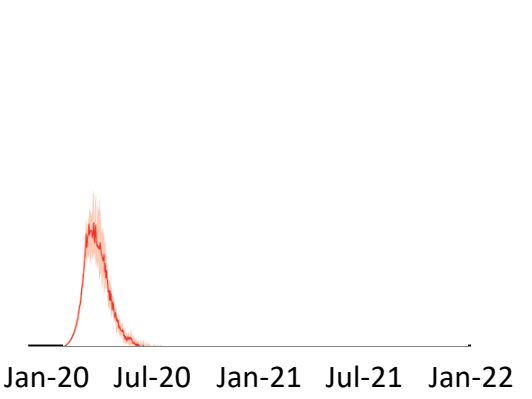
Model estimates at **68% tracing** and **18% testing** in a **part-time reopening** scenario



Model estimates at **68% tracing** and **75% testing** in a **full reopening** scenario



Model estimates at **68% tracing** and **75% testing** in a **part-time reopening** scenario



Source: *The Lancet Child and Adolescent Health* (link).

07. VACCINE TRIALS

01 Latest pandemic developments

02 Viral mutations and comorbidities

03 Second wave prevention

04 National testing policies

05 Governments policy response

06 Re-opening schools

07 Vaccine trials

THE WHO SOLIDARITY TRIAL REDUCES THE TIME FOR TEST TREATMENTS AND VACCINES BY 80%

SOLIDARITY trial for treatment candidates

- Around **15% of COVID-19 patients require hospitalization**, causing hospitals to become overwhelmed
- Treatments to **reduce hospitalization time** and **free up hospital beds** are in critical need
- On 21-Mar, the WHO announced a **global megatrial of the four most promising COVID-19 treatments**
- The aim of this trial is twofold:

i. To **repurpose drugs already approved for other diseases**, bypassing the years required to develop and test a new drug

ii. To **investigate unapproved drugs that have performed well** in animal studies against other deadly coronaviruses

- The four treatments that will be tested are:

1. **Remdesivir,** an unapproved drug that was originally developed to combat Ebola
2. **Lopinavir/ritonavir combined,** an approved combination drug used to treat HIV infection
3. **Lopinavir/ritonavir combined with interferon-β,** an unapproved combination developed to treat MERS
4. **Hydroxychloroquinone and chloroquine,** approved drugs that are used to treat rheumatology conditions and malaria

SOLIDARITY trial for vaccine candidates

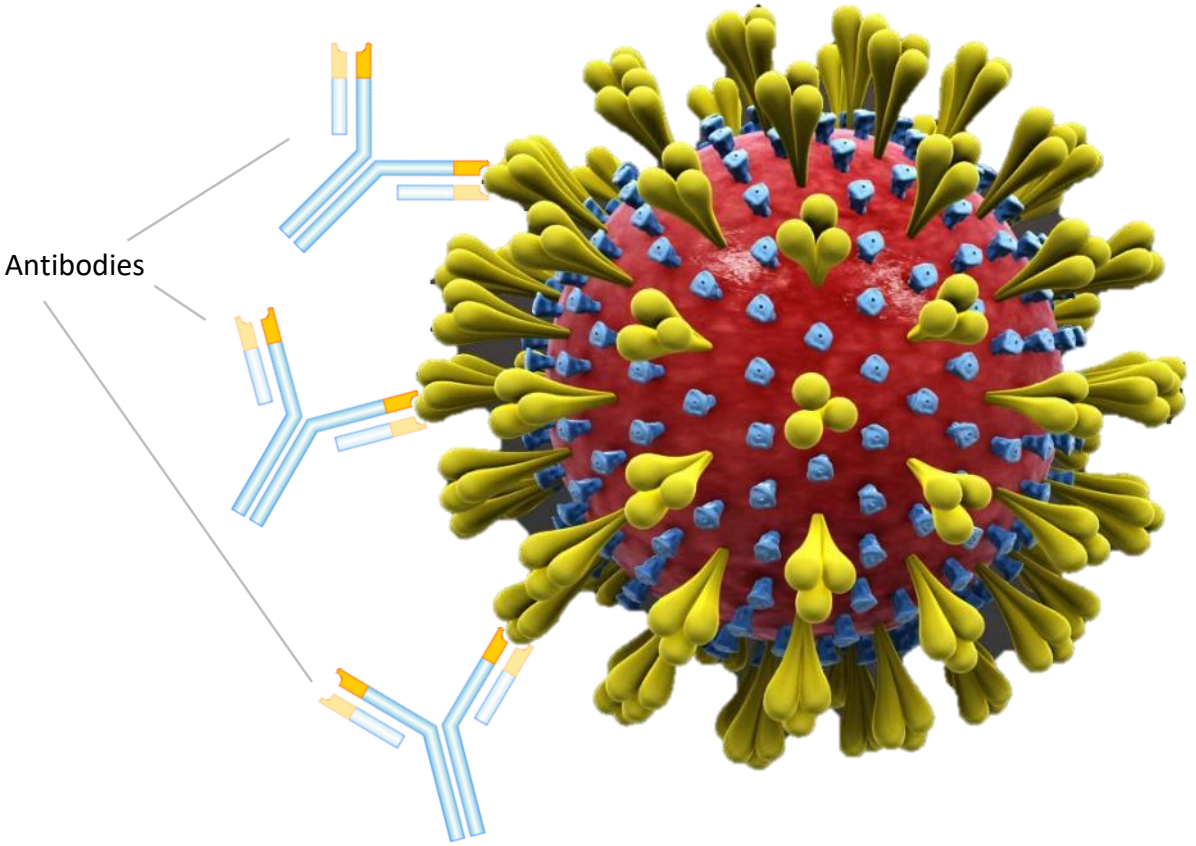
- On 27-Apr, the WHO announced that the SOLIDARITY trial would also focus on vaccine development
- As of 28-Aug, **143 vaccines** are under **pre-clinical investigation**, while **33 vaccines** are undergoing **clinical evaluation**

Stage of clinical evaluation	Developer	Estimated completion date
1	Inovio Pharmaceuticals (link)	Apr-21
	Moderna, Inc. (link)	Sep-21
1/2	BioNTech SE (link)	Aug-20
	Sinovac Biotech Ltd. (link)	Dec-20
	University of Oxford (link)	May-21
	Sinopharm Group (link)	Nov-21
	Sinopharm Group (link)	Nov-21
2	CanSino Biologics Inc. (link)	Jan-21

Sources: *Science* (link) and the WHO (link 1, link 2).

AN EFFECTIVE VACCINE AGAINST SARS-COV-2 WILL IDEALLY PRODUCE LASTING ANTIBODIES

Antibodies against SARS-CoV-2 recognize the virus and allow the immune system to destroy it before it can multiply to vast numbers



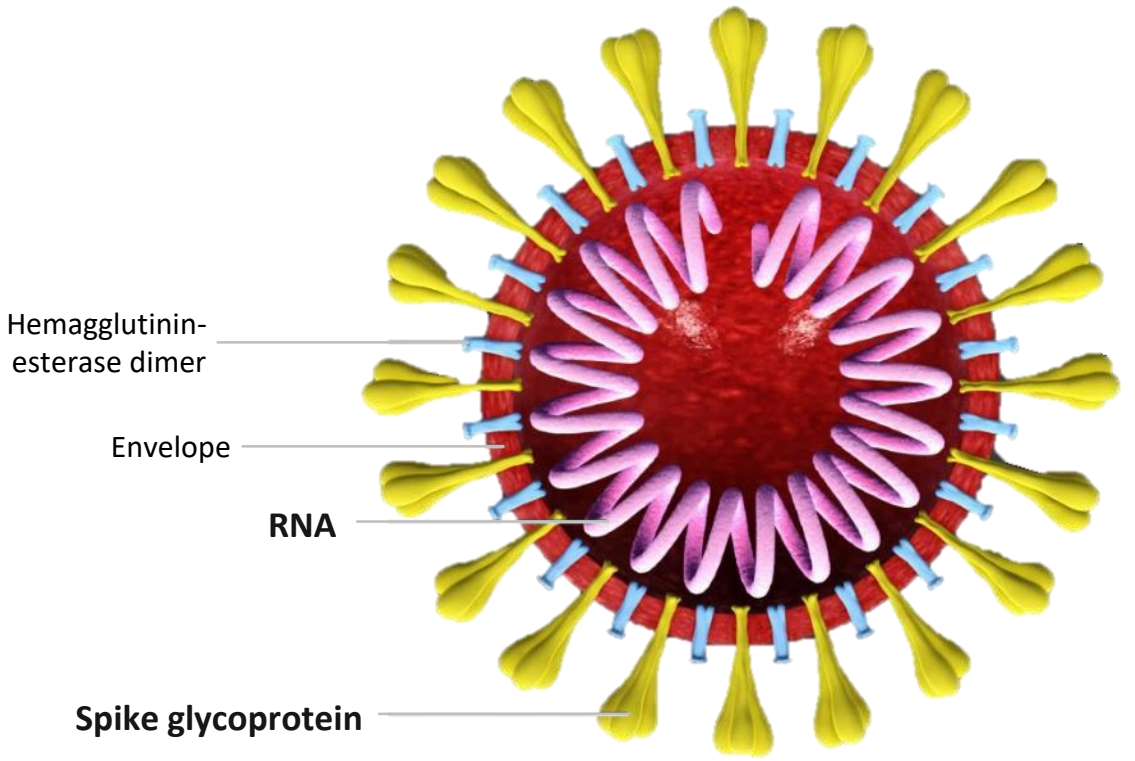
Background

- A **vaccine** stimulates the immune system to produce antibodies against a disease
- **Antibodies** are disease-specific proteins that tag germs or infected cells for attack by the immune system
- Efforts to produce a vaccine are **complicated** by news that **SARS-CoV-2 antibodies** are **not long-lasting**
- This means that **any potential vaccine against SARS-CoV-2** would only grant **short-term immunity**, requiring **repeated vaccinations** over the course of a year

Sources: CDC (link 1, link 2); *New England Journal of Medicine* (link); Scientific Animations (link); The Guardian (link); The New York Times (link).

STILL, POTENTIAL COVID-19 VACCINES MUST BE THOROUGHLY TESTED FOR ANY NEGATIVE SIDE-EFFECTS BEFORE WIDESPREAD ROLLOUT

Current vaccine candidates utilize different parts of SARS-CoV-2, mainly its genetic material (RNA) and surface proteins, to generate antibodies



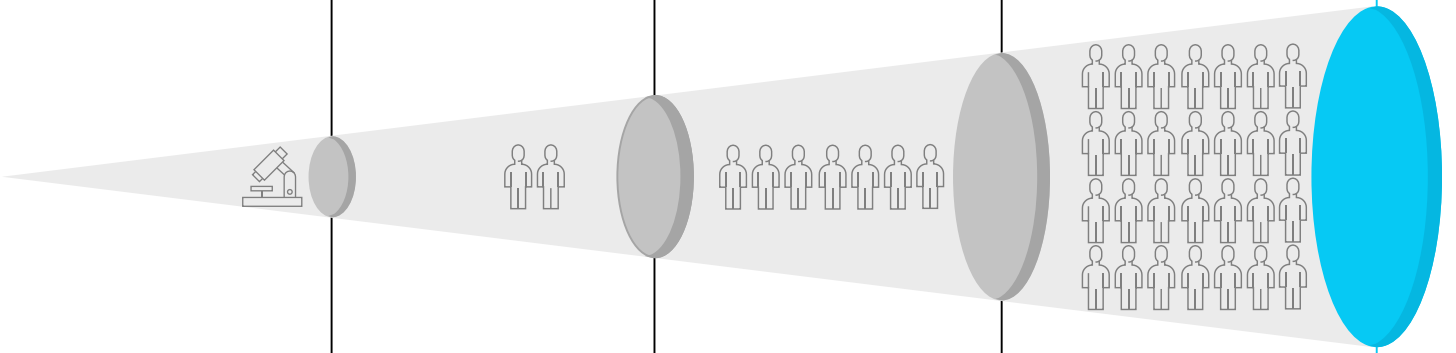
Sources: Financial Times (link); *Nature* (link); *Nature Reviews Microbiology* (link); Scientific Animations (link); The New York Times (link).

Background

- Since the SARS and MERS pandemics of 2003 and 2012, scientists have **warned of the need** for governments to **prioritize** the **development of vaccines** against emerging coronaviruses
- Historically, **coronavirus vaccine development** has been **challenged** by evidence of **antibody-dependent enhancement (ADE)**
- In **ADE**, the **weak binding of antibodies** to a virus **enhances its entry** into human cells, causing **more severe infection**
- Therefore, it is of the **utmost importance** for any vaccine to **undergo all stages** of clinical trial investigations

THE RECENTLY APPROVED RUSSIAN VACCINE BYPASSED PHASE III TRIALS, WHICH ARE ESSENTIAL FOR IDENTIFYING NEGATIVE SIDE EFFECTS

COVID-19 vaccine candidates currently under development



PRECLINICAL
89 vaccines

Preclinical testing

The vaccine is given to **animals** to see if an **immune response** is produced

PHASE I
23 vaccines

Phase I safety trials

The vaccine is given to a **small number of people** to **confirm animal results**, **test safety**, and **identify required dosage**

PHASE II
14 vaccines

Phase II expanded trials

The vaccine is given to **hundreds of people** to see **if it acts differently** in different age and ethnic groups

PHASE III
9 vaccines

Phase III efficacy trials

The vaccine is given to **thousands of people** to see **how many become infected** compared to people who received a **placebo treatment**

EARLY APPROVAL*
3 vaccines

CanSino Biologics
Limited military use

Gamaleya Research Institute
Widespread use

Sinovac Biotech
Limited use

Early approval

Trial results are reviewed, and the vaccine can be approved for **widespread** or **limited use**

Note (*): vaccines have been given early approval before completing Phase III trials.
Sources: Bloomberg (link); The New York Times Coronavirus Vaccine Tracker (link); WHO (link).

DISCLAIMER

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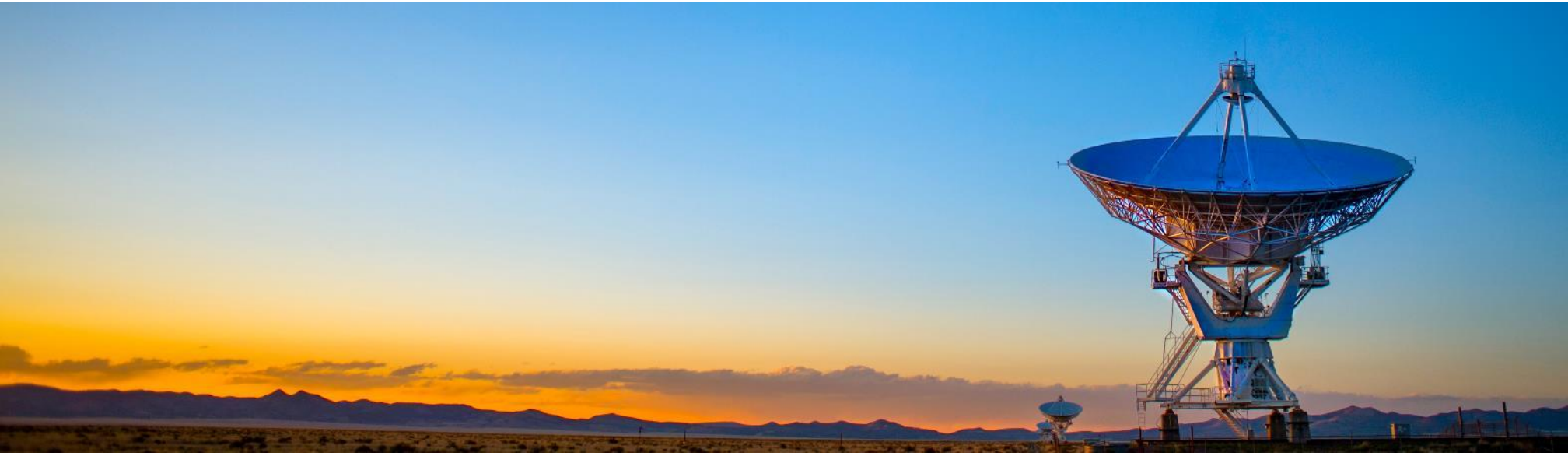
READ OUR LATEST INSIGHTS ABOUT COVID-19 AND ITS GLOBAL IMPACT ONLINE

Oliver Wyman and our parent company Marsh & McLennan (MMC) have been monitoring the latest events and are putting forth our perspectives to support you clients and the industries you serve around the world. The Coronavirus Hub will be updated daily as the situation evolves.

Visit our dedicated COVID-19 website

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