# Lessons learned from the global COVID-19 pandemic


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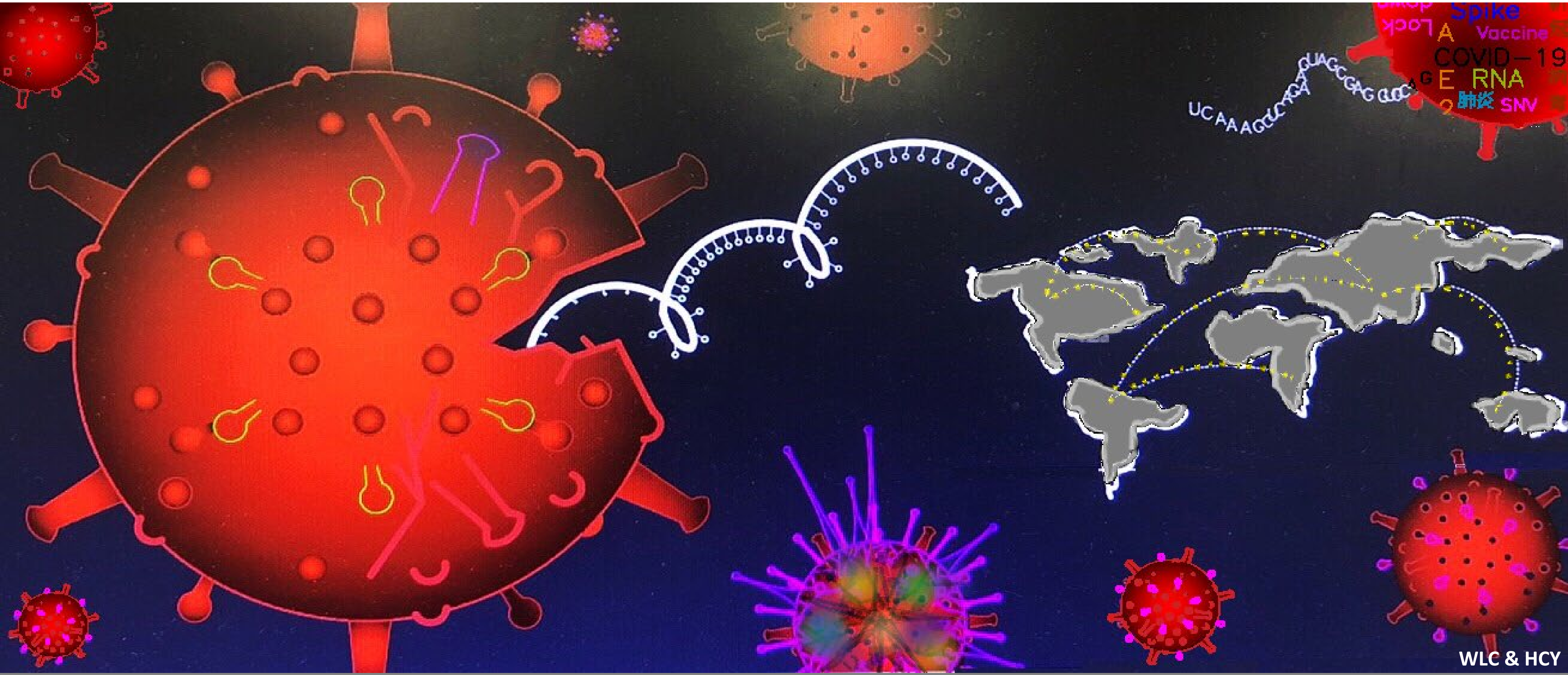
**2023-07-18**



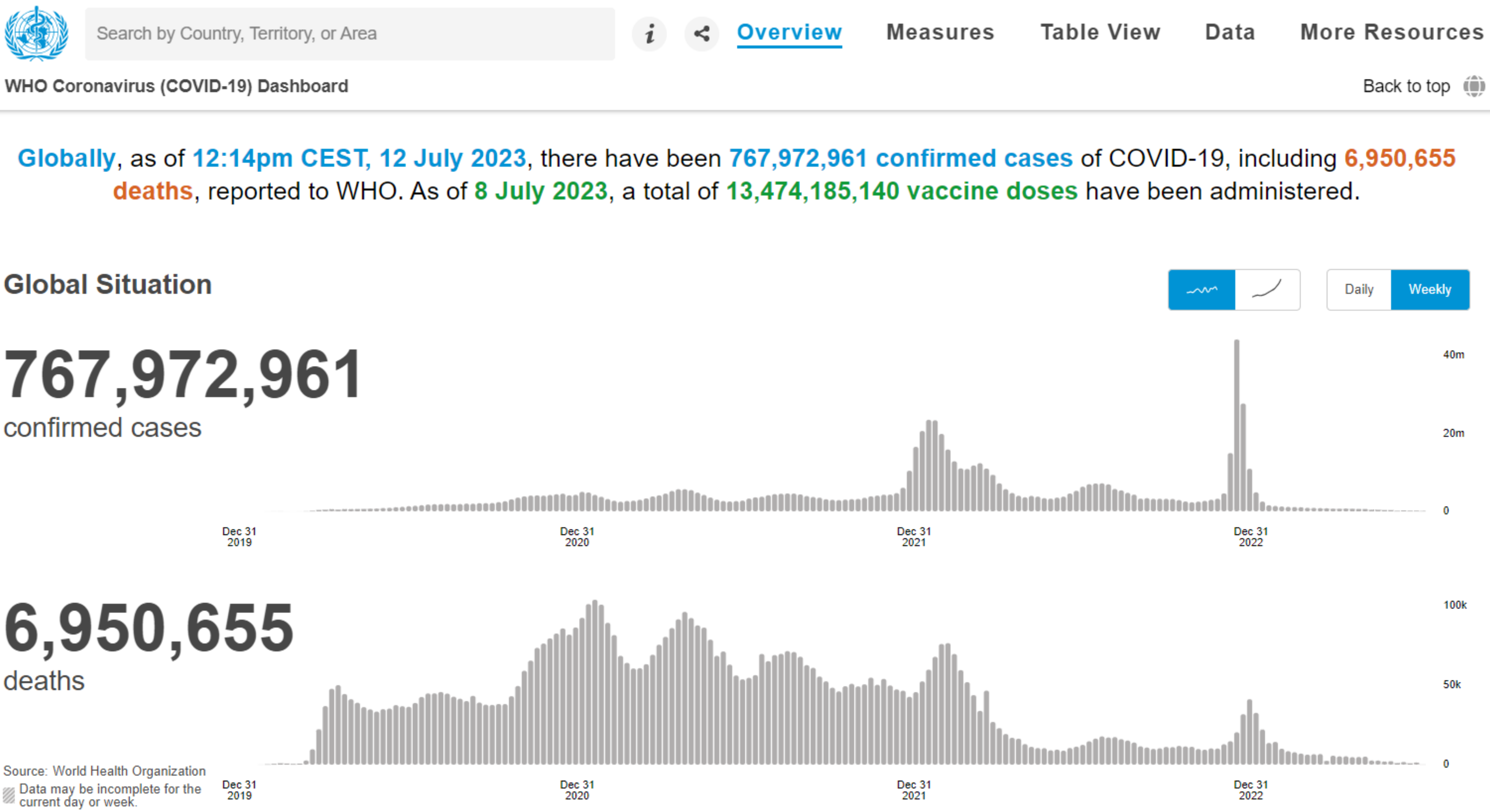
# COVID-19: Coronavirus disease 2019

- Dec 2019: the first case of the human-to-human transmission of a novel coronavirus was reported in Wuhan, China.
- Feb 2020: World Health Organization (WHO) gave the disease a name, "Coronavirus disease 2019" (i.e., COVID-19).
- Feb 2020, the International Committee on Taxonomy of Viruses (ICTV) named the causal agent for COVID-19, "Severe Acute Respiratory Syndrome Coronavirus 2" (i.e., SARS-CoV-2).
- SARS-CoV-2 (Beta genera) as the 7th human coronavirus: Other six are: OC43 (Beta, 1960-1970), 229E (Alpha, 1960-1970), SARS-CoV (Beta, 2003), NL63 (Alpha, 2004), HKU1 (Beta, 2005), and MERS-CoV (Beta, 2012, 2015, 2018). Green color: common colds.

# Symptoms of COVID-19

- Incubation period: 2 to 14 days after exposure
- Pre-symptomatic transmission ("before symptoms")
- Common symptoms are similar to other colds and flu:
  - ✓ Fever
  - ✓ Cough
  - ✓ Tiredness
  - ✓ Loss of taste or smell
  - ✓ Headache
  - ✓ Sore throat
  - ✓ Shortness of breath

# Statistics of COVID-19 Infection and Deaths

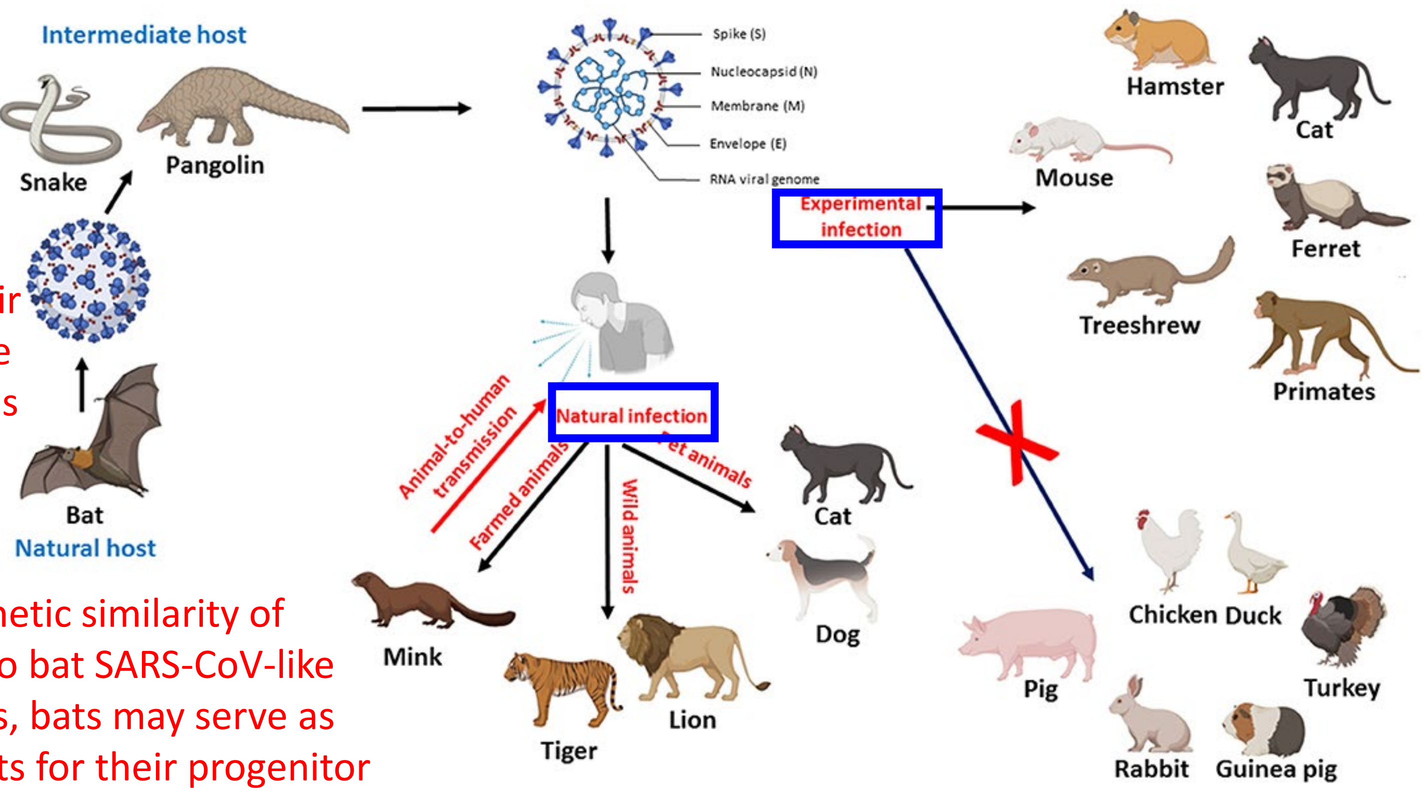



Source: WHO Coronavirus (COVID-19) Dashboard

# Origin of SARS-CoV-2

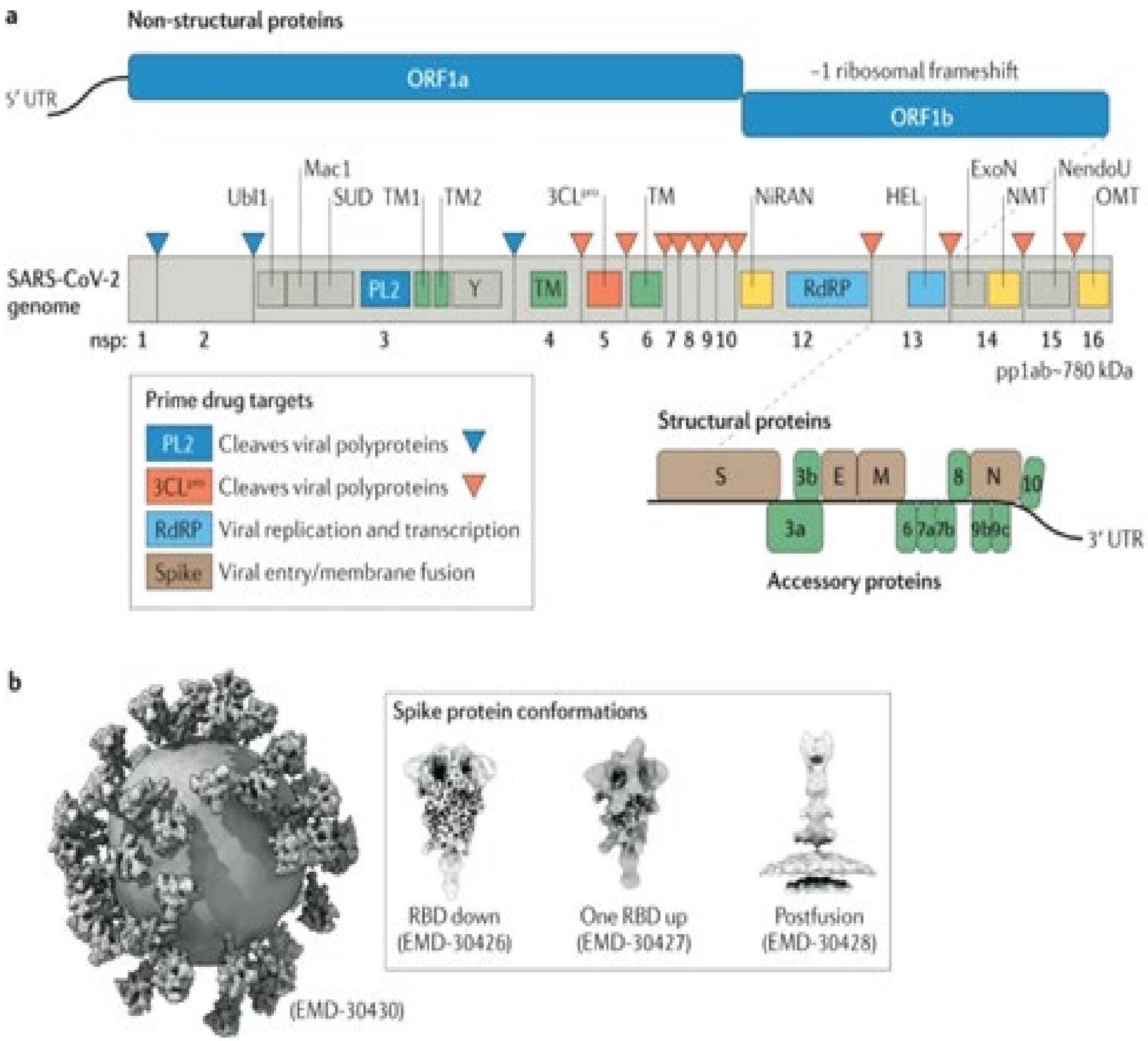
**There are two competing ideas: a "zoonotic emergence" and a "laboratory escape" scenario.**

No bat reservoir or intermediate animal host was confirmed.

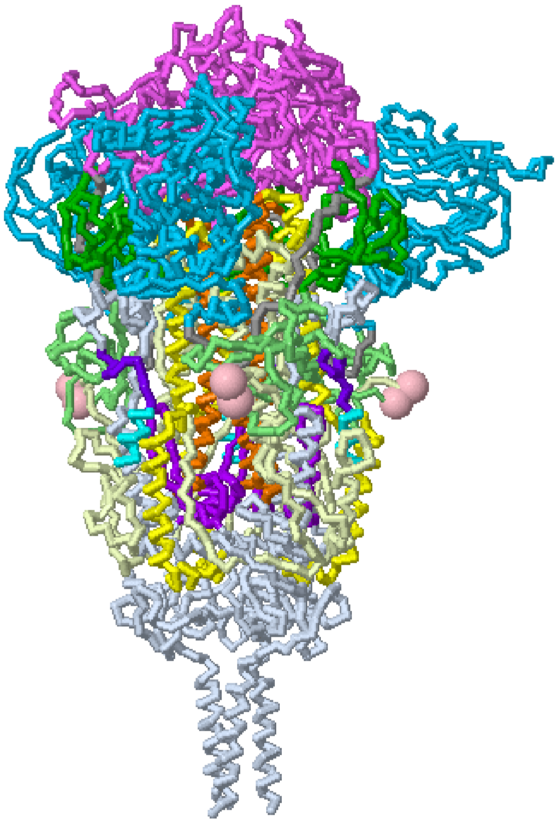



Given the genetic similarity of SARS-CoV-2 to bat SARS-CoV-like coronaviruses, bats may serve as reservoir hosts for their progenitor

# Structure and Mechanisms of SARS-CoV-2



# Spike protein of SARS-CoV-2




**S protein** is responsible for the following:

(1) Attachment at the host cell surface

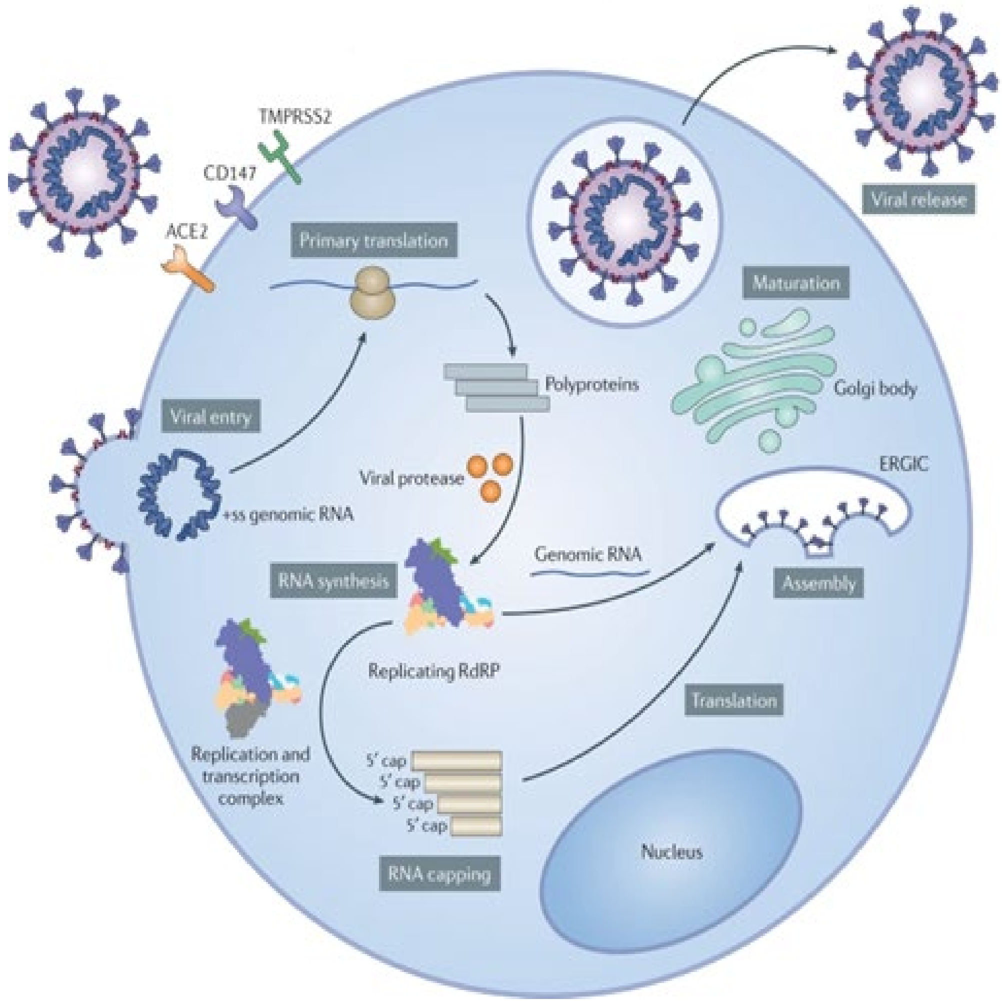
(2) Fusing the viral and host cell membranes

(3) Viral entry  (start of the infection)

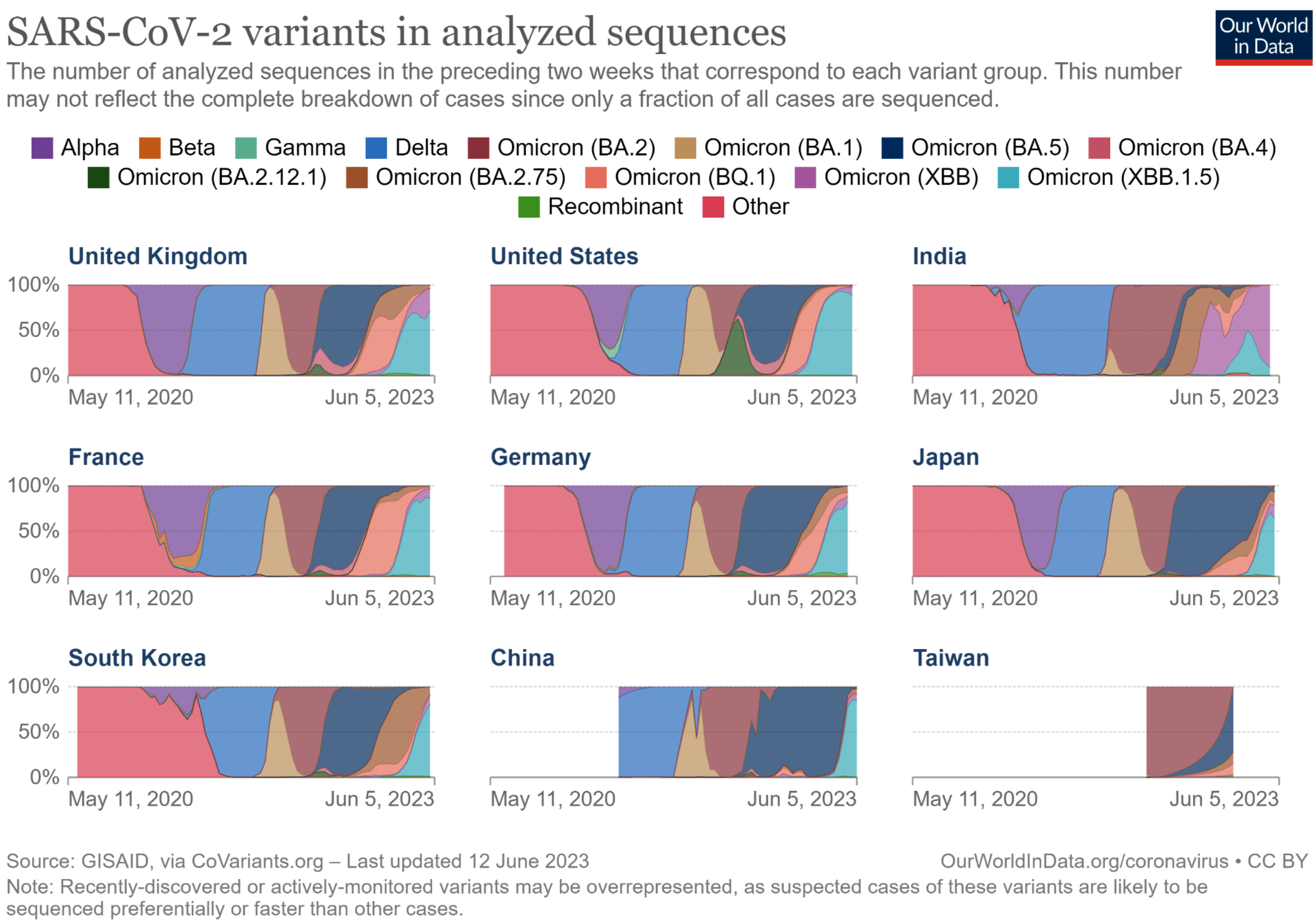
(4) Main target of neutralizing antibodies

(5) Vaccine and therapeutic design

# Entry pathways of SARS-CoV-2




Haitao Yang & Zihe Rao (2021, Nature Reviews Microbiology)

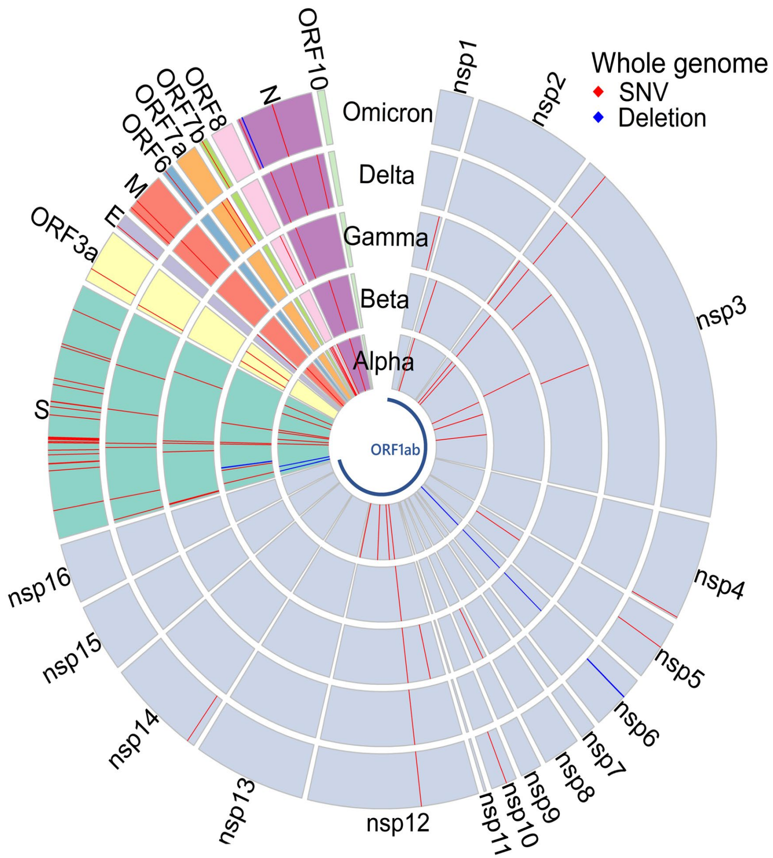


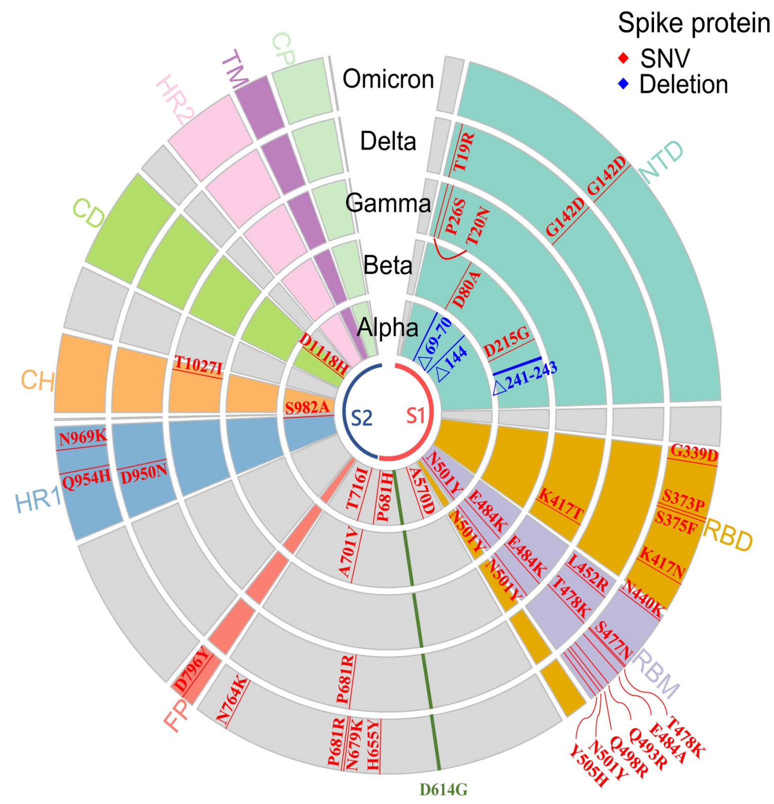

XBB.1.5 is the most transmissible Omicron sub-variant currently.

# Basic reproductive number R0

- Basic reproductive number **R0**:
  - Influenza **1.3**
  - 1918 Spanish flu **1.8**
  - Wu-Han variant **2.2 – 2.6**
  - D614G **3**
  - Alpha **4 – 5**
  - Delta **5 – 8**
  - Omicorn **> Delta**
  - Early estimates of the R0 of BA.4 and BA.5 is **18.6**

# Variants of SARS-CoV-2



# COVID-19 diagnostic testing

- **A positive antigen test** that the person tested is **currently infected with COVID-19**, specifically during the **acute phase** of the infection.
- **A positive antibody test** suggests that the person tested **had a previous COVID-19 infection**; their immune system responded by producing antibodies (such as IgM and IgG) to combat the virus.
- **PCR tests** are considered the **"gold standard"** for COVID-19 testing because they are **highly accurate and sensitive in detecting the presence of the virus**; they are more reliable in identifying COVID-19 infections.

# COVID-19 therapeutics

- **Antiviral Drugs** such as **Remdesivir** and **Molnupiravir** for inhibiting or interfering with **viral RNA replication**.
- **Immune Modulators** such as **Dexamethasone**, **Tocilizumab**, and **Baricitinib** for reducing **inflammation** and suppressing the **immune response**.
- **Monoclonal antibodies targeting SARS-CoV-2,** such as **Casirivimab and imdevimab (Regeneron)** and **Bamlanivimab and etesevimab (Eli Lilly)** for **neutralizing the virus and reducing viral replication**.
- **Convalescent plasma** for passively transferring antibodies from whom have recovered from COVID-19 to **help the recipient's immune response**.

# COVID-19 vaccines

| Vaccine platform | Advantages | Disadvantages |
|---|---|---|
| **mRNA** (Pfizer-BioNTech and Moderna) | Safe and well-tolerated; Highly adaptable to new pathogen; Native antigen expression | Lower immunogenicity; Requirement of low temperature storage and transportation; Potential risk of RNA-induced interferon response |
| **Viral vector** (Oxford-AstraZeneca and Johnson & Johnson/Janssen) | Stronger immune response; Preservation of native antigen; Mimicking natural infection | More complicated manufacturing process; Risk of genomic integration; Response dampened by pre-existing immunity against vector |
| **Protein subunit** (Novavax and Medigen Vaccine Biologics) | Safe and well-tolerated | Lower immunogenicity; Requirement of adjuvant or conjugate to increase immunogenicity |
| **Inactivated virus** (Sinovac and Bharat Biotech) | Stronger immune response; Safer than live attenuated virus | Potential epitope alteration by inactivation process |

Li et al (ACS Cent. Sci. 2021)

# Non-Pharmaceutical Interventions (NPIs)

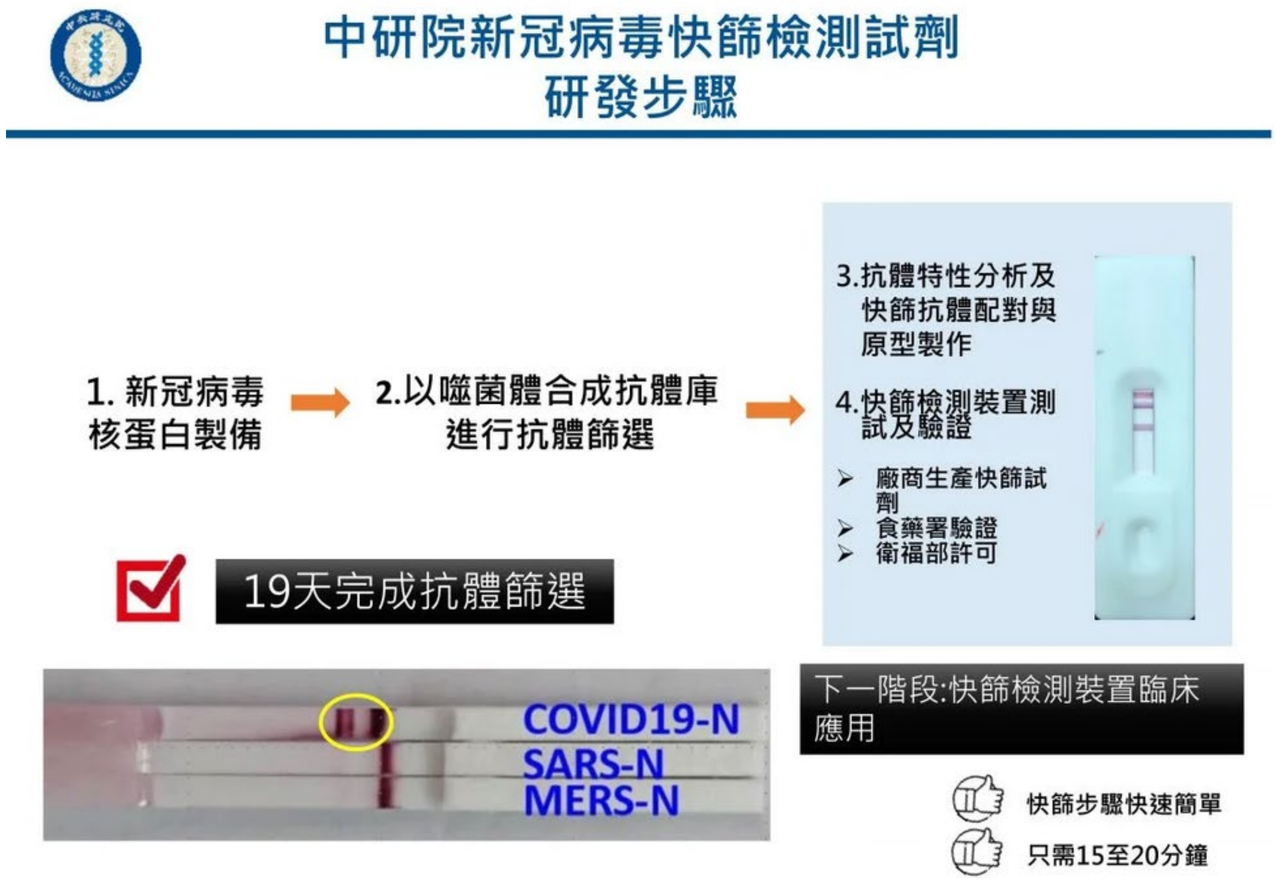
- NPIs, such as **social distancing**, **wearing masks**, **lockdowns**, and **quarantine measures**, are a range of measures and actions that can be taken to
  - **slow the transmission**
  - **protect vulnerable populations**
  - **ease the burden on healthcare systems**
  - **buy time for vaccine development and distribution**
  - **complement vaccine effectiveness**
- **Combining vaccination efforts with NPIs** offers the most effective approach to managing and mitigating the pandemic.

## President James Liao's address on Mar 20, 2020

"…, Academia Sinica rapidly assembled a task force during the Lunar New Year period to initiate research work in **rapid viral detection**, **antibody screening**, **drug synthesis**, and **vaccine development**. In addition, we established working groups among different research organizations and academics in order to share information, materials, and methodologies for use in COVID-19 research …"

In February 2020, Academia Sinica successfully synthesized Remdesivir at the "hundreds of milligrams level" with a purity of 97%, and further improved it to the "grams level" with a purity of 99%.

In March 2020, Academia Sinica discovered antibodies capable of detecting viral antigens, which can be applied as rapid screening reagents.



**When the SARS outbreak occurred in Taiwan, Academia Sinica promptly constructed two P3 negative-pressure laboratories for developing COVID-19 rapid screening, viral testing, and vaccine and therapeutics.**

https://research.sinica.edu.tw/covid19-p3lab-academiasinica/

**In January 2021, Academia Sinica repurposed existing medicines (mefloquine, nelfinavir, and extracts of Ganoderma luciudum, Perilla frutescens, and Mentha haplocalyx) as anti-COVID-19 virus agents**

# In June 2023, Academia Sinica and Moderna jointly launch the Forward-looking Innovation Award to accelerate mRNA research in Taiwan

大紀元 台灣

## 中共肺炎病毒變異 中研院分析有6大分型

HEHO health & hope

## 中研院發現全球流行同一株新冠病毒！第6型病毒適應性強

日期：2020-12-14 作者：王芊淩

CNA 中央通訊社

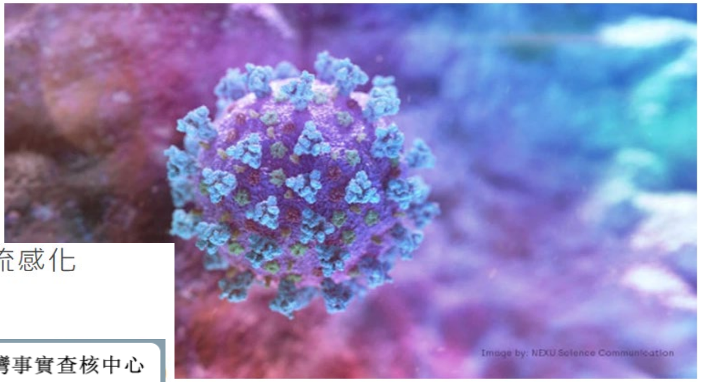
## 英國變種病毒 中研院：第6型病毒株子型 可能將繼續變異

最新更新：2020/12/30 17:35

蘋果即時

## 【武肺變種】台確診首例！中研院QA解疑 「現有疫苗還可有效對抗」

更新時間： 2020/12/31 11:09



SETN三立新聞網 SETN.COM

## 變種病毒傳播更快！中研院揭「源頭真相」：恐繼續變異

2020/12/31 06:00:00

追蹤三立：

蘋果即時

## 中研院揪「至尊」病毒株 醫：武肺漸流感化

更新時間： 2020/12/13 03:00

台灣事實查核中心 Taiwan FactCheck Center

最新查核報告 政治與政策 生活 健康 科技資安 環境能源 國際 科學研究 研究動

研究與動態

分享：

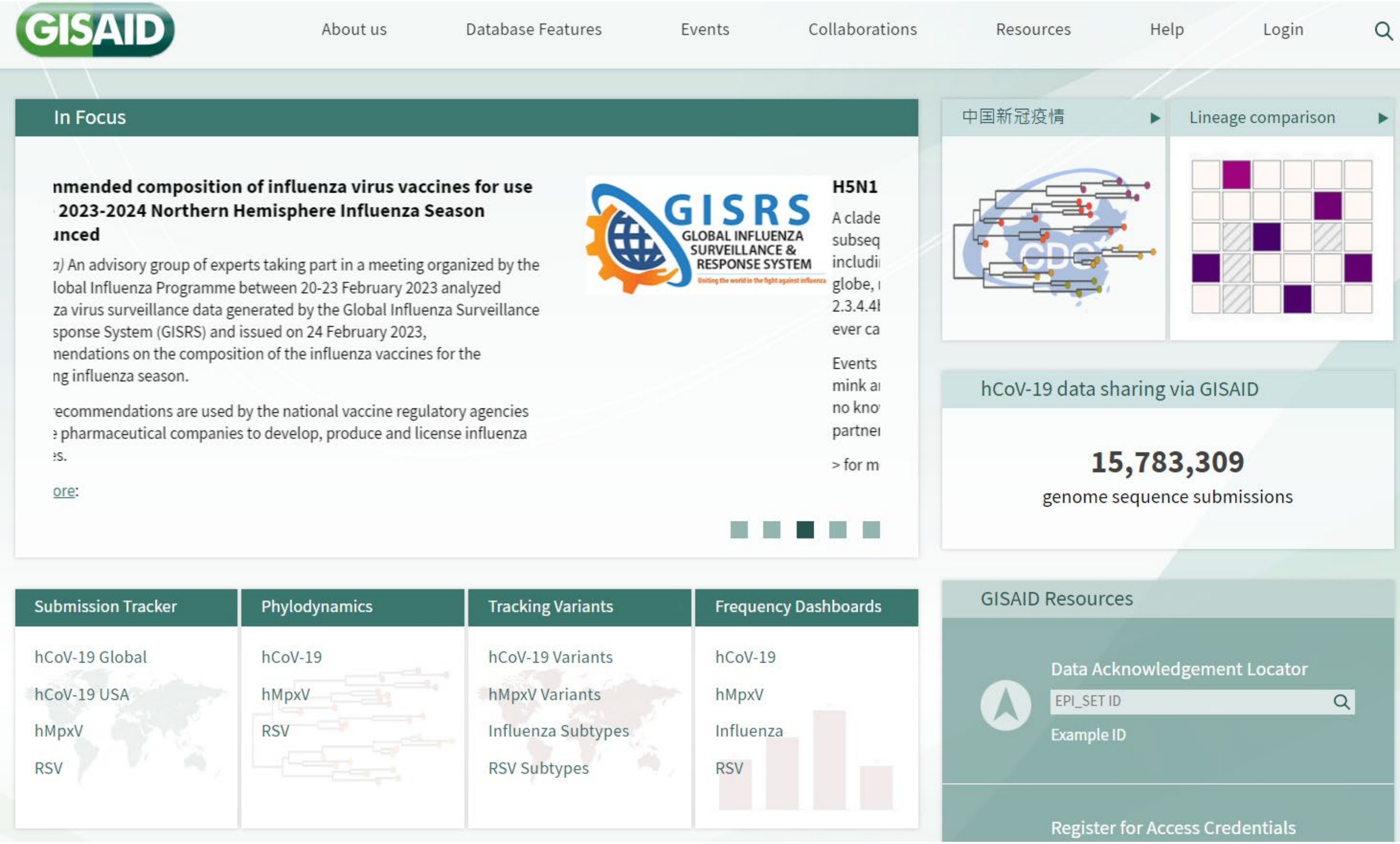
## 【中研院團隊解惑】10個Q&A 掌握變種病毒

更新日期：2021-02-19

記者馬麗昕、劉芮菁／報導

對新冠病毒的知識掌握越多，就越能幫助我們用「科學」來有效防疫。查核中心觀察社群媒體的「變種病毒」假訊息增多，為此查核中心訪問中研院「病毒即時監測跨領域團隊」成員，包括中研院統計科學研究所研究員楊欣洲，與生物醫學科學研究所研究員林宜玲，整理出10個問答，讓讀者可以簡單搞懂變種病毒。

# GISAID (Global Initiative on Sharing Avian Influenza Data)



# FASTA data → Data QC → Alignment

- **March 31, 2020: 1,932 strains:**

(For the initial classification and signature SNV analysis)

- **April 19, 2020: 6,228 strains:**

(For the main analysis)

- **June 8, 2020: 38,248 strains:**

(For a rapid strain typing)

**Genome annotation**

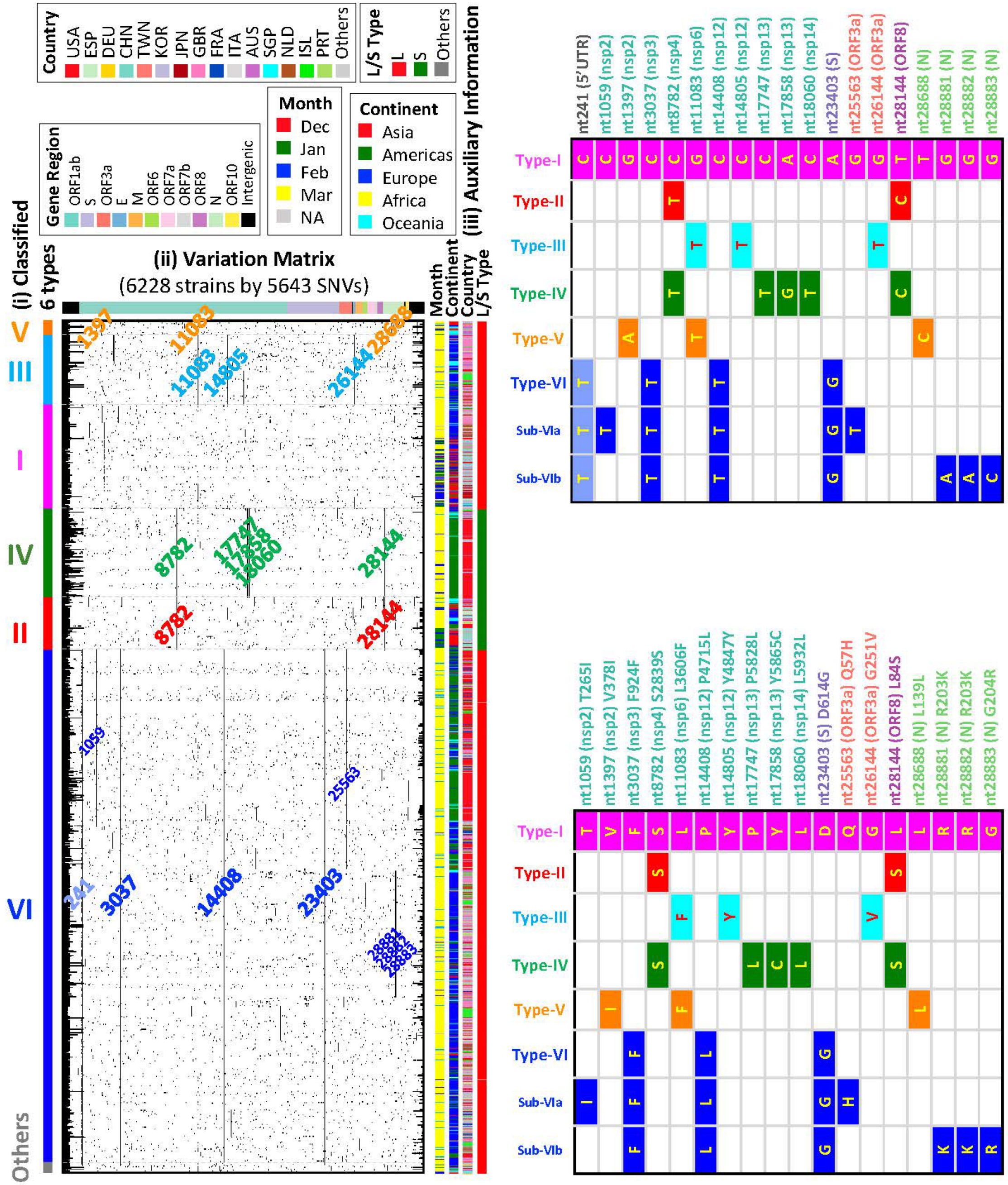
| **No.** | **Strain** | **Country** | **Date** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | … | 265 | **266** | **267** | **268** | **…** | **805** | **…** | 29675 | … | 29903 | **PP** |
| | | | | 5'UTR | … | 5'UTR | **nsp1** | **nsp1** | **nsp1** | **…** | **nsp1** | **…** | 3'END | … | 3'END | **Protein** |
| | | | | … | … | G>T | **A>T** | **T>G** | **T>G** | **…** | **G>A** | **…** | G>A | … | C>T | **NT** |
| | | | | … | … | NA | **M>L** | **M>R** | **M>R** | **…** | **G>G** | **…** | NA | … | NA | **AA** |
| **1** | **EPI_ISL_581117** | **Europe/UK /England** | **2020/09/21** | … | … | T | **A>T** | **T>G** | **NA** | **…** | **G>G** | **…** | NA? | … | NA? | |
| **2** | **EPI_ISL_601443** | **Europe/UK /England** | **2020/09/20** | … | … | T | **A>T** | **T>G** | **NA** | **…** | **-** | **…** | NA? | … | NA? | |
| : | : | : | : | : | : | : | **:** | **:** | **:** | **:** | **:** | **:** | : | : | : | |
| **>1M** | **EPI_ISL_414380** | **Asia/Singa-pore** | **2021/03/05** | … | … | G | **A>A** | **T>T** | **NA** | **…** | **G>A** | **…** | --- | … | --- | |

**Strain metadata**

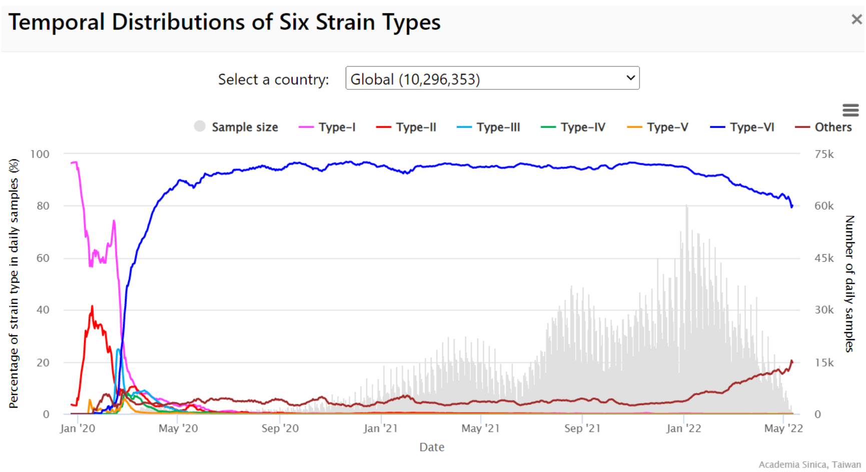
**Nucleotide sequence**

Remark: Variations were detected by comparing to the reference genome of **Wuhan-Hu-1** (Wu et al., Nature 579, 265-269 (2020)).

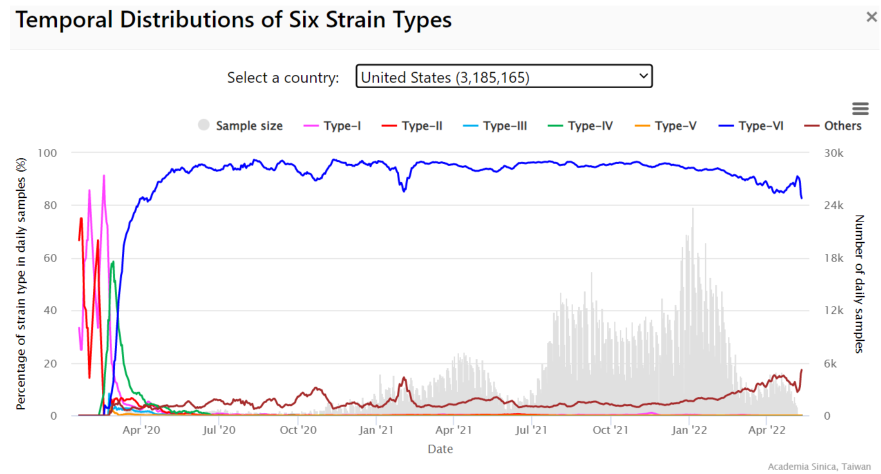
In <u>April 2020</u>, Academia Sinica identified six major types of COVID-19 virus and Type VI becomes the dominant strain in the world.



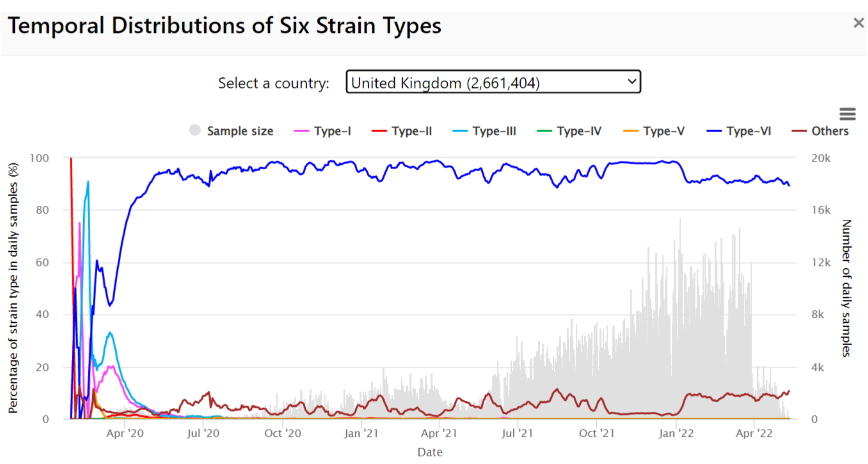
# Type VI became the dominant strain in the world



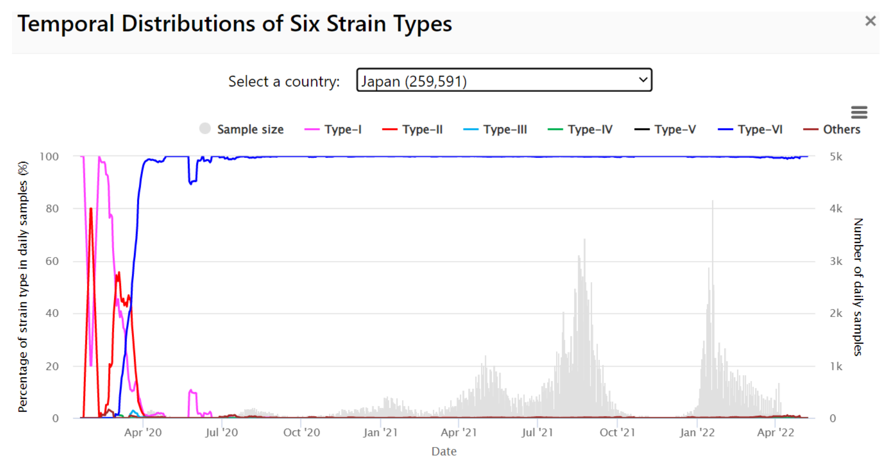

Distribution of Strain Types over time: Global




Distribution of Strain Types over time: United-States

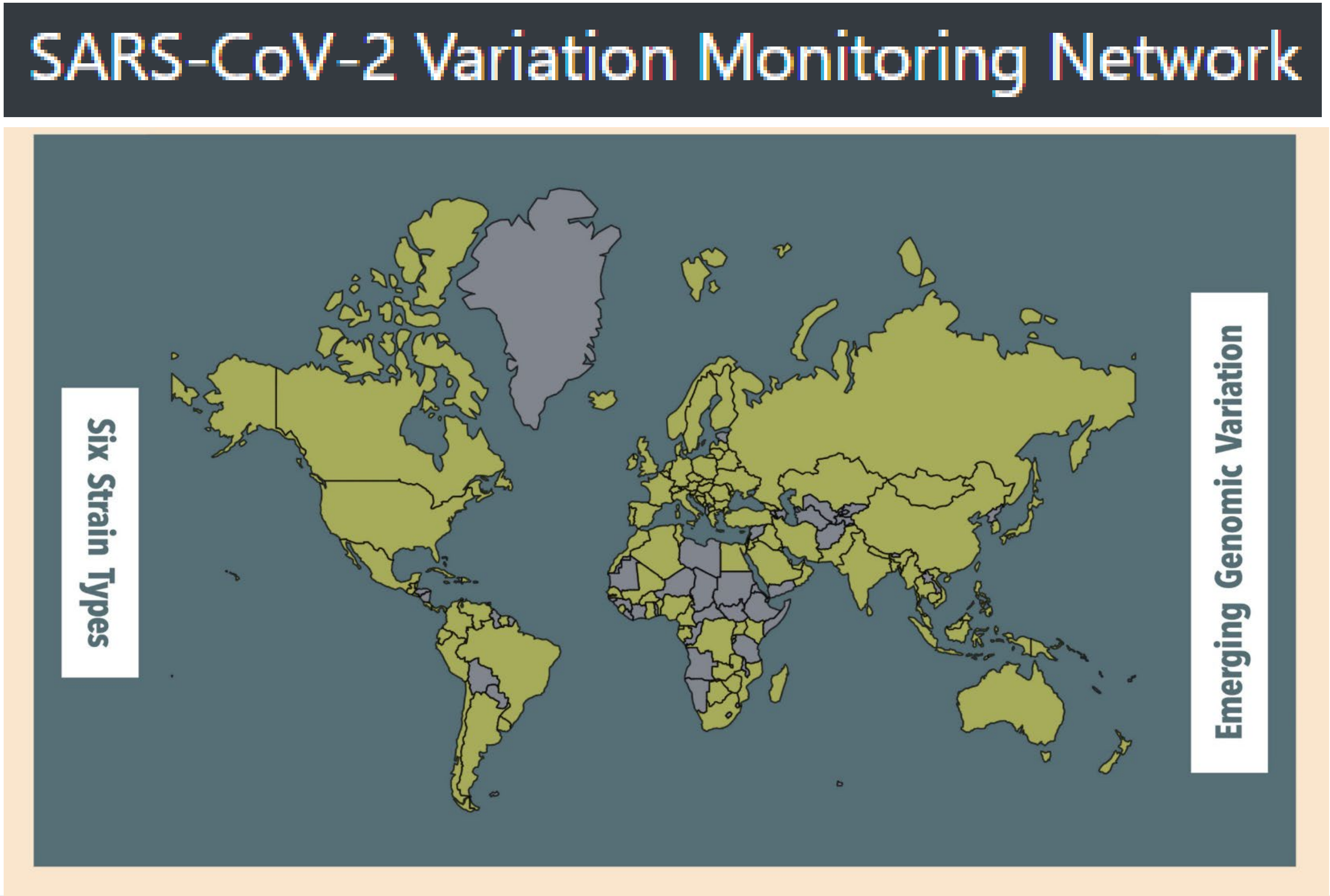



Distribution of Strain Types over time: United-Kingdom

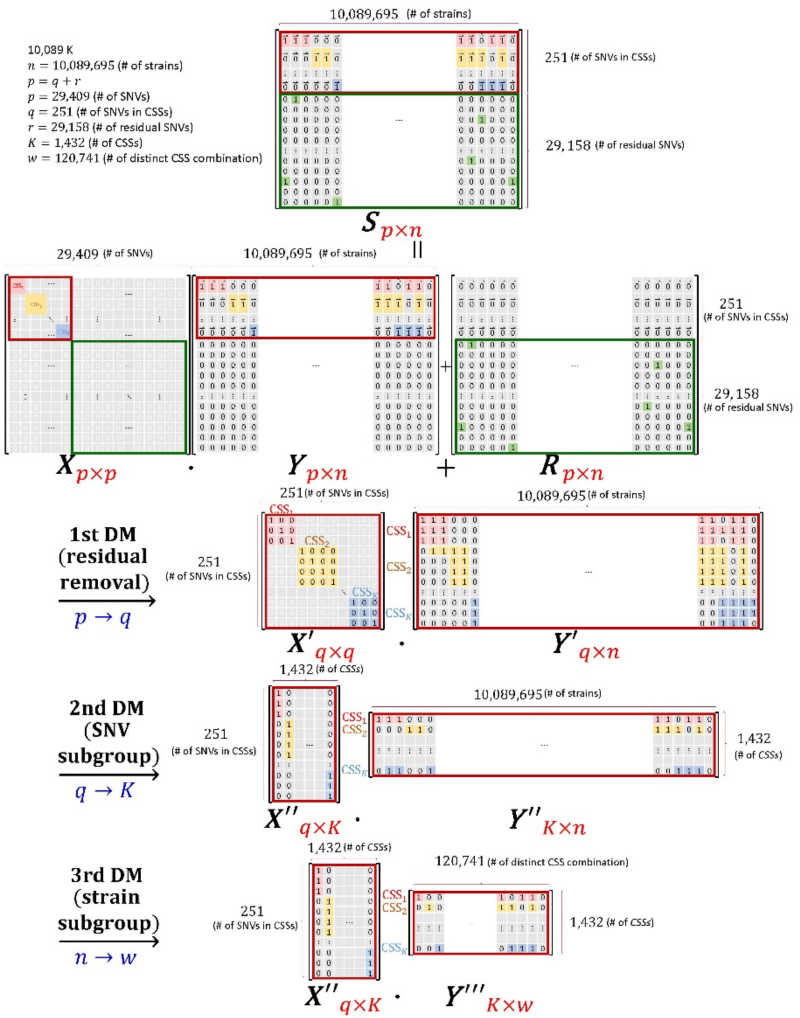



Distribution of Strain Types over time: Japan

**In December 2020, Academia Sinica established the SARS-CoV-2 Variation Monitoring Network to track the transmission dynamics and evolution of SARS-CoV-2 variants.**

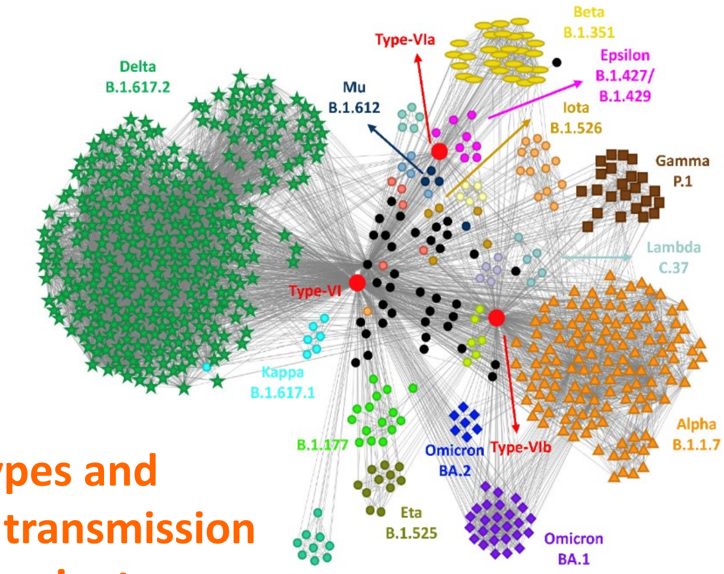


# Subtyping of major SARS-CoV-2 variants reveals different transmission dynamics based on 10 million genomes

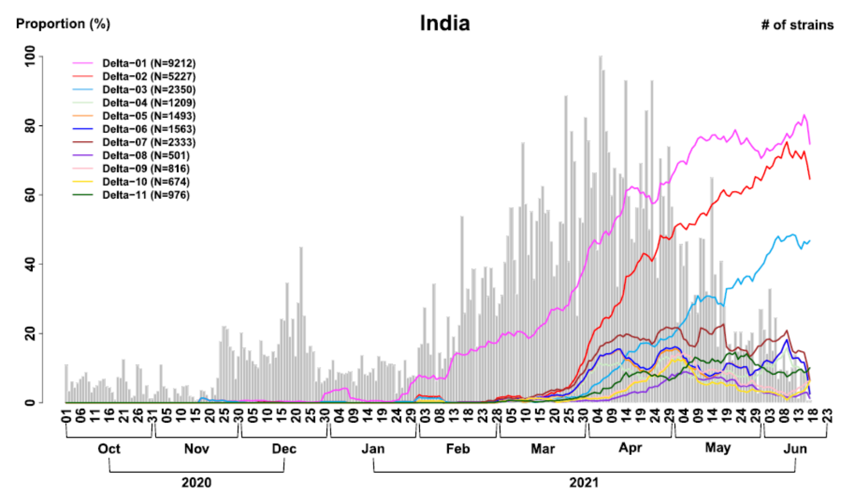



## (A) An efficient data dimensionality reduction

## (B) Virus network analysis




## (C) Subtypes and dynamic transmission of Delta variant



# Taiwan's experience with the COVID-19 pandemic (1)

**Lessons from SARS in 2003**:

- Regular reviews for **infection control** and **drills** in the medical care system have been held periodically. The hospitals could **activate immediate measures** such as triage, quick isolation, strictly controlled crowd flow, medical task force, and epidemic prevention materials to **maintain the normal operation of the medical care system**.
- Residents remained **self-alert** during the disease pandemic, voluntarily put on **face masks**, **wash hands** properly, and practiced **social distancing**.

# Taiwan's experience with the COVID-19 pandemic (2)

- In January 2020, when news of a "new and unknown respiratory disease emerging in China" was first disclosed, an inter-ministerial **Central Epidemic Command Center** was activated, providing four important principles — **Rapid measures**, **Early deployment**, **Prudent actions**, and **Transparency** for blocking virus spread into Taiwan.
- **Taiwan CDC** began to implement relevant prevention strategies, including **Surveillance and laboratory diagnosis**, **Border control**, **Control of community transmission**, **Medical system response and preparedness**, and **Health education and fighting disinformation**.
- When the supply of face masks met the domestic demand, Taiwan began to **donate medical supplies to more than 80 countries worldwide** to assist them in combating COVID-19 and to realize the spirit of "**Taiwan Can Help, and Taiwan is Helping!**"

Chen (2021, Nature Immunology)

# Lessons Learned from the Global COVID-19 Pandemic

- Preparedness and Early Response
- Importance of Global Cooperation
- Healthcare System Strengthening
- Vaccine Development and Distribution
- Importance of Public Health Measures
- Health Inequities and Vulnerable Populations
- Digital Transformation and Telemedicine
- Risk Communication and Misinformation
- Economic Impact and Social Resilience

**COVID-19 is not the final global health challenge we will face, highlighting the ongoing need for vigilance, preparedness, and investment in public health infrastructure to effectively respond to future infectious diseases.**

# Thank you for your attention!