COVID-19
Vaccines and Variants

Sharon A. Savage, M.D.

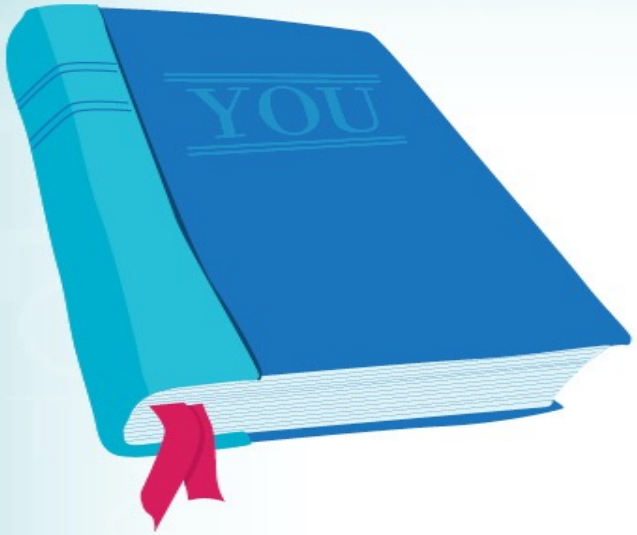
Team Telomere Medical Advisory Board Member

We are all learning about COVID-19 together

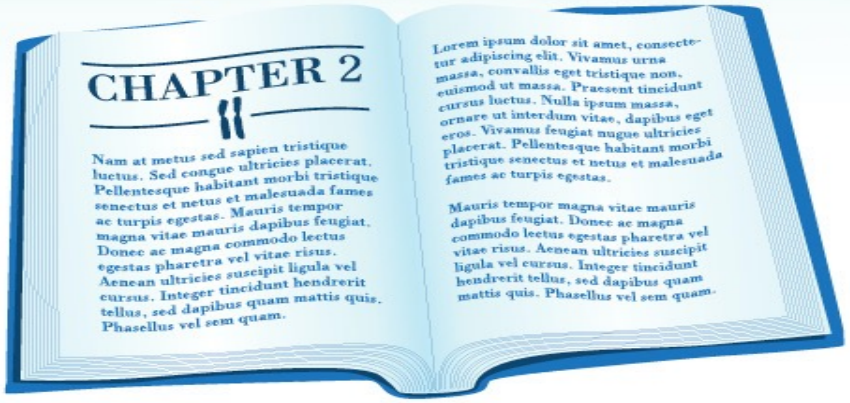
The Scientific Method

https://www.weareteachers.com/free-scientific-method-posters/

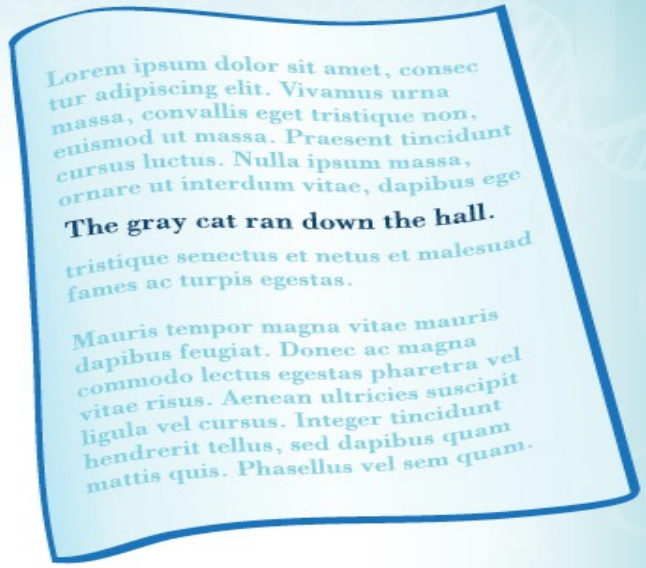
A brief refresher on DNA, RNA and proteins



BOOK – GENOME



CHAPTERS – CHROMOSOMES



SENTENCE – GENE

National Society of Genetic Counselors

The gray cat ran down the hall.

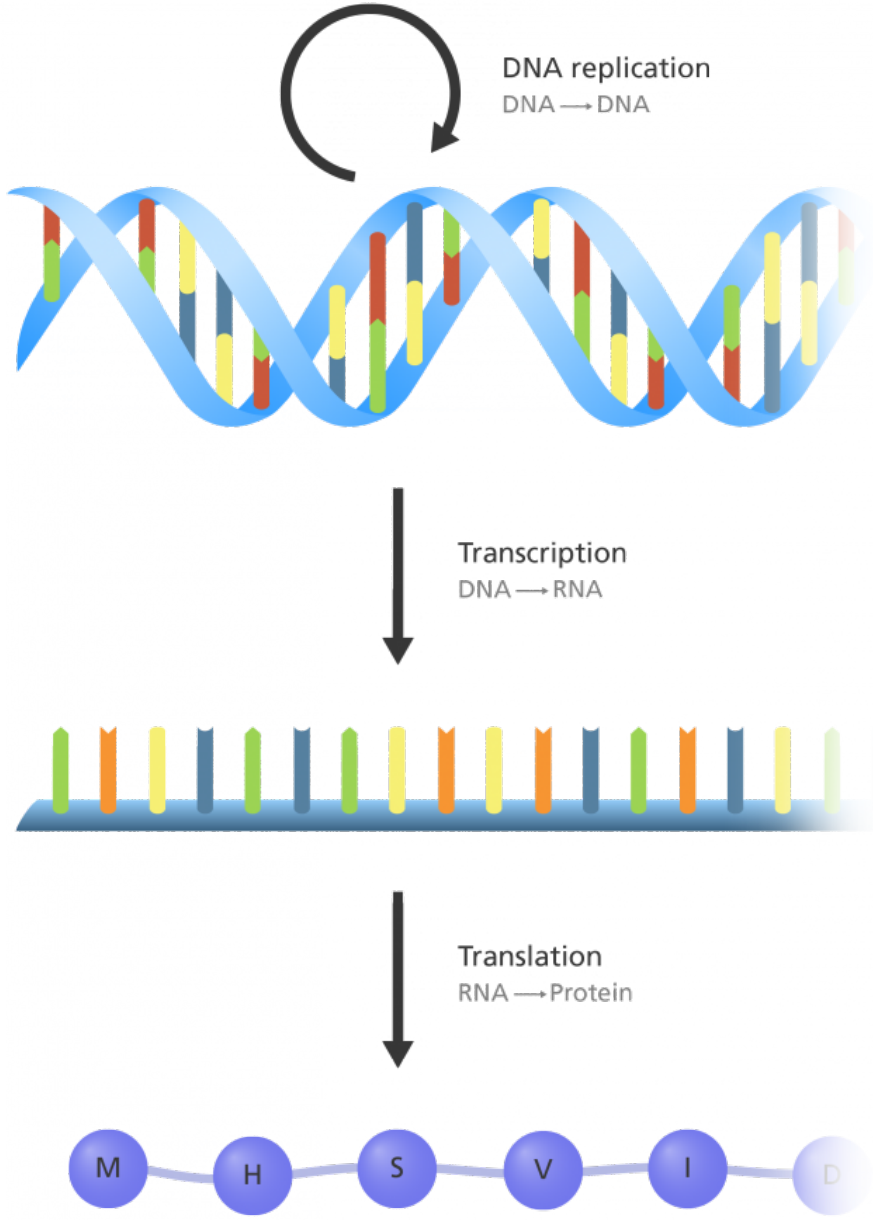
The gray cat ran down the ball.

Changes in DNA might change the way a gene works.

DNA

RNA

Protein



Transcription – uses DNA as a template to make specific mRNA molecules, specific for a gene

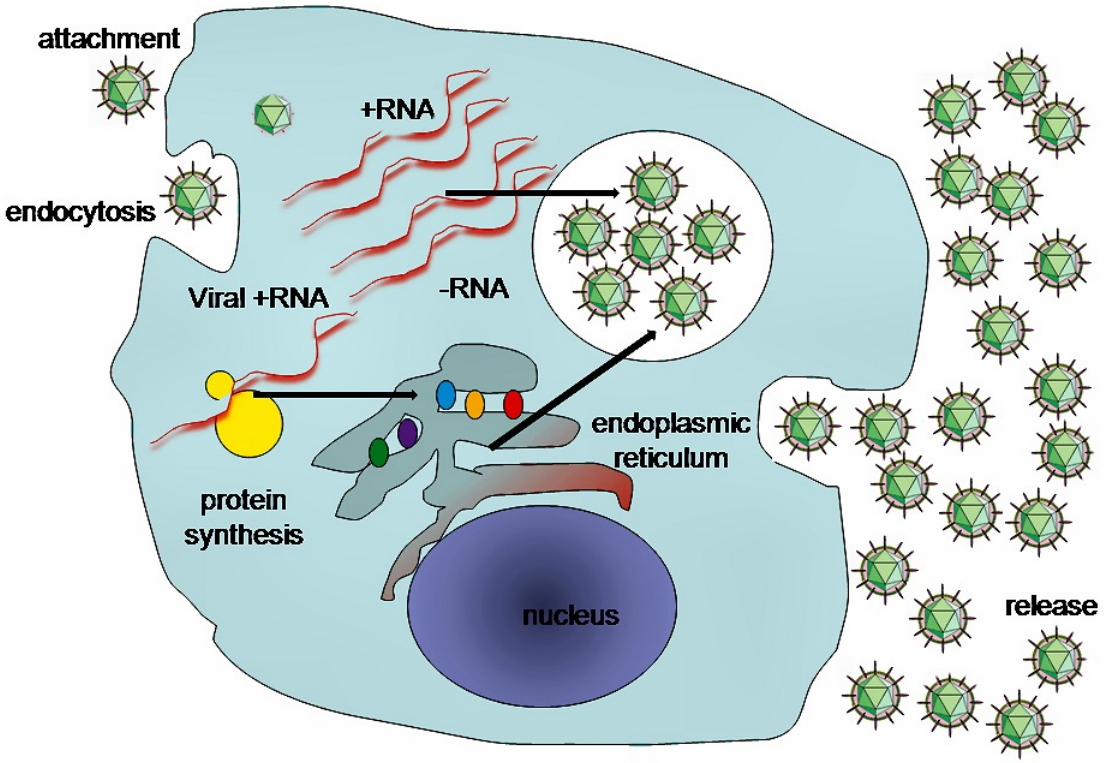
Translation – mRNA uses the information in genes to create a blueprint for making proteins. Once cells finish making a protein, they quickly break down the mRNA. mRNA from vaccines does not enter the nucleus and does not alter DNA.

Adenine (A)
Thymine (T)
Cytosine (C)
Guanine (G)
Uracil (U)

Amino acid

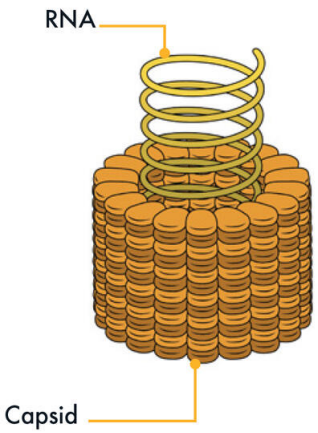
What is a virus?

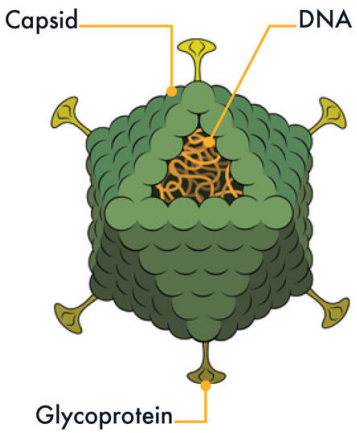
- An infectious agent that contains nucleic acid (DNA or RNA) and a protein coat
- It has no means of locomotion, must be taken in by cells to survive
- It takes over cellular replication mechanism, replicates every 2-3 hours
- There is evidence that viruses existed in humans as long as 7 million years ago

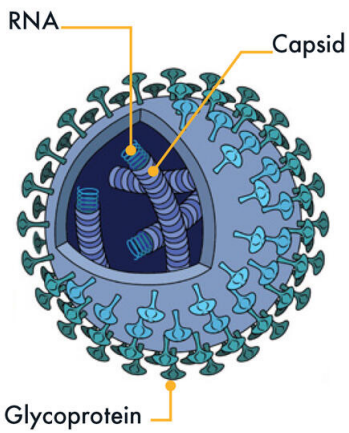


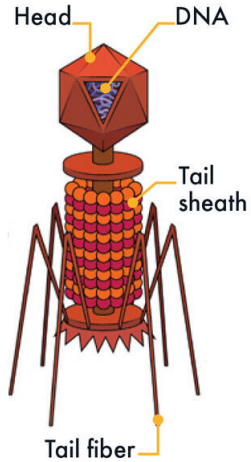
Slide courtesy of Dr. Phil Taylor

Types of Viruses









Helical viruses, like the Tobacco Mosaic Virus, which infects a number of different types of plants, have a slinky-shaped capsid that twists around and encloses its genetic material.

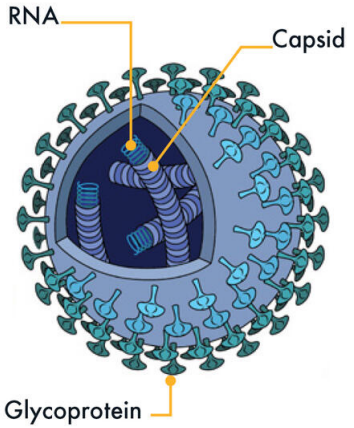
Polyhedral viruses, like adenoviruses, which are known to cause a range of illnesses from pink eye to pneumonia, are composed of genetic material surrounded by a many-sided capsid, usually with 20 triangular faces.

Spherical viruses, like the infamous Coronavirus, are essentially helical viruses enclosed in a membrane known as an envelope, which is spiked with sugary proteins that assist in sticking to and entering host cells.

Complex viruses, like bacteriophages, which infect and kill bacteria, resemble a lunar lander, and are composed of a polyhedral "head" and a helical body (or "tail sheath"), and legs (or "tail fibers") that attach to a cell membrane so that it can transfer its genetic material.

https://hmsc.harvard.edu/world-viruses

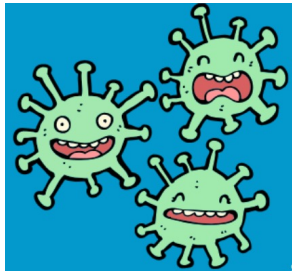
Definitions



- **Coronavirus:**
  - Any of a family (Coronaviridae) of large single-stranded RNA viruses with a lipid envelope studded with club-shaped spike proteins,
  - Infects birds and many mammals including humans
  - Includes the causative agents of MERS, SARS, and COVID-19

- **SARS-CoV-2:**
  - Severe Acute Respiratory Syndrome CoronaVirus 2, a newly discovered coronavirus
  - The cause of a novel Coronavirus outbreak began in Wuhan, China in late 2019

What is COVID-19?



- A NEW illness caused by a NOVEL virus
- The infectious disease caused by SARS-CoV-2
  - Mild to severe respiratory illness
  - Transmitted primarily by contact with infectious material (such as respiratory droplets) or with contaminated objects or surfaces
  - Characterized especially by fever, cough, and shortness of breath and may progress to pneumonia and respiratory failure

Where are we now?

episphere.github.io/mortalitytracker

Bioinformatics, 37(14), 2021, 2073–2074
doi: 10.1093/bioinformatics/btaa933
Advance Access Publication Date: 2 November 2020
Applications Note

Data and text mining

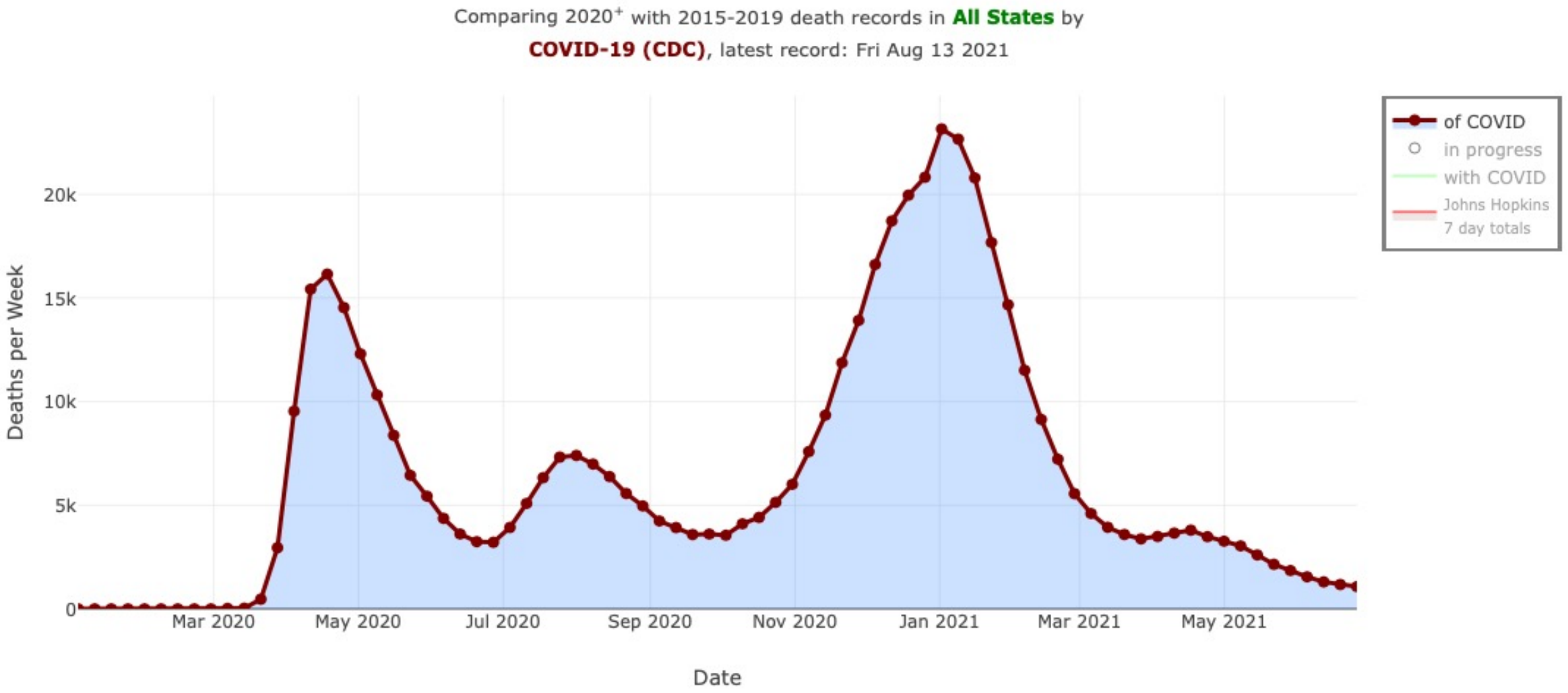
Mortality Tracker: the COVID-19 case for real time web APIs as epidemiology commons

Jonas S. Almeida[1,*], Meredith Shiels[1], Praphulla Bhawsar[1], Bhaumik Patel[1], Erika Nemeth[2], Richard Moffitt[2], Montserrat Garcia Closas[1], Neal Freedman[1] and Amy Berrington[1]

[1]Division of Cancer Epidemiology and Genetics, National Cancer Institute, Rockville, MD, USA and [2]Department of Biomedical Informatics, Stony Brook University (SUNY), Stony Brook, NY, USA

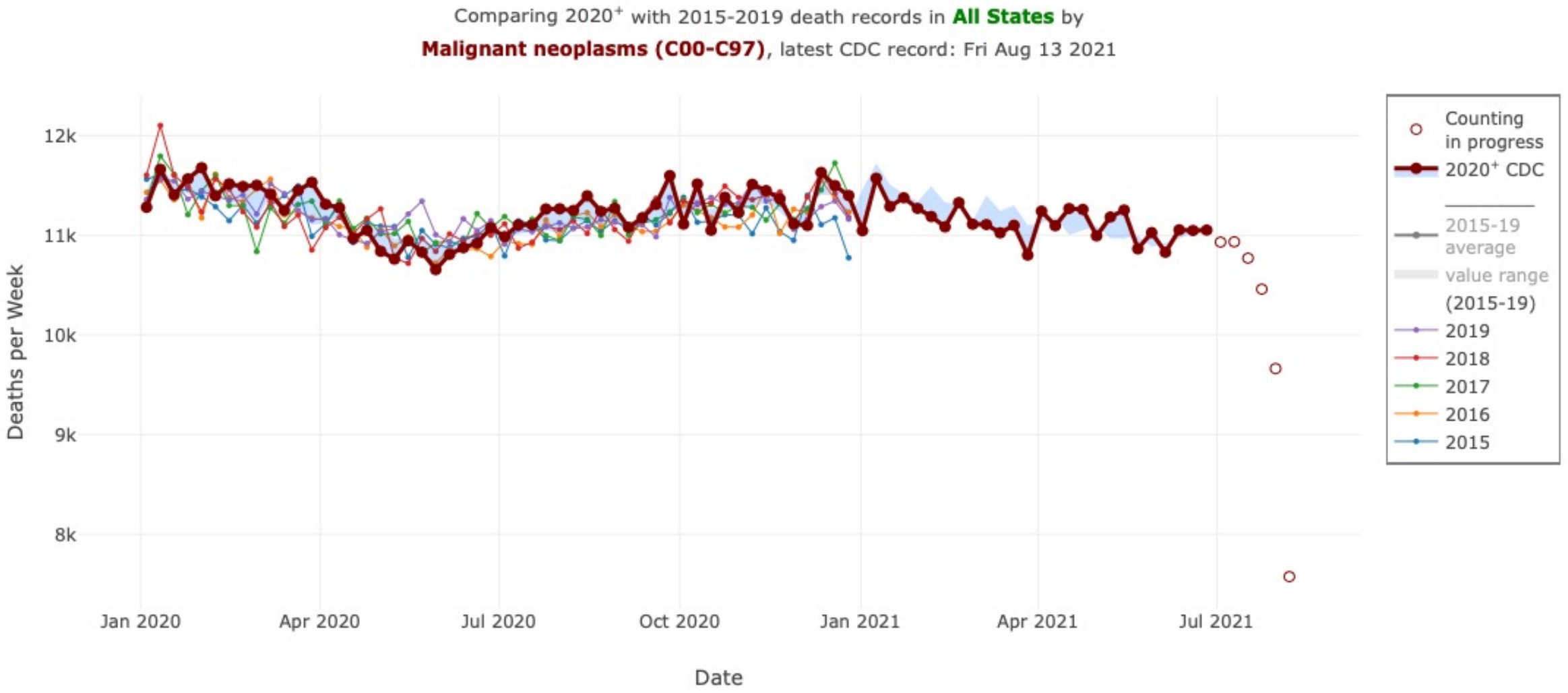
Number of deaths per week due to COVID-19

~3,000– 22,000 per week +/-



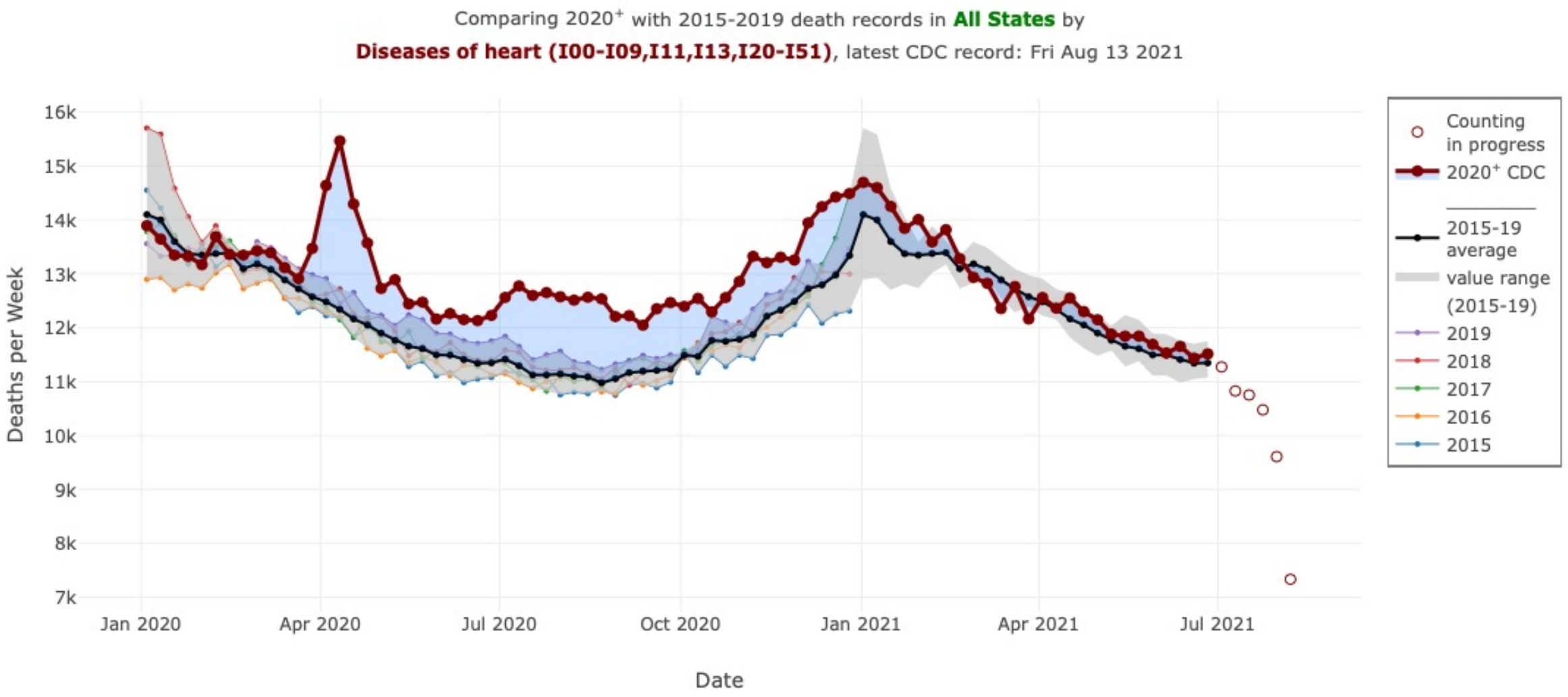
Number of deaths per week due to Cancer

~11,000 per week +/-

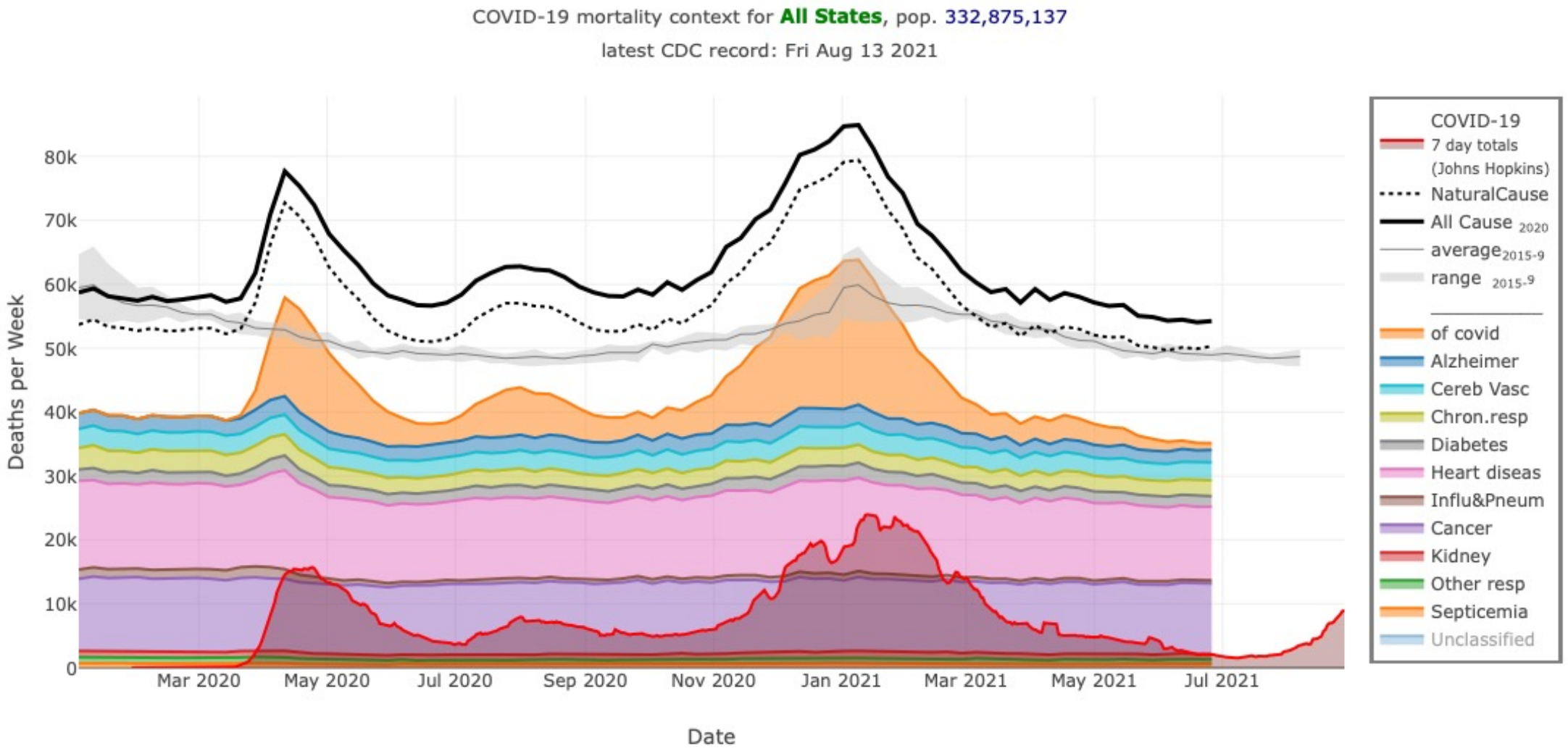


Number of deaths per week due to heart diseases

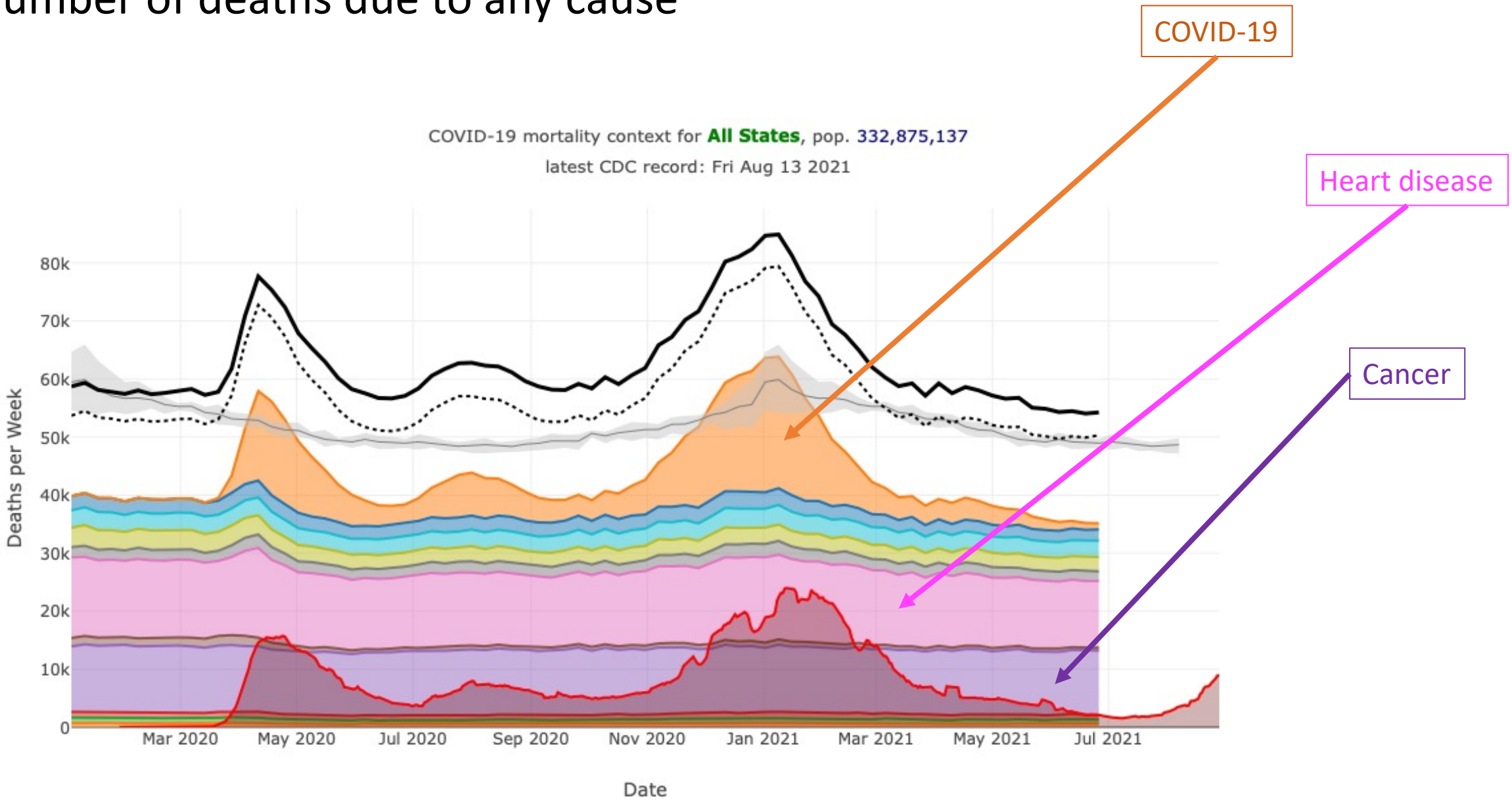
~13,000 per week +/-



Number of deaths due to any cause



Number of deaths due to any cause



How do we end the pandemic?

“An ounce of prevention is worth a pound of cure.”

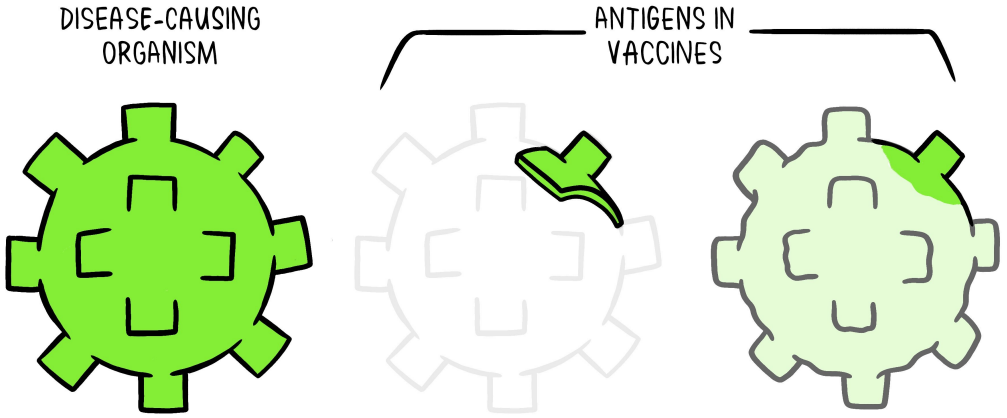
– Benjamin Franklin

How do we end the pandemic?

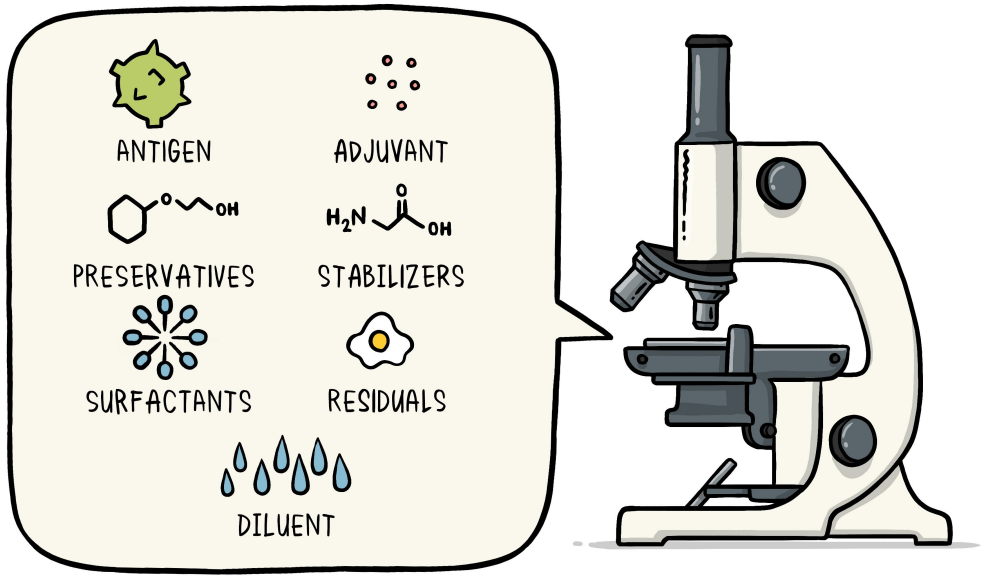
Dr. Neelam Giri receiving her first Moderna COVID-19 vaccine at the NIH

How do vaccines work?

How are vaccines developed?

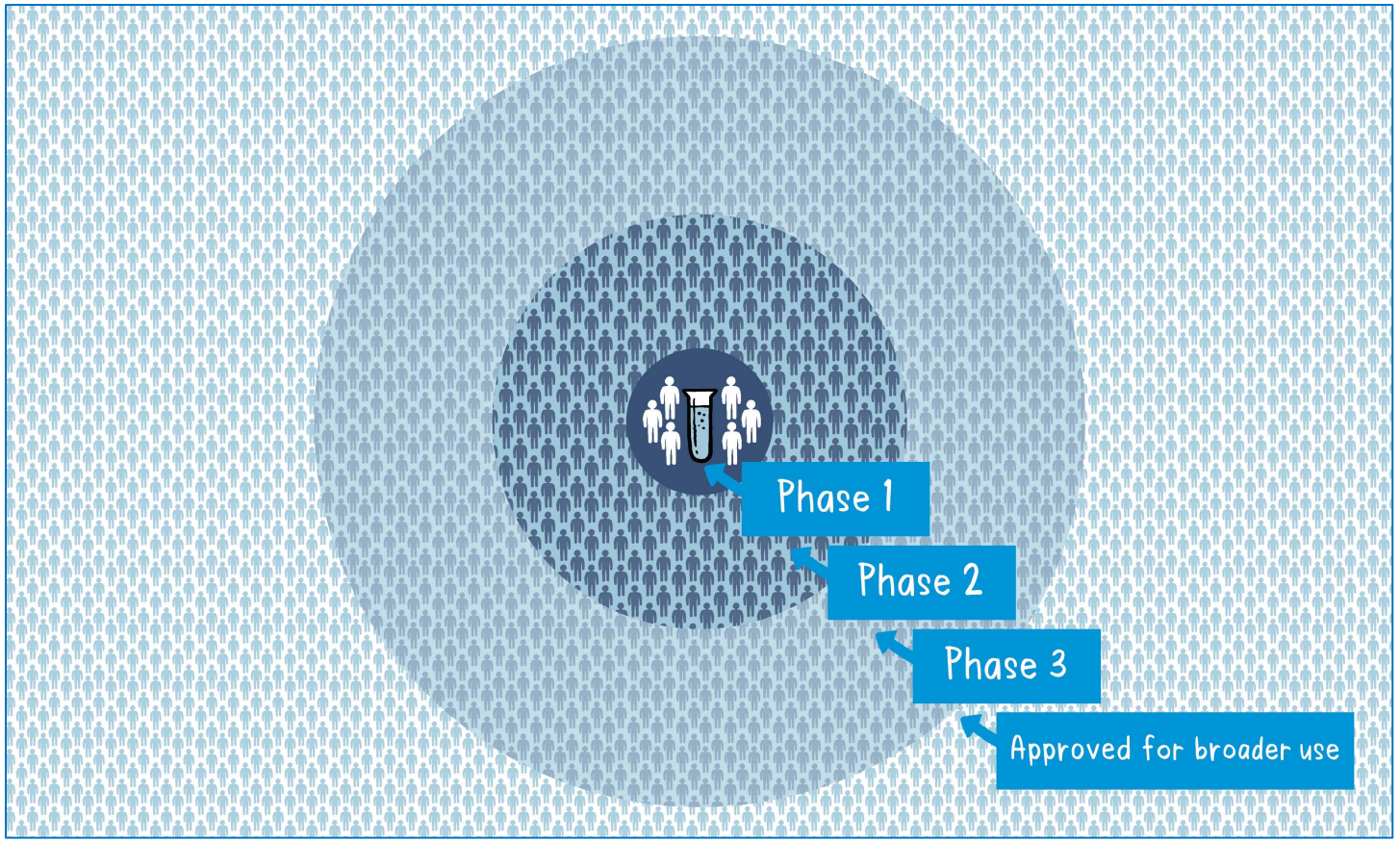


The key ingredient in a vaccine is the antigen. It's either a tiny part of the disease-causing organism, or a weakened, non-dangerous version, so your body can learn the specific way to fight it without getting sick.



https://www.who.int/news-room/feature-stories/detail/how-are-vaccines-developed

Human clinical trial phases of testing required for approval by the FDA

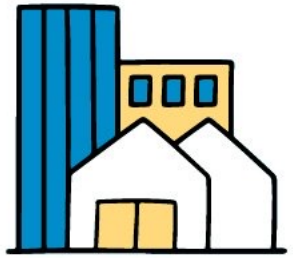


Trial phase	No. of persons	Duration	Study goal
Phase I	10s	<1 yr	Find best dose with fewest side effects (safety)
Phase II	100s	~2 yrs	Further tests safety as well as efficacy
Phase III	100s to 1000s	1-3 yrs	Confirms & expands safety/efficacy from Phase I/II studies into randomized/blinded studies that allows comparison of treatment group with a control group

Vaccine efficacy and effectiveness

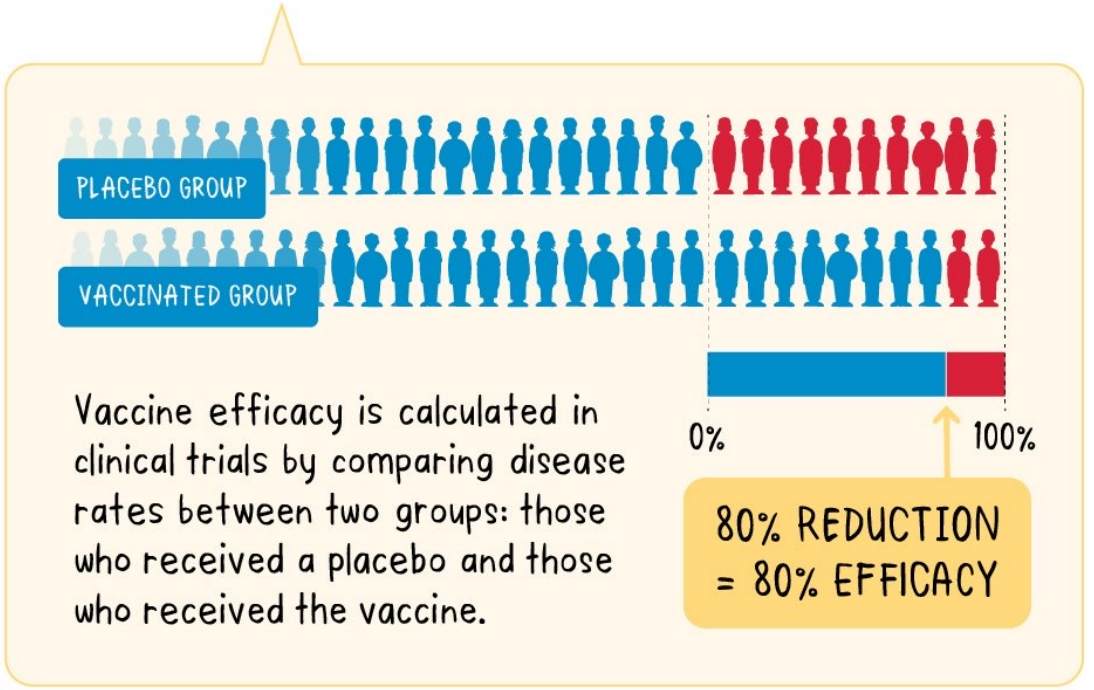
Vaccine efficacy

refers to how the vaccine performs in ideal conditions – controlled clinical trials.



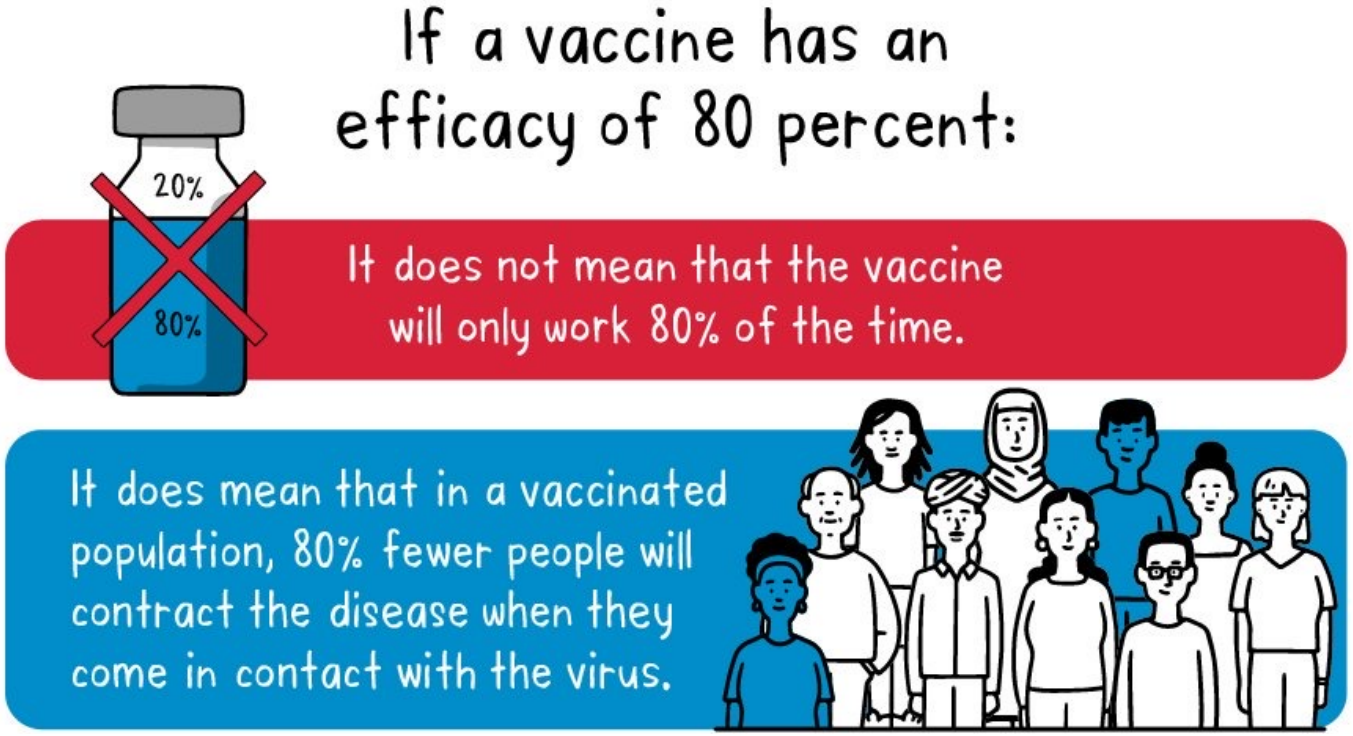
Vaccine effectiveness

refers to how the vaccine performs in the wider populations.



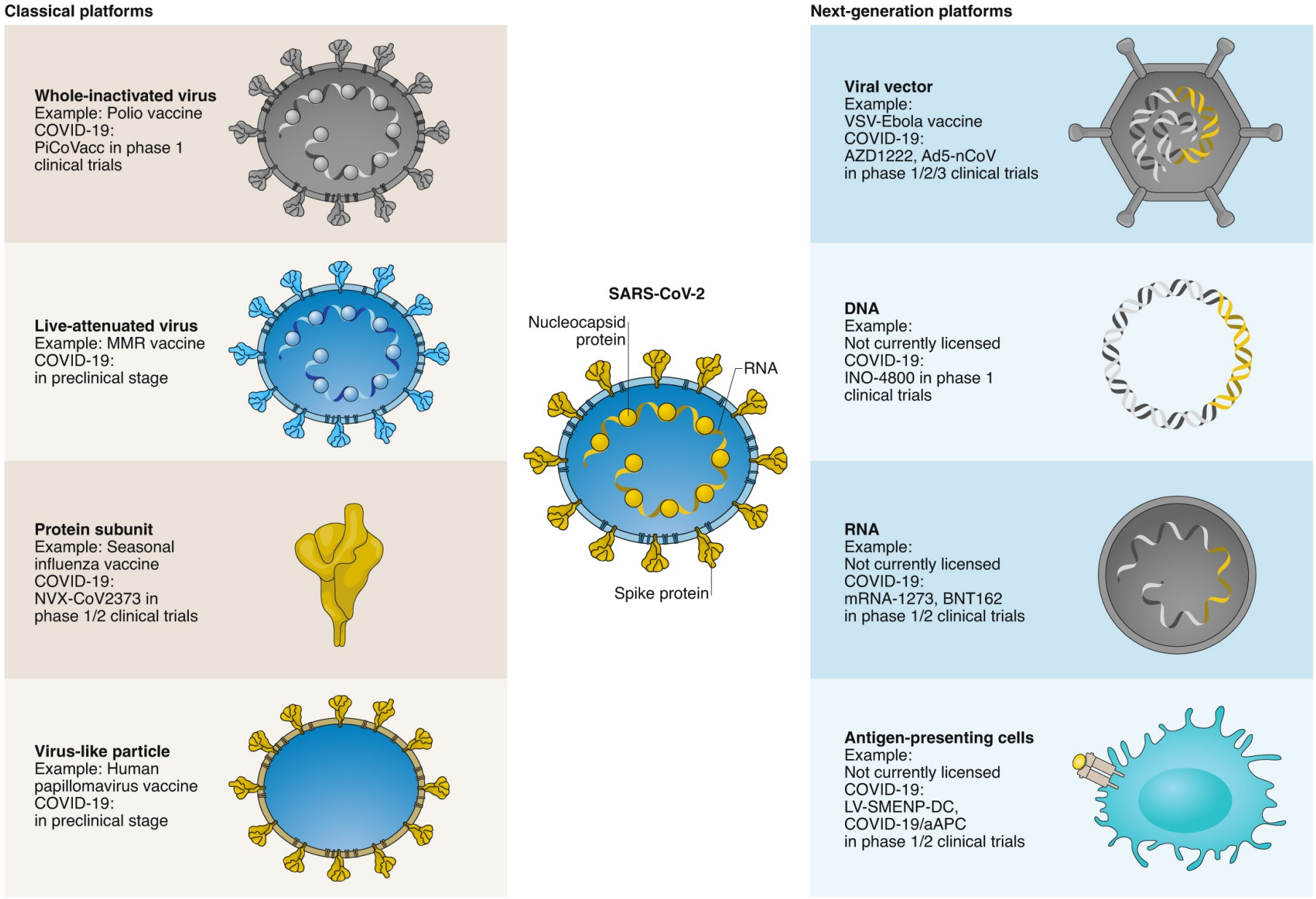
https://www.who.int/news-room/feature-stories/detail/vaccine-efficacy-effectiveness-and-protection

Vaccine efficacy and effectiveness



https://www.who.int/news-room/feature-stories/detail/vaccine-efficacy-effectiveness-and-protection

Types of Vaccines



Nature Materials. **19,** 810–812 (2020)

mRNA vaccines are safe

- mRNA is a non-infectious, non-integrating platform
- there is ***no potential risk of infection or insertional mutagenesis***
- mRNA is ***degraded by normal cellular processes***, and its *in vivo* half-life can be regulated through the use of various modifications and delivery methods
- the inherent immunogenicity of the mRNA can be adjusted to further increase the safety profile

Pardi, N., Hogan, M., Porter, F. *et al.* mRNA vaccines — a new era in vaccinology. *Nat Rev Drug Discov* **17,** 261–279 (2018).

COVID-19 mRNA Vaccines

- mRNA vaccines inject cells with instructions to generate a protein that is normally found on the surface of SARS-CoV-2, the virus that causes COVID-19.

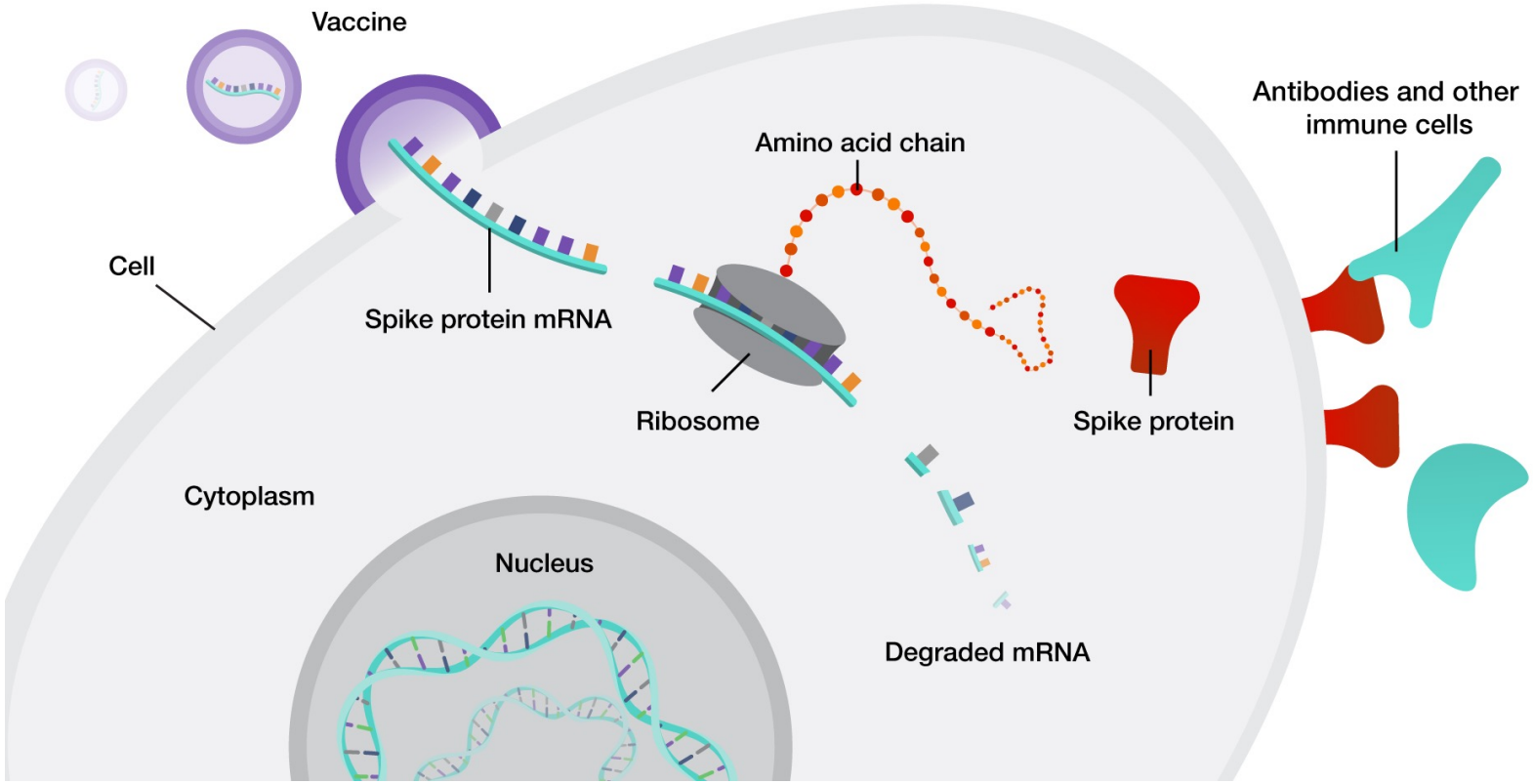
- The protein that the person makes in response to the vaccine can cause an immune response without a person ever having been exposed to the virus that causes COVID-19. Later, if the person is exposed to the virus, their immune system will recognize the virus and respond to it.

- mRNA vaccines are safe and cannot alter your DNA, and you cannot get COVID-19 from the vaccine.

- mRNA vaccines may seem to have arrived quickly, but this technology is built on decades of scientific research that have made these vaccines a reality.

https://www.genome.gov/about-genomics/fact-sheets/Understanding-COVID-19-mRNA-Vaccines

COVID-19 mRNA Vaccines

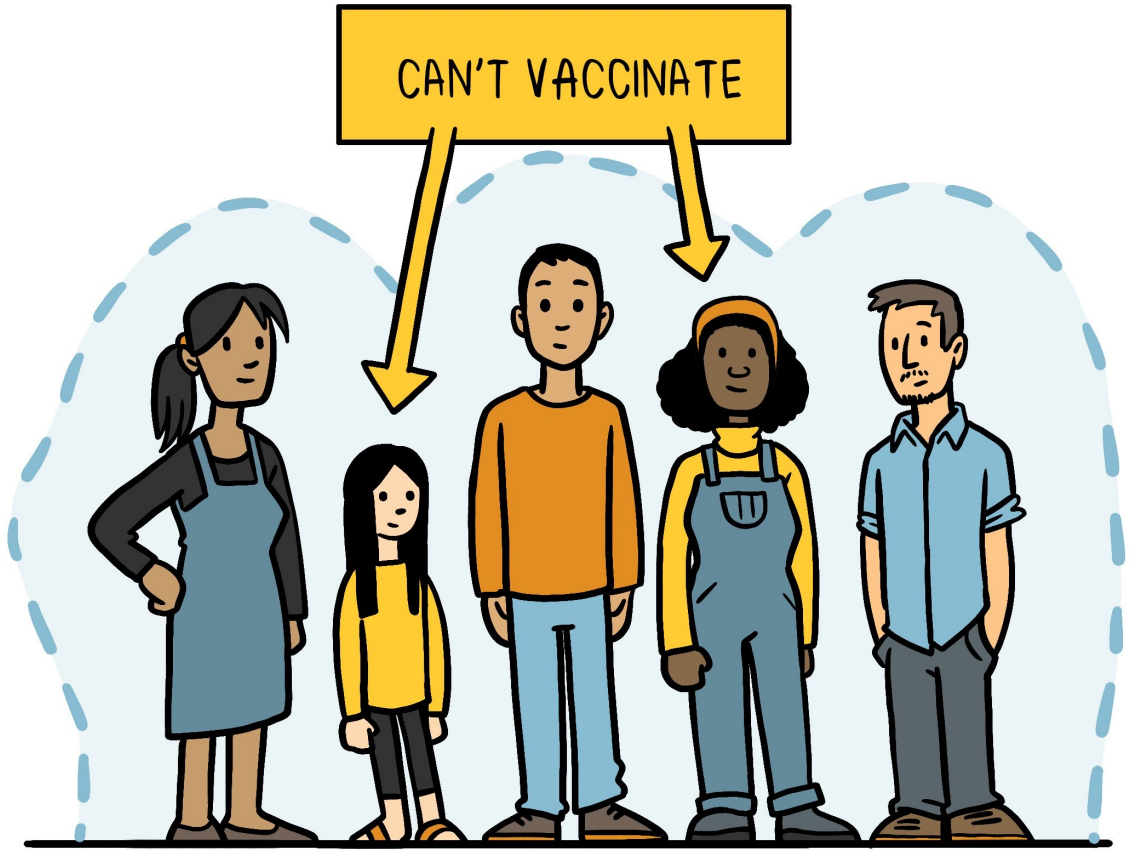


https://www.genome.gov/about-genomics/fact-sheets/Understanding-COVID-19-mRNA-Vaccines

Vaccines - https://youtu.be/CrsnwQZIak8

3 minute video

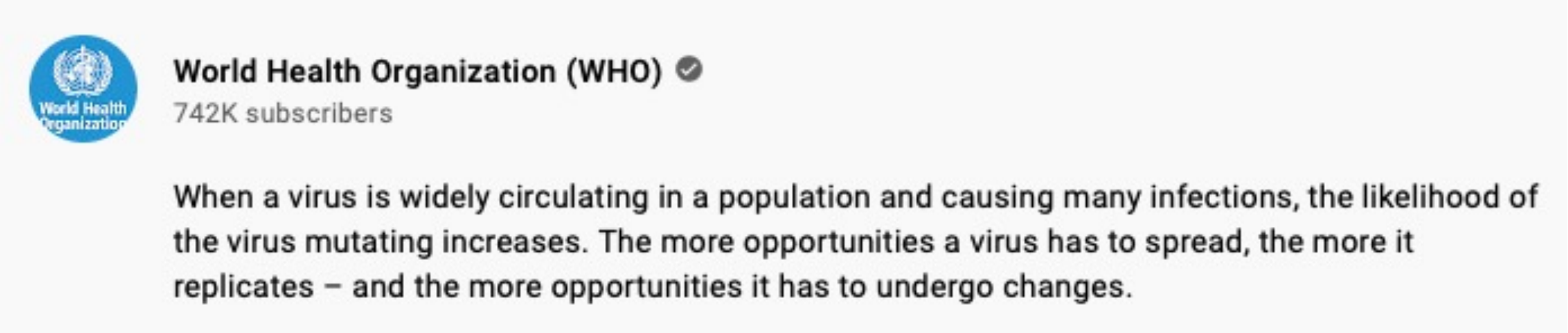
A vaccine protects an individual...



Community vaccination protects the whole community,
even those who can't vaccinate.

https://www.who.int/news-room/feature-stories/detail/how-do-vaccines-work

What causes a virus to change?



https://youtu.be/qD8dAbov5JU

https://youtu.be/01b-74ljqWc

https://youtu.be/xLvY210yQkE

What causes a virus to change?

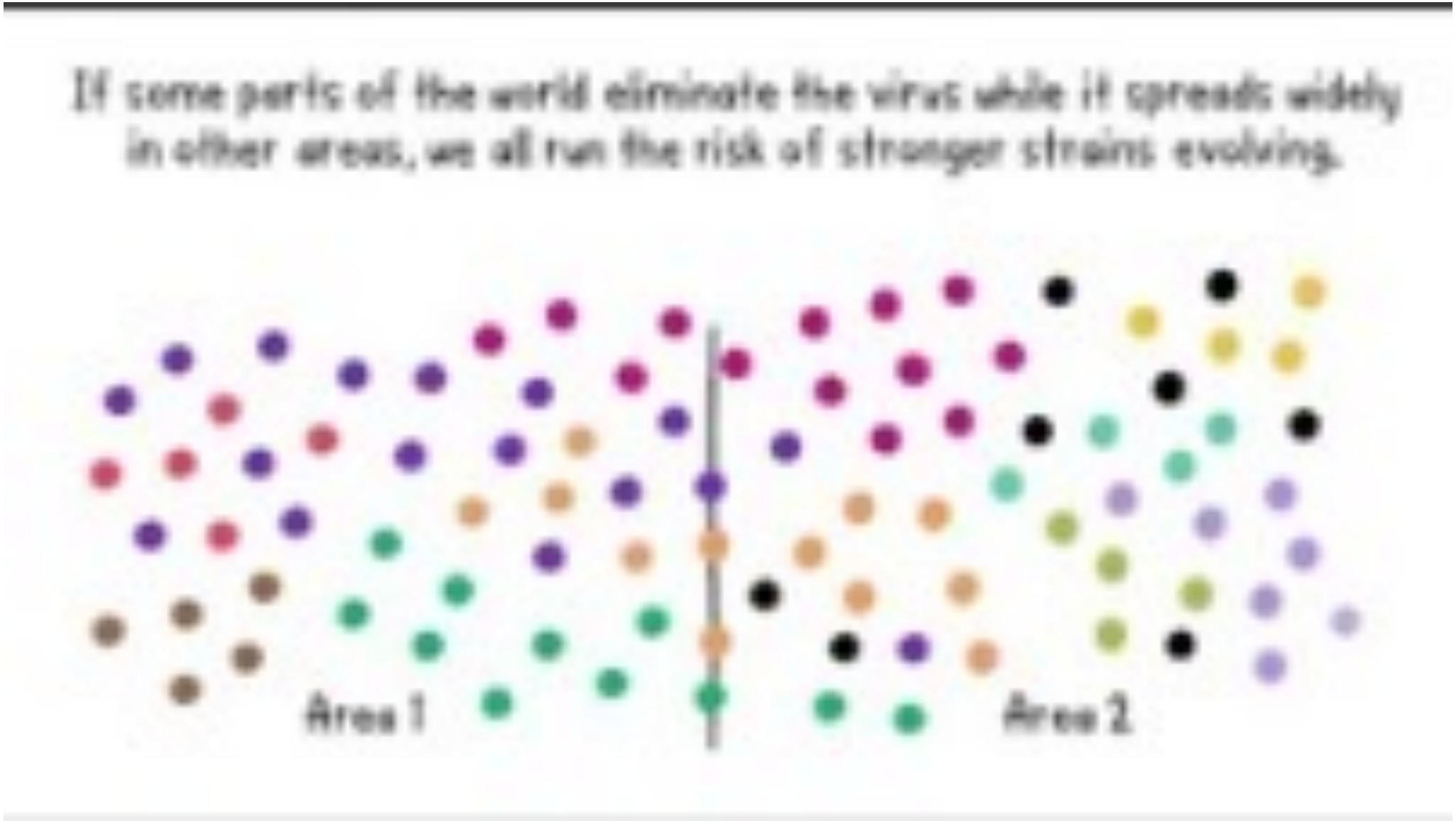
Most of the time, these tiny variations don't alter how the virus works.

https://youtu.be/qD8dAbov5JU

Stop the spread of viral variants

https://youtu.be/01b-74ljqWc

Stopping viral variants is a group effort



https://youtu.be/xLvY210yQkE

Why should I get vaccinated?

"The number of children experiencing a parent dying of COVID-19 is staggering, with an estimated 37,300 to 43,000 already affected."

From: **Estimates and Projections of COVID-19 and Parental Death in the US**

JAMA Pediatr. 2021;175(7):745-746. doi:10.1001/jamapediatrics.2021.0161

Table. Estimated Number of Children Aged 0 to 17 Years Who Will Lose a Parent Owing to the COVID-19 Pandemic Under Various Scenarios

Characteristic	Estimated children experiencing parental loss, median (range)[a]		
	Age 0-17 y	Age 0-9 y	Age 10-17 y
Bereavement multiplier	0.078 (0.059-0.126)	0.021 (0.016-0.054)	0.057 (0.043-0.071)
Morality owing to the COVID-19 pandemic			
Current mortality estimates from February 2020 to February 2021[2]			
479 000 Recorded COVID-19 deaths	37 337 (28 195-60 119)	9863 (7717-25 923)	27 474 (20 478-34 196)
552 000 Estimated excess deaths[b]	43 027 (32 492-69 281)	11 366 (8893-29 873)	31 661 (23 599-39 408)
Future mortality scenarios			
1 500 000 COVID-19 deaths	116 922 (88 295-188 264)	30 887 (24 167-81 177)	86 035 (64 128-107 086)

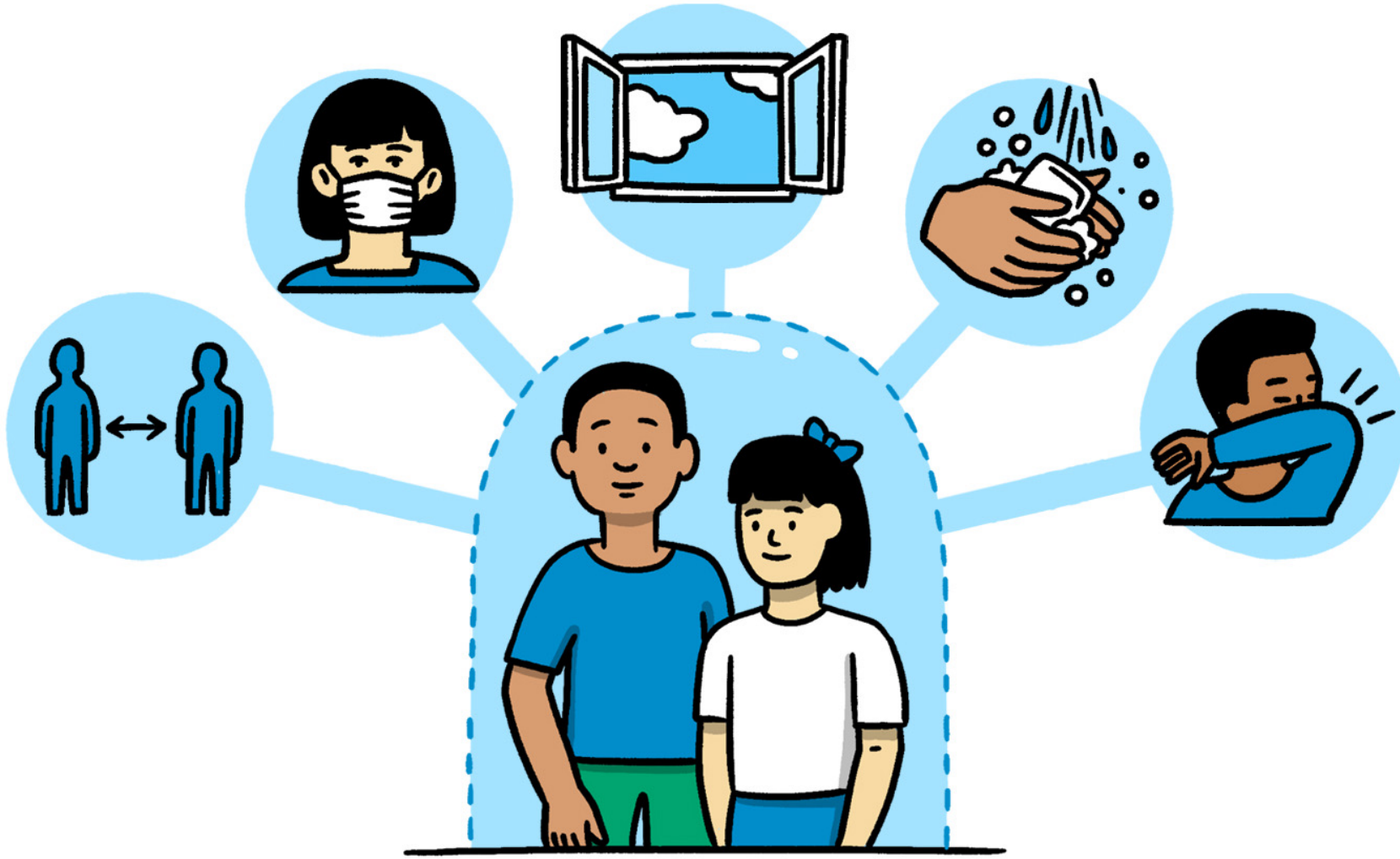
[a] Estimates are based on the median of 40 simulations with the ranges of simulation results given in parentheses.

[b] Excess deaths refer to the difference between the number of observed deaths and the number of expected deaths for the same time period, and thus captures all-cause mortality that is both directly and indirectly due to the pandemic.

Estimated Number of Children Aged 0 to 17 Years Who Will Lose a Parent Owing to the COVID-19 Pandemic Under Various Scenarios
[a] Estimates are based on the median of 40 simulations with the ranges of simulation results given in parentheses.
[b] Excess deaths refer to the difference between the number of observed deaths and the number of expected deaths for the same time period, and thus captures all-cause mortality that is both directly and indirectly due to the pandemic.

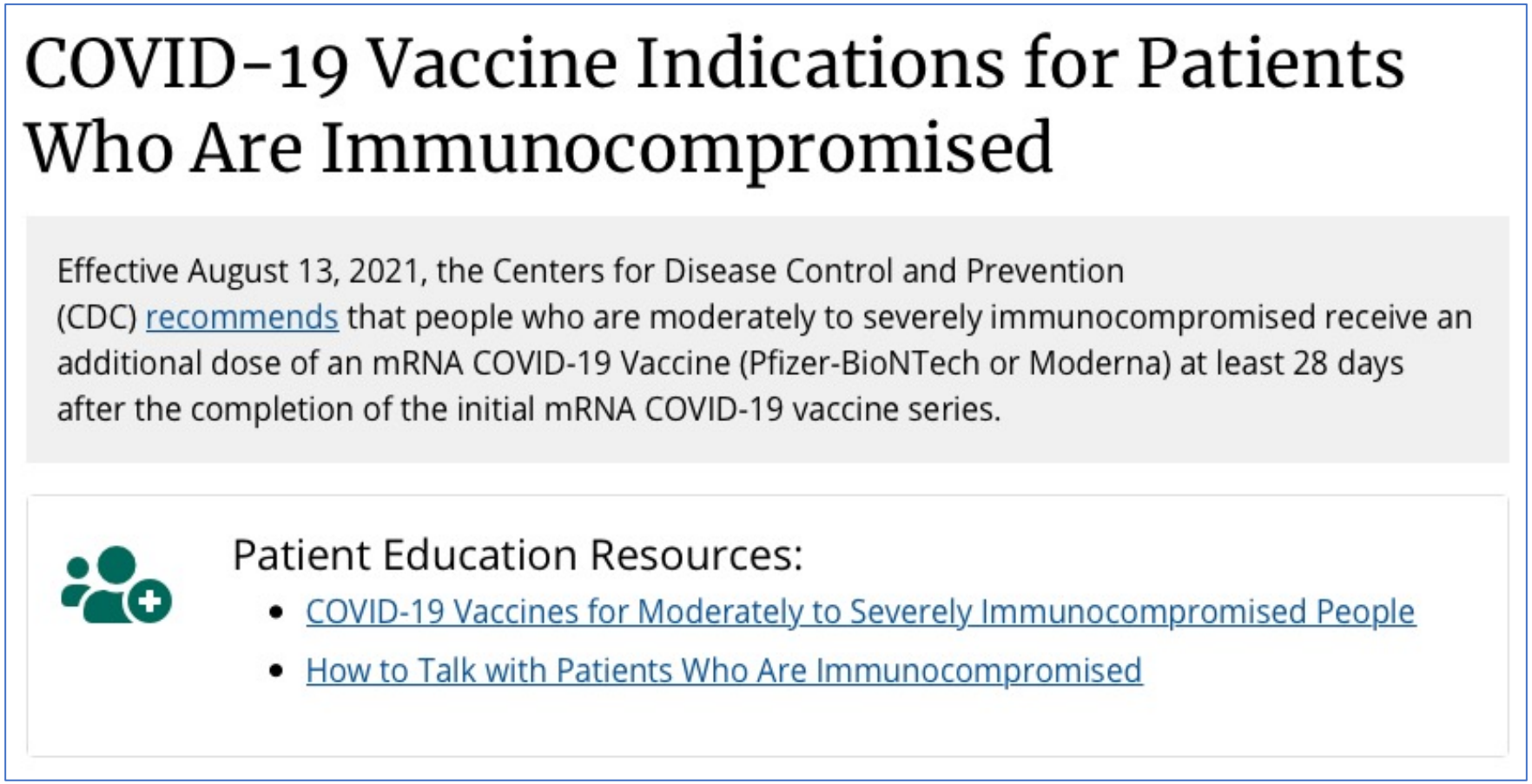
Results

Our model suggests that each COVID-19 death leaves 0.078 children aged 0 to 17 parentally bereaved. This represents a 17.5% to 20.2% increase in parental bereavement absent COVID-19. Although the bereavement multiplier is small, it translates into large numbers of children who have lost a parent. As of February 2021, 37300 children aged 0 to 17 years had lost at least 1 parent due to COVID-19, three-quarters of whom were adolescents (**Table**). Of these, 20600 were non-Hispanic White children and 7600 were non-Hispanic Black children. When we rely on excess deaths, we estimate that 43000 children have lost a parent. A natural herd immunity strategy that results in 1.5 million deaths[4] demonstrates the potential effect of inaction: 116900 parentally bereaved children.



COVID-19 vaccine trials for children are still under way.
For now, following proven health measures is the best way to keep them safe.

Special topics – Immunocompromised people



COVID-19 Vaccine Indications for Patients Who Are Immunocompromised

Effective August 13, 2021, the Centers for Disease Control and Prevention (CDC) recommends that people who are moderately to severely immunocompromised receive an additional dose of an mRNA COVID-19 Vaccine (Pfizer-BioNTech or Moderna) at least 28 days after the completion of the initial mRNA COVID-19 vaccine series.

Patient Education Resources:

- COVID-19 Vaccines for Moderately to Severely Immunocompromised People
- How to Talk with Patients Who Are Immunocompromised

https://www.cdc.gov/vaccines/covid-19/clinical-considerations/immunocompromised.html
https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/immuno.html
https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-07/07-COVID-Oliver-508.pdf

Who Needs an Additional COVID-19 Vaccine?

Currently, CDC is recommending that moderately to severely immunocompromised people receive an additional dose. This includes people who have:

- Been receiving active cancer treatment for tumors or cancers of the blood
- Received an organ transplant and are taking medicine to suppress the immune system
- Received a stem cell transplant within the last 2 years or are taking medicine to suppress the immune system
- Moderate or severe primary immunodeficiency (such as DiGeorge syndrome, Wiskott-Aldrich syndrome)
- Advanced or untreated HIV infection
- Active treatment with high-dose corticosteroids or other drugs that may suppress your immune response

People should talk to their healthcare provider about their medical condition, and whether getting an additional dose is appropriate for them.

https://www.cdc.gov/vaccines/covid-19/clinical-considerations/immunocompromised.html
https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/immuno.html
https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-07/07-COVID-Oliver-508.pdf

Special topics – Immunocompromised people

- **When can I get a 3rd dose?**
  - *At least 4 weeks after your second dose*

- **Can you mix and match Pfizer and Moderna vaccines?**
  - *No. Current recommendation is to use the same vaccine*

- **What about the J&J/Janssen single vaccine?**
  - *There aren't enough data to make a recommendation yet*

https://www.cdc.gov/vaccines/covid-19/clinical-considerations/immunocompromised.html
https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/immuno.html
https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-07/07-COVID-Oliver-508.pdf

Special topics – Immunocompromised people

- **Why should an immunocompromised person get a 3rd dose?**
  - *Their immune system may need extra help in responding to the vaccine.*

- **What are the risks of a 3rd dose?**
  - *The safety, efficacy, and benefit of additional doses of COVID-19 vaccine in immunocompromised people continues to be evaluated.*
  - *So far, reactions reported after the third mRNA dose were similar to that of the two-dose series: fatigue and pain at injection site were the most commonly reported side effects, and overall, most symptoms were mild to moderate.*

https://www.cdc.gov/vaccines/covid-19/clinical-considerations/immunocompromised.html
https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations/immuno.html
https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-07/07-COVID-Oliver-508.pdf

Special topics – Kids and schools

www.healthychildren.org

Special topics – Kids and schools

Schools and Child Care Programs

Plan, Prepare, and Respond

Updated Aug. 25, 2021 Languages Print

School and Program Administrators

K-12 Schools Guidance

Strategies to reduce the spread of COVID-19 and maintain safe operations

K-12 Guidance

ECE/Child Care Guidance

Guidance for all types of early childhood education (ECE) and child care programs

ECE/Child Care Guidance

"Transmission of SARS-CoV-2 within schools can be limited with strict implementation of layered mitigation strategies, including universal and correct use of masks and physical distancing."

https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/index.html

Myth busters

- https://www.cdc.gov/coronavirus/2019-ncov/vaccines/facts.html
- https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters

Myth busters

- https://www.cdc.gov/coronavirus/2019-ncov/vaccines/facts.html

Do COVID-19 vaccines contain microchips?

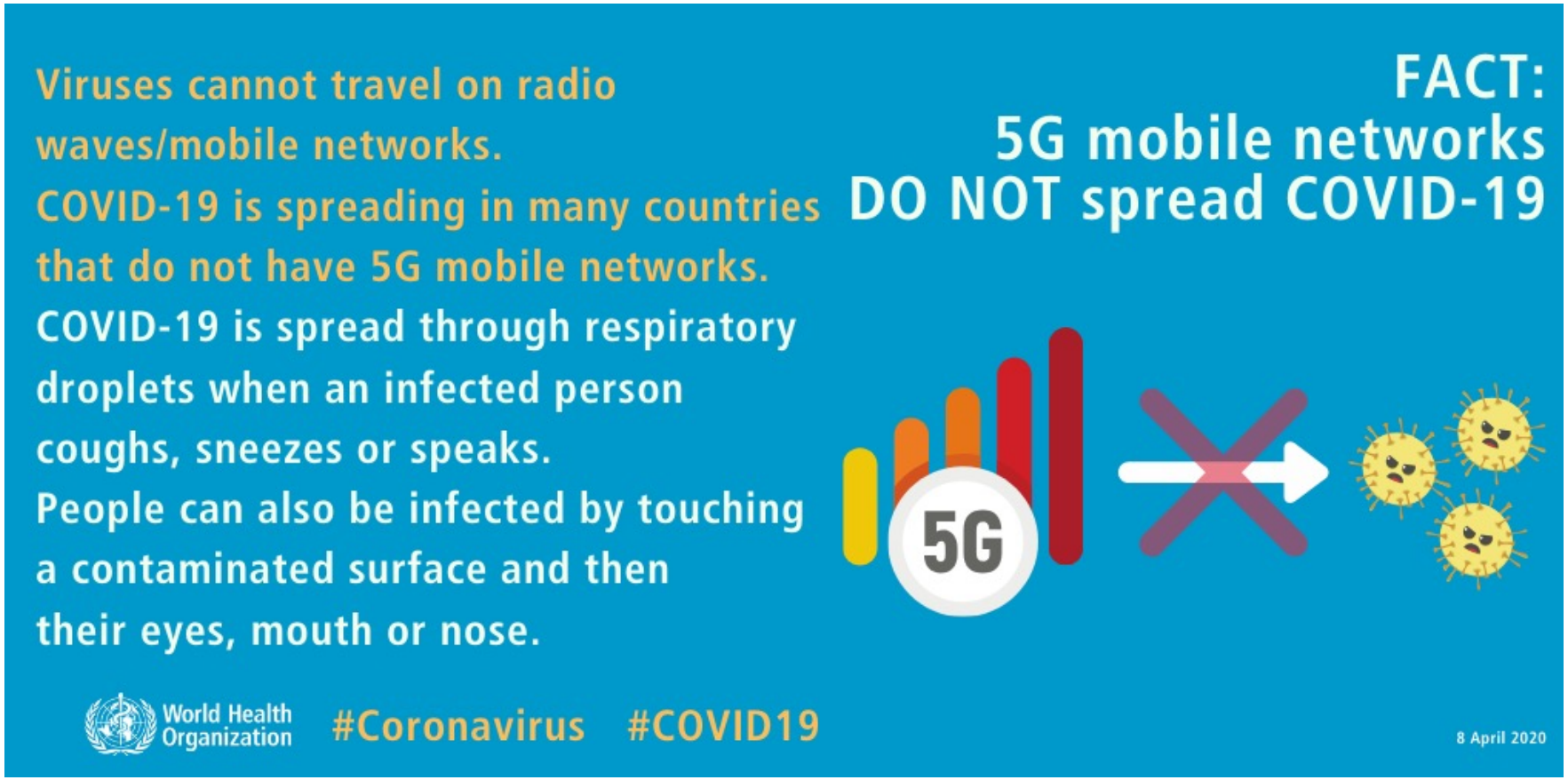
No. COVID-19 vaccines do not contain microchips. Vaccines are developed to fight against disease and are not administered to track your movement. Vaccines work by stimulating your immune system to produce antibodies, exactly like it would if you were exposed to the disease. After getting vaccinated, you develop immunity to that disease, without having to get the disease first.

Learn more about the ingredients in the COVID-19 vaccinations authorized for use in the United States.

Learn more about how mRNA COVID-19 vaccines work.

Myth busters

- https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters



Top tips for navigating the infodemic

World Health Organization

1. Assess the source:

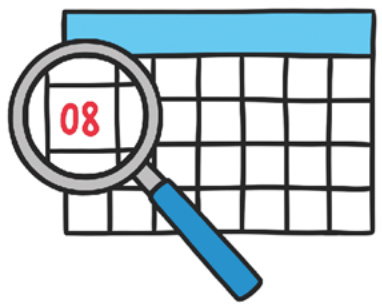
Who shared the information with you and where did they get it from? Even if it is friends or family, you still need to vet their source.

2. Go beyond headlines:

Headlines may be intentionally sensational or provocative.

3. Identify the author:

Search the author's name online to see if they are real or credible.



4. Check the date:

Is it up to date and relevant to current events? Has a headline, image or statistic been used out of context?

5. Examine the supporting evidence:

Credible stories back up their claims with facts.

6. Check your biases:

Think about whether your own biases could affect your judgment on what is or is not trustworthy.

7. Turn to fact-checkers:

Consult trusted fact-checking organizations, such as the International Fact-Checking Network and global news outlets focused on debunking misinformation.

Resources & Suggested Reading

- https://www.cdc.gov
- https://www.who.int
- https://www.genome.gov/about-genomics/fact-sheets/Understanding-COVID-19-mRNA-Vaccines
- https://www.niaid.nih.gov
- https://episphere.github.io/mortalitytracker/
- https://www.idsociety.org