Interpreting and Understanding COVID-19 Data

The COViD-TASER Team

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Thank you National Science Foundation RAPID grant (DUE- 2032688)

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Outline of Talk

- Motivations for the Project (March 2020 and March 2021)
- Citizens' Comparisons of Relative Size
- Citizens' Interpretations of Log and Linear Scaled Graphs
- See <u>www.COVIDTASER.com</u> for animated versions of applets presented in slides and paper describing methods in depth.





A family story: March, 2020

TV announcer in March, 2020: 10% of people over 70 with a confirmed COVID-19 case died of it.

My mother in law: Is 10% a big risk?

Me: 10% is a 1 in 10 chance. What is something you do 10 times a day?

Mother in law: Well, I go to the bathroom about 10 times a day.

Me: What if you died one of those times you went into the bathroom?



Mother in law: Well, I'd never go in there again! **GEORGIA**

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Members Of The Coronavirus Task Force Hold A Press Briefing | TIME



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DAYS SINCE FIRST CASE



DAYS SINCE FIRST CASE





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A New Challenge in March 2021

Half of Americans intend to get a COVID-19 vaccine; 19% already have

% of U.S. adults who say, thinking about vaccines to prevent COVID-19, they ...



From Pew Research Center

https://www.pewresearch.org/science/2 021/03/05/growing-share-of-americanssay-they-plan-to-get-a-covid-19-vaccineor-already-have/ps_2021-03-05_covid-19-vaccines_00-01/

Those disinclined to be vaccinated cite concerns about side effects, pace of vaccine development and desire for more information as top reasons why

Among the U.S. adults who say they probably/definitely will NOT get a vaccine to prevent COVID-19, % who say each of the following is a major/minor reason

	Major rea	ison	Minor reason	NET
Concern about side effects	72		17	89
The vaccines were developed and tested too quickly	67		18	85
Want to know more about how well they work	61		19	80
Have seen too many mistakes from the medical care system in the past	46	28		74
Do not think I need it	42	26		68
Do not get vaccines in general	36	22		57

Anaphylaxis after COVID-19 vaccination

Severe allergic reactions, including <u>anaphylaxis</u>, can occur after any vaccination.

Anaphylaxis after COVID-19 vaccination is rare. If this occurs, vaccination providers can effectively and immediately treat the reaction.

CDC and FDA scientists have evaluated reports from people who experienced a type of severe allergic reaction—anaphylaxis—after getting a COVID-19 vaccine. Anaphylaxis after COVID-19 vaccination is **rare** and occurred in approximately 2 to 5 people per million vaccinated in the United States based on events reported to VAERS. This kind of allergic reaction almost always occurs within 30 minutes after vaccination. Fortunately, vaccination providers have medicines available to effectively and immediately treat patients who experience anaphylaxis following vaccination. Learn more about COVID-19 vaccines and allergic reactions.

Reports of death after COVID-19 vaccination

- FDA requires vaccination providers to report any death after COVID-19 vaccination to VAERS.
- Reports of death to VAERS following vaccination do not necessarily mean the vaccine caused the death.
- CDC follows up on any report of death to request additional information and learn more about what occurred and to determine whether the death was a result of the vaccine or unrelated.
- To date, VAERS has not detected patterns in cause of death that would indicate a safety problem with COVID-19 vaccines.
- CDC, FDA, and other federal partners will continue to monitor the safety of COVID-19 vaccines.

Scary CDC information on the vaccine?

Over 109 million doses of COVID-19 vaccines were administered in the United States from December 14, 2020, through March 15, 2021. During this time, VAERS received 1,913 reports of death (0.0018%) among people who received a COVID-19 vaccine. CDC and FDA physicians review each case report of death as soon as notified and CDC requests medical records to further assess reports. A review of available clinical information including death certificates, autopsy, and medical records revealed no evidence that vaccination contributed to patient deaths. CDC and FDA will continue to investigate reports of adverse events, including deaths, reported to VAERS.

Should You Be Concerned About Blood Clots, Bleeding and the AZ-Vaccine?

There is no evidence so far of a link between the AstraZeneca shots and a few new cases in Europe of serious illness and deaths. But investigations are underway.





What types of problems caused the countries to take precautionary steps?

The cascade of decisions to pause the use of <u>AstraZeneca's vaccine</u>, mainly by European countries, followed reports of four serious cases in Norway, which were described among health workers under age 50 who received the vaccine. Most developed clots or bleeding abnormalities and had low platelet counts, health authorities there said. Two of them have died from brain hemorrhages, and the other two are hospitalized. The death of a 60-year-old woman in Denmark and of a 57-year-old man in Italy also fueled quick decisions, although none of the deaths have been fully investigated to determine whether there is any link to the shots they received.

Project Context



National Science Foundation RAPID grant (DUE- 2032688) focused on applying STEM Education research to investigate how United States (US) and South Korea (SK) citizens understand media-used COVID-19 Quantitative Data Representations (QDRs).

- Characterize the extent particular meanings are productive for understanding pandemic QDRs.
- Extend constructs developed in our and colleagues' research programs to explain individuals' meanings for pandemic QDRs.

- Characterize the extent particular meanings are productive for understanding pandemic QDRs.
- Create QDRs that better support individuals in understanding the COVID-19 pandemic including its health risks.

Phase 1: How are people interpreting COVID-19 data?

We designed an interview protocol by collecting representations of COVID-19 data that we hypothesized would be interpreted differently by citizens with varying mathematical understandings.

We used zoom to conduct task-based clinical interview with 25 US citizens and 7 SK citizens between April 2nd, 2020 and May 11th, 2020 (Ginsburg, 1997; Goldin, 1997).



We analyzed participants' responses by transcribing and coding interviews using models of mathematical thinking as guidance.

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Phase 1 Research Questions

General: How do citizens' mathematics support them in assessing the severity of COVID-19?

For this talk: How do citizens make comparisons of relative sizes of quantities related to COVID-19?

How do citizens interpret graphs related to COVID-19? How do their meanings for slope constrain or afford them in attempts to make sense of the severity of COVID-19?

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Background Research Related To Relative Size



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Relative size item given to U.S. 12th graders

In 1980 the populations of Towns A and B were 5000 and 6000, respectively. In 1990 the populations of Towns A and B were 8000 and 9000, respectively.

Brian claims that from 1980 to 1990 the two towns' populations grew by the same amount. Use mathematics to explain how Brian might have justified his answer.

Darlene claims that from 1980 to 1990 the population of Town A had grown more. Use mathematics to explain how Darlene might have justified her answer. (NAEP M069601)

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3%

24%

Correct

Partially

Correct

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1996 NAEP item presented in Thompson & Saldanha (2003) ASER

Project Aspire Quick Background

Project Aspire was a multi-year National Science Foundation funded assessment creation project let by Pat Thompson. (Thompson, 2016)

Pat, Hyunkyoung, Surani, other graduate students, and I created and validated a 43-item diagnostic assessment to model teachers' mathematical meanings for teaching.

We administered the assessment to 619 secondary mathematics teachers in the United States and Korea from various convenience samples.



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Relative size item given to U.S. and S.K. Secondary Mathematics Teachers

A container has a volume of m liters. One gallon is 189/50 times as large as one liter. What is the container's volume in gallons? Explain.

부피가 *m* 리터의 용기가 있다. 1 갤런은 1 리터의 $\frac{189}{50}$ 배 만큼 크다. 이 용기의 부피를 갤런으로 나타내고, 그 이유를 설명하시오.

Response	Korean HS	Korean MS	US less than calc	US calc or above
Correct	64%	47%	32%	44%
Incorrect	36%	53%	68%	56%
Total	262 teachers	101 teachers	169 teachers	72 teachers

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$$G = \frac{189}{50}L$$

$$G = \frac{189}{50}M$$

$$G = \frac{189}{50}M$$

$$G = \frac{189}{50}M$$

$$G = \frac{189}{50}M$$

COVID-19 Interview Items and Results

For more details see: <u>Hyunkyoung Yoon^a Cameron O'Neill Byerley^b Suran iJoshua^a Kevin Moore ^bMin Sook</u> <u>Park^c Stacy Musgrave^d Laura Valaas^e James Drimalla^b</u> United States and South Korean citizens' interpretation and assessment of COVID-19 quantitative data. Journal of Mathematical Behavior.



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Flu versus Covid-19 Rates

Scientists (such as Wu and team) estimate the symptomatic fatality rate for COVID-19 is between 0.9 and 2.1%. The symptomatic fatality rate for the seasonal flu is usually about 0.1% in the U.S.

A. How should this data impact decision making about social distancing?

B. Suppose there are two hypothetical situations. In one situation 50 million people get the flu. In the other situation 50 million people get the coronavirus. Assuming the death rates of .1% and 2.1% how many times as many people will die from the coronavirus as the flu?





Flu versus Covid-19 Rates

 아래 데이터들이 사회적 거리두기에 대한 의사결정에 어떻게 영향을 주어야한다고 생각합니까?

- a. 과학자들은 COVID-19 치사율을 0.66 에서 2.1%로 추정했다. 독감으로 인한 치사율은 미국에서 보통 0.1% 정도이다.
- b. 5 천만 명의 사람들이 독감에 걸렸고, 5 천만 명의 사람들이 코로나 바이러스에 걸렸다고 가정해보세요. 독감 사망률이 0.1%, 코로나 바이러스 사망률이 2.1% 라고 하면 독감보다 코로나 바이러스 때문에 사망하는 사람들이 몇 배나 많을까요?



Eunseok: 0.1% of 50 million is 1/1000 of 50 million. Then... isn't it 50,000? 1 million people would die when death rate of the coronavirus is 2.1% since it is like 2/100. Then isn't that 20 times more?

Amelia: The numbers of 50 million and 50 million do not matter. You're comparing 0.1 to 2.1. You could be saying you are comparing one to 21. I guess we'll take 21 times. We'll take 21 times as many.





Interviewer: Alright. One point five. What does it mean to have a death rate of one point five percent?

Katie: It is a very low death rate....It is very low. Especially, if you think about how many people there are in the world or are in the US. It is very, very low. If you look at rates of cancer, rates of heart disease, they are much, much higher. So, umm...I mean it is not a very high death rate. But there has also been a lot of discussion that people that have the coronavirus have lung damage afterwards.





G: This, this if you look at this like I'm looking at 0.1 from the flu and 2.1 that's a big difference.

I: Okay, how much bigger?

G: [laughs] Almost a hundred percent[laughs]...umm..

I: How many times bigger I guess is a better way to ask it.

G: I mean you're looking at point one to two point one that's like two times. Two times...[pause for 6 seconds] I want to say two times but I know it is way more.

I: Yeah, it is bigger than two. I'll give you a second to think about it. This is a hard question.

G: I feel dumb for this now. I'm a teacher.

I: I research how math teachers think about percents.

G: [laughs]

I: I knew it was a hard question when I asked it because I've asked this question to lots of people.

G: So I'm not the only one. I feel... Because it's point one percent. [pauses to think] So that is point zero one. [pause to write on scratch paper] Okay. I guess I want to say almost a 200 percent. [laughs]

I: You're laughing again.

Gertrude: Oh my gosh.

I: You didn't sound sure so I was just I was just doing wait time. Umm the way I've been thinking about it is that point one percent is a tenth of one percent. And so point one fits into one percent ten times. One percent is ten times as large as point one percent. Does that hint help you?

G: So point one is like...[pauses and looks at scratch paper] oh so that's like 2,000 then. [pauses] And that would be point one to two point. [pauses for 50 seconds to think.] So, two...so, two hundred percent right?

Mike: oh gosh you're gonna make me...[do math].

Interviewer: Okay this is a safe space though! ...

Mike: Why did I agree to do this? But, yeah I revoke my consent.

M: So so that's point one percent and then...Okay did I do that right? So that's ten percent... one percent so that's ten percent... one percent. I know gosh I'm embarrassed now

Interviewer: You can totally use a calculator.

. . .

M: Oh gosh, I thought...you should have told me that before.

[...] Okay, I had it right on the first one okay so it would be twenty-one times more people died if there was a 2.1 percent mortality rate with 50 million people infected

Responses to "Flu vs. COVID-19 rates" Approximately Asked to Said 2% of a Said 2.1% and Incorrect Said scientists multiplicative large number incorrectly make 0.1% are both correct comparison. multiplicative is very large. multiplicative small so COVIDestimated comparison. comparison infection fatality 19 is not too but citizen serious rates for COVIDdidn't 19. respond

Flu is more severe than COVID-19	1	1	2	3 incl. Katie	1 incl. Katie	2
COVID-19 is more severe than flu	12 incl. Eunseok and Amelia and Mike	9 Incl. Gertrude	1	12 incl. Eunseok and Amelia	1	0
nsure if flu or OVID-19 is vorse	0	0	1	2	0	0
Subtotal	13	10	4	17	2	2

Interactive COVID-19 Risk Comparison Tool



Initial Findings from Relative Risk Applet

- Peoples' mindsets don't often change after seeing our applet. Some participants identify the non-COVID categories as helpful in understanding relative riskiness, but there hasn't been dramatic changes in mindsets.
- Most people's initial estimates (prior to seeing the applet) of the percent risk of COVID hospitalization and COVID death are significantly off from the estimates from our relative risk applet.
 - The NYT reported on a similar phenomena in their March 18th daily briefing (see the aside).
- Some people's meanings for percent are insufficient to make sense of the very low percent risks (like vaccines).
 - There are also some participants whose meanings for percent are insufficient to make quantitative sense of any of the percentages.



March 18, 2021

By David Leonhardt

Good morning. Republicans tend to underestimate Covid risks — and Democrats tend to exaggerate them.

That's a central finding from <u>a survey of 35,000 Americans</u> by Gallup and Franklin Templeton. It finds that both liberals and conservatives suffer from misperceptions about the pandemic — in opposite directions. "<u>Republicans</u> <u>consistently underestimate risks</u>, while <u>Democrats consistently overestimate</u> <u>them</u>," Jonathan Rothwell, Gallup's principal economist, and Sonal Desai, a Franklin Templeton executive, write. Background Research Related to Conceptions of Graph and Slope

Background Research: Teachers' Meanings for Graph, Slope, and Rate of Change

Thompson, P. W., Hatfield, N. J., Yoon, H., Joshua, S., & Byerley, C. (2017). Covariational reasoning among US and South Korean secondary mathematics teachers.

Thompson, P. W. (2015). Researching Mathematical Meanings for Teaching.

Byerley, C., & Thompson, P. W. (2017). Secondary mathematics teachers' meanings for measure, slope, and rate of change.

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The values of function f give the rate of change (in grams/hr) of a bacterial culture's mass t hours after measurements began.



Over what intervals within the first 8 hours is the culture's mass increasing? Explain.

- a) $0 < t \le 1.4$ and $5.5 < t \le 8$
- b) 0 < t < 8
- c) 0 < t < 3 and $7 < t \le 8$

© Arizona Board of Regents, 2014. Project Aspire.

Background research: Models of People's Understandings of Graph

Moore, K. C., & Thompson, P. W. (2015). Shape thinking and students' graphing activity. In *Proceedings of the 18th Meeting of the MAA Special Interest Group on Research in Undergraduate Mathematics Education* (pp. 782-789). Pittsburgh, PA: RUME.

Moore, K. C., Stevens, I. E., Paoletti, T., Hobson, N. L., & Liang, B. (2019). Pre-service teachers' figurative and operative graphing actions. *The Journal of Mathematical Behavior*, *56*, 100692.

What does the graph tell you? What does a point on the graph mean?



OurWorldInData.org/coronavirus • CC BY

What does the following graph tell you? What does a point on the graph mean?



Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time) OurWorldInData.org/coronavirus • CC BY What does the following graph tell you? Total Coronavirus Cases in the United States



www.Worldometer.com

Slope as Steepness

Graph 1 is steep, so it was growing quickly in SK.

But in Graph 2 it is shallow, so it was growing slowly in SK.

Slope as a Comparison of Changes in Two Quantities

Graph 1 and 2 are on differently scaled axes, but they show the same SK data and rate of total confirmed cases.



Slope as Steepness Graph 1 is steep, so it was growing quickly.

But in Graph 2 it is shallow, so it was growing slowly.

OurWorldInData.org/coronavirus • CC BY

Slope as Comparison of Changes in Two Quantities

Graph 1 and 2 are on differently scaled axes, but they show the same SK data and rate of total confirmed cases.

Our World

in Data

Add country

United States

South Korea

May 11, 2020



Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time) OurWorldInData.org/coronavirus • CC BY Slope as Steepness They slopes of two graphs similar so their rates must be close.

Graphs 1 and 2 are concave down so the rate of change is decreasing. Slope as Comparison of Changes in Two Quantities

Graph 1 and 2 are on differently scaled axes and Graph 2 is logarithmic.

Graph 2 illustrates an increasing rate of change in total cases due to the scale.



Slope as Steepness They are similar so their rates must be close.

Graph 2 is concave down so the rate of change is decreasing.

Slope as Comparison of Relative Size of Two Quantities

Graph 1 and 2 are on differently scaled axes and Graph 2 is logarithmic.

Graph 2 illustrates an increasing rate of change in total cases due to the scale.

Total Coronavirus Cases in the United States



Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time) OurWorldInData.org/coronavirus • CC BY



What are productive and unproductive meanings for graphs?

Table 3. Responses to "South Korea Cases", "Three Country Cases", and "Log Scaled Cases" items

"South Korea Cases", "Three Country Cases", and "Log Scaled Cases"				
	Focused only on steepness	Gave quantitative meanings to steepness	Unclear	
The log scaled graph looks different or less scary than other graphs	10 incl. <u>Bumsoo</u>	5	3	
The log scaled graph looks same as other graphs	0	7 incl. Gertrude	0	
Unclear	2	2	3	
Subtotal	12	14	6	

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What are productive and unproductive meanings for graphs?

- Int. We can look at March 10. What could we say about the, like how long it takes to multiply by 10?
- Gertrude Eight days.

- Int. Okay, so it took eight days to multiply by ten. What does the slope of the log graj tell us? Like the steepness of it? What... what information is that telling us?
- Gertrude It's telling us the rate. How fast it's growing, the rate of change.
- Int. Okay and so it took eight days so there's kind of two ways to think about the rate took eight days to multiply by ten. You could also say it took eight days to go up 900.
- Gertrude And then here it took from March 10 to 18, it took eight days again.
- Int. To do what?

Gertrude To multiply by 10.

Mary Frances Early College of Education Total Coronavirus Cases in the United States



What are productive and unproductive meanings for graphical QDRs?

- How did you determine that "the slope is 2"? You said, "the confirmed cases Int. increased from 2000 to 3000, which means the slope is 2."
- P. Yeah, just a guess. The slope is steeper than 45 degrees and lower than 90 degrees. It looks like about two-thirds. [He gestures to the line cutting the first quadrant into a 1/3 and 2/3 piece]. So [the slope in the SK graph] would be twice as much [as a slope of 1].
- Did you draw a hypothetical 45-degree graph? Int.
- Ρ. Yes, that's right. [The slope of the SK graph] is steeper than that. Oh, it has increased rapidly. I thought it would be really fast at 90 degrees. The closer the slope is to 90 degrees the worse the pandemic is. But in between, I thought [the slope would] be 2 because it is between 90 degrees and 45 degrees.



Morphing Linear and Log Graphs



Design to Support People's Understanding of Graphs with **Different Scaled** Axes (see animation on www.covidtaser.c

Draft of Surani's Log Video

<u>https://youtu.be/ElkOfplKfqU</u>



Conclusions

- Mathematics and science educators have a roll in helping students develop meanings for graphs that are productive in interpreting graphs of various scales in various contexts.
- We can also contribute to the global effort to fight COVID-19 by using our experience as educators to help design ways to convey scientific knowledge to others.
- Our big focus right now is helping citizens' understand the relative risk of COVID-19 and the COVID-19 vaccine.
- Details of research methods in: Yoon, H., Byerley, C. O. N., Joshua, S., Moore, K., Park, M. S., Musgrave, S., ... & Drimalla, J. (2021). United States and South Korean citizens' interpretation and assessment of COVID-19 quantitative data. *The Journal of Mathematical Behavior*, 100865.

Please give us feedback! cameron.byerley@gmail.com www.covidtaser.com

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