

Interpreting and Understanding COVID-19 Data: Focus on Slope

The COViD-TASER Team:

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



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Summary of Talk

- Explain origin and goals of COVID-TASER project.
- Explain research questions and study design.
- Give a brief overview of all of the mathematical topics relevant to understanding COVID-19 data that we studied.
- Focus on how citizen's understanding of slope impacted their assessment of the severity of COVID-19.
- Share our quantitative data representations for audience feedback.

Creation of Visualizations of Data: The Application of STEM Education Research



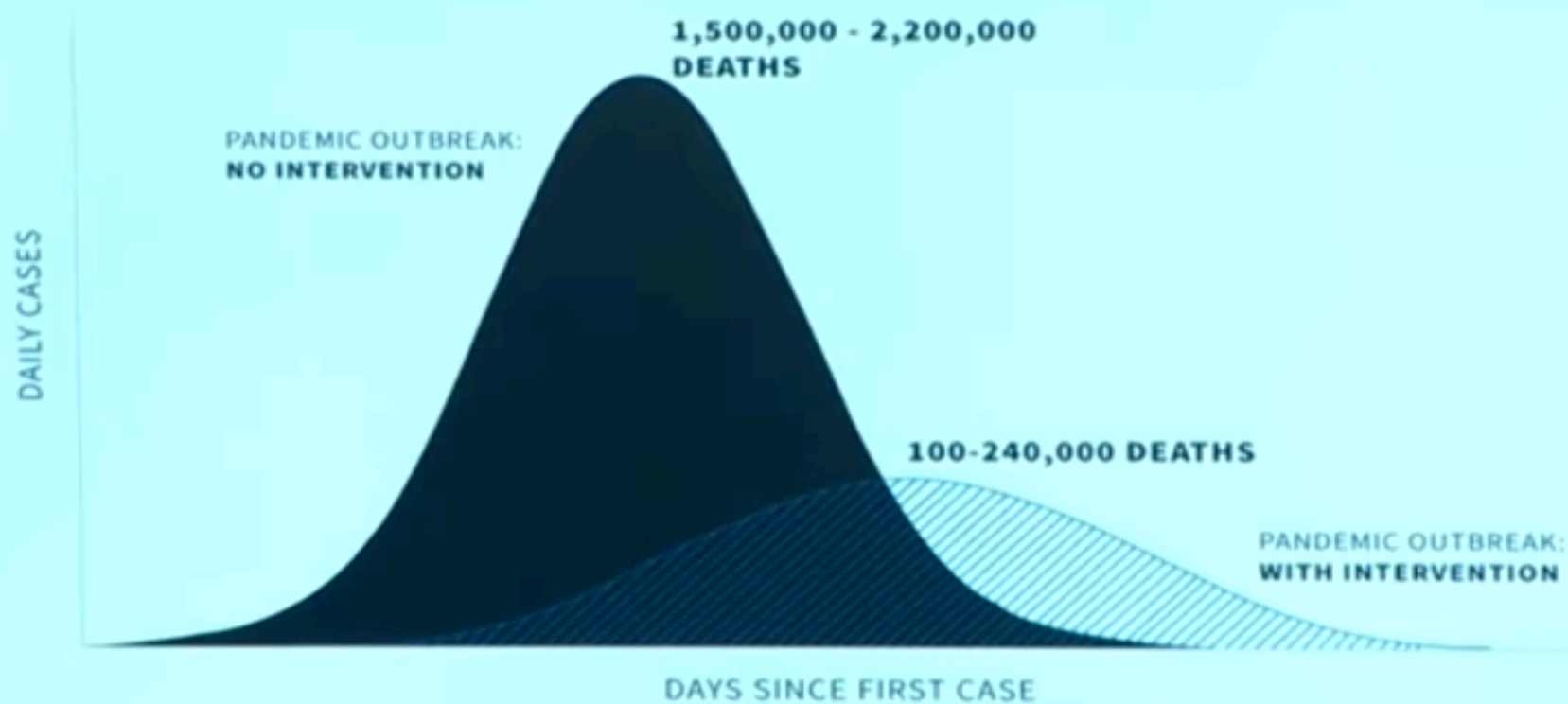
National Science Foundation COVID-TASER RAPID grant (DUE- 2032688) focused on applying STEM Education research to investigate how United States (US) and South Korea (SK) citizens understand media-used COVID-19 QDRs.

- 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.
- Create QDRs that better support individuals in understanding the COVID-19 pandemic including its health risks.
- Clarify those ways of thinking that are critical for well-being outside of the mathematics classroom.





GOALS OF COMMUNITY MITIGATION



- 1 Delay outbreak peak
- 2 Decompress peak burden on hospitals/infrastructure
- 3 Diminish overall cases and health impacts
- 4 Decreases fatalities



DAILY CASES

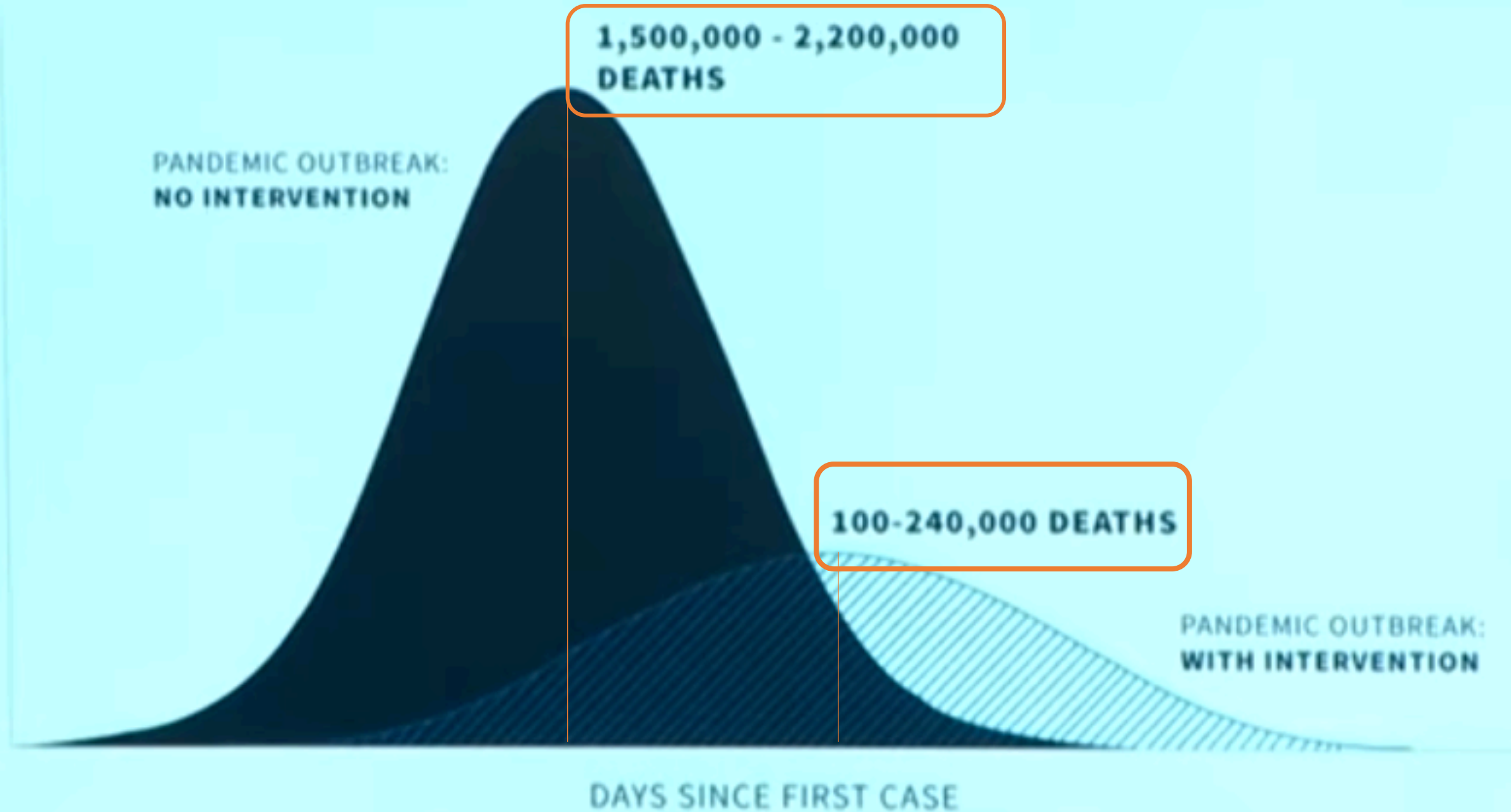
PANDEMIC OUTBREAK:
NO INTERVENTION

1,500,000 - 2,200,000
DEATHS

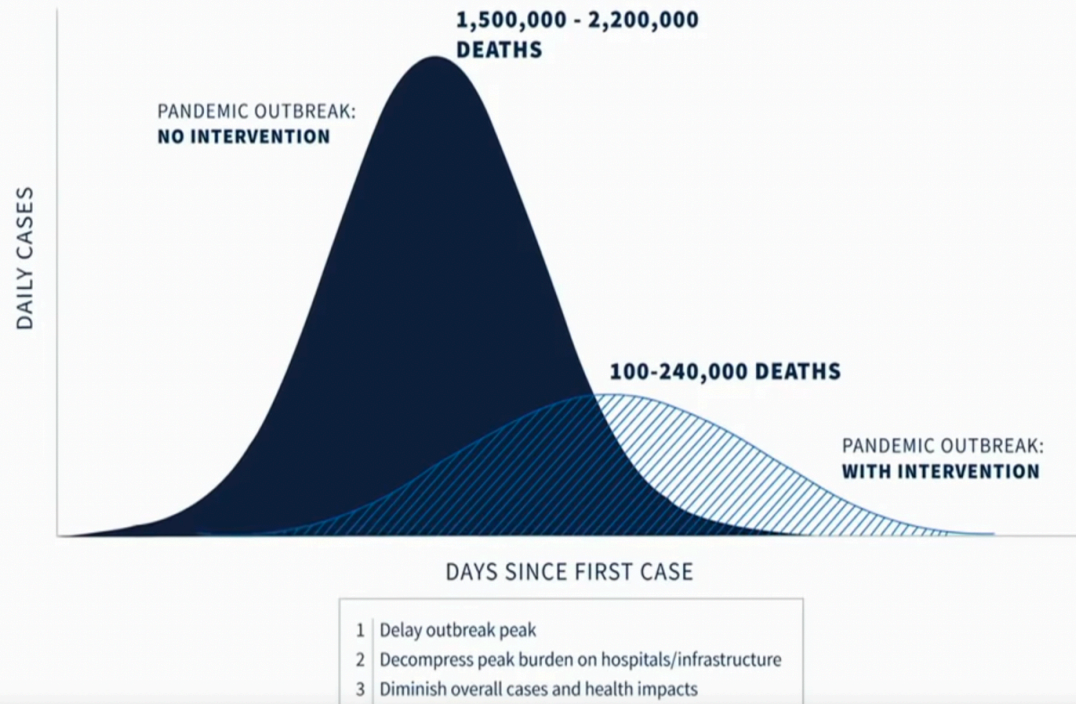
100-240,000 DEATHS

PANDEMIC OUTBREAK:
WITH INTERVENTION

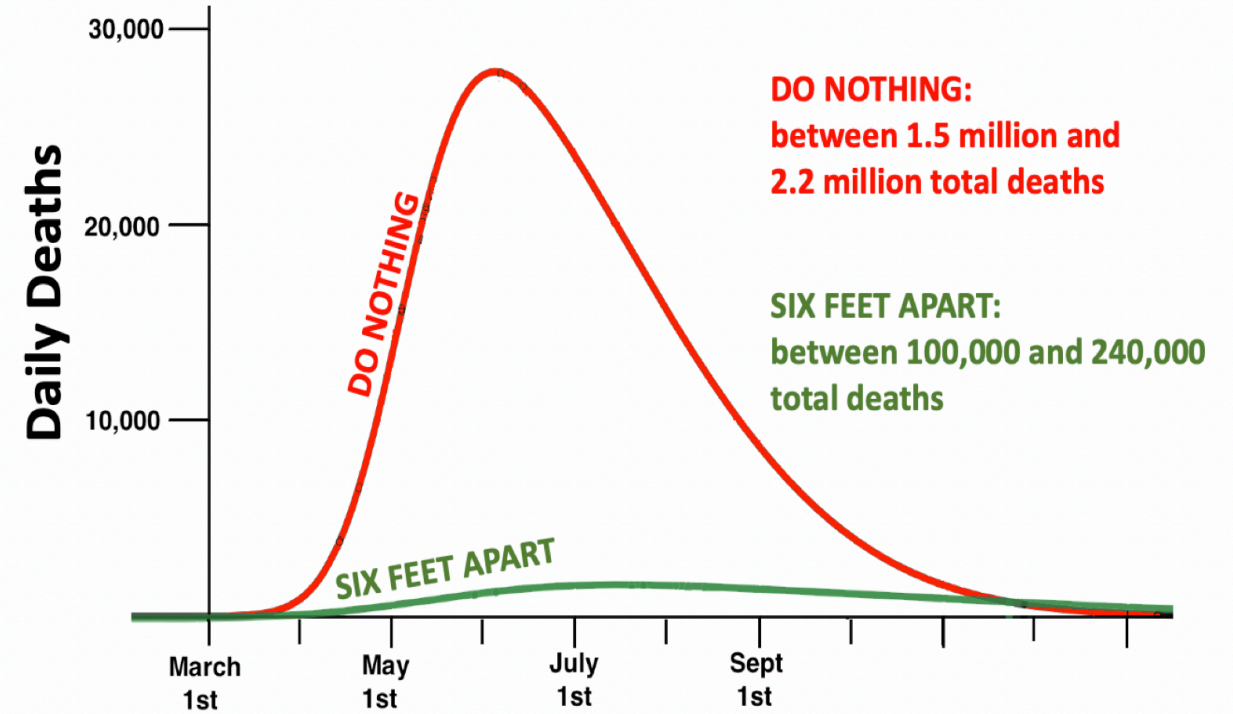
DAYS SINCE FIRST CASE



GOALS OF COMMUNITY MITIGATION



STAY 6 FEET APART



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Research Questions

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

Emphasis for this talk: 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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Study Design

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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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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Project Aspire Quick Background

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

Pat, Hyunkyung, 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.

See “Publications” on www.pat-thompson.net for details.



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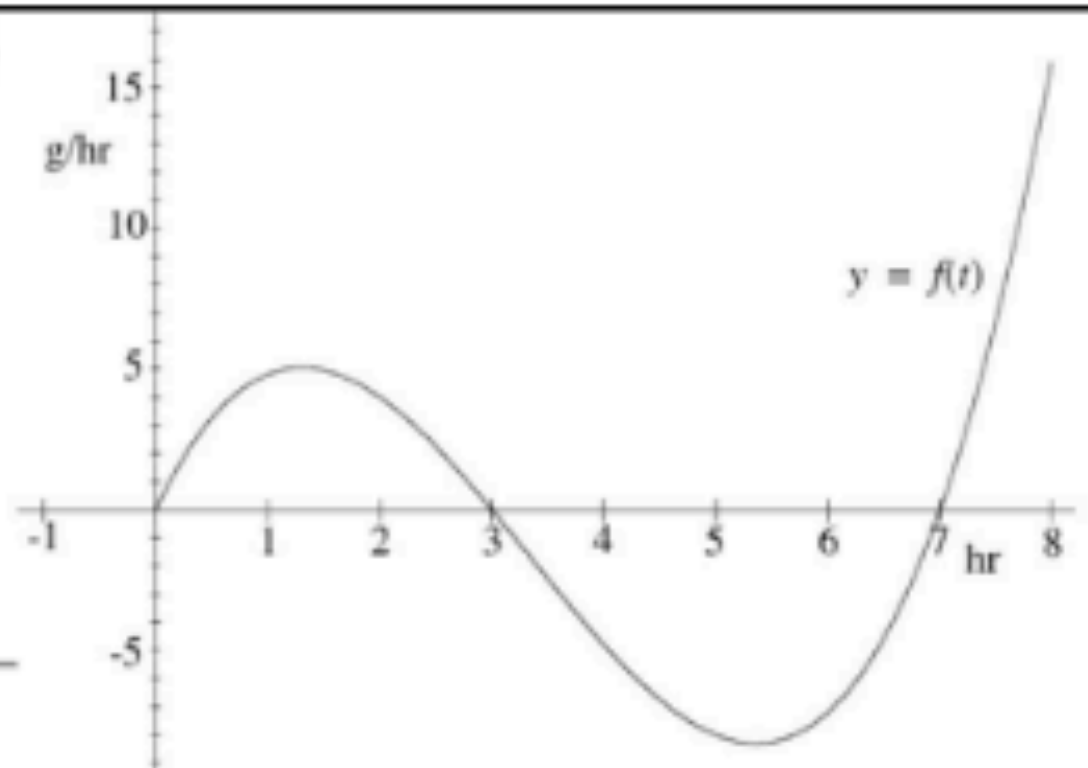
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The values of function f give the rate of change (in grams/hr) of a bacterial culture's mass t hours after measurements began.

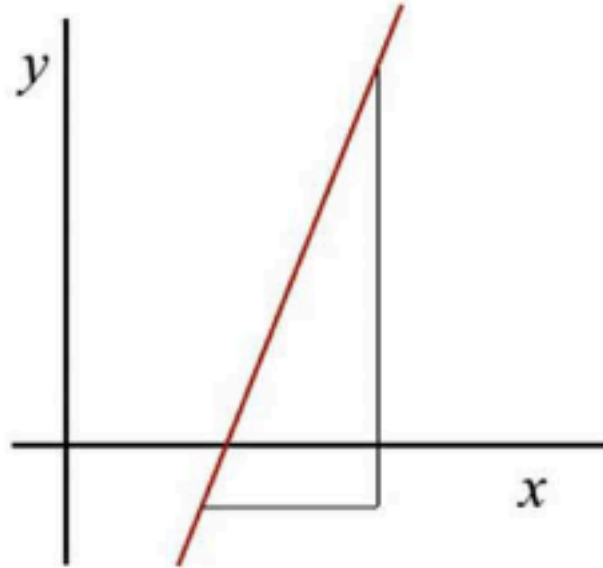
Over what intervals within the first 8 hours is the culture's mass increasing? Explain.

- a) $0 < t \leq 1.4$ and $5.5 < t \leq 8$
- b) $0 < t < 8$
- c) $0 < t < 3$ and $7 < t \leq 8$
- d) None of the above. My answer is _____
- e) I don't know



86 out of 239 US high school math teachers chose c.

There are two quantities P and Q whose values vary. The measure of P is y and the measure of Q is x . y and x are related so that $y = mx + b$. The graph of their relationship is given below, with x and y in the same scale. What is the numerical value of m ?



Thirty-three of 158 US high school teachers (21%) estimated a value of the slope from two to three.

A car went from San Diego to El Centro, a distance of 90 miles, at 40 miles per hour. At what speed would it need to return to San Diego if it were to have an average speed of 60 miles per hour?

Response	Korea HS math teachers	Korea MS math teachers	US less than calc	US calc or greater
Correct	90%	71%	35%	55%
Incorrect	10%	29%	65%	35%
Total Teachers	264 teachers	102 teachers	178 teachers	72 teachers



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Item © Arizona Board of Regents. Project Aspire. 2014

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COVID-19 Interview Items and Results

Learn more in: Yoon, H., Moore, K., Park, M. S., Musgrave, S., Valaas, L., Drimalla, J., & Byerley, C. O. N.
COVID-19• COVID-19 data representations are interpreted in multiple ways by US and South Korean citizens• Citizens' mathematics and beliefs impact how they assess the severity of COVID-19• Models of students' mathematical thinking are useful to improve COVID-19 data.



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Flu versus Covid-19 Rates Task

Scientists (such as Wu and team) estimate the symptomatic fatality rate for COVID-19 is between 0.66 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?



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Gertrude: *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.*

Interviewer: *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's 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 [math] teacher.*

I: *I research how math teachers think about percents.*

G: *[laughs]*



[continued on next slide]

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

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! [laughs]

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



Donald J. Trump ✓

@realDonaldTrump



So last year 37,000 Americans died from the common Flu. It averages between 27,000 and 70,000 per year. Nothing is shut down, life & the economy go on. At this moment there are 546 confirmed cases of CoronaVirus, with 22 deaths. Think about that!

8:47 AM · Mar 9, 2020 · [Twitter for iPhone](#)

127.9K Retweets **289.3K** Likes

Read the following statement comparing the flu and coronavirus. Comment on the argument the person is making.

The CDC estimates in the U.S. from October 1st 2019 to April 4th, 2020 there have been 24,000-62,000 deaths from flu, 39-56 million flu illnesses and 410,000-740,000 hospitalizations. We don't shut down the economy and life for the flu. On April 15th in the U.S. there are 10,592 confirmed cases of coronavirus, with 225 deaths. The flu is worse than the coronavirus and we don't shut things down for the flu so we shouldn't for the coronavirus.

Bumsoo's Thinking

Bumsoo's computed the average number of new cases per month for the flu in the US, and the average number of new confirmed cases per day for COVID-19 and concluded that COVID-19 is more serious than the flu.

Bumsoo: What's the US population now? [Interview says 328 million]

Bumsoo: Korean media usually provides ratios. For example, the ratio of 50 million people [current SK population] to 100 people. In this way, 62,000 people look really big, but it's actually calculated at a very low percentage, so it's right not to interrupt your daily life. But looking at it now, I think the standards are not consistent. The flu is five months from October to March. 62,000 in five months is about 3,000 people in a month [he made a small computational error]. But by April 2nd, there will be 10,000 [COVID-19 confirmed cases] per day. If you look at it like this, I think corona is much more dangerous. Corona data is on a daily basis and flu is on a monthly basis.

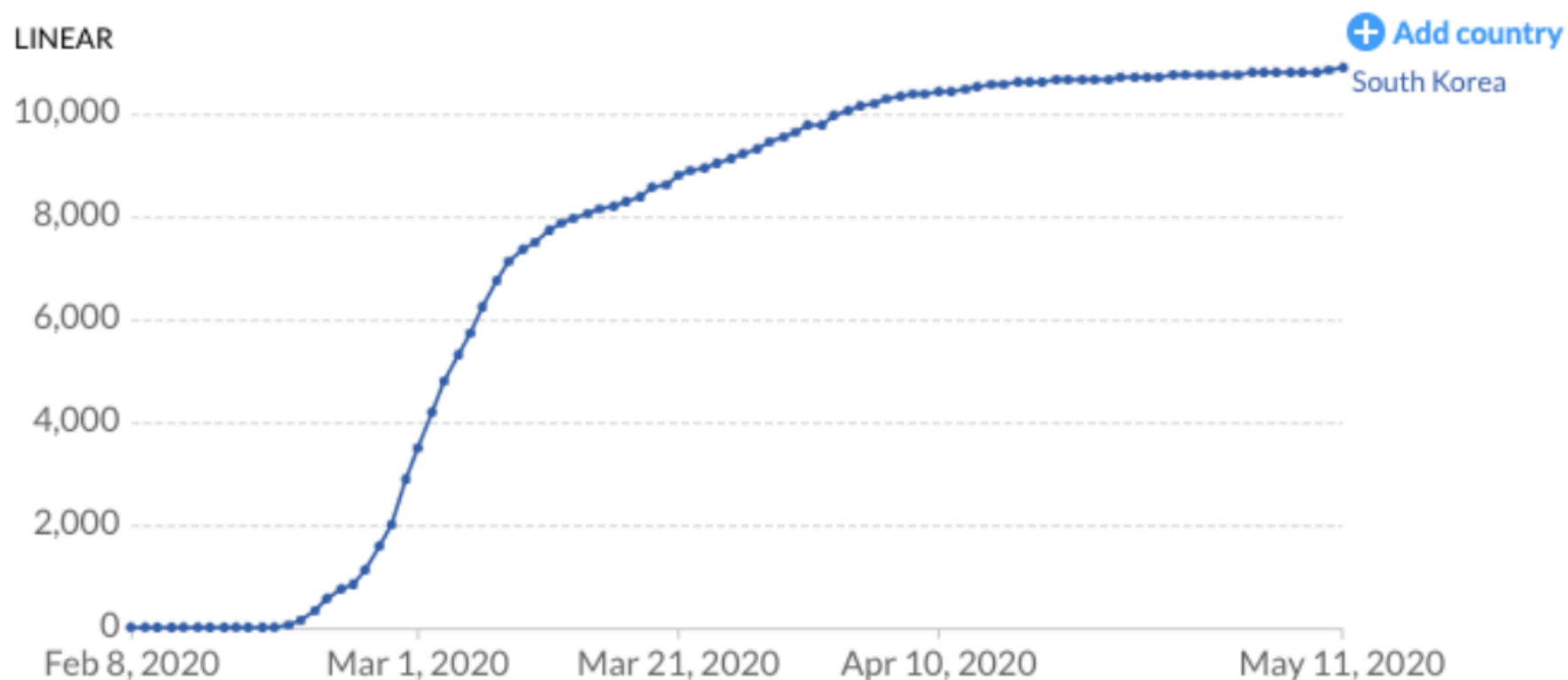
What does the graph tell you? What does a point on the graph mean?

Total confirmed COVID-19 cases

The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing.

Our World
in Data

LINEAR



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

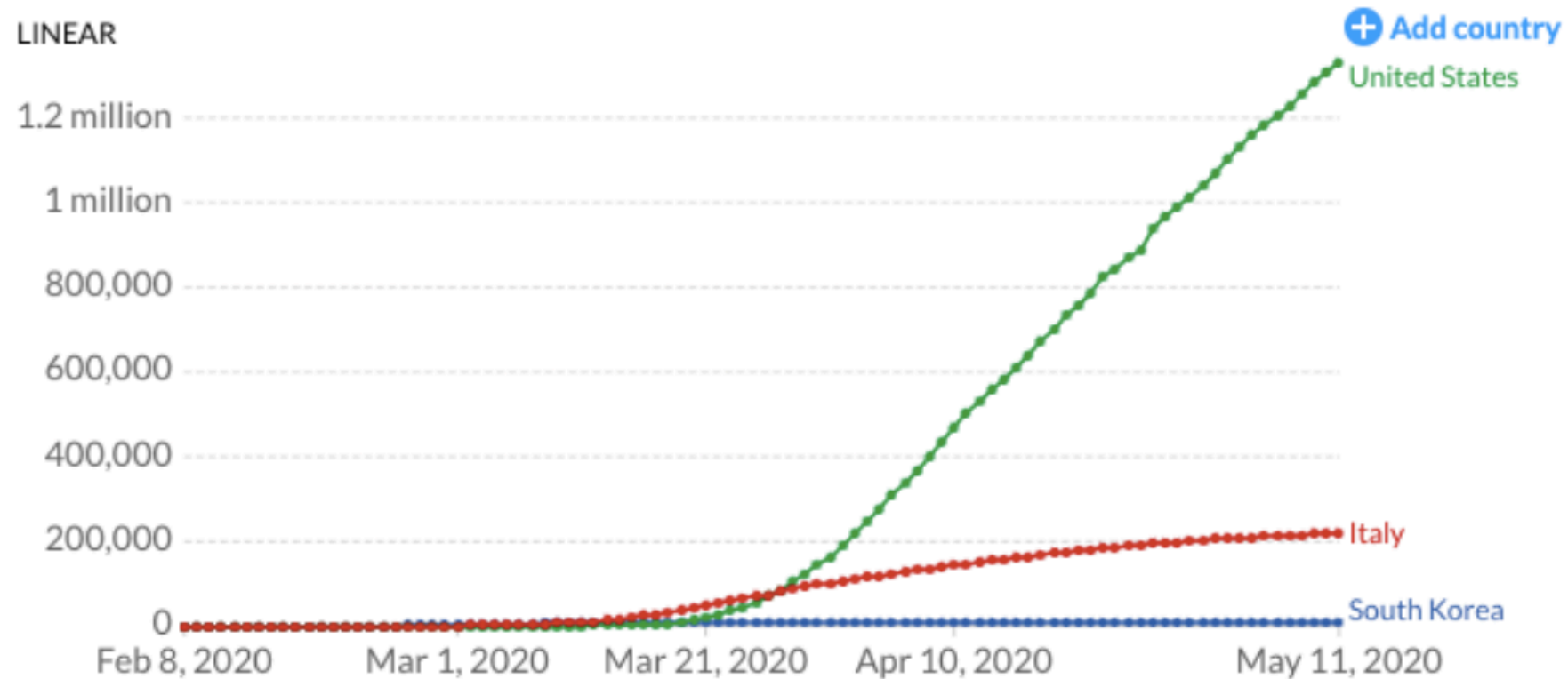
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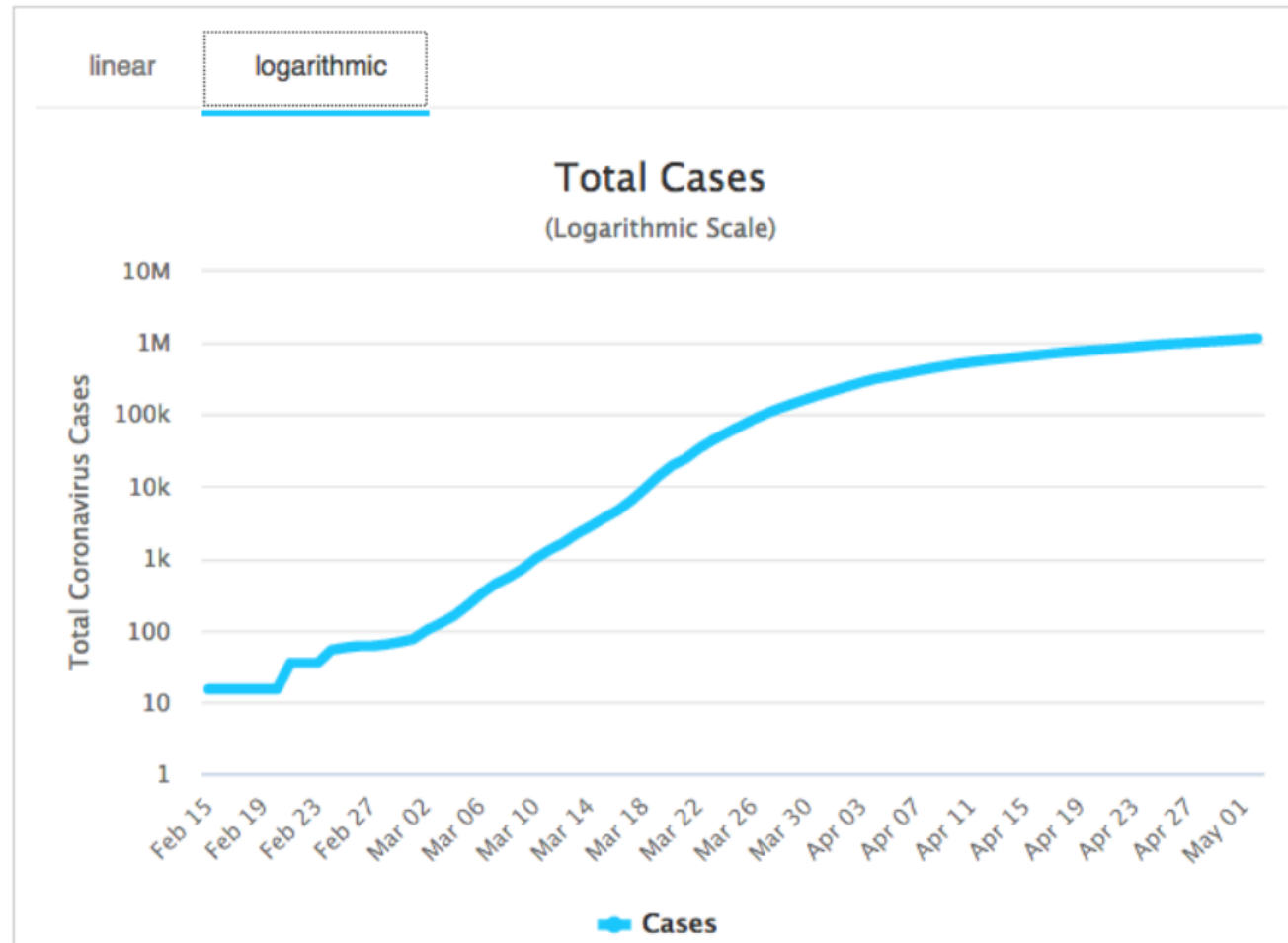
LINEAR



Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time)
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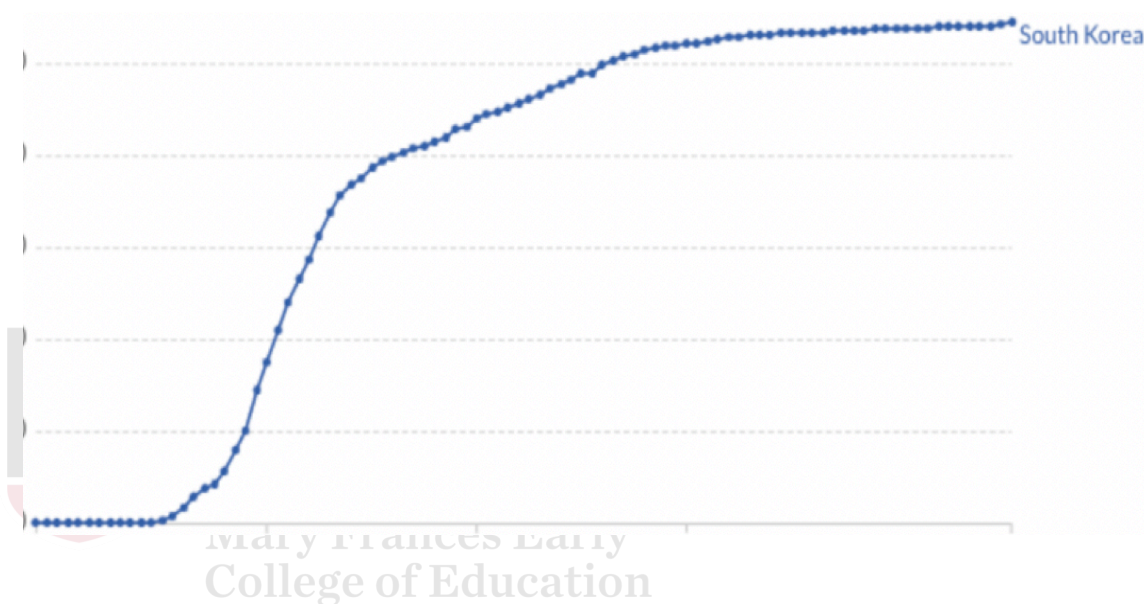
Total Coronavirus Cases in the United States



Slope as Steepness

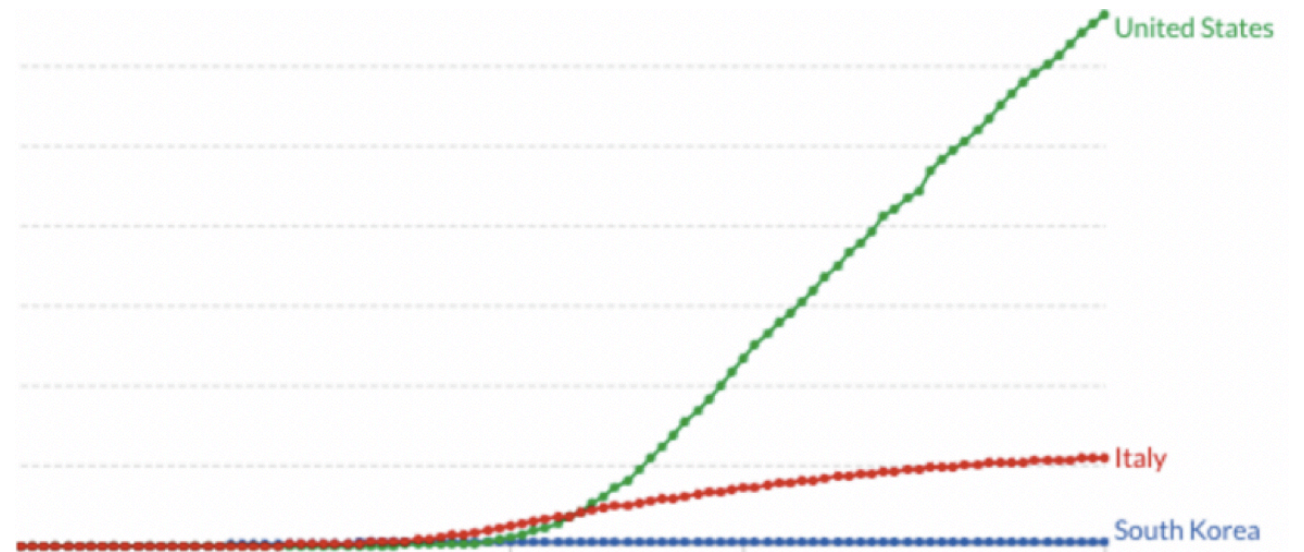
Graph 1 is steep, so it was growing quickly in SK.

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.



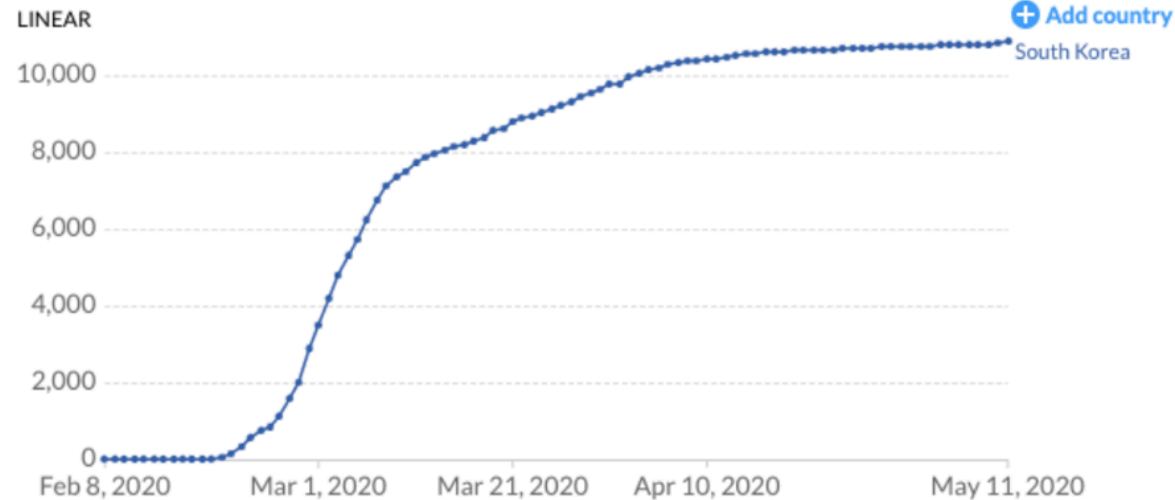
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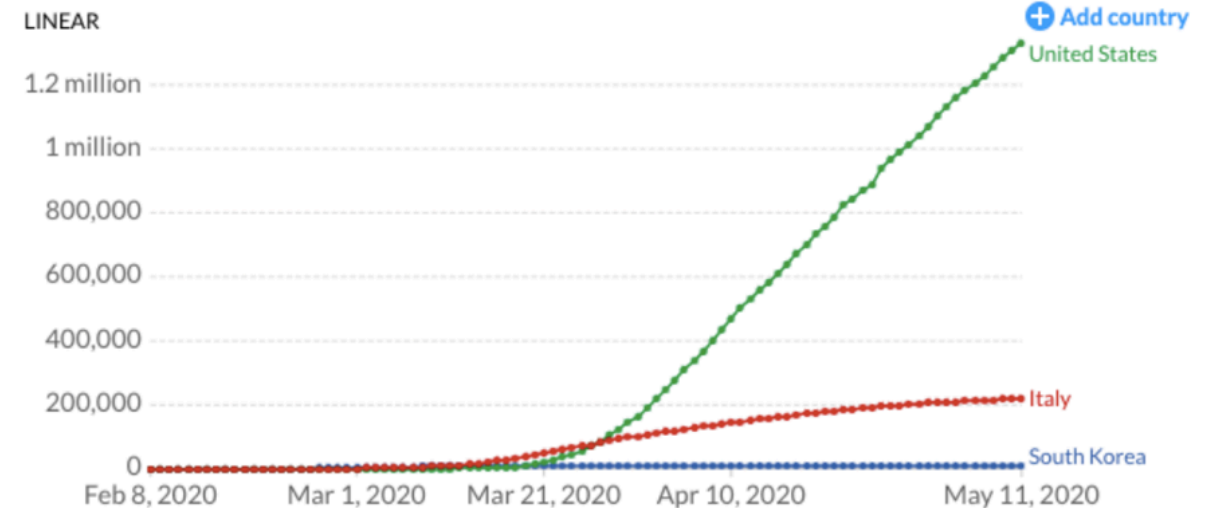
Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time)
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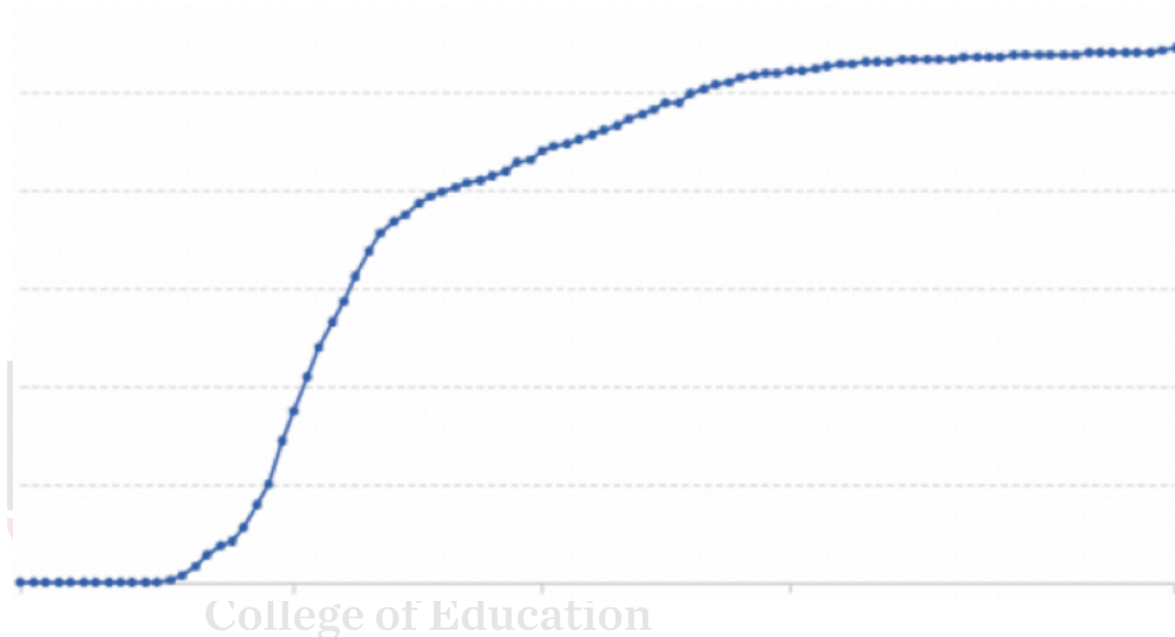


Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time)
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Slope as Steepness

The slopes of two graphs similar so their rates must be close.

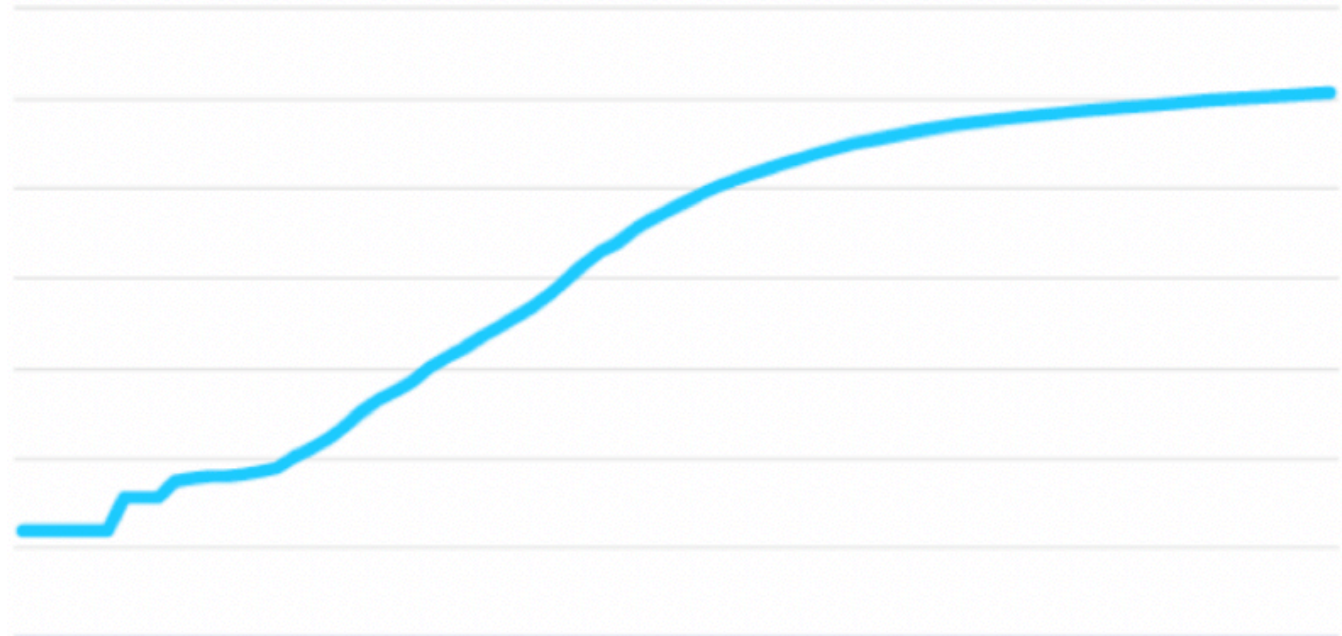
Graphs 1 and 2 are concave down so the rate of change is decreasing.



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.

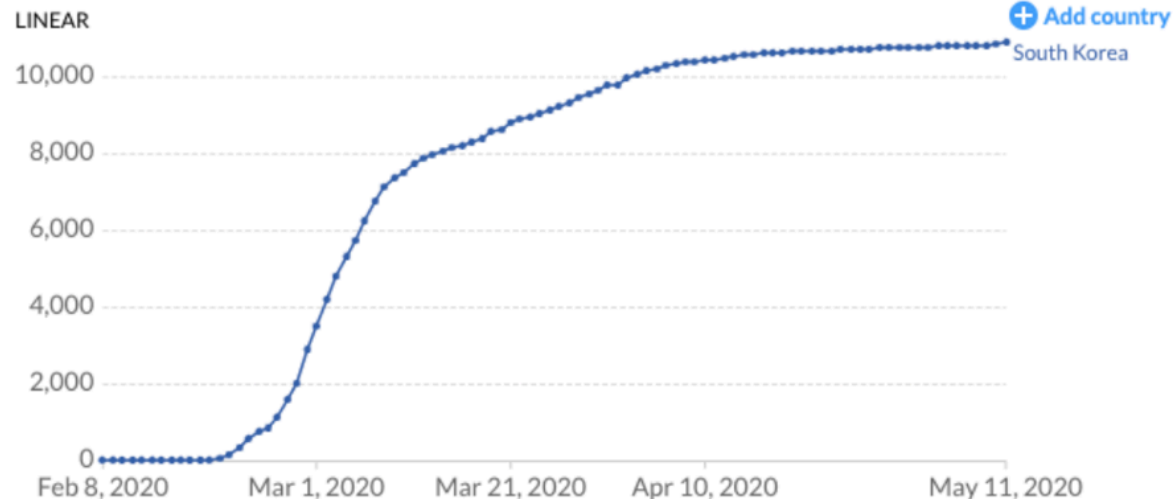
Slope as Comparison of Relative Size of Two Quantities

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.

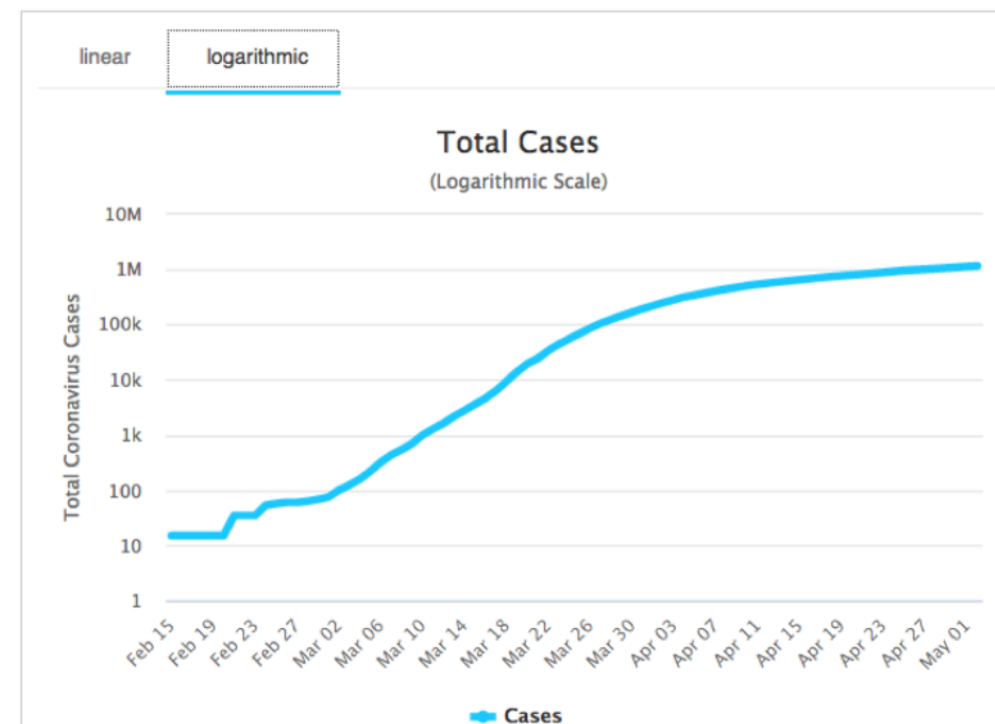
Total confirmed COVID-19 cases

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Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time)
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Total Coronavirus Cases in the United States



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 graph 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.

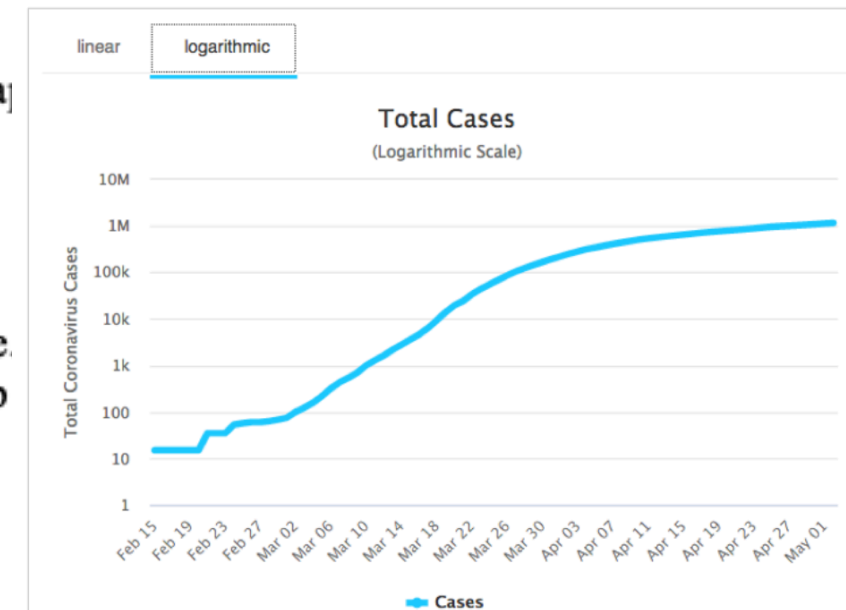
Int. Okay and so it took eight days so there's kind of two ways to think about the rate, took eight days to multiply by ten. You could also say it took eight days to go up 900.

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.

Total Coronavirus Cases in the United States



What are productive and unproductive meanings for graphical QDRs?

Int. How did you determine that “the slope is 2”? You said, “the confirmed cases increased from 2000 to 3000, which means the slope is 2.”

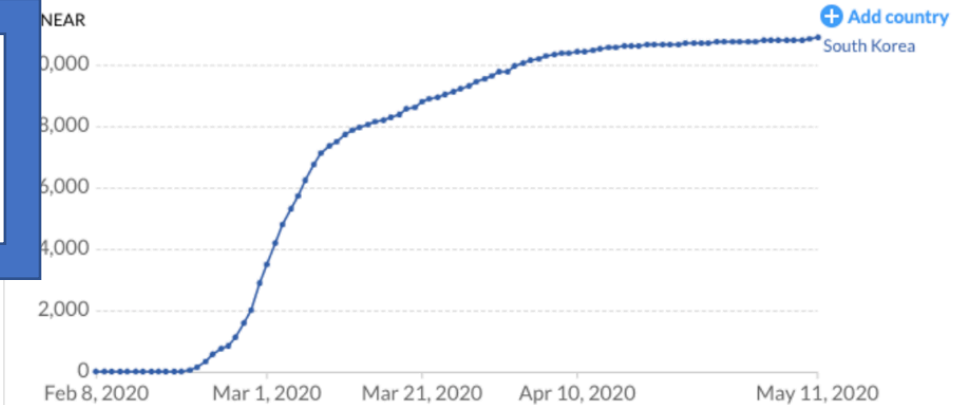
P. Yeah, just a guess. The slope is steeper than 45 degrees and lower than 90 degrees. It looks like about two-thirds. [He gestures to the line cutting the first quadrant into a $\frac{1}{3}$ and $\frac{2}{3}$ piece]. So [the slope in the SK graph] would be twice as much [as a slope of 1].

Int. Did you draw a hypothetical 45-degree graph?

P. 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.

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Source: European CDC – Situation Update Worldwide – Last updated 11th May, 11:15 (London time)
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OK, so what next?



Design Improved QDRs

- (a) improving label wording and position;
- (b) adding quantities' values to axes in response to figurative forms of thought;
- (c) supporting operative thought by proportionally scaling graphs to convey appropriate relative size in response to participants having difficulty making relative comparisons of written large numbers;
- (d) simplifying and replacing vague or incorrect terms (intervention, mitigation);
- (e) creating dynamic and narrated QDRs that direct individual's attention *away from perceptual features* of QDRs such as a graphs' steepness and *toward quantitative features* of QDRs so that they understand behavior implications.



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**We'd like Feedback on our
Pilot Data Representations!**

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Send Questions or Thoughts to: cbyerley@uga.edu



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References