Using Cognitive Skills and Social Attitudes of Ordinary Citizens to Predict Preparedness for Pandemic:
Lessons from PIAAC

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Introduction

- Since 2020, the world has been facing a tragic pandemic caused by a small virus that led to the death of millions of people.
- In spite of availability of cutting-edge technologies, the countermeasures launched by the US and Western nations are not as effective as expected.
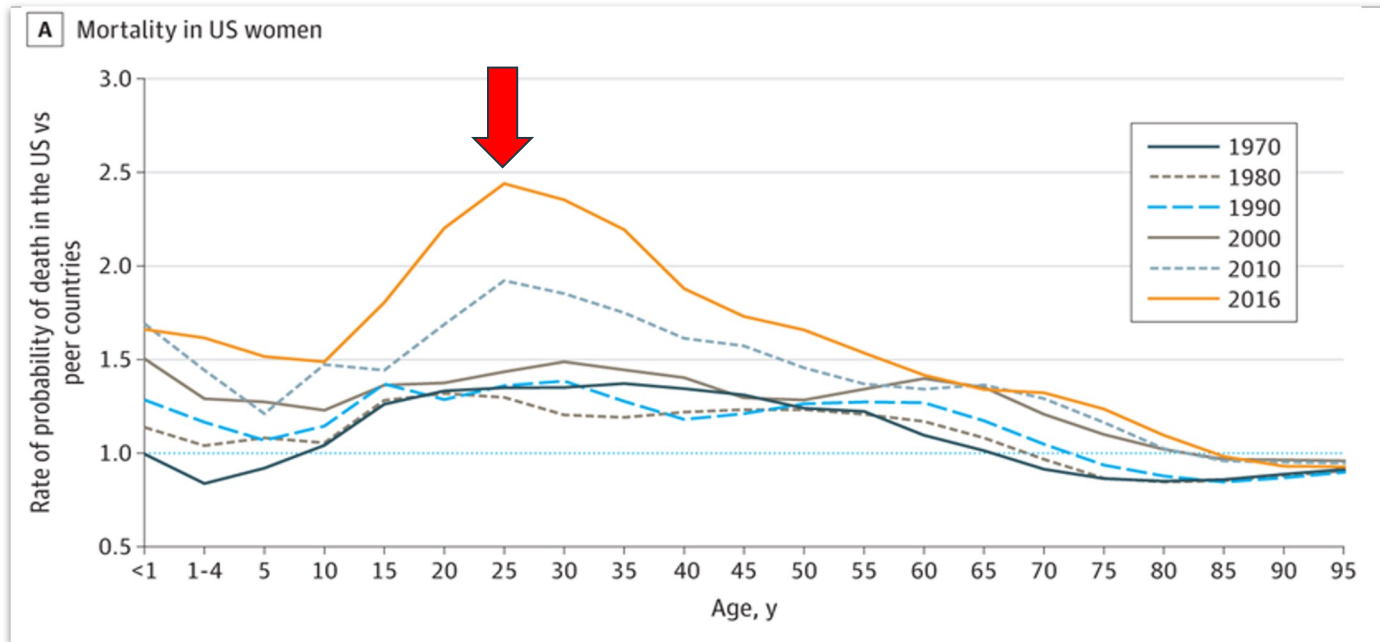
Lit Review

- However, the relatively poor performance of the USA in public health is not unforeseeable.
- In the past there are many other indicators. In spite of better medical technologies and higher living standards, the life expectancy of Americans is decreasing and adult mortality rates are increasing.
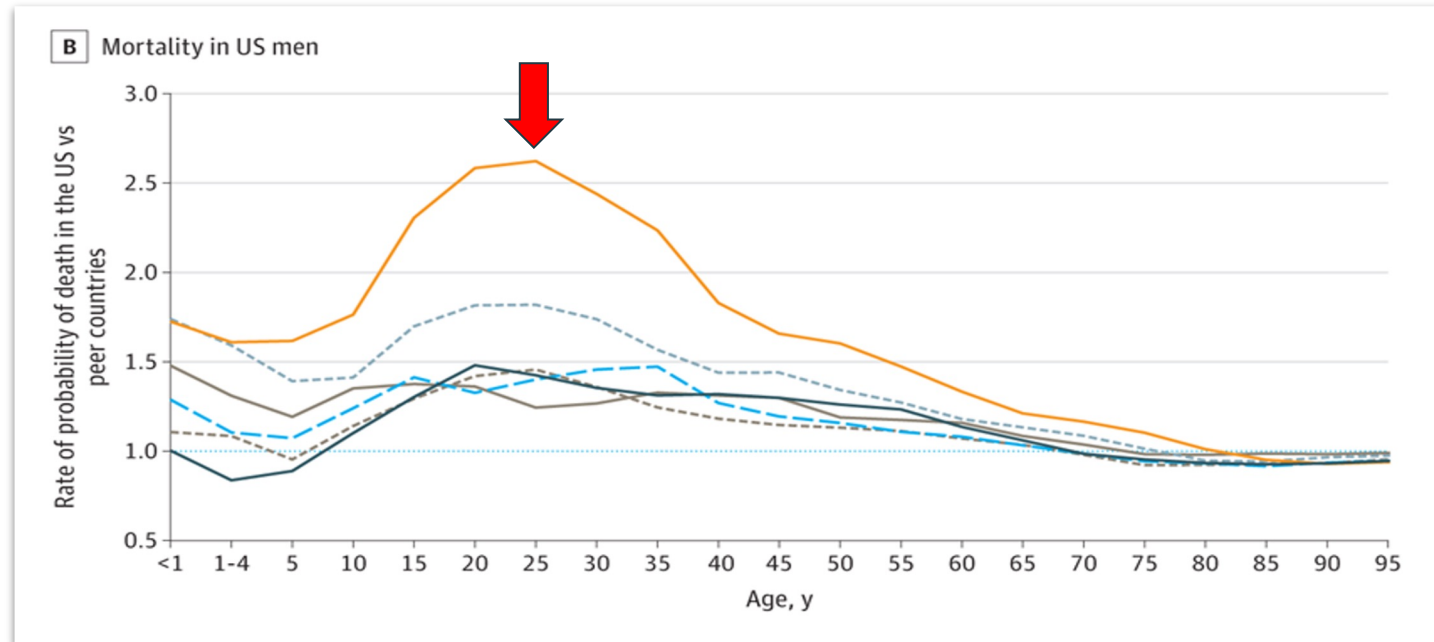
Lit Review Cont..

- Orange line: 2016
- Others: Previous years
- Source: Sterling et al. (2022)

A Mortality in US women

Lit Review Cont..

- Orange line: 2016
- Others: Previous years
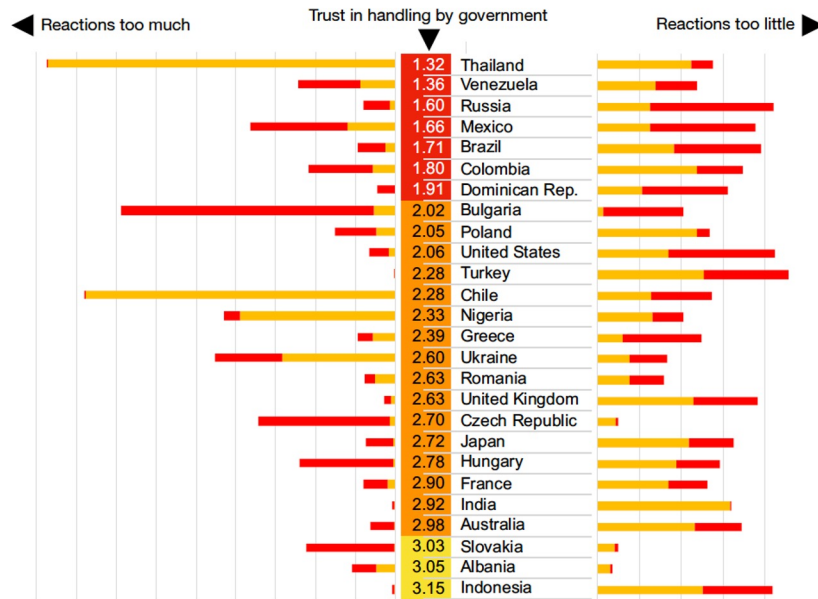- Source: Sterling et al. (2022)

Lit Review Cont..

- Obesity rates are getting worse in the US.
- Source: Sterling et al. (2022)

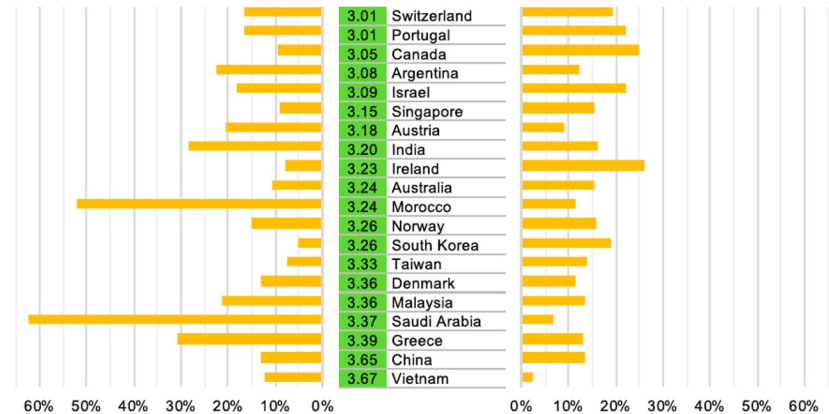**B** Rate of obesity in men and women aged 50-54 y
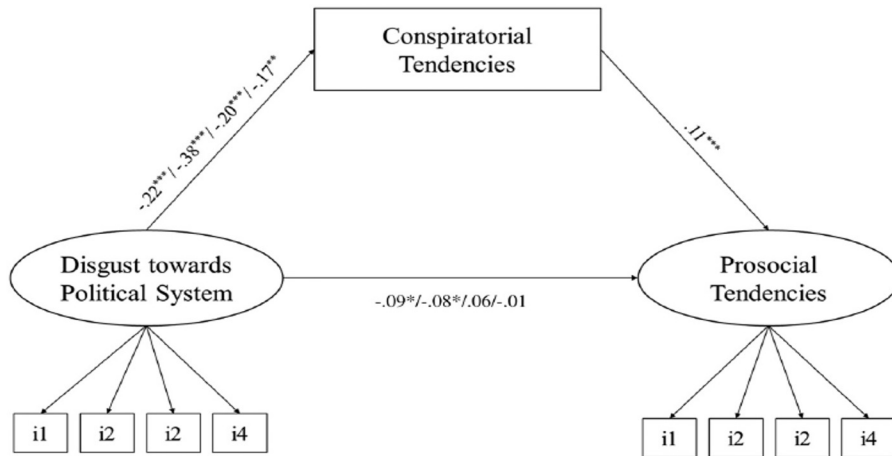
Legend:
- 1-Fold poverty
- 1- to 2-Fold poverty
- 2- to 4-Fold poverty
- >4-Fold poverty

Y-axis: Rate of obesity, %

X-axis (Time period): 1971-1974, 1976-1980, 1988-1994, 1999-2002, 2003-2006, 2009-2012, 2013-2016
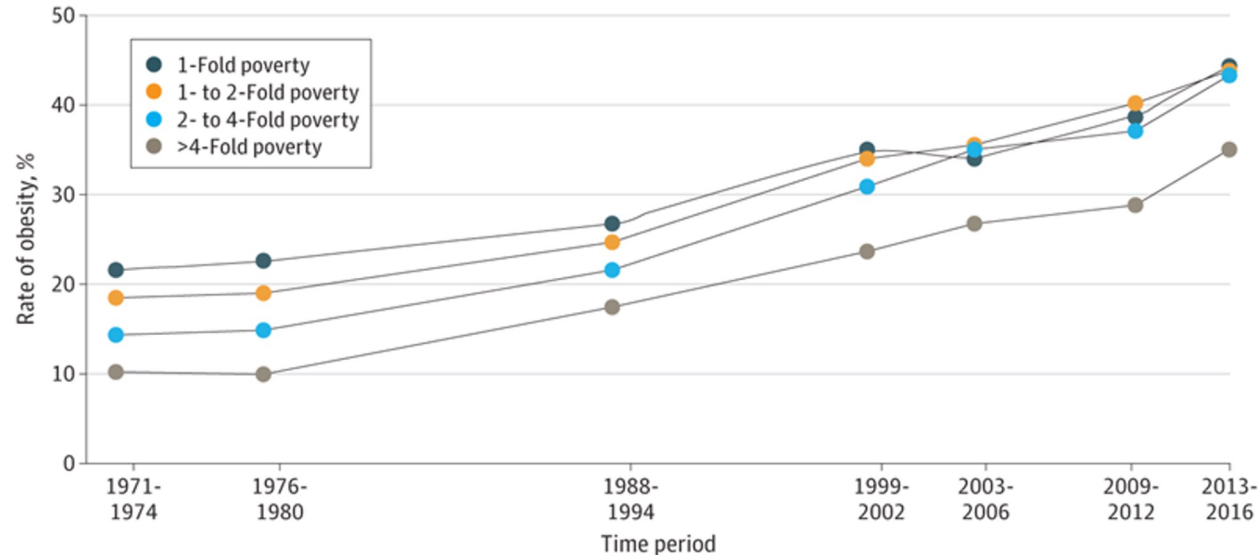
Lit Review Cont..

Rieger & Wang (2021)'s study indicates social trust variables as important predictors of pandemic control.

Trust in Government Actions During the COVID-19 Crisis   977

◄ Reactions too much   Trust in handling by government   Reactions too little ►

Value	Country
1.32	Thailand
1.36	Venezuela
1.60	Russia
1.66	Mexico
1.71	Brazil
1.80	Colombia
1.91	Dominican Rep.
2.02	Bulgaria
2.05	Poland
2.06	United States
2.28	Turkey
2.28	Chile
2.33	Nigeria
2.39	Greece
2.60	Ukraine
2.63	Romania
2.63	United Kingdom
2.70	Czech Republic
2.72	Japan
2.78	Hungary
2.90	France
2.92	India
2.98	Australia
3.03	Slovakia
3.05	Albania
3.15	Indonesia

Value	Country
3.01	Switzerland
3.01	Portugal
3.05	Canada
3.08	Argentina
3.09	Israel
3.15	Singapore
3.18	Austria
3.20	India
3.23	Ireland
3.24	Australia
3.24	Morocco
3.26	Norway
3.26	South Korea
3.33	Taiwan
3.36	Denmark
3.36	Malaysia
3.37	Saudi Arabia
3.39	Greece
3.65	China
3.67	Vietnam

60% 50% 40% 30% 20% 10% 0%   0% 10% 20% 30% 40% 50% 60%

Lit Review Cont..

Moon et al. (2021) shows that skepticism and disposition to conspiracy theories made the pandemic worse.

Distrust the government -> accept conspiracy theories and reduce prosocial behaviors (don't care about other people).

Gap

In 2019 the Global Health Security Index rated many Western developed nations as the most prepared countries for countering pandemic.

USA is Number 1.

Rank	OVERALL SCORE	Score
1	United States	83.5
2	United Kingdom	77.9
3	Netherlands	75.6
4	Australia	75.5
5	Canada	75.3
6	Thailand	73.2
7	Sweden	72.1
8	Denmark	70.4
9	South Korea	70.2
10	Finland	68.7
11	France	68.2
12	Slovenia	67.2
13	Switzerland	67.0
14	Germany	66.0
15	Spain	65.9
16	Norway	64.6
17	Latvia	62.9

Rank	1. PREVENTION OF THE EMERGENCE OR RELEASE OF PATHOGENS	Score
1	United States	83.1
2	Sweden	81.1
3	Thailand	75.7
4	Netherlands	73.7
5	Denmark	72.9
6	France	71.2
7	Canada	70.0
8	Australia	68.9
9	Finland	68.5
10	United Kingdom	68.3
11	Norway	68.2
12	Slovenia	67.0
13	Germany	66.5
14	Ireland	63.9
15	Belgium	63.5
16	Brazil	59.2
17	Kazakhstan	58.8

Rank	2. EARLY DETECTION & REPORTING FOR EPIDEMICS OF POTENTIAL INTERNATIONAL CONCERN	Score
1	United States	98.2
2	Australia	97.3
2	Latvia	97.3
4	Canada	96.4
5	South Korea	92.1
6	United Kingdom	87.3
7	Denmark	86.0
7	Netherlands	86.0
7	Sweden	86.0
10	Germany	84.6
11	Spain	83.0
12	Brazil	82.4
13	Lithuania	81.5
13	South Africa	81.5
15	Thailand	81.0
16	Italy	78.5
17	Greece	78.4

Rank	3. RAPID RESPONSE TO AND MITIGATION OF THE SPREAD OF AN EPIDEMIC	Score
1	United Kingdom	91.9
2	United States	79.7
3	Switzerland	79.3
4	Netherlands	79.1
5	Thailand	78.6
6	South Korea	71.5
7	Finland	69.2
8	Portugal	67.7
9	Brazil	67.1
10	Australia	65.9
11	Singapore	64.6
12	Slovenia	63.3
13	France	62.9
14	Sweden	62.8
15	Spain	61.9
16	Malaysia	61.3
17	Canada	60.7

Gap Con...

- This prediction is understandable because the USA and European nations have better technologies.
- However, when the COVID19 pandemic broke out, the outcome is surprisingly: Those highly rated countries did not do well!

Barking Up The Wrong Tree

Question

If the criteria used by the Global Health Security Index cannot predict pandemic control, then what are the really important factors?

Hypothesis

Having a few elite scientists and medical researchers is insufficient.

Cognitive skills and social mentalities (sense of civil responsibilities) of ordinary citizens, as indicated in the PIAAC survey, might be more important.

Data sources

- **Worldometer**: Pandemic data as of March 16, 2022
- **Programme for International Assessment of Adult Competencies (PIAAC)**: Round 1-3 from 2012 to 2017
  - Cover 37 countries: e.g., USA, UK, Japan, South Korea, Germany…etc.
  - Cognitive domains: Literacy, numeracy, and problem solving
  - Social attitudes: e.g, willingness to do voluntary work, trust other people…etc.

Methodologies and Results

- **Model comparison**: Identify the best overall model.
- **XGBoost**: Identify the most important factors contributing to pandemic control.
- **Data visualization**: Find the relationship between the independent variables and the outcome.

Model comparison

Eight different modeling methods were used to select the best model. XGBoost (Extreme Gradient Boosting) is the best in terms of RASE.

Method	N	RASE
XGBoost	37	0.00053
Fit Least Squares	30	1117.7
Neural Boosted	20	493.5
Bootstrap Forest	37	742.7
Support Vector Machines	30	834.9
Boosted Tree	37	825.1
Fit Stepwise	30	1016.4
Generalized Regression Lasso	37	1176.6

XGBoost

- Boosting consists of a series of partition trees.
- In boosting the subsequent partition tree models are fine-tuned by learning the errors from the previous models.
- No further improvement after 22 iterations.
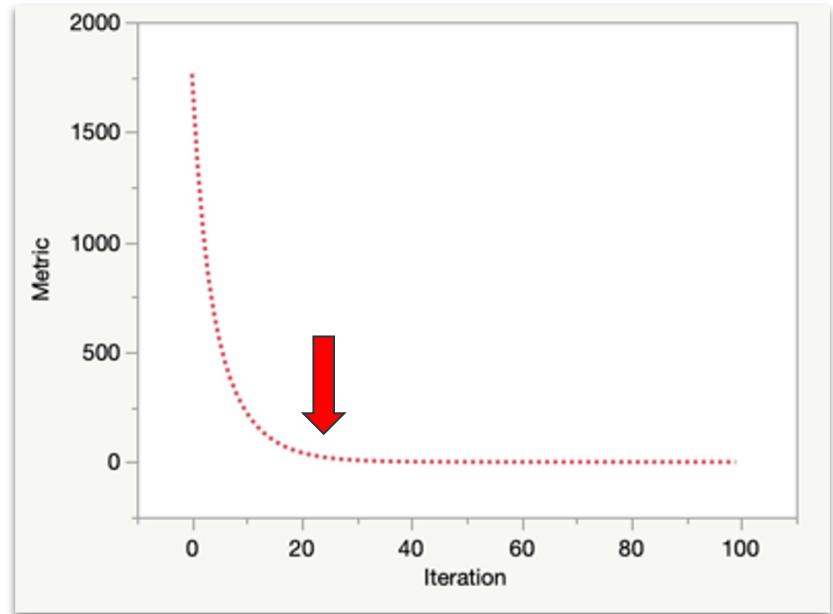
Variable importance in terms of information gain

Gain: The average improvement in information gain by partitioning with the variable

Feature	Splits	Gain	Cover
Mean(I_Q07b)	12	1444840	31.4167
Mean(I_Q07a)	30	802428	18.5
Mean(I_Q04d)	5	675620	13.6
Mean(I_Q04m)	54	262030	24.4074
Mean(I_Q06a)	23	231796	16.1739
Mean(I_Q04h)	35	154715	13.9714
Mean(H_Q01a)	19	124862	21.5789
Mean(H_Q03b)	9	95425.2	15.5556
Mean(I_Q04b)	14	86414.2	15.4286
Mean(G_Q01e)	62	80528.8	20.3387
Mean(PVNUM5)	89	71451.3	36.7416
Mean(PVPSL5)	47	53592.3	18.4468
Mean(PVLIT5)	6	50514.6	18.5
Mean(G_Q01a_T)	28	25163	11.7857
Mean(F_Q05b)	38	12504.8	17.8421
Mean(F_Q05a)	296	10393.5	3.16892
Mean(G_Q01f)	125	8821.47	23.96
Mean(I_Q05f)	15	7302.67	13.8667

Variable importance in terms of number of splits across all decision trees

Splits: The number of splits by this variable across all the partition trees, also known decision trees.

Cover: The amount of data covered by the splits involving the variable.

| Feature	Splits	Gain	Cover
Mean(F_Q05a)	296	10393.5	3.16892
Mean(G_Q01f)	125	8821.47	23.96
Mean(G_Q01a)	120	7239.56	4.69167
Mean(PVNUM5)	89	71451.3	36.7416
Mean(G_Q01e)	62	80528.8	20.3387
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Mean(I_Q04b)	14	86414.2	15.4286
Mean(I_Q07b)	12	1444840	31.4167
Mean(H_Q01e)	11	627.15	11.5455
Mean(I_Q04l)	10	389.812	12.5
Mean(H_Q02d)	10	320.995	16.9
Mean(H_Q03b)	9	95425.2	15.5556

Data visualization

- 1 = strongly agree
- 5 = Strongly disagree
- More agreement to "there are only a few people you can trust completely" -> higher deaths /1M population.

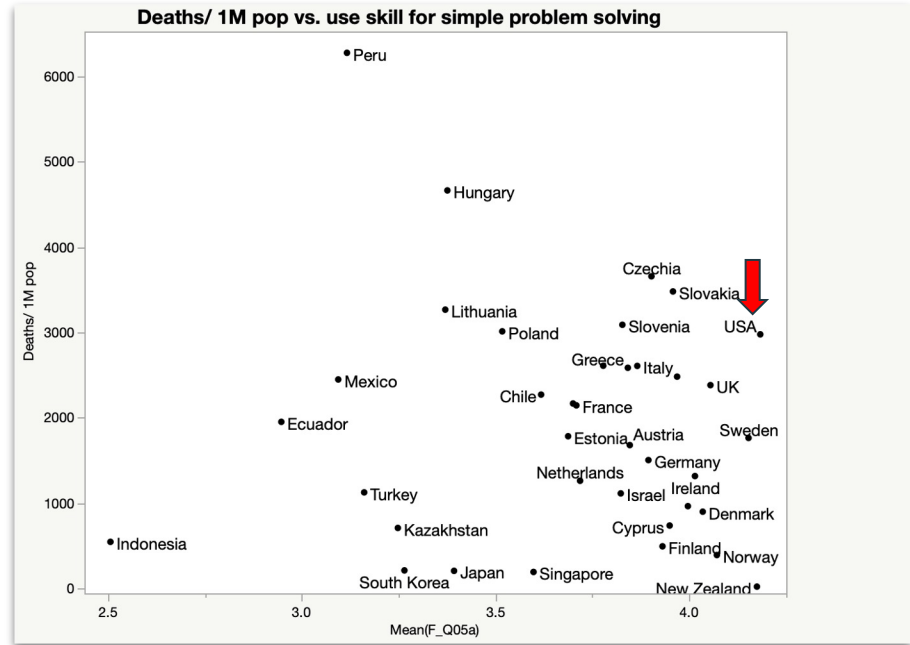
Deaths/ 1M pop vs. Social trust - Trust only few people
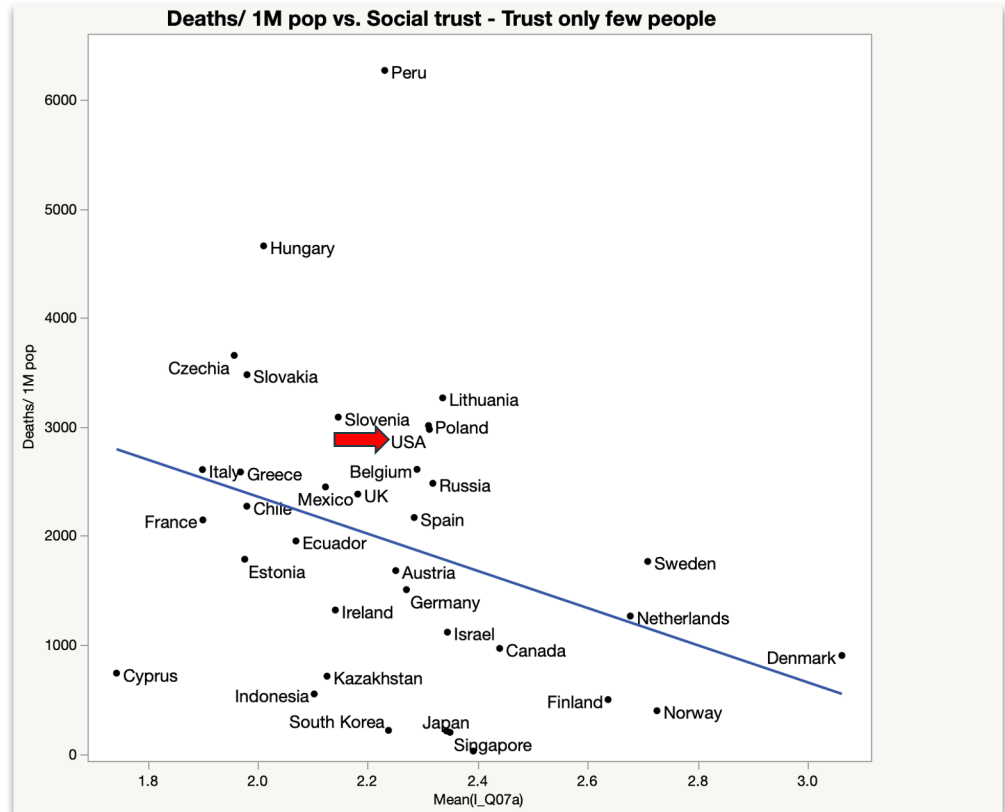
Data visualization

- 1 = strongly agree
- 5 = Strongly disagree
- More agreement to "If you are not careful, other people will take advantage of you" -> higher deaths /1M population

Deaths/ 1M pop vs. Social trust - Other people take advantage of you
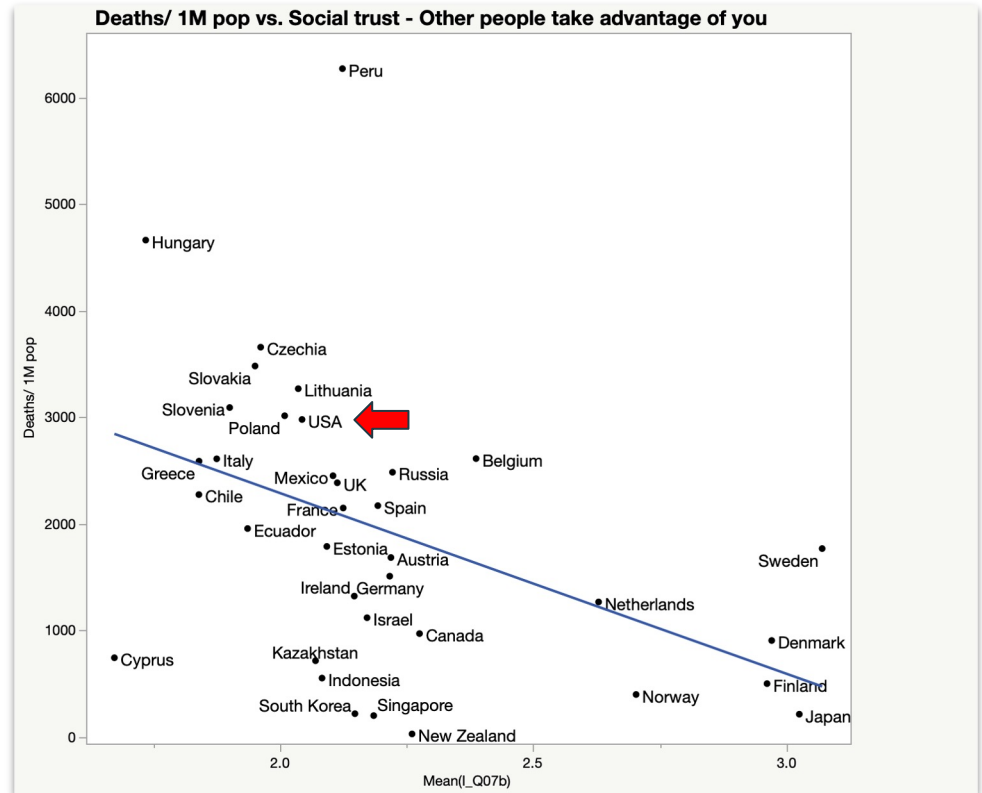
Data visualization

- 1= Never
- 5 = Everyday
- The pattern is not clear

Data visualization

- 1= Never
- 5 = Everyday
- No pattern at all
- Although these two variables are identified as important predictors in terms of the number of splits across all decision trees, no discernible pattern is observed.

Deaths/ 1M pop vs. use skill to read manuals and instruction
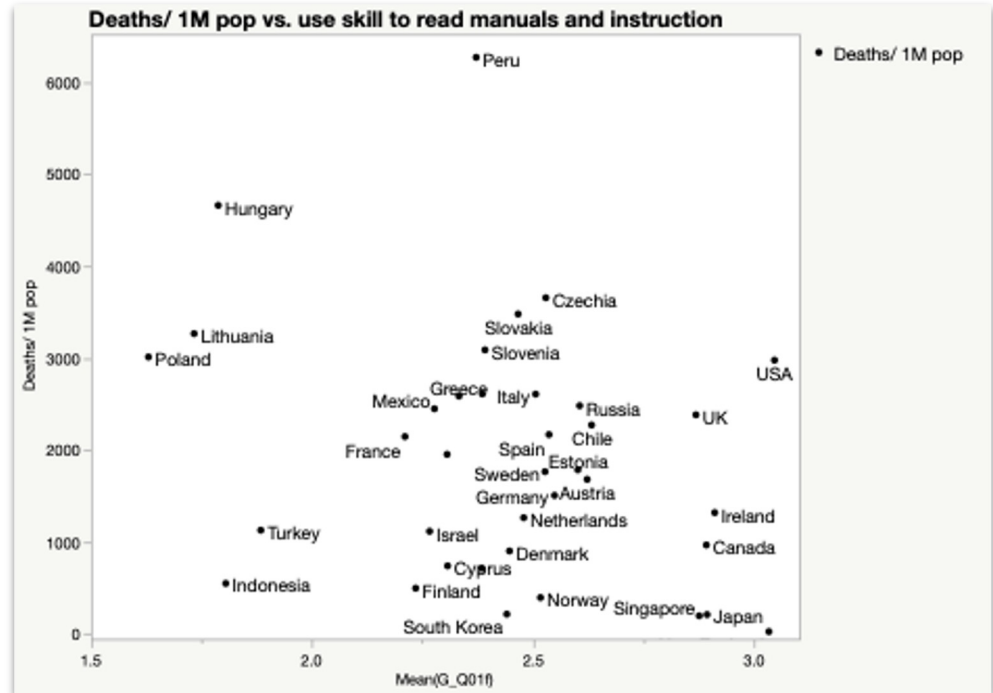
Data visualization

- Higher score = better problem solving skill
- Problem solving skill is not highly ranked in terms of information gain, but there is some degree of negative association between problem solving and deaths/ 1 M population. Literacy and numeracy were examined and they have no relationship with deaths by COVID19.

Deaths/ 1M pop vs. Porblem solving skill
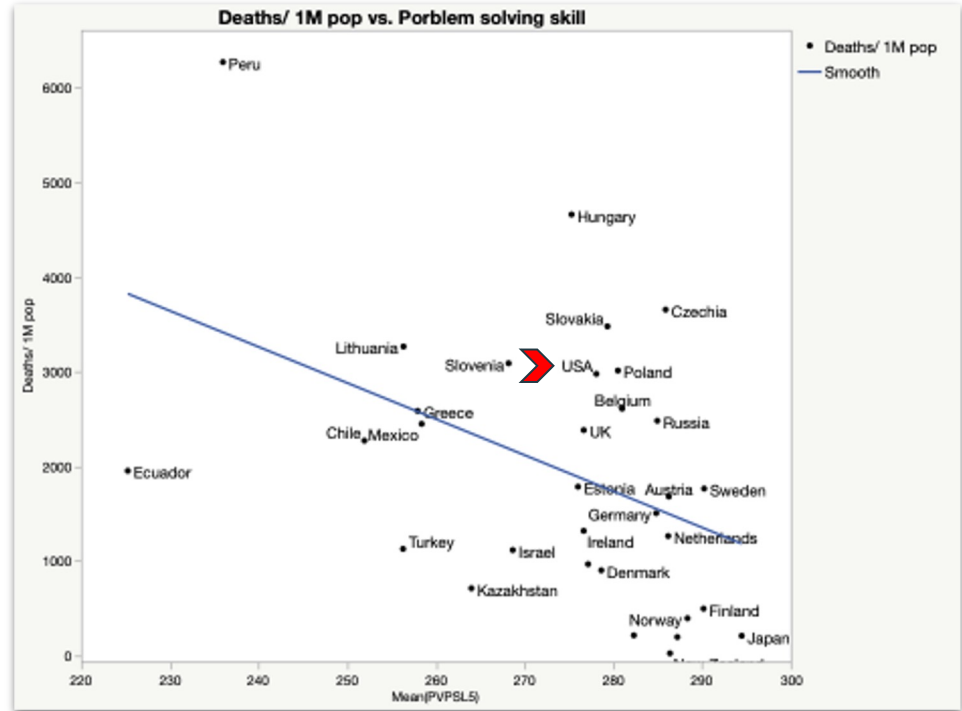
Conclusion and Discussion

- In line with the literature, variables related to social trust are important predictors of pandemic control in terms of reducing deaths/1 M.
- Between the three key skill sets (literacy, numeracy, and problem solving) measured by PIAAC, problem solving skill is slightly associated with the outcome of pandemic control while the other two are not.

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Thank You !