



# After the Dust has Settled: Covid-19 outcomes, GHS index, strategy, and structural determinants

---

Dr Matt Boyd  
Prof Nick Wilson  
(New Zealand)  
10 March 2026

# Adapt Research

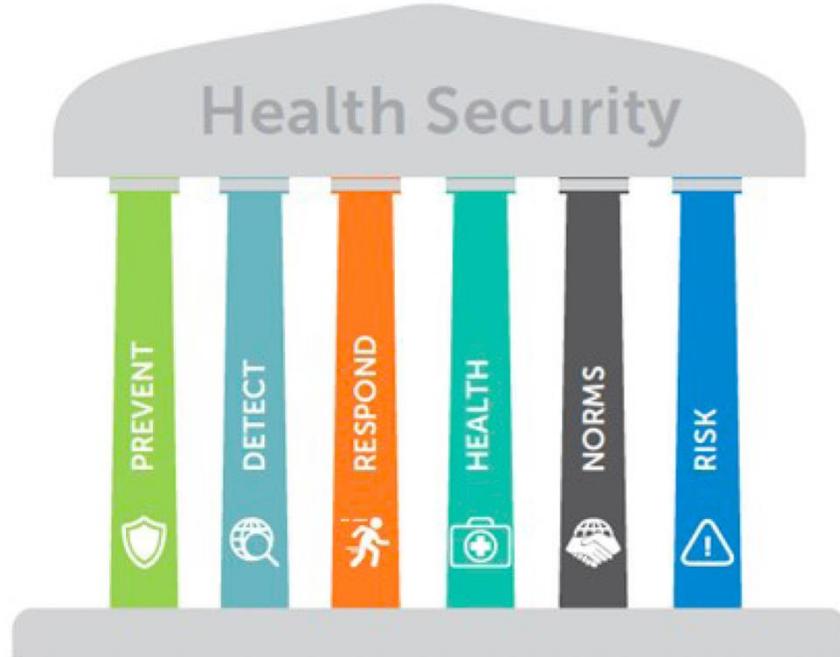
As we build our world we build our minds



University  
of Otago

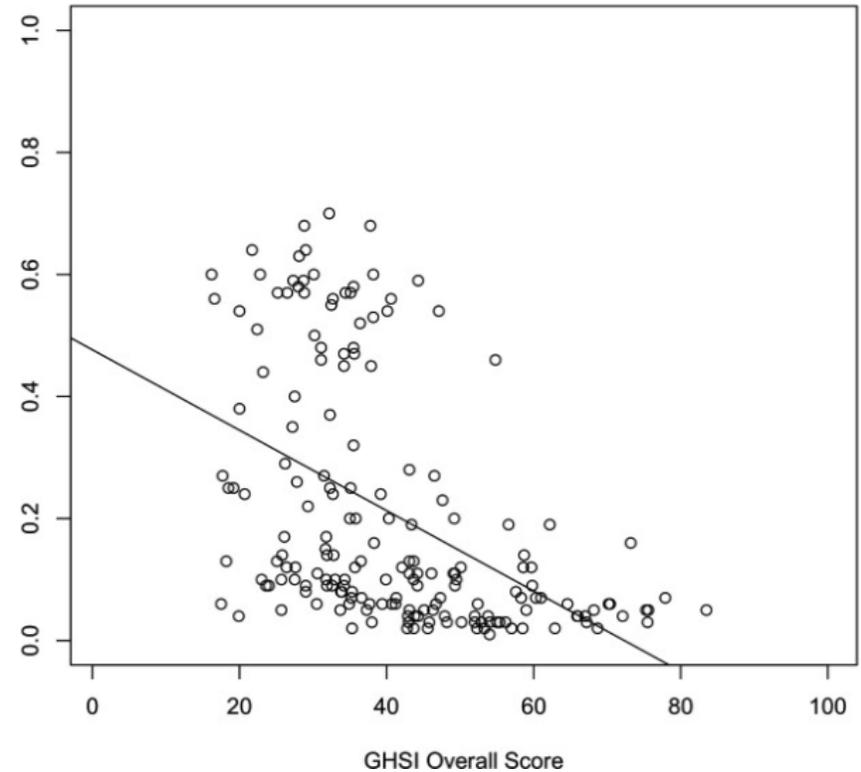
ŌTĀKOU WHAKAIHU WAKA

# The GHS Index & pre-Covid validation



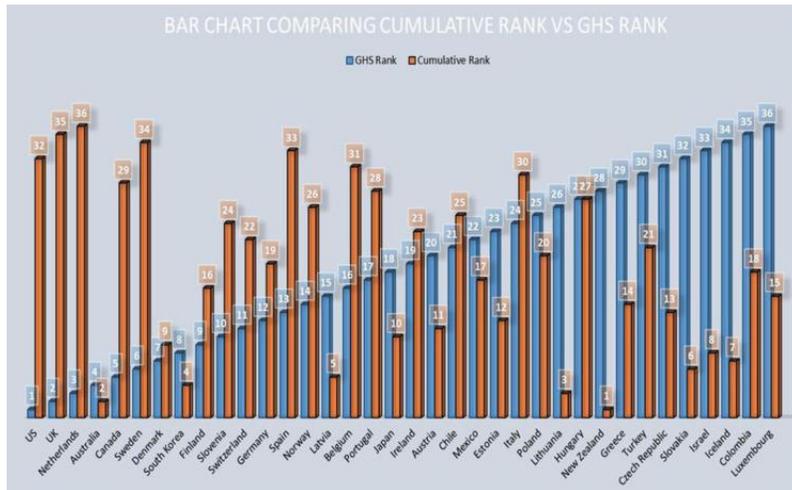
GHS Index 2021 (p.13)

Proportion of communicable disease deaths vs GHS Index



Boyd et al. 2020

# Based on early Covid-19 data, GHS Index had 'no explanatory power'\*

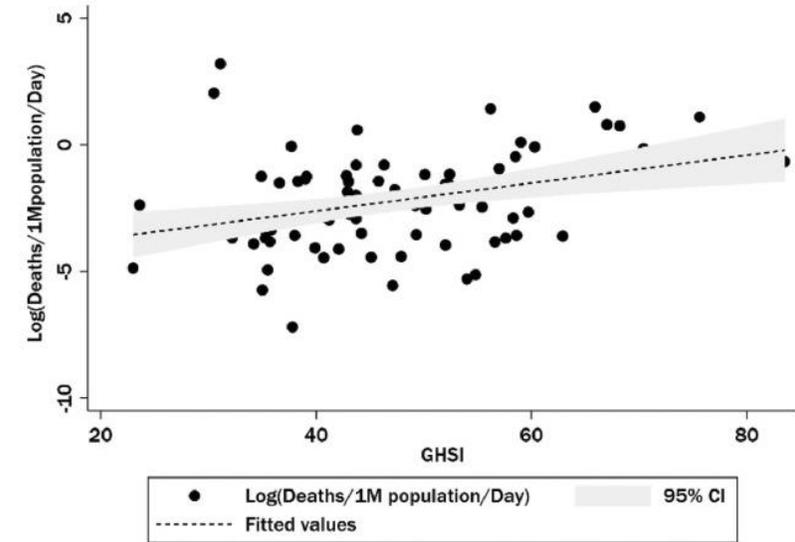


Abbey et al. 2020; OECD

Correlation results of some epidemiological indices and health service indicators

Correlated variables	Pearson correlation coefficient	P-value
Cumulative confirmed cases Vs GHSI	0.519	<0.01
Confirmed cases Vs Health Expenditure	0.120	0.422
Cumulative deaths Vs GHSI	0.495	<0.01
Cumulative deaths Vs Health Expenditure	0.142	0.342
Cumulative fatality rate Vs GHSI	0.035	0.816
Cumulative fatality rate Vs Health Expenditure	0.113	0.450
Attack rate Vs GHSI	0.177	0.239
Attack rate Vs Health Expenditure	0.024	0.873

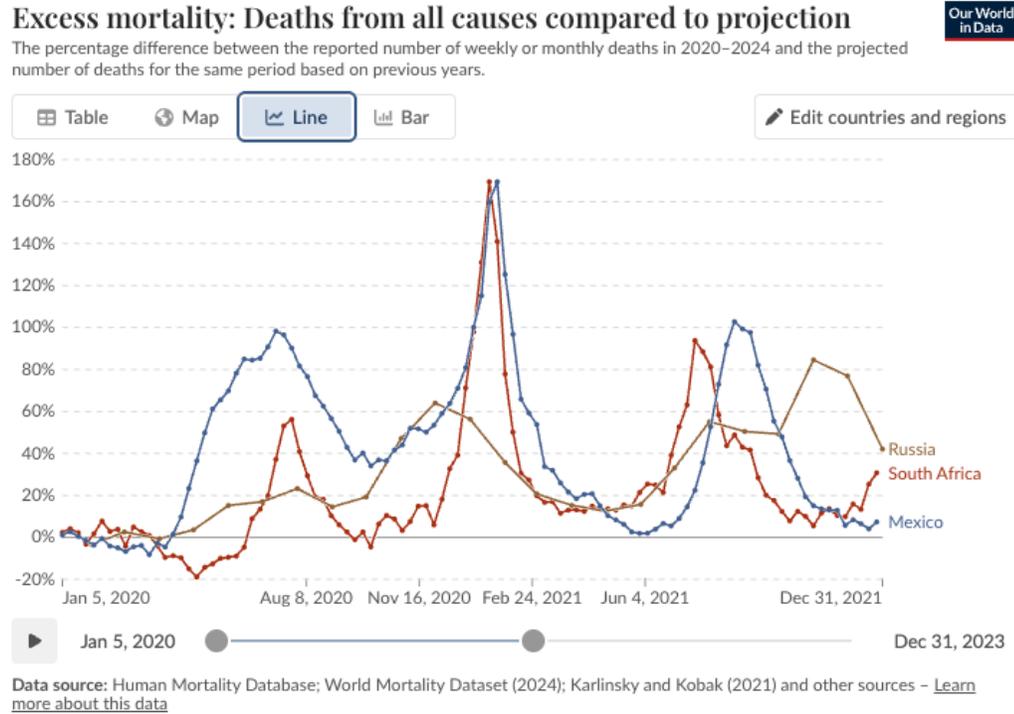
Okoroiwu et al. 2021; Africa



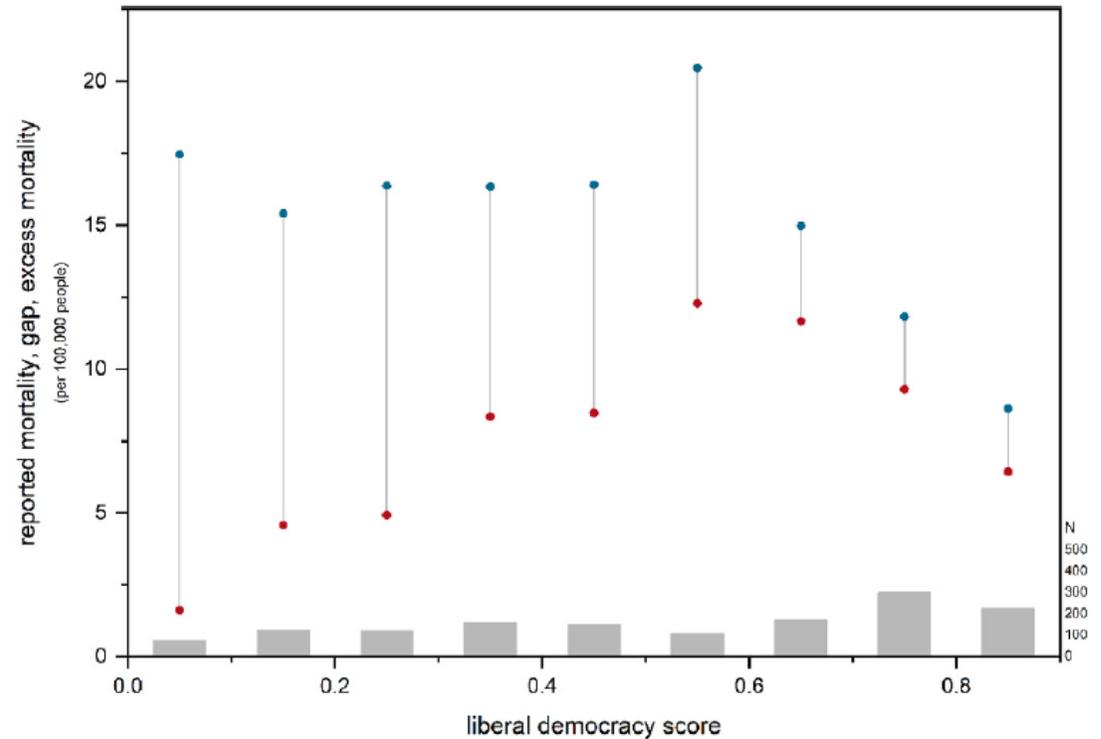
Aitken et al. 2020; n=100 countries

\* König & Winkler (2021)

# Systematic reporting flaws in Covid-19 data

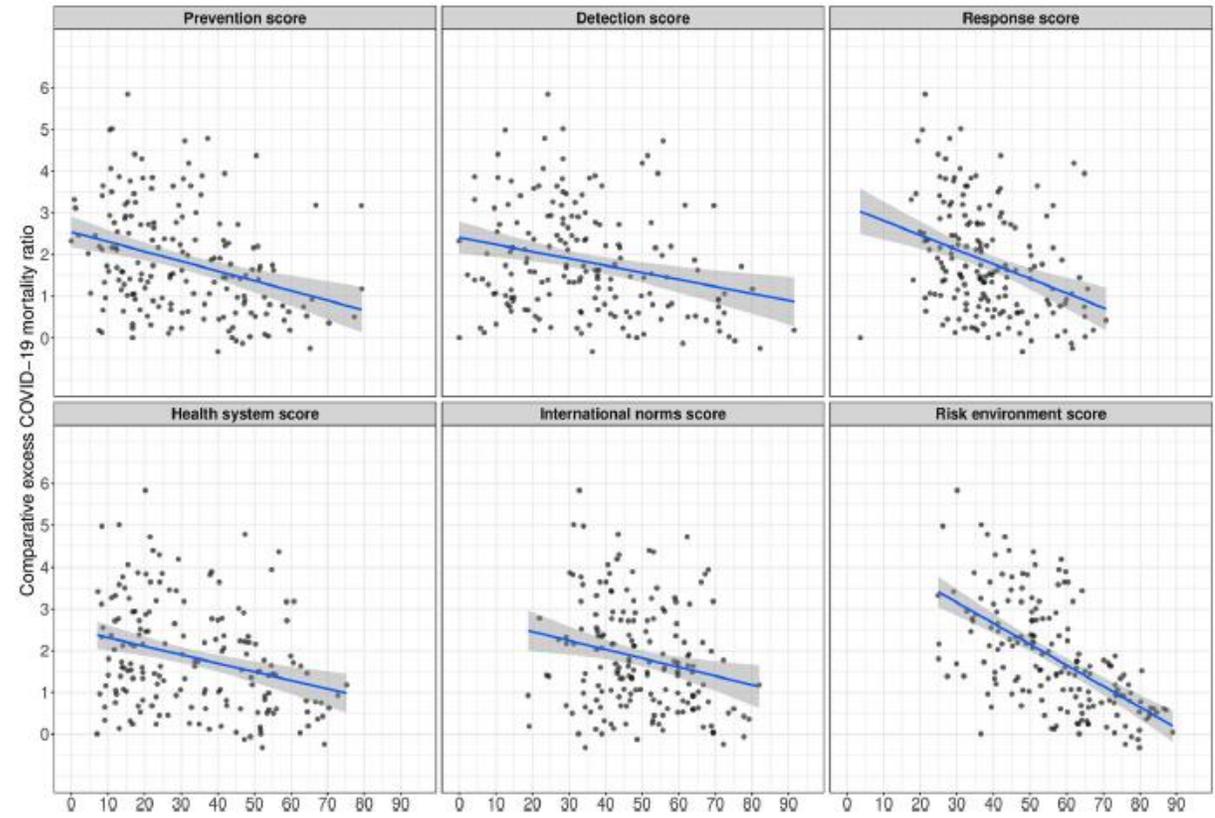
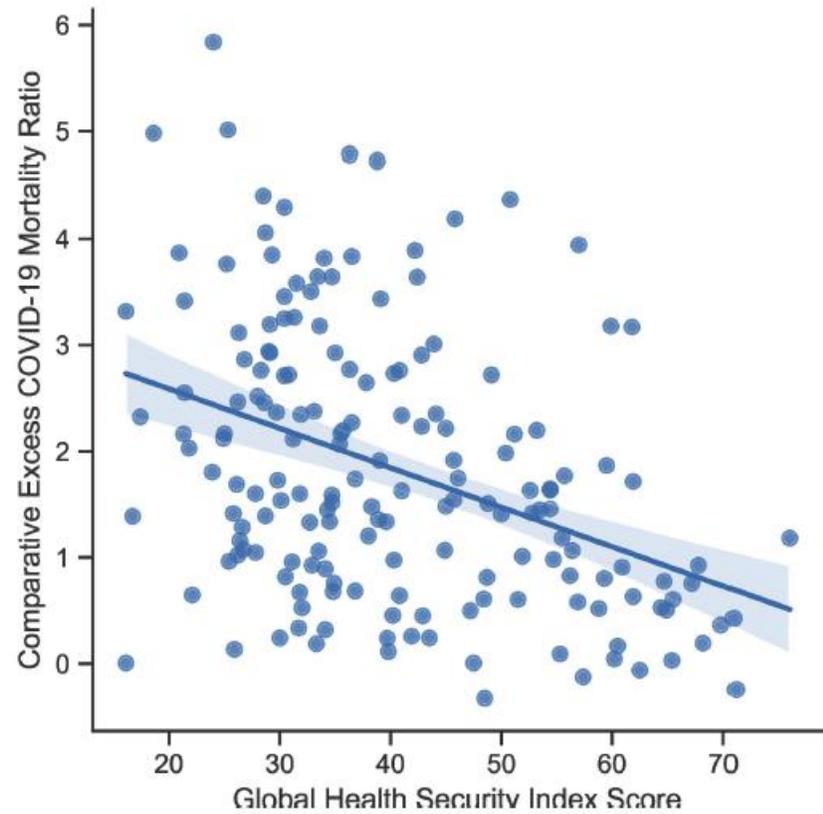


Our World in Data 2026



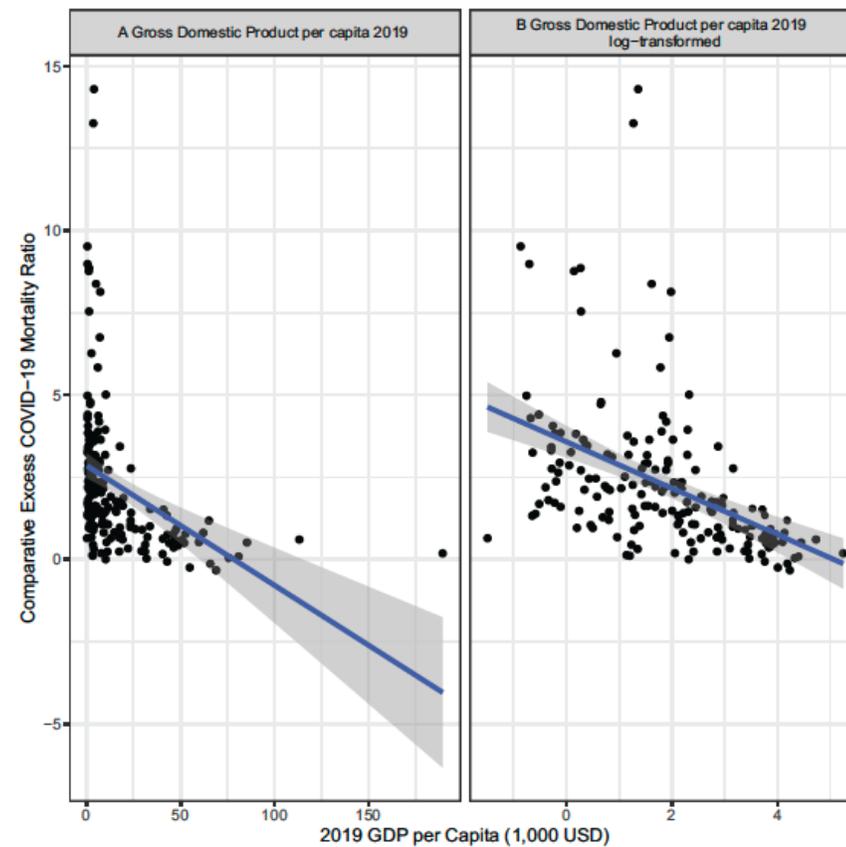
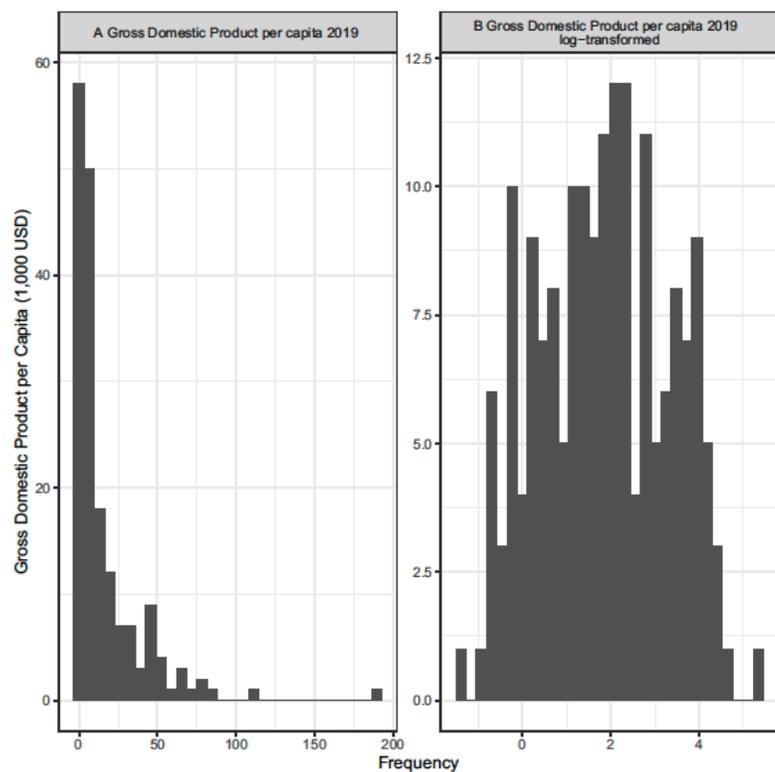
Neumayer et al 2022

# Ledesma et al 2023: GHS Index predicts outcomes (CMRs)



Correcting for mortality reporting issues & population age structure

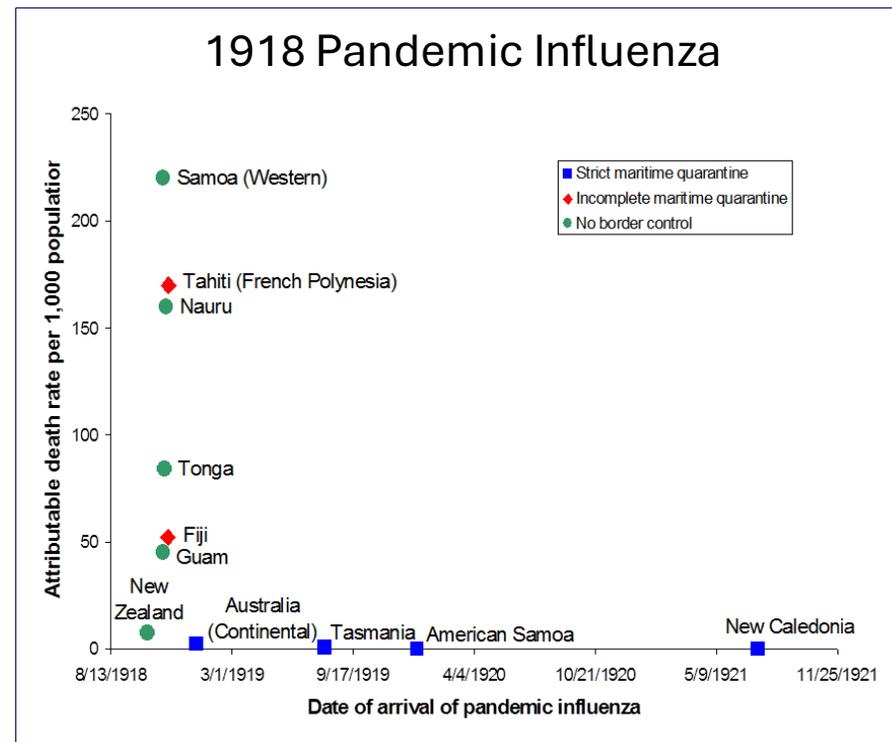
# Dieleman et al 2024: No, you need to transform the data first...



# ...and then the findings disappear

	Income-adjusted analysis (Ledesma <i>et al</i> )		Log-transformed income-adjusted	
	Coefficient (corrected 95% CI)	P value	Coefficient (corrected 95% CI)	P value
<b>Pandemic preparedness capacity</b>				
Overall score	-0.21 (-0.41 to 0.02)	0.0004*	-0.11 (-0.32 to 0.10)	0.0740
Overall risk environment and country vulnerability to biological threats	-0.30 (-0.50 to 0.10)	<0.0001*	-0.25 (-0.50 to 0.01)	0.0016
(6.1) Political and security risk	-0.15 (-0.30 to 0.00)	0.0014	-0.09 (-0.25 to 0.06)	0.0454
(6.1.1) Government effectiveness	-0.21 (-0.35 to 0.06)	<0.0001*	-0.16 (-0.31 to 0.00)	0.0009*
(6.2) Socio-economic resilience	-0.23 (-0.39 to 0.07)	<0.0001*	-0.19 (-0.44 to 0.07)	0.0156
(6.2.3) Social inclusion	-0.13 (-0.24 to 0.02)	0.0002*	-0.08 (-0.26 to 0.11)	0.1599
(6.2.4) Public confidence in government	-0.08 (-0.15 to 0.00)	0.0008*	-0.06 (-0.14 to 0.02)	0.0087
(6.2.6) Inequality	-0.11 (-0.23 to 0.01)	0.0035	-0.10 (-0.22 to 0.02)	0.0055

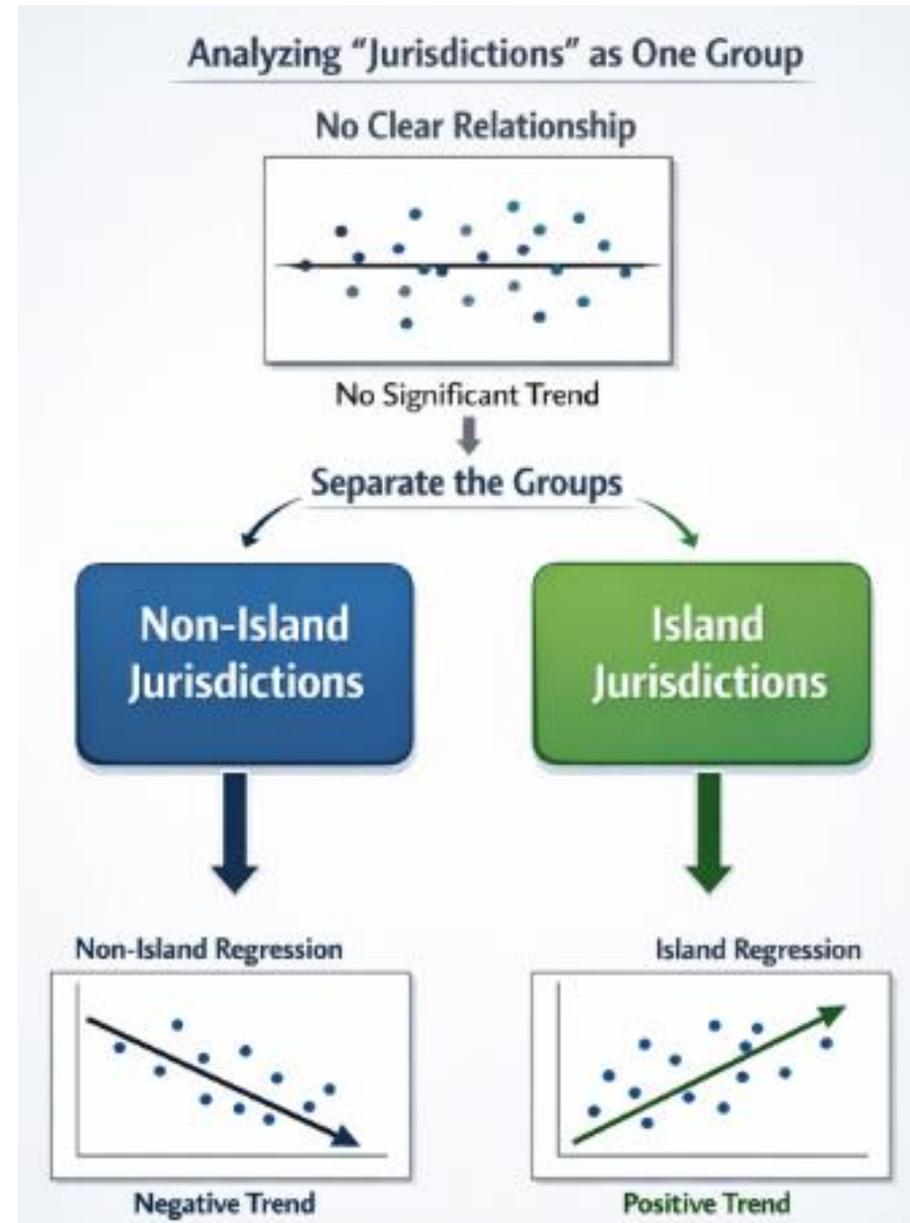
Is something else is going on? Islands might systematically differ from non-islands



**Table 1:** Descriptive values for jurisdiction groups included in the analysis

Variable	Statistic	All jurisdictions	Islands	Non-Islands
GBD data	n	204	58*	146
Excess mortality 2020-2021 (deaths per 100k population)	Mean	116	53	141
	Median	95.5	39.5	115
	SD	101.5	68.3	102
	Range	-103 to 521	-103 to 265	-17 to 521
Age-standardised excess mortality 2020-2021 (per 100k population)	Mean	155	59	193
	Median	122.4	32.1	169.6
	SD	153.4	79.1	159.2
	Range	-59.6 to 897.4	-59.6 to 333.7	-29.4 to 897.4

Need to  
untangle  
opposing  
effects



# Research questions

---

Do relationships between GHS Index scores and excess mortality due to Covid-19 remain after appropriate data transformations and statistical tests?

---

Are there any associations between GHS Index scores and macroeconomic performance through the pandemic period?

---

Does consideration of island and non-island jurisdictions separately demonstrate any important patterns in relationships between GHS Index scores and Covid-19 pandemic health and/or macroeconomic outcomes?

# Our method

---

All countries (not regional subset, pairwise deletion to preserve 'n')

---

Cumulative excess mortality (not reported deaths/cases)

---

Age-standardization (to compare across jurisdictions)

---

Log-transform skewed variables (GDP, population)

---

Cube-root transform excess mortality (due to negative values)

---

Separate islands and non-islands (theory-based differences)

---

Evaluate GDP (PPP!) growth as well as health outcomes

---

Theory-based controls (wealth, corruption [effectiveness] +/- population size, preparedness)

---

Hierarchical analysis (identify which variables to take forward)

# Variables used in the analyses

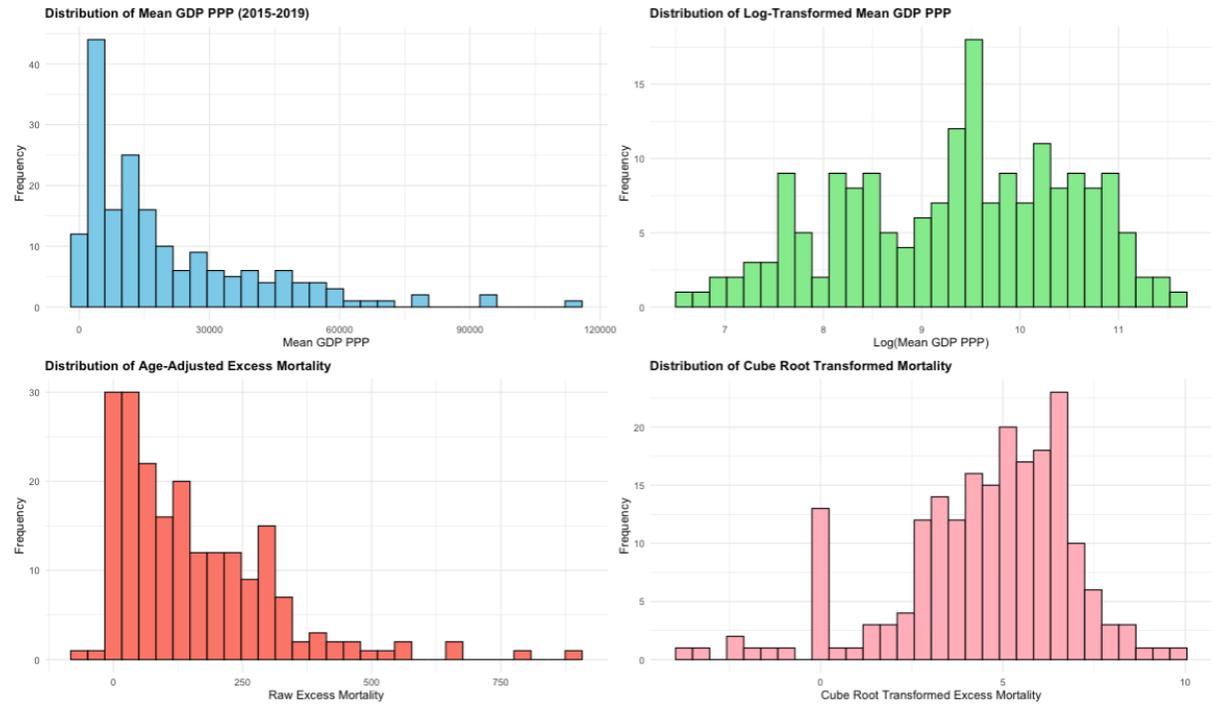
Variable	Source
<b>Age-standardized excess mortality (2020–2021)</b> [Dependent – health outcome]	Global Burden of Disease Study (GBD) Demographics Collaborators
<b>GDP per capita growth (2019–2020)</b> [Dependent – economic outcome]	World Bank World Development Indicators (PPP-adjusted GDP per capita)
<b>GDP per capita growth (2020–2021)</b> [Dependent – economic outcome]	World Bank World Development Indicators
<b>GHS Index overall score (2019)</b> [Primary independent variable]	Global Health Security Index (NTI, Johns Hopkins Center for Health Security, Economist Intelligence Unit)
<b>GHS Index category scores</b> [Independent – secondary analyses]	Global Health Security Index
<b>Mean GDP per capita (PPP), 2015–2019</b> [Control variable]	World Bank World Development Indicators
<b>Government corruption</b> [Control variable]	COVID-19 National Preparedness Collaborators dataset
<b>Trust in government; trust in individuals</b> [Controls – sensitivity analysis]	COVID-19 National Preparedness Collaborators dataset

# Data coverage & skew

**Table S1:** Number of jurisdictions with available data for each variable

	All Jurisdictions (n)	Non-Islands (n)	Islands (n)
Age-standardised excess mortality (2020-21)	204	146	58
GDP per capita growth 2020-2021	183	136	47
GHS Index scores (2019, 2021)	194	145	49
<b>Control variables</b>			
GDP per capita mean 2015-2019 (PPP, 2017)	184	137	47
GDP per capita + government corruption	155	128	27
GDP per capita + government corruption + trust in government	105	89	16
GDP per capita + government corruption + trust in government + trust in individuals	64	56	8

Pre- (L) and post- (R) transformation data

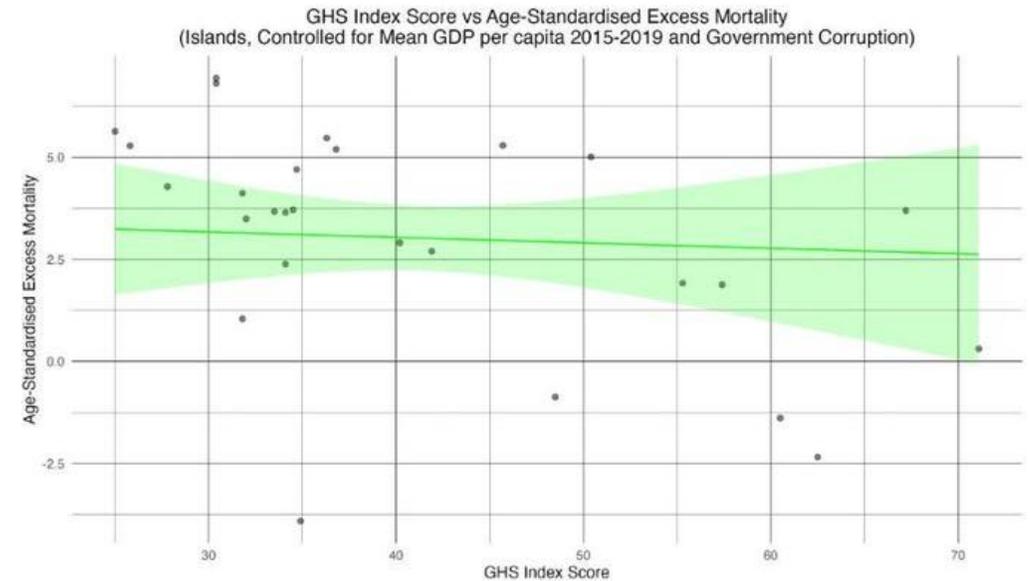
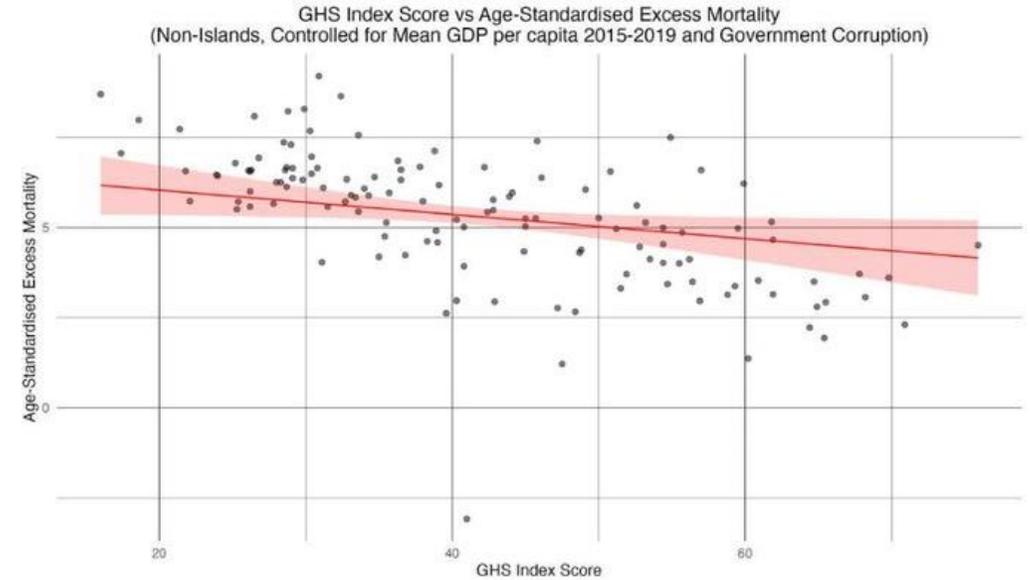
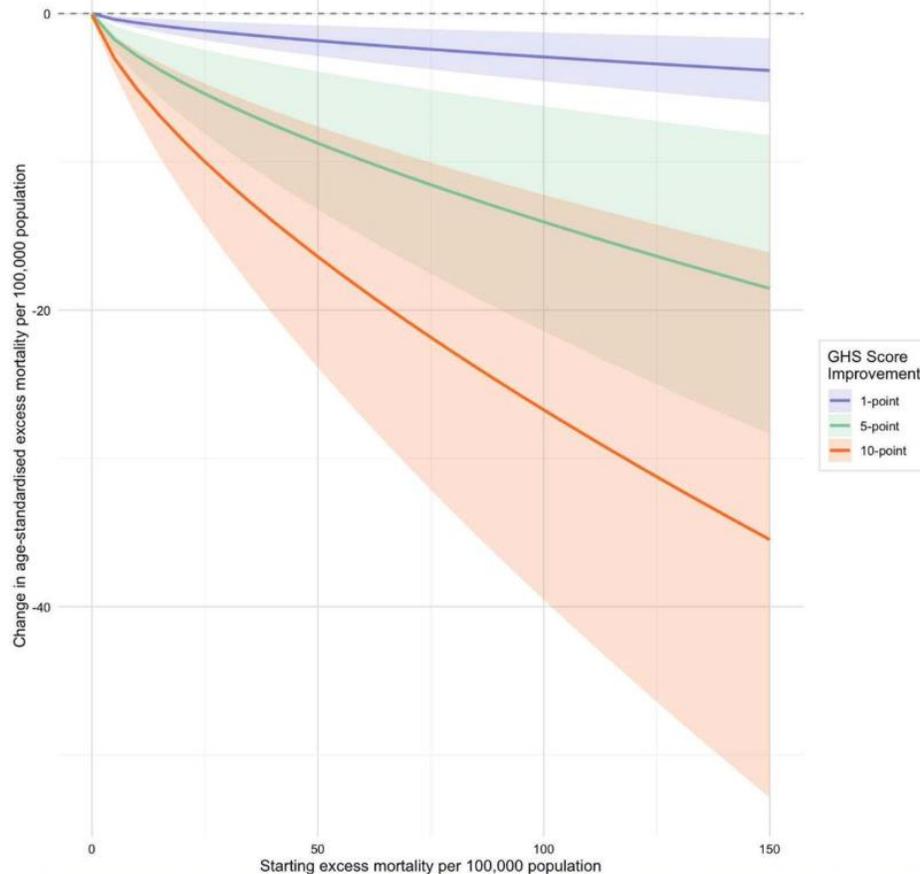


## Regression results

Group	Model	Depend. Variable	Indep. Variable	Control Variables	Coefficient (SE) <sup>#</sup>	T-Value	P-Value (unadjusted)	R <sup>2</sup>	Adj. R <sup>2</sup>	N
<b>Age-standardised excess mortality 2020–2021</b>										
All	1	EM	GHSI 2021	GDP	-3.091 (0.86)	-3.61	0.000387*	0.22	0.21	189
All	2	$\sqrt[3]{EM}$	GHSI 2019	ln(GDP)	0.011 (0.01)	0.79	0.432050	0.20	0.19	182
All	3	$\sqrt[3]{EM}$	GHSI 2019	ln(GDP)+ corruption	-0.005 (0.01)	-0.38	0.704835	0.46	0.45	155
Islands	1	EM	GHSI 2021	GDP	0.647 (1.53)	0.42	0.675088	0.10	0.06	47
Islands	2	$\sqrt[3]{EM}$	GHSI 2019	ln(GDP)	0.027 (0.04)	0.75	0.458671	0.06	0.01	45
Islands	3	$\sqrt[3]{EM}$	GHSI 2019	ln(GDP)+ corruption	0.012 (0.03)	0.34	0.733720	0.53	0.46	27
Non-Islands	1	EM	GHSI 2021	GDP	-5.353 (0.89)	-5.99	<0.000001*	0.36	0.35	142
Non-Islands	2	$\sqrt[3]{EM}$	GHSI 2019	ln(GDP)	-0.050 (0.01)	-4.46	0.000017*	0.46	0.45	137
Non-Islands	3	$\sqrt[3]{EM}$	GHSI 2019	ln(GDP)+ corruption	-0.046 (0.01)	-3.48	0.000683*	0.49	0.48	128

# GHS Index overall score

Predicted change in excess mortality (non-islands)  $n = 128$ ,  $p = 0.00068$ ,  $\text{adj } R^2 = 0.45$



GHS Index  
2019  
category  
scores

**Table 3:** Second-level hierarchical analysis (2019 GHS Index Category Scores): Regression results (Model 3) for those jurisdictions and dependent variables showing statistical significance at first-level analysis

Group	Depend. Variable	Indep. Variable	Control Variables	Coeff. (SE)	T-Value	Corrected P-Value	R <sup>2</sup>	Adj. R <sup>2</sup>	N
<b>Non-island jurisdictions: category scores vs age-standardised excess mortality 2020-2021</b>									
Non-Islands	$\sqrt[3]{EM}$	2019 Overall Score	ln(GDP) + corrupt	-0.046 (0.01)	-3.48	Meets Bonferroni threshold at level 1 (see above)	0.49	0.48	128
Non-Islands	$\sqrt[3]{EM}$	Prevention	ln(GDP) + corrupt	-0.024 (0.01)	-2.20	0.044551*	0.46	0.45	128
Non-Islands	$\sqrt[3]{EM}$	Detection	ln(GDP) + corrupt	-0.019 (0.01)	-2.99	0.014004*	0.48	0.47	128
Non-Islands	$\sqrt[3]{EM}$	Response	ln(GDP) + corrupt	-0.029 (0.01)	-2.88	0.014004*	0.48	0.46	128
Non-Islands	$\sqrt[3]{EM}$	Health System	ln(GDP) + corrupt	-0.027 (0.01)	-2.57	0.022846*	0.47	0.46	128
Non-Islands	$\sqrt[3]{EM}$	Compliance	ln(GDP) + corrupt	-0.018 (0.01)	-1.60	0.135899	0.45	0.44	128
Non-Islands	$\sqrt[3]{EM}$	Risk Environment	ln(GDP) + corrupt	-0.058 (0.02)	-2.57	0.022846*	0.47	0.46	128

This tells the story you would have expected *a priori* (in non-islands at least)

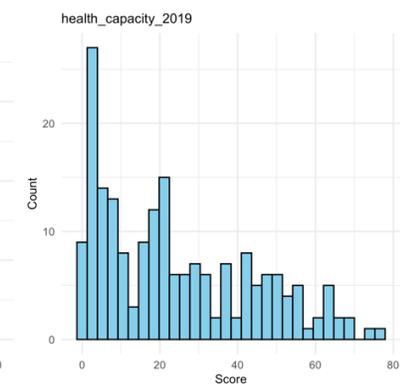
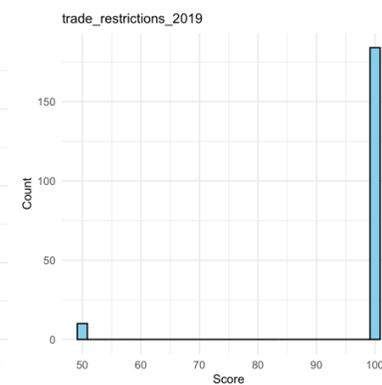
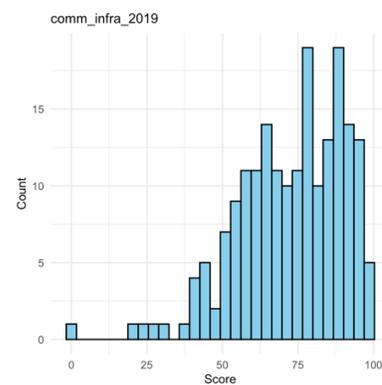
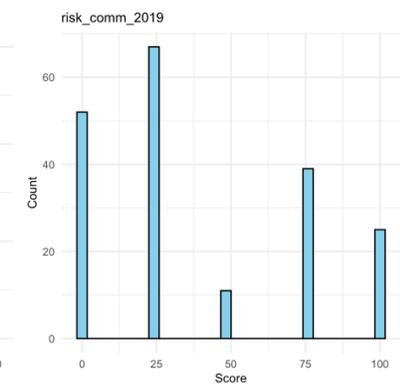
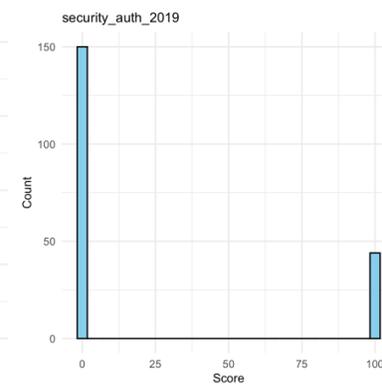
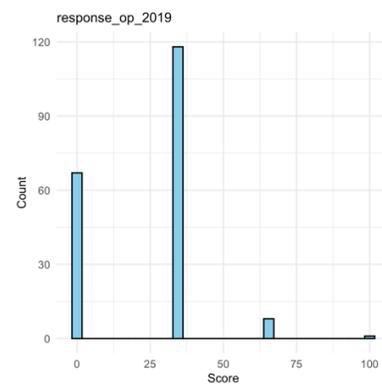
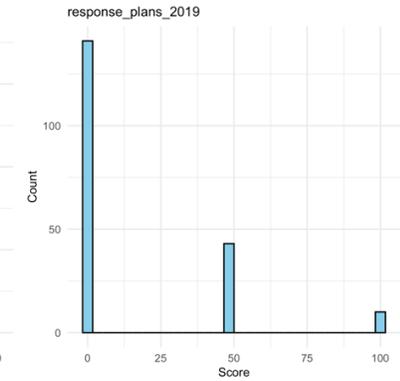
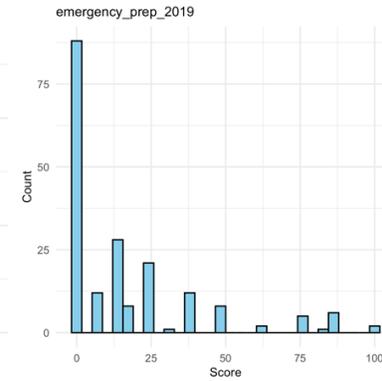
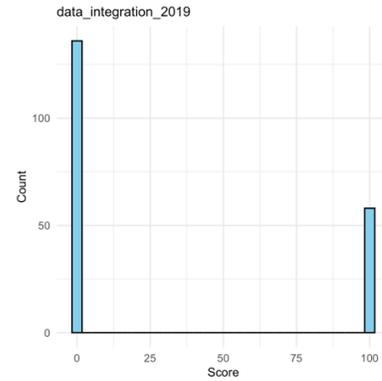
## Sensitivity analysis: Trust in govt/individuals

**Table S2: Age-standardised Excess Mortality 2020-2021 vs GHS Index Overall Score (2021 and 2019) across all analyses**

Group	Model	Dependent Variable	Independent Variable	Control Variables	Coefficient (SE)	T-Value	P-Value	R <sup>2</sup>	Adj. R <sup>2</sup>	N
All	Model 1	EM	GHSI 2021	GDP	-3.091 (0.86)	-3.61	0.000387*	0.22	0.21	189
All	Model 2	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP</u>	0.011 (0.01)	0.79	0.432050	0.20	0.19	182
All	Model 3	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP + corruption</u>	-0.005 (0.01)	-0.38	0.704835	0.46	0.45	155
All	Sensitivity	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP + corruption + trust govt + trust indivs</u>	-0.006 (0.02)	-0.27	0.789155	0.60	0.57	64
Islands	Model 1	EM	GHSI 2021	GDP	0.647 (1.53)	0.42	0.675088	0.10	0.06	47
Islands	Model 2	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP</u>	0.027 (0.04)	0.75	0.458671	0.06	0.01	45
Islands	Model 3	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP + corruption</u>	0.012 (0.03)	0.34	0.733720	0.53	0.46	27
Islands	Sensitivity	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP + corruption + trust govt + trust indivs</u>	0.046 (0.09)	0.49	0.674571	0.88	0.59	8
Non-Islands	Model 1	EM	GHSI 2021	GDP	-5.353 (0.89)	-5.99	<0.000001*	0.36	0.35	142
Non-Islands	Model 2	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP</u>	-0.050 (0.01)	-4.46	0.000017*	0.46	0.45	137
Non-Islands	Model 3	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP + corruption</u>	-0.046 (0.01)	-3.48	0.000683*	0.49	0.48	128
Non-Islands	Sensitivity	<u>cube_r EM</u>	GHSI 2019	<u>ln GDP + corruption + trust govt + trust indivs</u>	-0.052 (0.02)	-3.14	0.002844	0.71	0.68	56

**Table notes:** Coefficient for Model 1 cannot be compared to other models due to untransformed EM and GDP per capita; Asterisk (\*) indicates p-value remains statistically significant against the pre-specified Bonferroni corrected p-value threshold of 0.0056; cube\_r: cube root transformed; EM: age-standardised excess mortality; ln: natural logarithm transformed; SE: standard error; Sensitivity: sensitivity analysis only, including all control variables (note the much lower N across the sensitivity analyses – compare to models 1-3 with caution).

# GHS Index 2019: indicator scores



## Macroeconomic outcomes & GHS Index

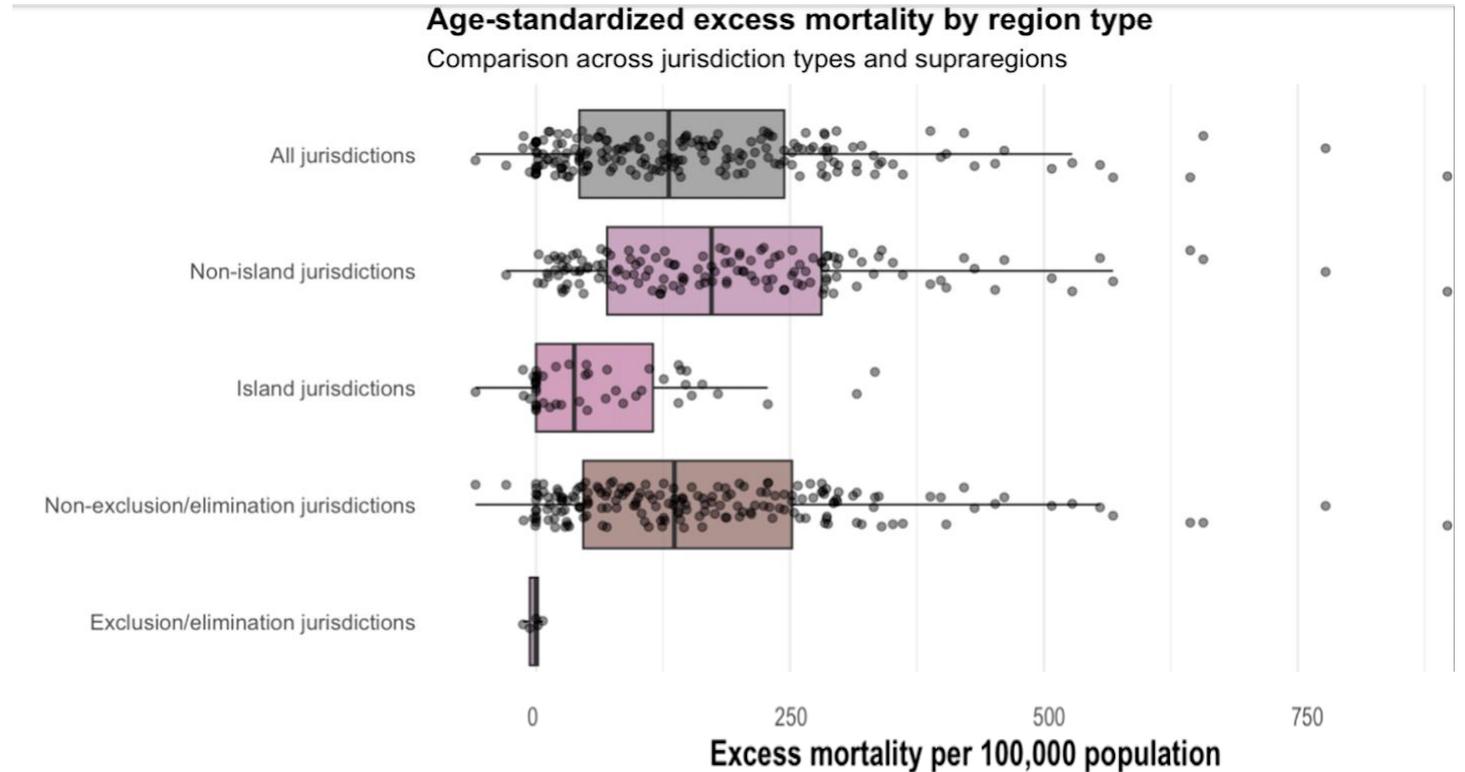
---

Statistical association persists in 'Model 3' only for 'all jurisdictions', and only for GDP growth in the first year of the pandemic.

---

Taking this forward to category scores, model fit is very poor (adj  $R^2 < 0.1$  in all cases) so we abandoned further GDP analysis.

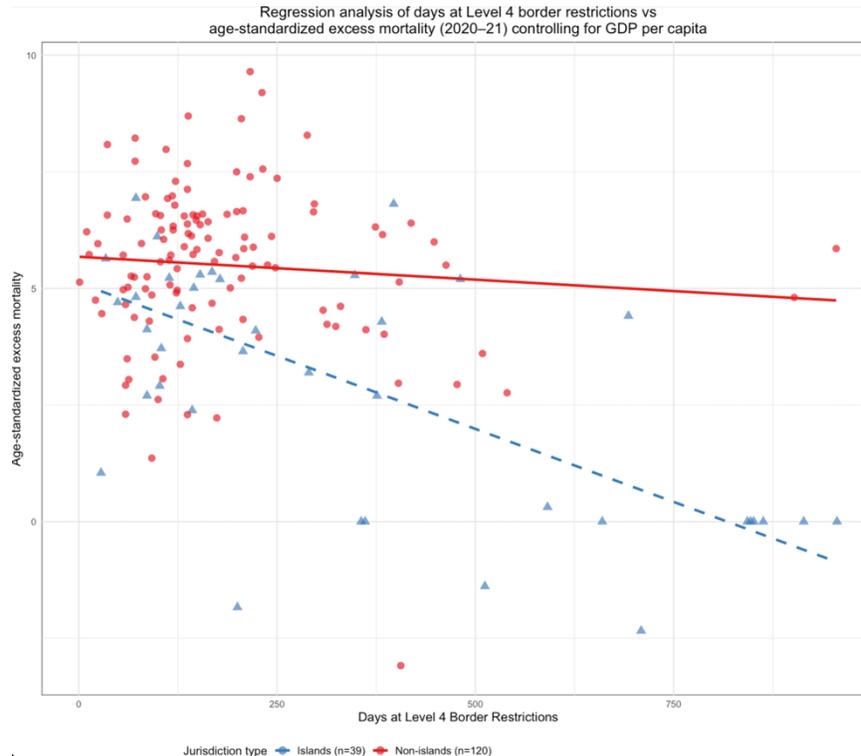
# Covid-19 control strategy



Exclusion/elimination (explicit):

- Australia, China, New Zealand, Singapore, Taiwan

# Border strategy



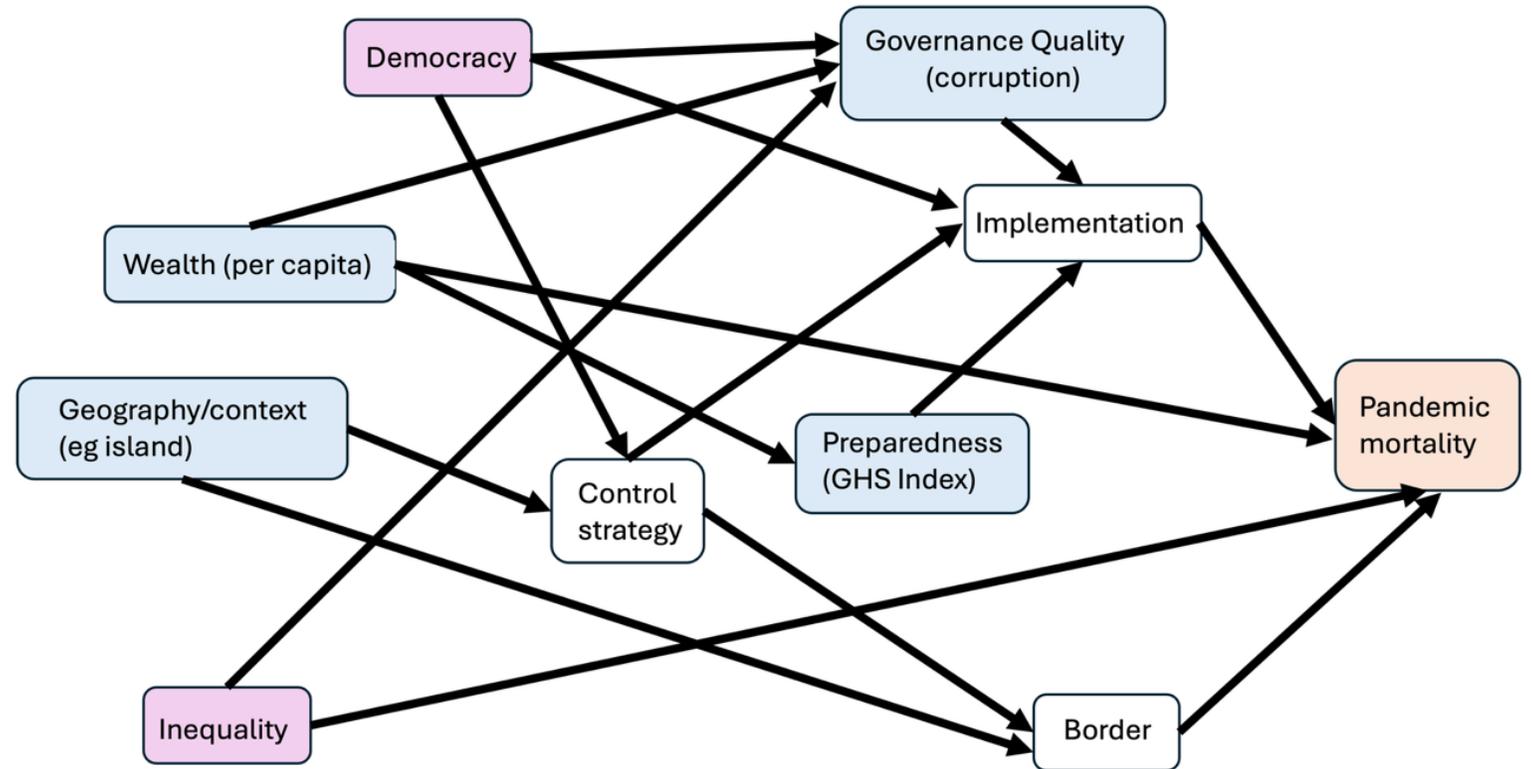
**Table 3:** Correlations between border restrictions and outcomes by jurisdiction type (only for the 159 (83%) of jurisdictions that enacted the highest level of border restrictions i.e. Oxford Stringency Index ‘level 4’)

Measure	Outcome	All jurisdictions	Islands	Non-islands
<b>Age-standardized excess mortality</b>				
Days until level 4	Age-standardized excess mortality	0.031 (n=159)	-0.256 (n=39)	0.112 (n=120)
Days at level 4	Age-standardized excess mortality	-0.473*** (n=159)	-0.624*** (n=39)	-0.127 (n=120)
Days until relaxation	Age-standardized excess mortality	-0.363*** (n=159)	-0.639*** (n=39)	-0.031 (n=120)

**Table 4:** Regression analysis of jurisdictions reaching level 4 border restrictions and outcomes (excess mortality and GDP growth)

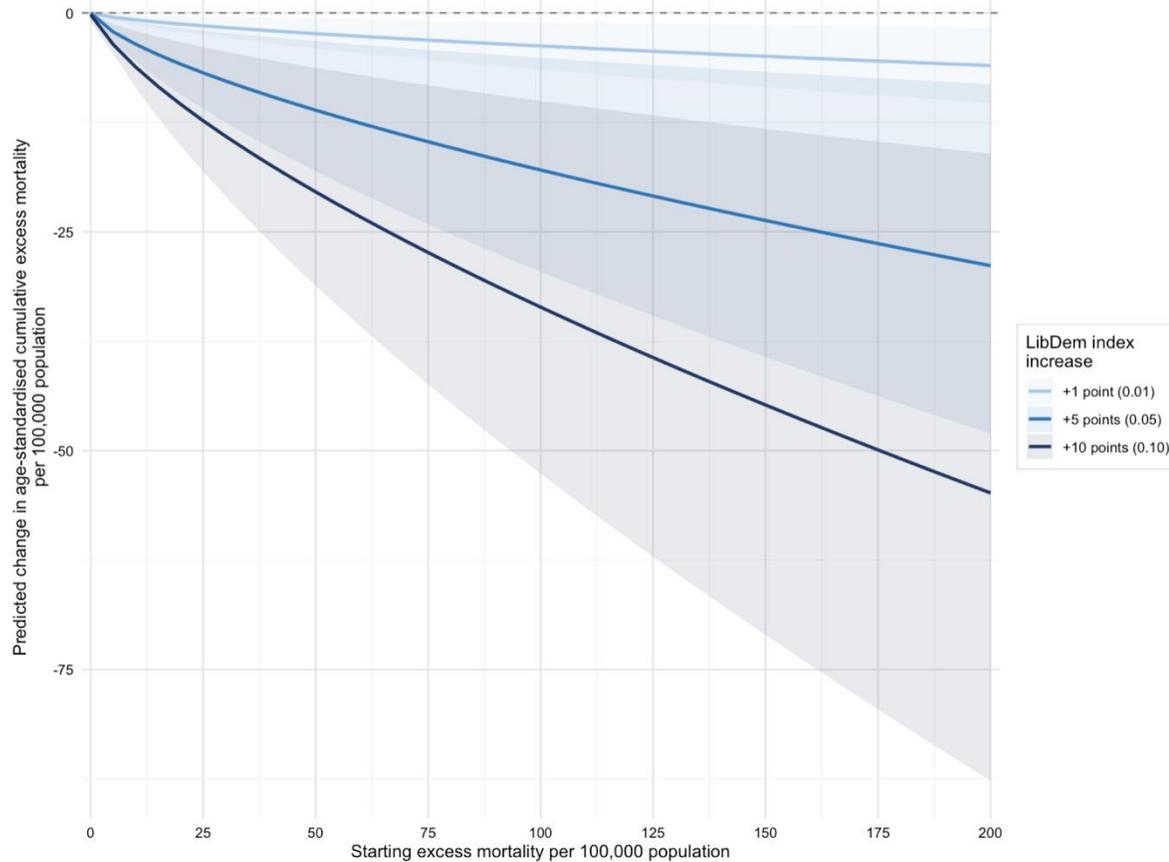
Measure	Outcome	Main effect	Island interaction	N
<b>Age-standardized excess mortality</b>				
Days until level 4	Age-standardized EM	-0.002	-0.012	151
Days at level 4	Age-standardized EM	-0.004***	-0.005***	151
Days until relaxation	Age-standardized EM	-0.003***	-0.005***	151

We now have  
a structural  
model

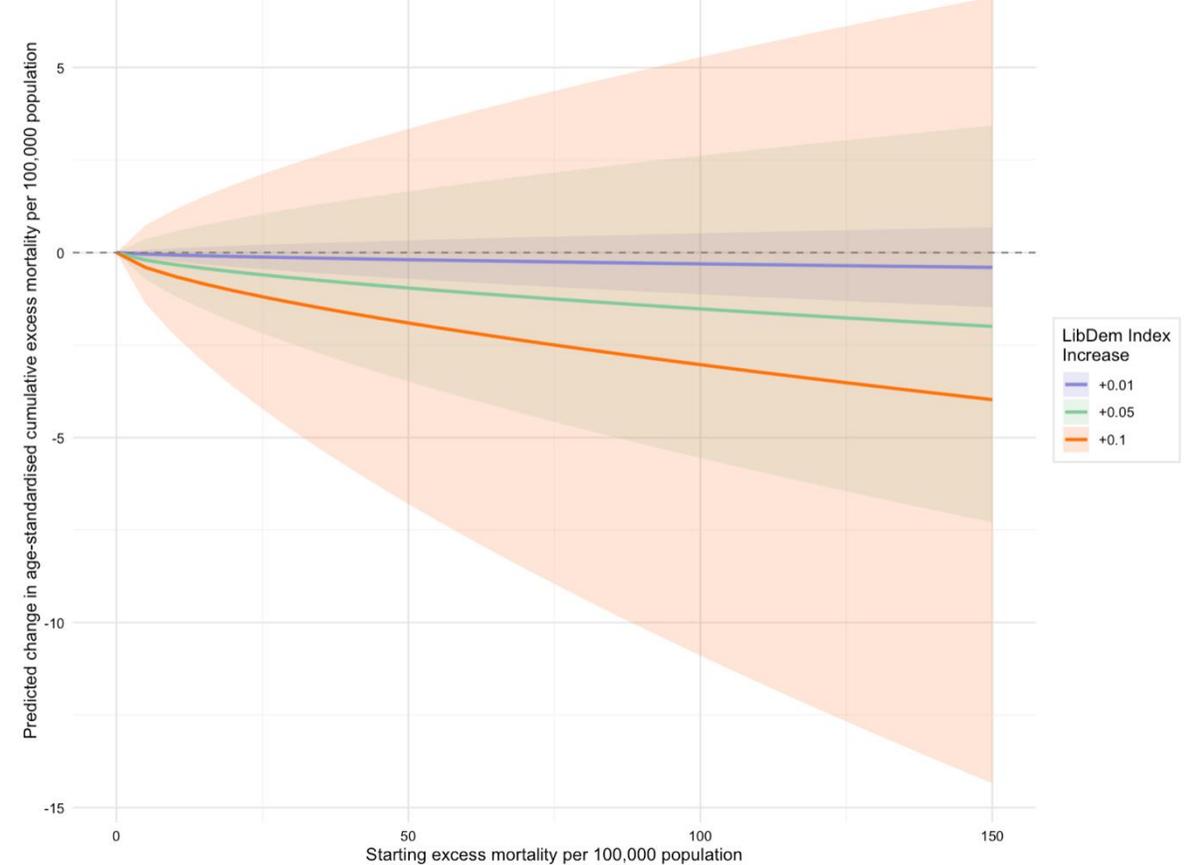


# Democracy's crisis advantage is conditional

Islands: predicted change in mortality by change in LibDem democracy index, n = 29 (p = 0.01)

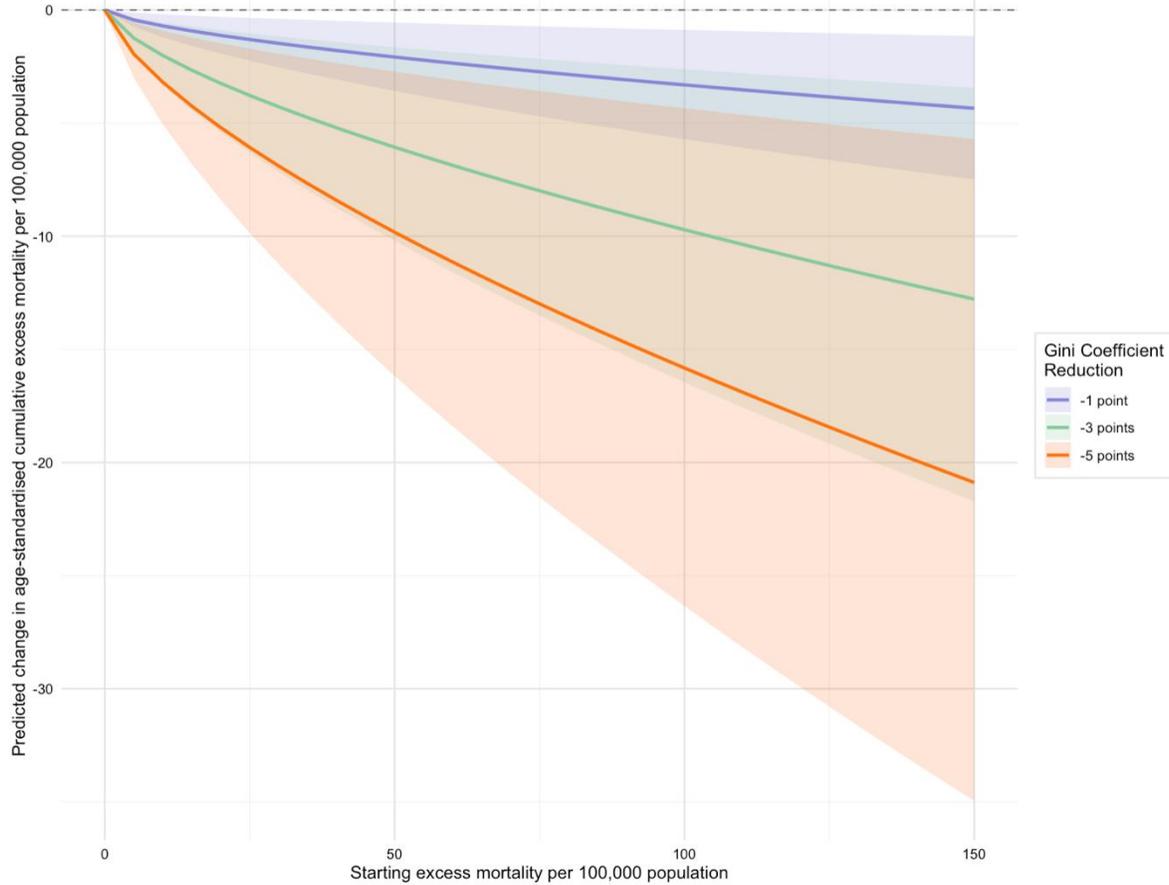


Non-islands: predicted change in mortality by change in democracy score, n = 134 (p = 0.47)

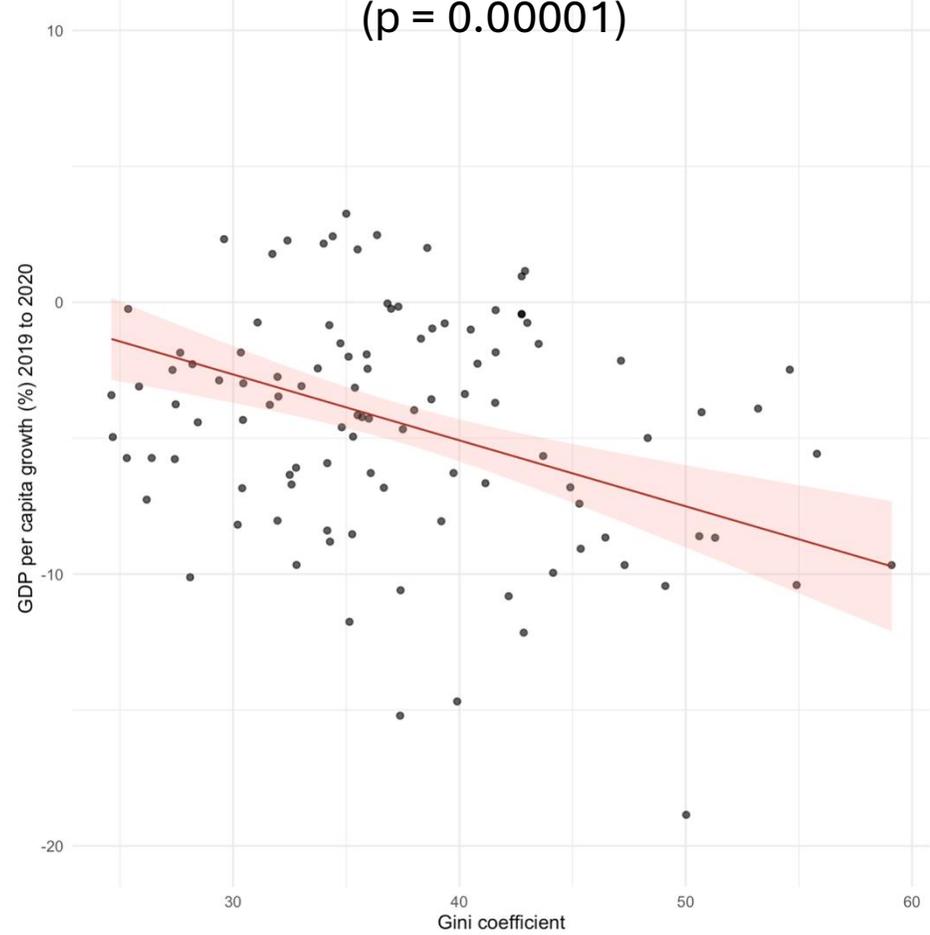


# Inequality (Gini coefficient) predicts mortality and early pandemic GDP contraction

Non-islands: predicted change in mortality by change in Gini inequality index, n = 99 (p = 0.01)



Non-islands: Gini & GDP growth 2019-2020, n = 99 (p = 0.00001)



# Limitations

---

Sample sizes are modest in some fully adjusted models for islands or when trust is included.

---

Possibly as yet unknown systematic differences between jurisdictions with data and without.

---

Ultimately, a correlation study and we can't infer causation.

---

Model fit in macroeconomic analyses was poor and GDP has limitations as a metric.

---

Focus on 2020–2021 (before widespread vaccination, late waves, & Russian invasion of Ukraine)

---

Have not accounted for geographic clustering (eg Kim 2025)

## Methodological strengths & uniqueness

- global data coverage of relatively high-impact pandemic
- appropriately age-standardized and cumulative excess mortality
- appropriate data transformations
- theoretically grounded controls and a plausible causal diagram
- explicit island stratification
- extension to democracy and inequality as predictors
- >> No prior work jointly satisfies all these conditions, particularly linking to both health and macroeconomic outcomes

# Conclusions

---

Data quality and appropriate analyses matter immensely

---

Preparedness as measured by GHS Index (and categories) important for non-islands

---

Islandness is a proxy for ability to implement strong border management supporting an exclusion/elimination strategy

---

Future iterations of GHS Index may need to treat islands differently (border control, quarantine/elimination)

---

Specific interventions operate within broader systems of governance

---

Features of politics and society appear to show major correlations with pandemic outcomes: GDP/wealth, Trust, Democracy/corruption, Inequality

---

Ability to *implement* strategy (eg border controls, exclusion/elimination strategy) is an important component of preparedness (and constraint on *what* to prepare)

# Citations for key papers

---

Boyd, M., Baker, M., & Wilson, N. (2025). **Global Health Security Index and COVID-19 pandemic mortality 2020–2021: a comparative study of islands and non-islands across 194 jurisdictions.** *BMJ Open*. doi:10.1136/bmjopen-2025-107918

---

Boyd, M., Baker, M., Kvalsvig, A., & Wilson, N. (2025). **Impact of Covid-19 Control Strategies on Health and GDP Growth Outcomes in 193 Sovereign Jurisdictions.** *PLoS Global Public Health*. doi:10.1371/journal.pgph.0004554

---

Boyd, M., Baker, M. G., & Wilson, N. (2026). **Democracy, Inequality and Covid-19 Pandemic Outcomes: Age-standardised excess mortality and GDP growth in island and non-island jurisdictions.** *MedRxiv*, doi:10.64898/2026.01.22.26344652 [updated version available on request to authors: [matt@adaptresearchwriting.com](mailto:matt@adaptresearchwriting.com)]

---

Boyd, M., Wilson, N., & Nelson, C. (2020). **Validation analysis of global health security index (GHSI) scores 2019.** *BMJ Glob Health*. doi: 10.1136/bmjgh-2020-003276