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Analyzing Factors Impacting COVID-19 Vaccination Rates

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Introduction

Our goal: to accurately represent COVID-19 vaccine utilization on a global scale, and identify key correlations with country indicators.

- The COVID-19 vaccine landscape is constantly changing.
- Vaccine utilization is underrepresented by rates alone.
- We introduce two indices: the **V**accine **U**tilization **I**ndex (**VUI**), and the **V**accination **A**cceleration **I**ndex (**VAI**).

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Methodology and Data Collection

We used R to analyze data, and Pearson correlations for index/indicator associations.

- Vaccination rate data -> *Our World in Data*
- Vaccine supply data -> *Multilateral Leaders Task Force on COVID-19*
- Country indicators -> *The World Bank*

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Indices

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Indices: Variables

Variable	Description
P_1D	% population with one dose at 150 days
P_2D	% population with two doses at 05/25/2022
PB	% population with a booster at 05/25/2022
DFV	Date of first vaccination (scaled)
AD	Administered doses (% of delivered)
POP	Total population (binned)

TABLE II
VARIABLES USED TO CALCULATE THE **VUI** AND **VAI**.

Scaling Formula

$$f(x) = \frac{(a-b)(x-min)}{(max-min)} + b$$

Example: Afghanistan

$$DFV = \frac{(10-0)(86-1)}{(321-1)} + 0 = 2.66$$

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Indices: **V**accine **U**tilization **I**ndex

$$\mathbf{VUI} = \max\{(AD), (P_2D + (0.1 * PB))\} + DFV$$

Country	**VUI**	P_2D	PB	DFV	AD
U.A.E.	100.00	97.01	52.53	0.97	90.94
Brunei	99.50	92.65	64.07	3.72	90.91
Chile	99.36	91.15	108.68	0.63	90.35
Cameroon	8.06	4.46	0.19	4.03	15.17
Djibouti	5.90	13.07	0.00	4.16	10.82
Burundi	0.00	0.11	0.00	10.00	1.83

TOP 3 AND BOTTOM 3 SCORING COUNTRIES ON THE **VUI**, BASED ON P_2D, PB, DFV, AND AD

Country	VUI
United Arab Emirates	100.00
Brunei	99.50
Chile	99.36
Samoa	98.00
Denmark	97.22
Singapore	96.48
Malta	96.11
Cuba	95.74
Mozambique	95.26
Italy	93.79
South Korea	92.88
Bhutan	92.76
Qatar	92.39
South Africa	92.33
Belgium	91.64
Gabon	28.51
Yemen	27.59
Mali	26.77
Bulgaria	24.79
Senegal	24.39
Malawi	23.51
Togo	22.60
Saint Vincent & Grenadines	22.49
Syria	22.11
Namibia	20.78
Congo	19.58
Democratic Republic of Congo	10.38
Cameroon	8.06
Djibouti	5.90
Burundi	0.00

TABLE IV
TOP 15 AND BOTTOM 15 SCORING COUNTRIES ON THE **VUI**.

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Indices: **V**accination **A**cceleration **I**ndex

$$\mathbf{VAI} = P_1D + POP - DFV$$

Country	**VAI**	P_1D	DFV	POP
Cuba	100.00	84.94	4.94	6
Uruguay	87.49	73.38	2.63	4
Seychelles	83.55	71.43	1.22	1
Liberia	5.14	1.63	4.94	4
Haiti	4.39	1.02	7.00	6
Burundi	0.00	0.07	10.00	6

TOP 3 AND BOTTOM 3 SCORING COUNTRIES ON THE **VAI**, BASED ON P_1D, DFV, AND POP

Country	VAI
Cuba	100.00
Uruguay	87.49
Seychelles	83.55
Bhutan	82.74
United Kingdom	80.61
Malta	79.28
Mongolia	76.03
Israel	74.75
San Marino	73.73
Fiji	71.84
United States	69.80
Maldives	69.43
Qatar	69.01
Hungary	68.90
Chile	67.41
Madagascar	8.51
Congo	8.21
Guinea-Bissau	8.21
Benin	8.03
Central African Republic	7.79
Gabon	7.47
Sierra Leone	7.23
South Sudan	7.02
Lesotho	6.78
Chad	6.76
Papua New Guinea	6.67
Djibouti	6.25
Liberia	5.14
Haiti	4.39
Burundi	0.00

TABLE V
TOP 15 AND BOTTOM 15 SCORING COUNTRIES ON THE **VAI**.

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Analysis

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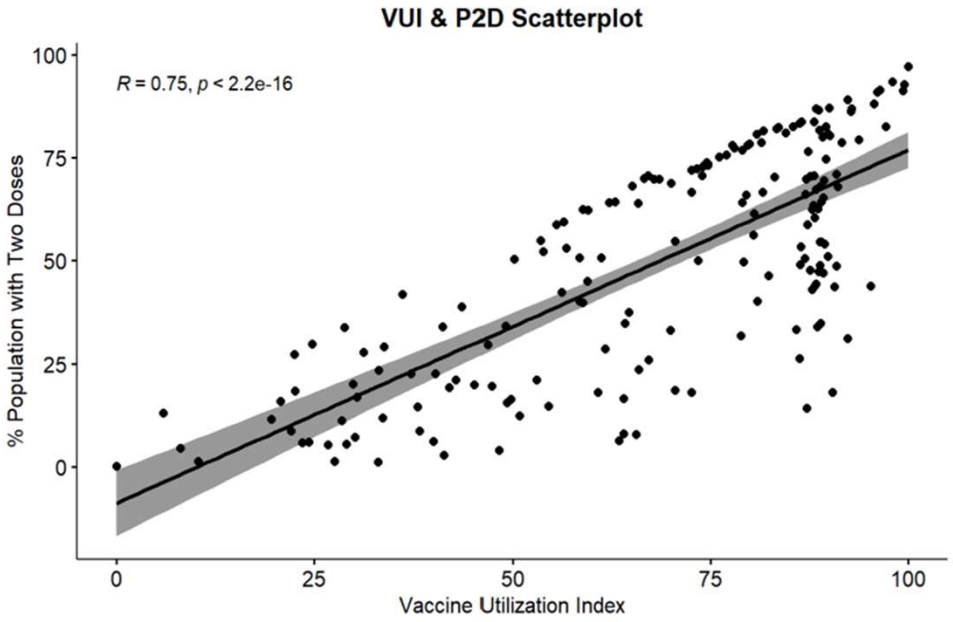
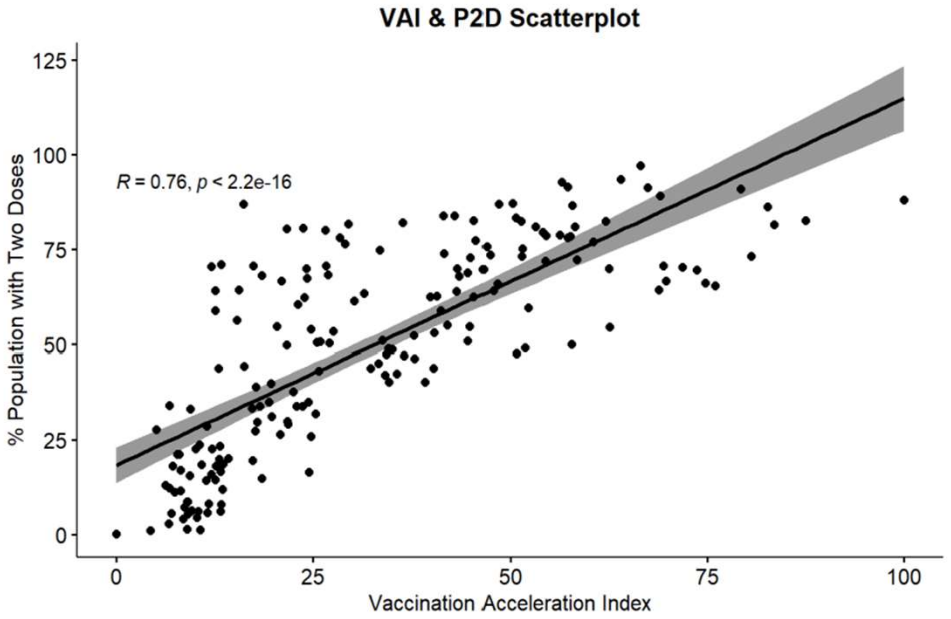
Analysis: Index Examination

VUI/VAI and P_2D

- Low P_2D still have excellent VUI scores.
- Strong early vaccine acceleration typically results in excellent vaccine utilization.





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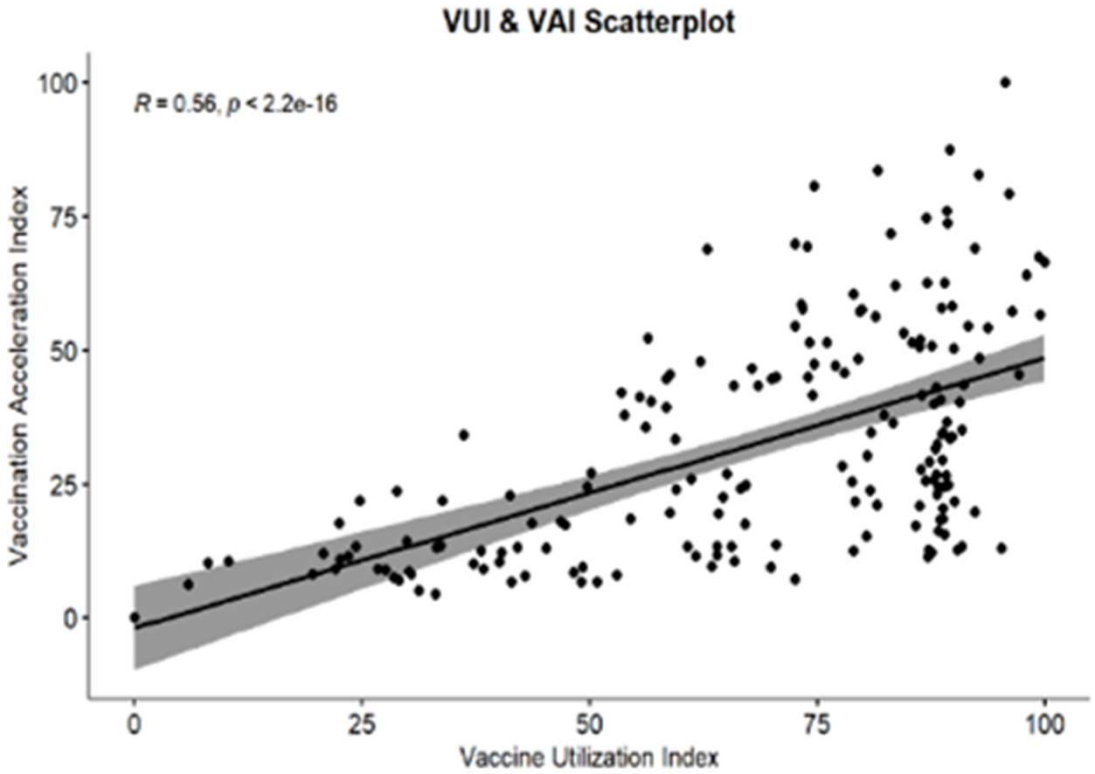
Analysis: Index Examination

VUI and VAI

- Cone effect; low VUI predicts low VAI, but high VUI has range of VAI.
- Cluster of high VUI, low VAI.



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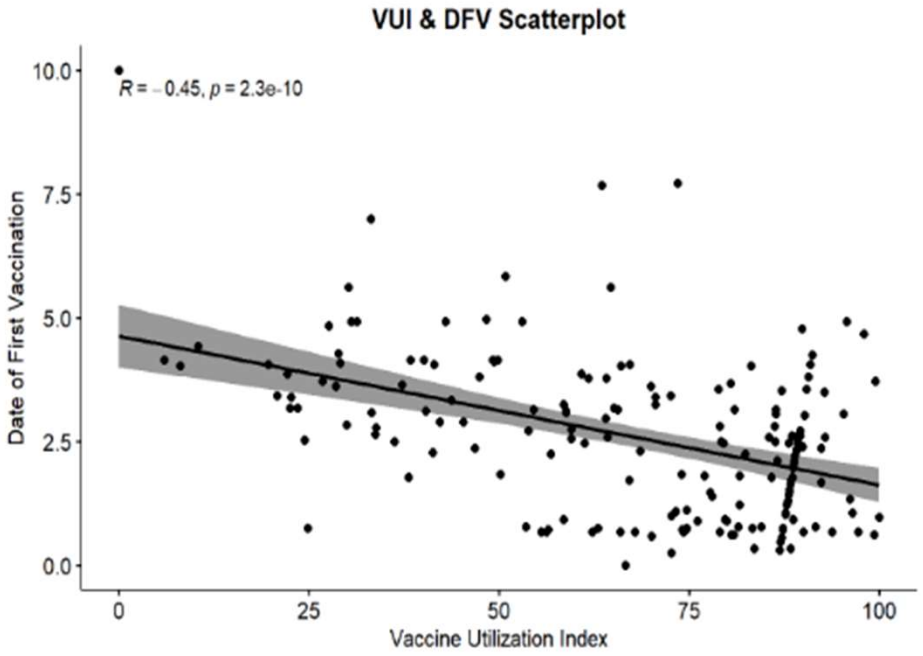
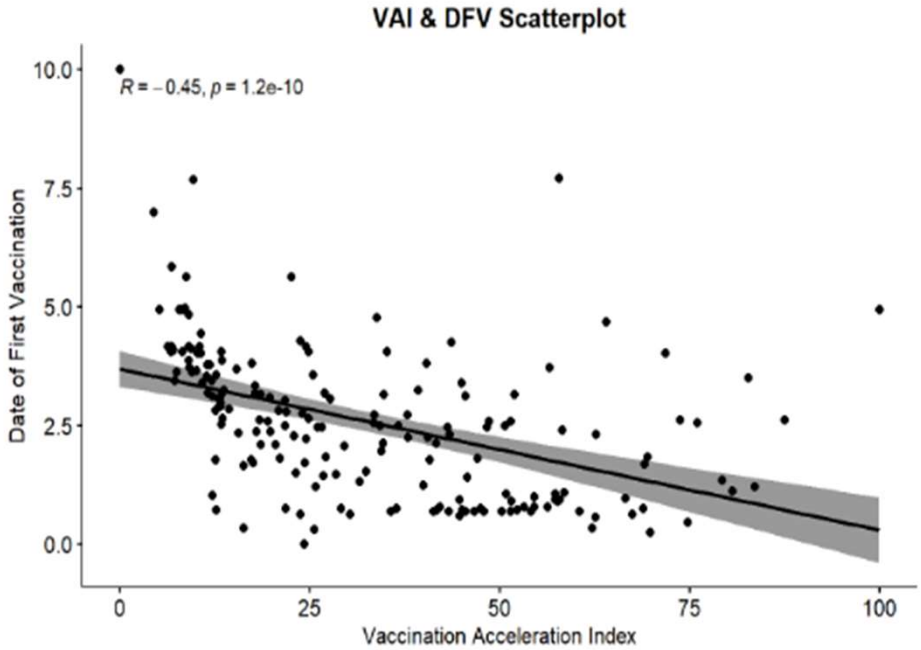
Analysis: Index Examination

VUI/VAI and DFV

- Lower DFV correlates to higher VUI, VAI values.
- Countries that started vaccinating earlier display better acceleration, utilization.





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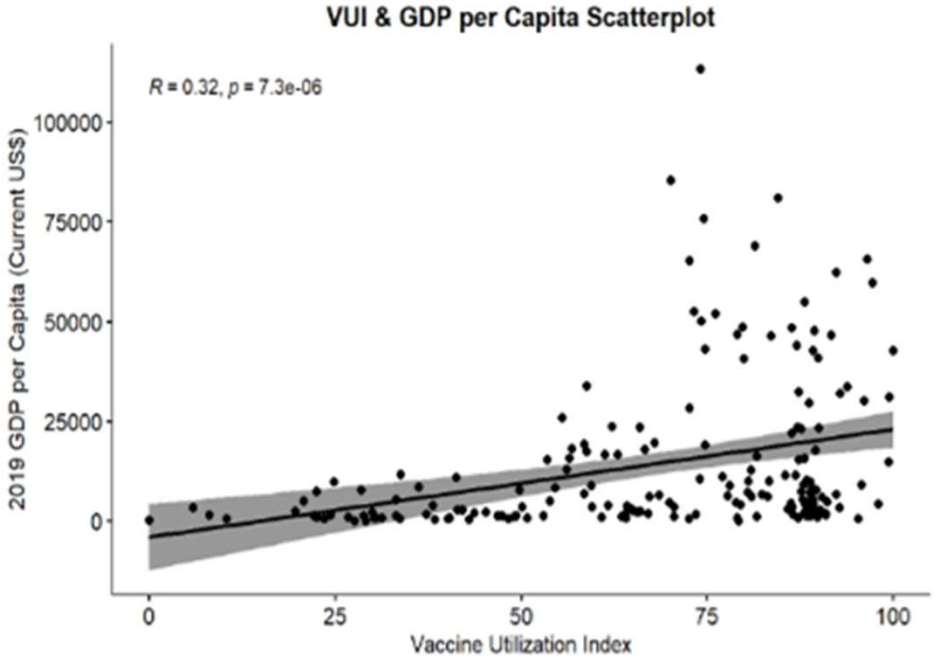
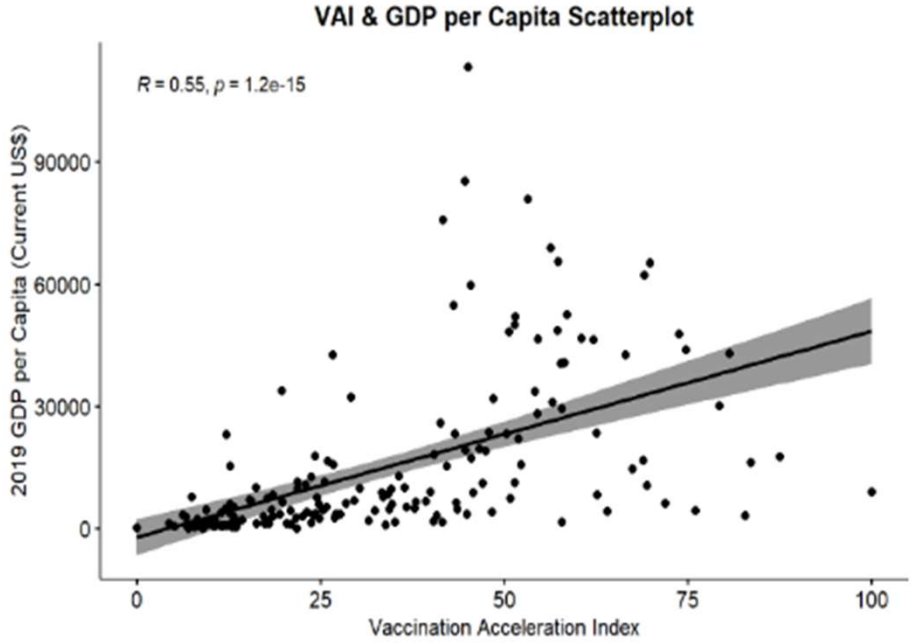
Analysis: Index Examination

VUI/VAI and GDP per capita

- Top GDP per capita countries have high VUI scores.
- Wealthy countries display excellent vaccine utilization and above-average early acceleration.





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Analysis: Pearson Correlations

- Pearson correlations are calculated between VUI, VAI and country indicators.
- Countries are split into GDP per capita and population sub-groups.
- Correlations classified under Series (Table III).

Series
Economic Policy & Debt
Education
Environment
Financial Sector
Gender
Health
Infrastructure
Poverty
Private Sector & Trade
Public Sector
Social Protection & Labor
Social: Health
Governance

TABLE III
INDICATOR CATEGORIES, ALL BUT LAST OBTAINED FROM THE WORLD BANK. GOVERNANCE INDICATORS ARE DEFINED IN THIS STUDY.

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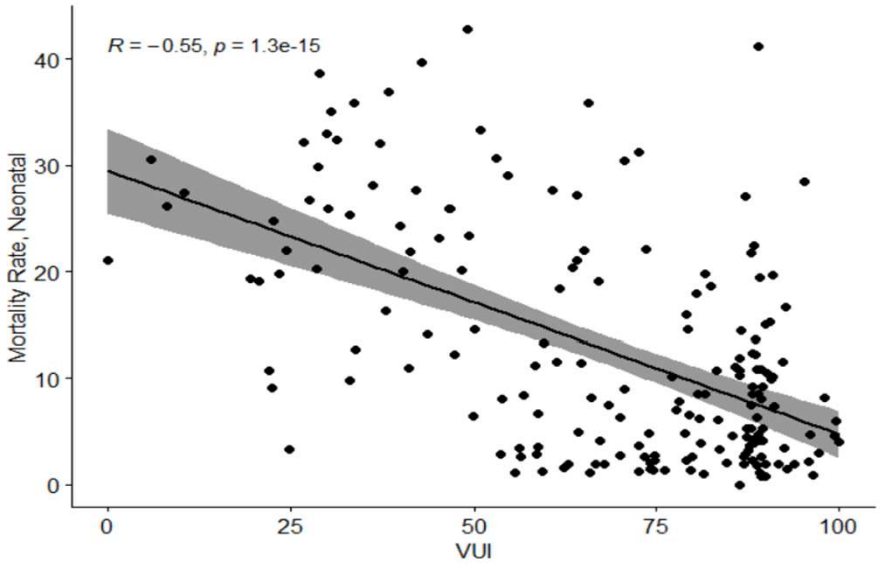
Analysis: Pearson Correlations

VUI (All Countries)

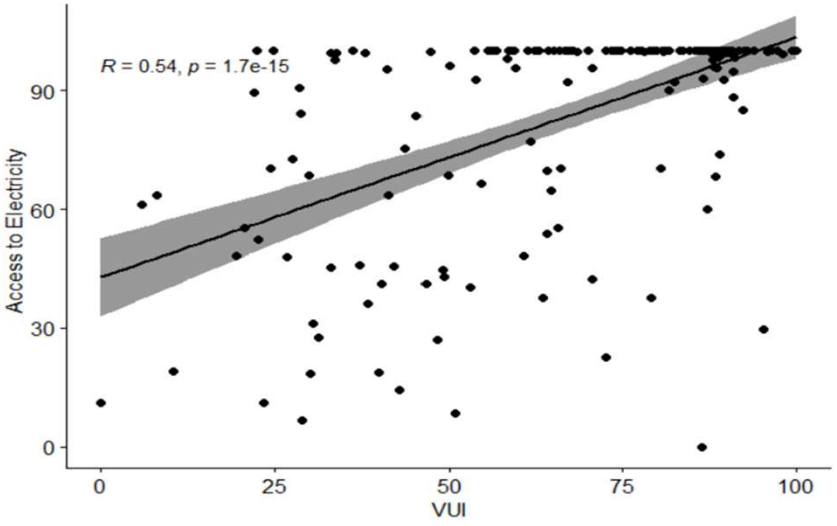
- Negative correlation with mortality rates.
- Countries predisposed to younger deaths tended to poorly utilize their vaccine supply.
- Positive correlation with access to electricity.

Data Set	Indicator	Correlation	Series
All Data	Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	-.558	Health
All Data	Mortality rate, under-5, male (per 1,000)	-.549	Health
All Data	Mortality rate, neonatal (per 1,000 live births)	-.546	Health
All Data	Mortality rate, under-5 (per 1,000)	-.545	Health
All Data	Access to electricity (% of Population)	.544	Environment
All Data	Mortality rate, infant, male (per 1,000 live births)	-.543	Health
All Data	Mortality rate, under-5, female (per 1,000)	-.541	Health
All Data	Mortality rate, infant (per 1,000 live births)	-.540	Health
All Data	Mortality rate, infant, female (per 1,000 live births)	-.536	Health
All Data	People using at least basic sanitation services (% of population)	.529	Health

VUI & Mortality Rate, Neonatal



VUI & Access to Electricity



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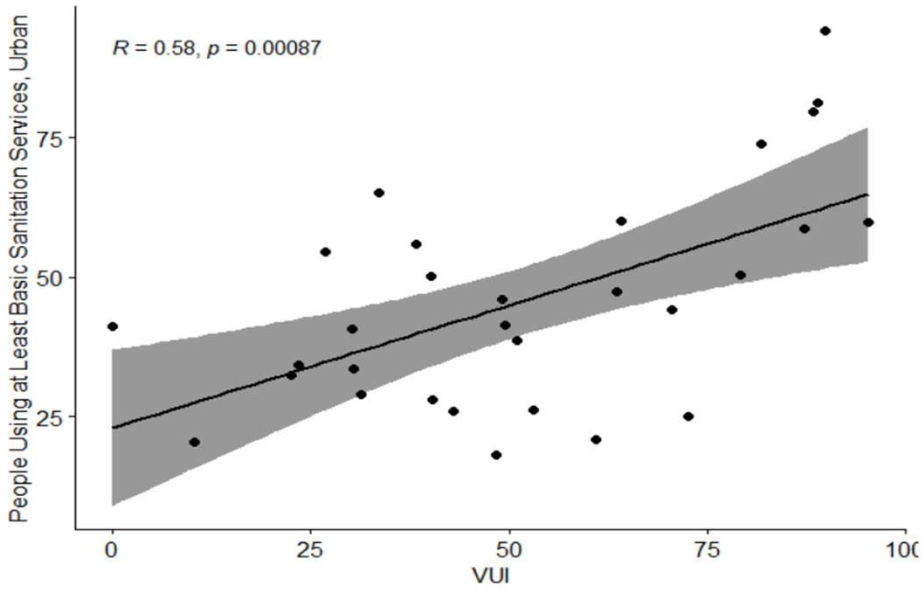
Analysis: Pearson Correlations

VUI (GDP per Capita Subgroups)

- Low-GDPPC countries that provide their population at least basic services are effective in utilizing COVID-19 vaccines.
- High GDPPC countries with less opportunity for political voice were more effective at utilizing their supply of vaccines

VUI & Basic Sanitation in Urban Population (Bottom 30 GDPPC Countries)



Data Set	Indicator	Correlation	Series
GDPPC Bottom	People using at least basic sanitation services, urban (% of urban population)	.576	Health
GDPPC Bottom	Cause of death, by non-communicable diseases (% of total)	.548	Health
GDPPC Bottom	People using at least basic sanitation services (% of the population)	.525	Health
GDPPC Bottom	Age dependency ratio, young	-.520	Health
GDPPC Bottom	Age dependency ratio (% of working-age Population)	-.519	Health
GDPPC Bottom	Access to electricity (% of Population)	.502	Environment
GDPPC Top	Immunization, BCG (% of one-year-old children)	.561	Health
GDPPC Top	Voice and Accountability: Estimate	-.533	Governance

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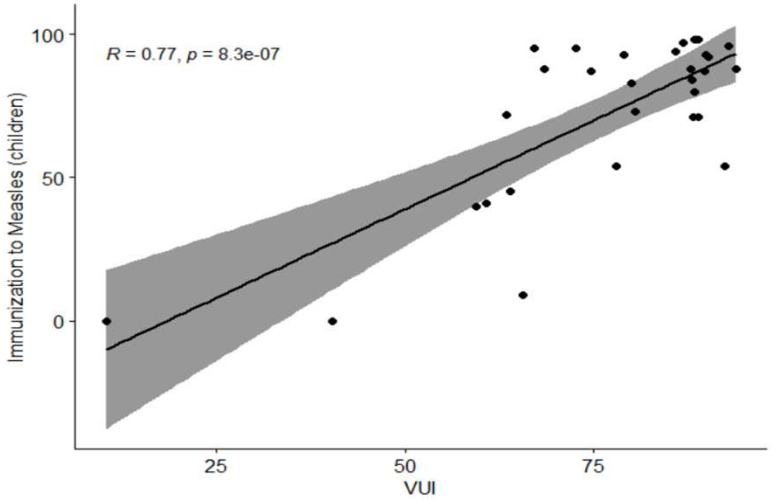
Analysis: Pearson Correlations

VUI (Population Subgroups)

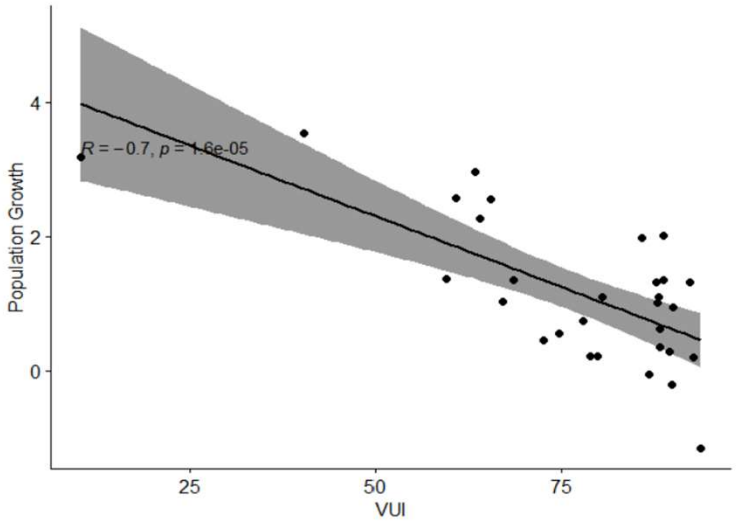
- Highly populated countries with good health indicators display high VUI.
- Highly populated countries with slower population growth indicates higher VUI.

Data Set	Indicator	Correlation	Series
Population Top	Immunization, measles second dose(% of children by the nationally recommended age)	.766	Health
Population Top	Access to electricity (% of Population)	.764	Environment
Population Top	People using at least basic drinking water services (% of Population)	.758	Health
Population Top	Age dependency ratio, young	-.745	Health
Population Top	Fertility rate, total (births per woman)	-.745	Health
Population Top	Age dependency ratio (% of working-age Population)	-.742	Health
Population Top	People using at least basic sanitation services (% of the population)	.738	Health
Population Top	Birth rate, crude (per 1,000 people)	-.706	Health
Population Top	Population growth (annual %)	-.701	Health
Population Top	Cause of death, by communicable diseases and prenatal and nutrition conditions (% of total) maternal,	-.658	Health

VUI & Immunization to Measles in Children (Top 30 Populated Countries)



VUI & Population Growth (Top 30 Populated Countries)



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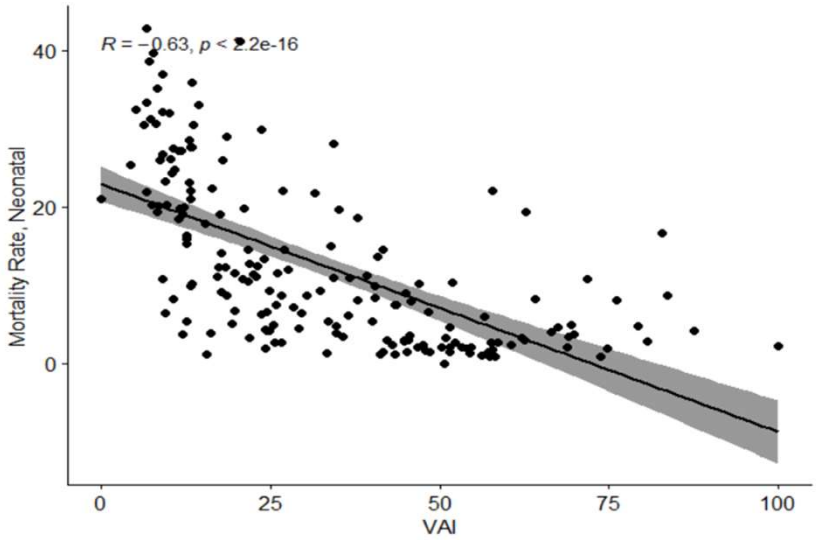
Analysis: Pearson Correlations

VAI (All Countries)

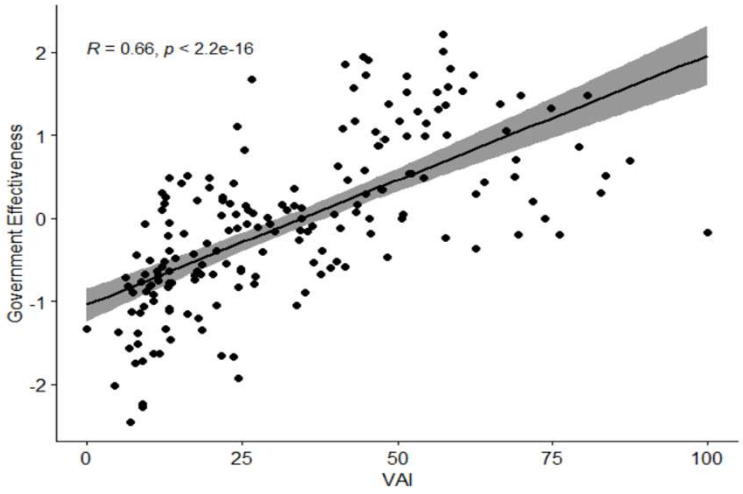
- Negative correlation with mortality rates.
- High correlations with government effectiveness indicators.
- Lower birth rate is associated with higher VAI scores.

VAI & Mortality Rate, Neonatal



Data Set	Indicator	Correlation	Series
All Data	Government Effectiveness: Estimate	.658	Governance
All Data	Birth rate, crude (per 1,000 people	-.637	Health
All Data	Age dependency ratio, young	-.632	Health
All Data	Rule of Law: Estimate	.631	Governance
All Data	Mortality rate, neonatal (per 1,000 live births)	-.630	Health
All Data	Mortality rate, infant, male (per 1,000 live births)	-.626	Health
All Data	Mortality rate, infant (per 1,000 live births)	-.624	Health
All Data	Mortality rate, infant, female (per 1,000 live births)	-.622	Health
All Data	Control of Corruption: Estimate	-.621	Governance
All Data	Mortality rate, under-5: male (per 1,000,	-.617	Health

VAI & Government Effectiveness



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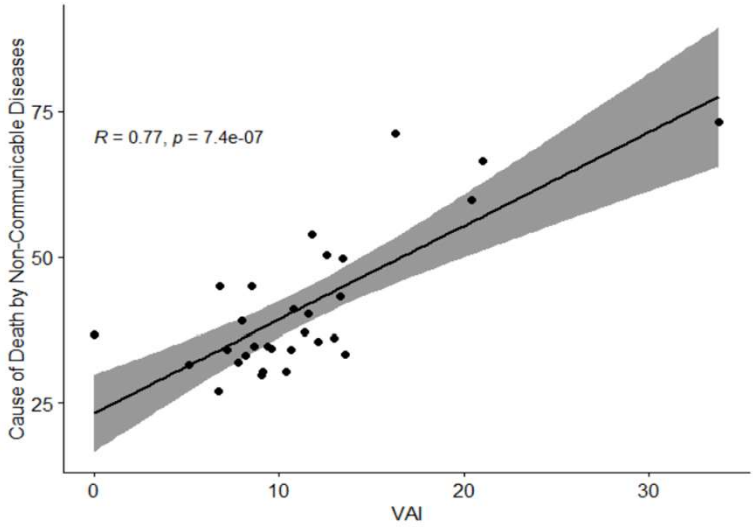
Analysis: Pearson Correlations

VAI (GDP per Capita Subgroups)

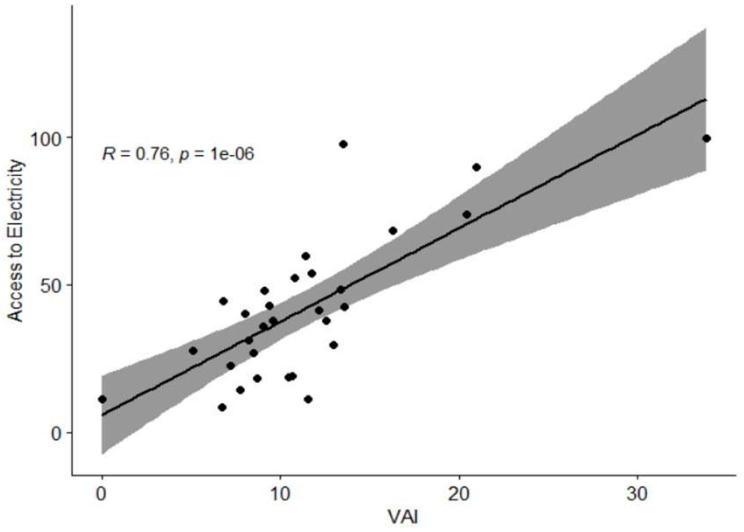
- High correlations in low GDPPC countries with VAI and access to basic services, health indicators.
- In low GDPPC countries, lower contagious disease mortality rates correlate with better vaccination acceleration.

Data Set	Indicator	Correlation	Series
GDPPC Bottom	Cause of death, by non-communicable diseases (% of total)	.768	Health
GDPPC Bottom	Access to electricity (% of population)	.761	Environment
GDPPC Bottom	Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	.729	Health
GDPPC Bottom	People using at least basic services, urban (% of urban population) sanitation	.707	Health
GDPPC Bottom	People using at least basic services (% of population) sanitation	.684	Health
GDPPC Bottom	People using at least basic sanitation rural (% of rural population) services,	.668	Health
GDPPC Bottom	Survival to age 65 female (% of cohort) ,	.654	Health
GDPPC Bottom	Mortality rate, female (per 1,000 female adults) adult,	-.643	Health
GDPPC Bottom	Life expectancy at birth, total (years)	.639	Health
GDPPC Bottom	Life expectancy at birth, female (years)	.636	Health

VAI & Cause of Death by Non-Communicable Diseases (Bottom 30 GDPPC Countries)



VAI & Access to Electricity (Bottom 30 GDPPC Countries)



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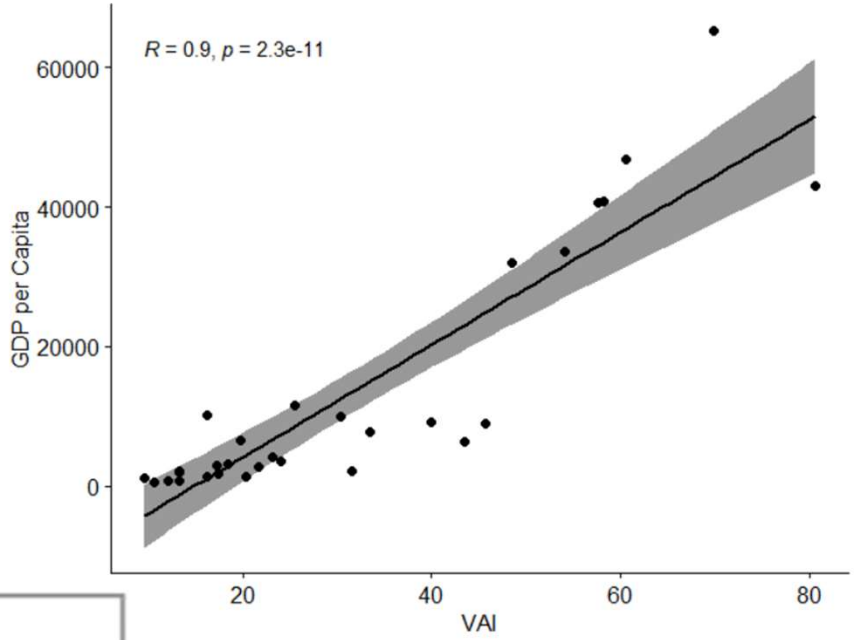
Analysis: Pearson Correlations

VAI (Population Subgroups)

- In highly populated countries, VAI correlated with governance and economic indicators.
- Strongest correlations observed in all subgroups.

VAI & GDP per Capita (Top 30 Populated Countries)



Data Set	Indicator	Correlation	Series
Population Bottom	Access to electricity (% of population)	.540	Environment
Population Top	Regulatory Quality: Estimate	.901	Governance
Population top	GDP per capita (current US$)	.896	Economic
Population top	GNI per capita, Atlas method (current US$)	.895	Economic
Population Top	Control of Corruption: Estimate	.879	Governance
Population Top	Rule of Law: Estimate	.865	Governance
Population Top	Government Effectiveness: Estimate	.849	Governance
Population Top	Population ages 65 and above (% of total population)	.841	Health
Population Top	Age dependency ratio, old	.827	Health
Population Top	Treatment for hypertension, male (% of male adults ages 30-79 with hypertension)	.806	Health
Population Top	Voice and Accountability: Estimate	.798	Governance

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Conclusions

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Conclusions

Two indices were designed to effectively summarize COVID-19 vaccine usage on a global scale.

- **Vaccine Utilization Index** - the utilization of the COVID-19 vaccine by country.
- **Vaccination Acceleration Index** - how each country accelerated their vaccination efforts within their first 150 days of vaccine administration.

Pearson correlations were drawn between index values and country indicators to determine attributes most associated with vaccine efforts.

- **VUI** values are most correlated with Health indicator quality.
- **VAI** values are correlated with Governance, Economic, and Health indicators.
- Other significant correlations are found within GDP per capita and population subgroups.

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Thank you