

SUPPLEMENTARY MATERIAL

Article title: Population-level effect of COVID-19 vaccination coverage on transmission and mortality during Omicron dominance: a global longitudinal analysis

TABLE S1: DESCRIPTION OF VARIABLES

The data used in this study was obtained from Our World in Data (OWID) coronavirus repository, a daily-updated collection of COVID-19-related data on vaccinations, tests, confirmed cases, confirmed deaths, policy response and other country-level characteristics, for over 200 countries/territories across the world. The variables are described below, including their original sources **as described by OWID**.

S/n	VARIABLE	SOURCE	DESCRIPTION
	Exposure		
1	People fully vaccinated per hundred	National government reports	Total number of people who received all doses prescribed by the initial vaccination protocol per 100 people in the total population
	Outcomes		
1	New cases per million	WHO COVID-19 dashboard	New confirmed cases of COVID-19 per 1,000,000 people. Counts can include probable cases, where reported.
2	New deaths per million	WHO COVID-19 dashboard	New deaths attributed to COVID-19 per 1,000,000 people. Counts can include probable deaths, where reported.
	Covariates		
1	Population	United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019 Revision	Population (latest available values). See https://github.com/owid/covid-19-data/blob/master/scripts/input/un/population_latest.csv for full list of sources
2	Population density	World Bank World Development Indicators, sourced from Food and Agriculture Organization and World Bank estimates	Number of people divided by land area, measured in square kilometers, most recent year available
3	Median age	UN Population Division, World Population Prospects, 2017 Revision	Median age of the population, UN projection for 2020
4	Population aged 65 or older	World Bank World Development Indicators based on age/sex distributions of United Nations World Population Prospects 2017 Revision	Share of the population that is 65 years and older, most recent year available

5	GDP per capita	World Bank World Development Indicators, source from World Bank, International Comparison Program database	Gross domestic product at purchasing power parity (constant 2011 international dollars), most recent year available
6	Human development index	United Nations Development Programme (UNDP)	A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living. Values for 2019, imported from http://hdr.undp.org/en/indicators/137506
7	Life expectancy	James C. Riley, Clio Infra, United Nations Population Division	Life expectancy at birth in 2019
8	Adult diabetes prevalence	World Bank World Development Indicators, sourced from International Diabetes Federation, Diabetes Atlas	Diabetes prevalence (% of population aged 20 to 79) in 2017
9	Cardiovascular death rate	Global Burden of Disease Collaborative Network, Global Burden of Disease Study 2017 Results	Death rate from cardiovascular disease in 2017 (annual number of deaths per 100,000 people)
10	Total COVID-19 tests	National government reports	Total tests for COVID-19. Only available until June 2022.
11	Hospital beds per thousand	OECD, Eurostat, World Bank, national government records and other sources	Hospital beds per 1,000 people, most recent year available since 2010
12	Stringency index	Oxford COVID-19 Government Response Tracker, Blavatnik School of Government	Government Response Stringency Index: composite measure based on 9 response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest response)

SENSITIVITY ANALYSIS 1: FIXED EFFECT NEGATIVE BINOMIAL REGRESSION

Variable	CASES			DEATHS		
	Rate Ratio	95% CI [†]	p-value	Rate Ratio	95% CI	p-value
Full vaccination coverage (%)	0.95	0.92, 0.98	0.003	0.91	0.89, 0.94	<0.001
Categorized [‡]						
<50% (reference)	1.00	-	-	1.00	-	-
50-59%	0.66	0.33, 1.34	0.30	0.63	0.38, 1.05	0.08
60-69%	0.19	0.07, 0.55	0.002	0.20	0.10, 0.39	<0.001
70-79%	0.12	0.04, 0.38	<0.001	0.18	0.08, 0.39	<0.001
≥80%	0.06	0.02, 0.19	<0.001	0.10	0.04, 0.24	<0.001

Table S2: Regression estimates for two fixed effects negative binomial models assessing the association between one-month-lagged full vaccination coverage(%) and the rates of new COVID-19 cases and death during the global Omicron variant dominance period. The sample includes 1,756 country-months of observations from 110 countries between Jan 2022 and April 2023. The models include an offset (log of population), as well as dummy variables for continent and months of the year. The robust standard errors were clustered at the country level. [†]95% CI = 95% confidence interval. [‡]Obtained from two separate models using the categorized vaccination coverage variable.

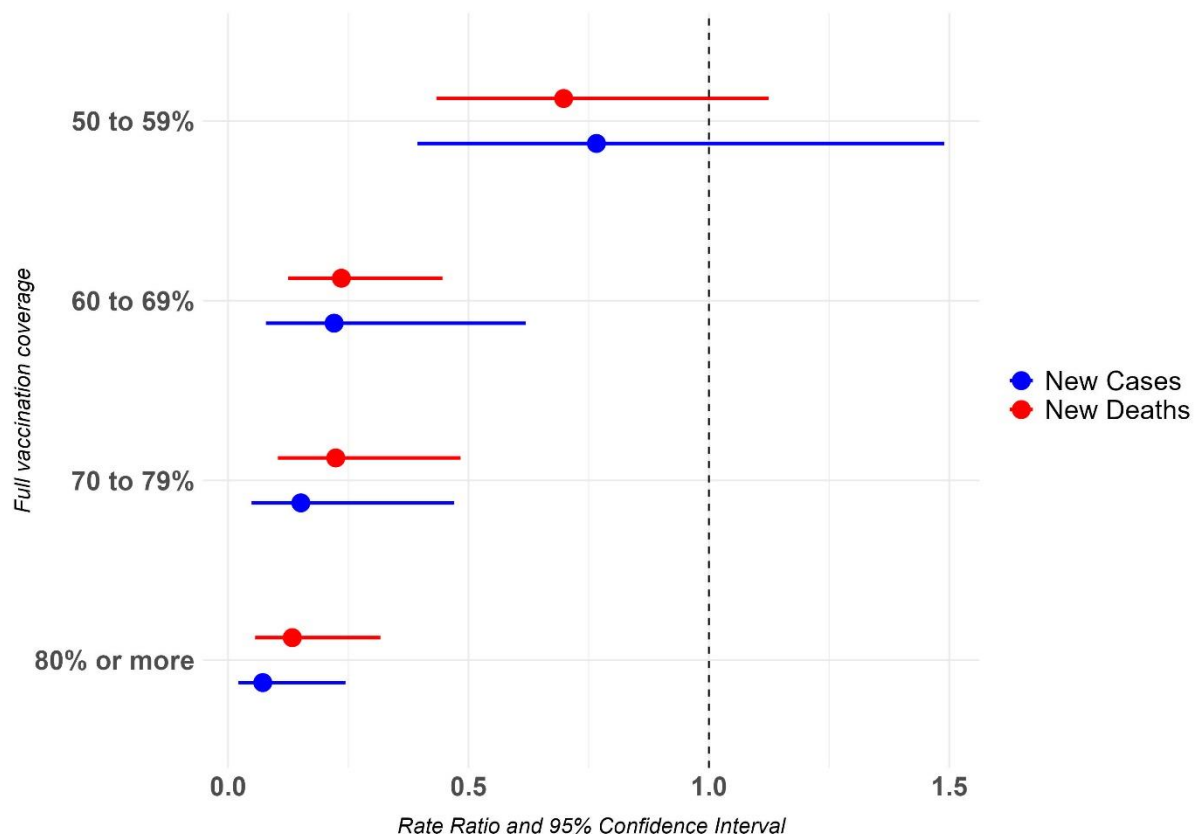


Figure S2: Adjusted regression estimates from two fixed effect models assessing the association between one-month-lagged full vaccination coverage and COVID-19 cases and deaths across 110 countries for months between January 2022 and April 2023 (corresponding to the period of global dominance of the Omicron variant). The models include fixed effects for country and time (month of the year). Robust standard errors are clustered at the country level.

SENSITIVITY ANALYSIS 2: ALTERNATIVE MISSING DATA STRATEGY – IMPUTING ZERO STRINGENCY FOR ALL MONTHS IN 2023

Variable	CASES			DEATHS		
	Rate Ratio	95% CI [†]	p-value	Rate Ratio	95% CI	p-value
Full vaccination coverage (%)	0.99	0.98, 1.01	0.3	0.96	0.94, 0.97	<0.001
<i>Categorized[‡]</i>						
<50% (reference)	1.00	-	-	1.00	-	-
50-59%	0.89	0.61, 1.29	0.50	0.70	0.50, 0.99	0.04
60-69%	0.51	0.31, 0.85	0.01	0.37	0.21, 0.53	<0.001
70-79%	0.54	0.29, 1.00	0.05	0.37	0.19, 0.58	<0.001
≥80%	0.37	0.18, 0.74	0.005	0.24	0.12, 0.42	<0.001
Stringency index	1.06	1.05, 1.06	<0.001	1.05	1.04, 1.05	<0.001
GDP per capita	1.00	1.00, 1.00	0.087	1.00	1.00, 1.00	0.40
Life expectancy	1.19	1.09, 1.31	<0.001	1.20	1.09, 1.33	<0.001
Population density	1.00	1.00, 1.00	0.60	1.00	1.00, 1.00	0.60
Median age	1.07	1.00, 1.14	0.05	1.16	1.08, 1.24	<0.001
Hospital beds per thousand	1.15	1.02, 1.29	0.02	1.00	0.88, 1.13	0.90
Adult diabetes prevalence in 2017	1.03	0.94, 1.12	0.50	0.99	0.91, 1.08	0.90
Death rate from cardiovascular disease in 2017 (per 100,000)	1.00	1.00, 1.00	0.60	1.00	1.00, 1.00	0.60
Total COVID-19 tests in 2021 (per million)	1.00	1.00, 1.00	0.05	1.00	1.00, 1.00	0.40

Table S3: Regression estimates for two random effects negative binomial models assessing the association between one-month-lagged full vaccination coverage (%) and the rates of new COVID-19 cases and death during the global Omicron variant dominance period. The sample includes 1,756 country-months of observations from 110 countries between Jan 2022 and April 2023. The models include an offset (log of population), as well as dummy variables for months of the year. The standard errors were clustered at the country level. [†]95% CI = 95% confidence interval. [‡]Obtained from an identical model using the categorized vaccination coverage variable instead of the continuous variable.

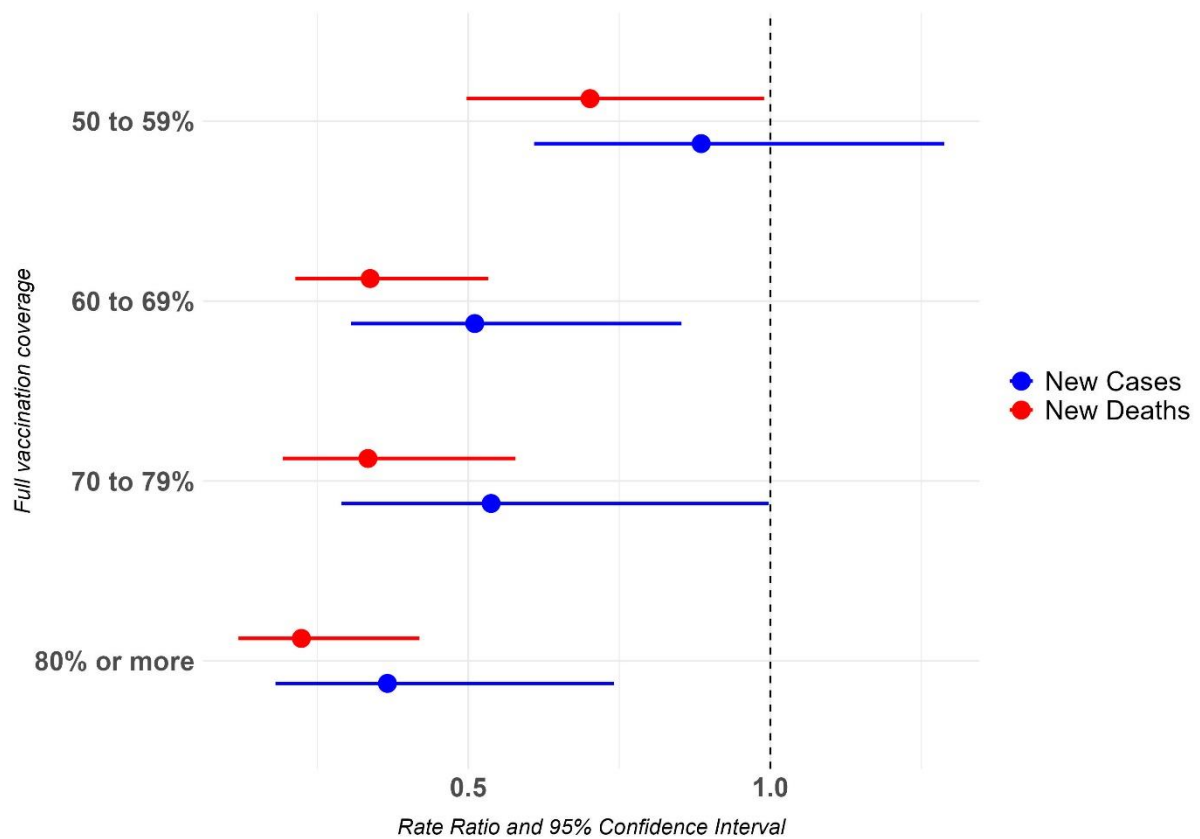


Figure S3: Adjusted regression estimates from two models assessing the association between one-month-lagged full vaccination coverage and COVID-19 cases and deaths across 110 countries for months between January 2022 and April 2023 (corresponding to the period of global dominance of the Omicron variant). Reference level is <50% vaccination coverage. The random effects models control for a wide range of country-level policy, sociodemographic and health factors, as well as for seasonality and continent. The standard errors are clustered at the country level.

SENSITIVITY ANALYSIS 3: NO LAGS FOR VACCINATION AND STRINGENCY INDEX

Variable	CASES			DEATHS		
	Rate Ratio	95% CI [†]	p-value	Rate Ratio	95% CI	p-value
Vaccination coverage	0.99	0.97, 0.99	0.034	0.96	0.94, 0.97	<0.001
<i>Categorized[‡]</i>						
<50% (reference)	1.00	-	-	1.00	-	-
50-59%	0.80	0.53, 1.23	0.30	0.74	0.51, 1.06	0.10
60-69%	0.47	0.29, 0.76	0.002	0.30	0.18, 0.49	<0.001
70-79%	0.64	0.36, 1.12	0.12	0.40	0.23, 0.73	0.002
≥80%	0.57	0.30, 1.09	0.09	0.27	0.14, 0.53	<0.001
Stringency index	1.06	1.06, 1.07	<0.001	1.05	1.05, 1.06	<0.001
GDP per capita	1.00	1.00, 1.00	0.003	1.00	1.00, 1.00	0.30
Life expectancy	1.20	1.10, 1.32	<0.001	1.20	1.09, 1.32	<0.001
Population density	1.00	1.00, 1.00	0.60	1.00	1.00, 1.00	0.70
Median age	1.07	1.00, 1.14	0.05	1.15	1.07, 1.23	0.001
Hospital beds per thousand	1.13	1.01, 1.28	0.04	1.01	0.89, 1.13	0.90
Adult diabetes prevalence in 2017	1.02	0.95, 1.09	0.60	0.99	0.91, 1.07	0.80
Death rate from cardiovascular disease in 2017 (per 100,000)	1.00	1.00, 1.00	0.50	1.00	1.00, 1.00	0.70
Total COVID-19 tests in 2021 (per million)	1.00	1.00, 1.00	0.05	1.00	1.00, 1.00	0.30

Table S4: Regression estimates for two random effects negative binomial models assessing the association between full vaccination coverage(%) and the rates of new COVID-19 cases and death during the global Omicron variant dominance period. The sample includes 1,756 country-months of observations from 110 countries between Jan 2022 and April 2023. The models include an offset (log of population), as well as dummy variables for months of the year. Standard errors are clustered at the country level. [†]95% CI = 95% confidence interval. [‡]Obtained from an identical model using the categorized vaccination coverage variable instead of the continuous variable.

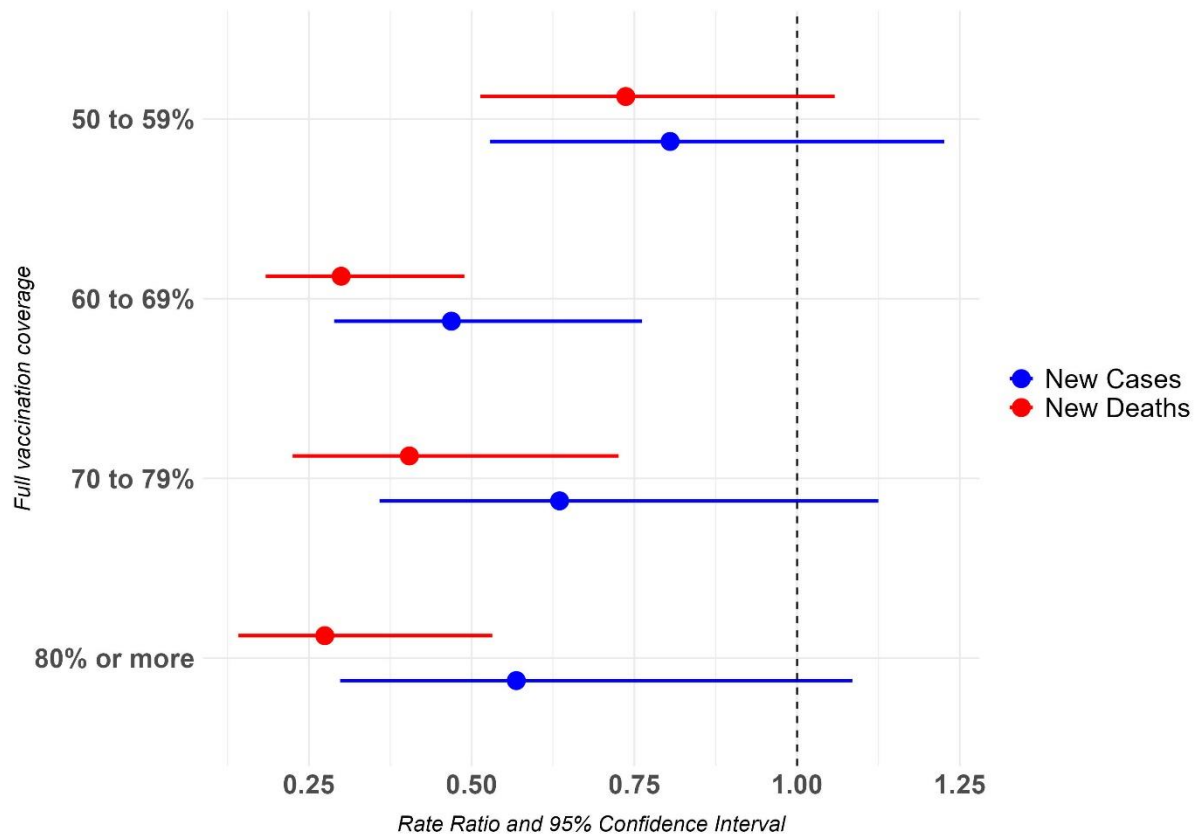


Figure S4: Adjusted regression estimates from two models assessing the association between full vaccination coverage and COVID-19 cases and deaths across 110 countries for months between January 2022 and April 2023 (corresponding to the period of global dominance of the Omicron variant). Reference level is <50% vaccination coverage. The random effects models control for a wide range of country-level policy, sociodemographic and health factors, as well as for seasonality and continent. The standard errors are clustered at the country level.

SENSITIVITY ANALYSIS 4: TWO-MONTH LAGS FOR VACCINATION AND STRINGENCY INDEX

Variable	CASES			DEATHS		
	Rate Ratio	95% CI [†]	p-value	Rate Ratio	95% CI	p-value
Vaccination coverage	1.00	0.99, 1.01	0.80	0.96	0.95, 0.98	<0.001
<i>Categorized[‡]</i>						
<50% (reference)	1.00	-	-	1.00	-	-
50-59%	1.46	0.99, 2.15	0.06	0.76	0.53, 1.09	0.13
60-69%	0.84	0.49, 1.42	0.50	0.49	0.30, 0.77	0.002
70-79%	0.73	0.39, 1.36	0.30	0.36	0.20, 0.63	<0.001
≥80%	0.53	0.26, 1.07	0.08	0.26	0.13, 0.49	<0.001
Stringency index	1.04	1.04, 1.05	<0.001	1.03	1.03, 1.04	<0.001
GDP per capita	1.00	1.00, 1.00	0.20	1.00	1.00, 1.00	0.50
Life expectancy	1.16	1.06, 1.26	0.001	1.18	1.07, 1.30	0.001
Population density	1.00	1.00, 1.00	0.40	1.00	1.00, 1.00	0.50
Median age	1.08	1.01, 1.15	0.02	1.17	1.09, 1.25	<0.001
Hospital beds per thousand	1.15	1.02, 1.29	0.02	1.00	0.88, 1.13	0.90
Adult diabetes prevalence in 2017	1.03	0.96, 1.11	0.40	1.00	0.92, 1.09	0.90
Death rate from cardiovascular disease in 2017 (per 100,000)	1.00	1.00, 1.00	0.40	1.00	1.00, 1.00	0.40
Total COVID-19 tests in 2021 (per million)	1.00	1.00, 1.00	0.05	1.00	1.00, 1.00	0.40

Table S5: Regression estimates for two random effects negative binomial models assessing the association between two-month-lagged full vaccination coverage (%) and the rates of new COVID-19 cases and death during the global Omicron variant dominance period. The sample includes 1,756 country-months of observations from 110 countries between Jan 2022 and April 2023. The models include an offset (log of population), as well as dummy variables for months of the year. The standard errors were clustered at the country level. [†]95% CI = 95% confidence interval. [‡]Obtained from an identical model using the categorized vaccination coverage variable instead of the continuous variable.

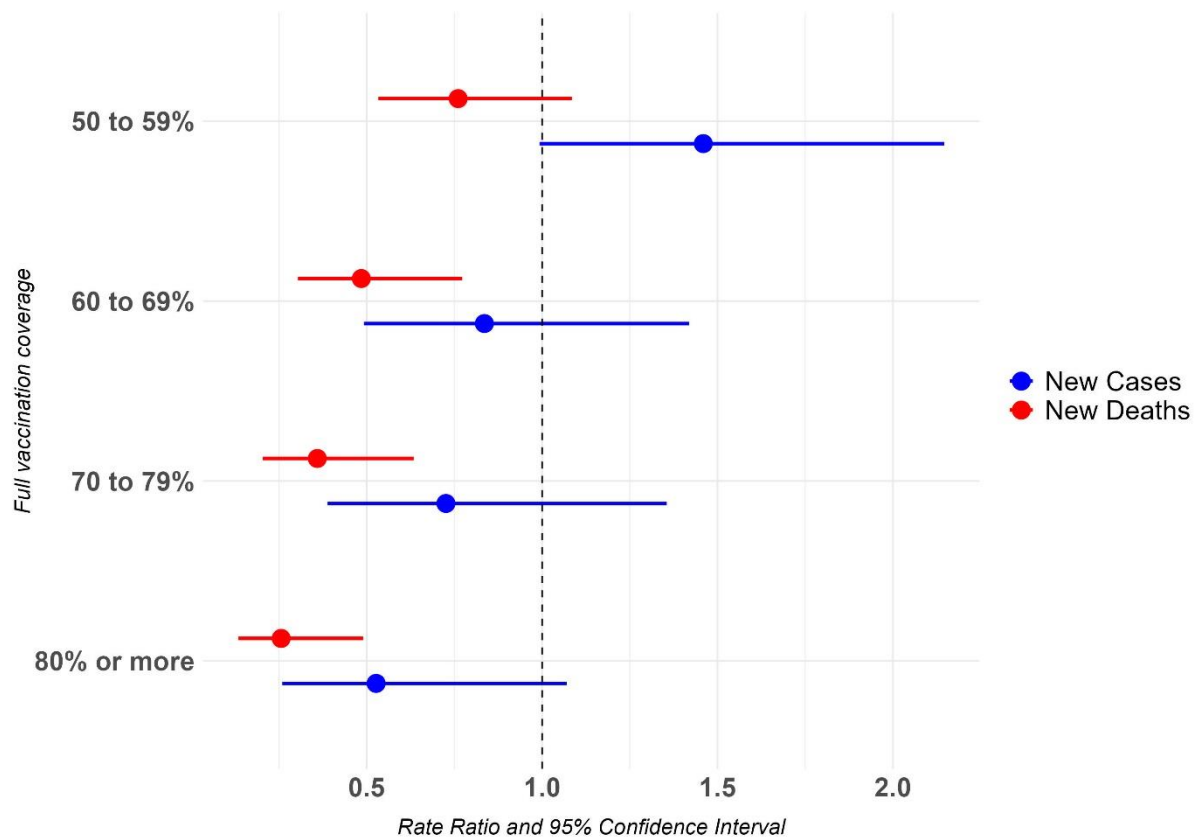


Figure S5: Adjusted regression estimates from two models assessing the association between two-month-lagged full vaccination coverage and COVID-19 cases and deaths across 110 countries for months between January 2022 and April 2023 (corresponding to the period of global dominance of the Omicron variant). Reference level is <50% vaccination coverage. The random effects models control for a wide range of country-level policy, sociodemographic and health factors, as well as for seasonality and continent. The standard errors are clustered at the country level.

SENSITIVITY ANALYSIS 5: BEGIN STUDY PERIOD FROM NOVEMBER 2021 (INSTEAD OF JANUARY 2022)

Variable	CASES			DEATHS		
	Rate Ratio	95% CI [†]	p-value	Rate Ratio	95% CI	p-value
Vaccination coverage	0.96	0.95, 0.97	<0.001	0.94	0.93, 0.95	<0.001
<i>Categorized[‡]</i>						
<50% (reference)	1.00	-	-	1.00	-	-
50-59%	0.54	0.38, 0.76	<0.001	0.46	0.34, 0.62	<0.001
60-69%	0.36	0.23, 0.56	<0.001	0.24	0.16, 0.36	<0.001
70-79%	0.35	0.20, 0.59	<0.001	0.25	0.15, 0.39	<0.001
≥80%	0.30	0.16, 0.55	<0.001	0.22	0.13, 0.39	<0.001
Stringency index	1.06	1.05, 1.06	<0.001	1.05	1.05, 1.05	<0.001
GDP per capita	1.00	1.00, 1.00	0.09	1.00	1.00, 1.00	0.14
Life expectancy	1.25	1.11, 1.40	<0.001	1.23	1.11, 1.36	<0.001
Population density	1.00	1.00, 1.00	0.90	1.00	1.00, 1.00	0.70
Median age	1.08	1.00, 1.16	0.05	1.16	1.08, 1.25	<0.001
Hospital beds per thousand	1.09	0.95, 1.25	0.20	0.98	0.87, 1.11	0.80
Adult diabetes prevalence in 2017	1.00	0.77, 1.31	0.90	0.98	0.90, 1.07	0.70
Death rate from cardiovascular disease in 2017 (per 100,000)	1.00	1.00, 1.00	0.50	1.00	1.00, 1.00	0.70
Total COVID-19 tests in 2021 (per million)	1.00	1.00, 1.00	0.90	1.00	1.00, 1.00	0.3

Table S6: Regression estimates for two random effects negative binomial models assessing the association between two-month-lagged full vaccination coverage (%) and the rates of new COVID-19 cases and death during the global Omicron variant dominance period. The sample includes 1,756 country-months of observations from 110 countries between Jan 2022 and April 2023. The models include an offset (log of population), as well as dummy variables for months of the year. The standard errors were clustered at the country level. [†]95% CI = 95% confidence interval. [‡]Obtained from an identical model using the categorized vaccination coverage variable instead of the continuous variable.

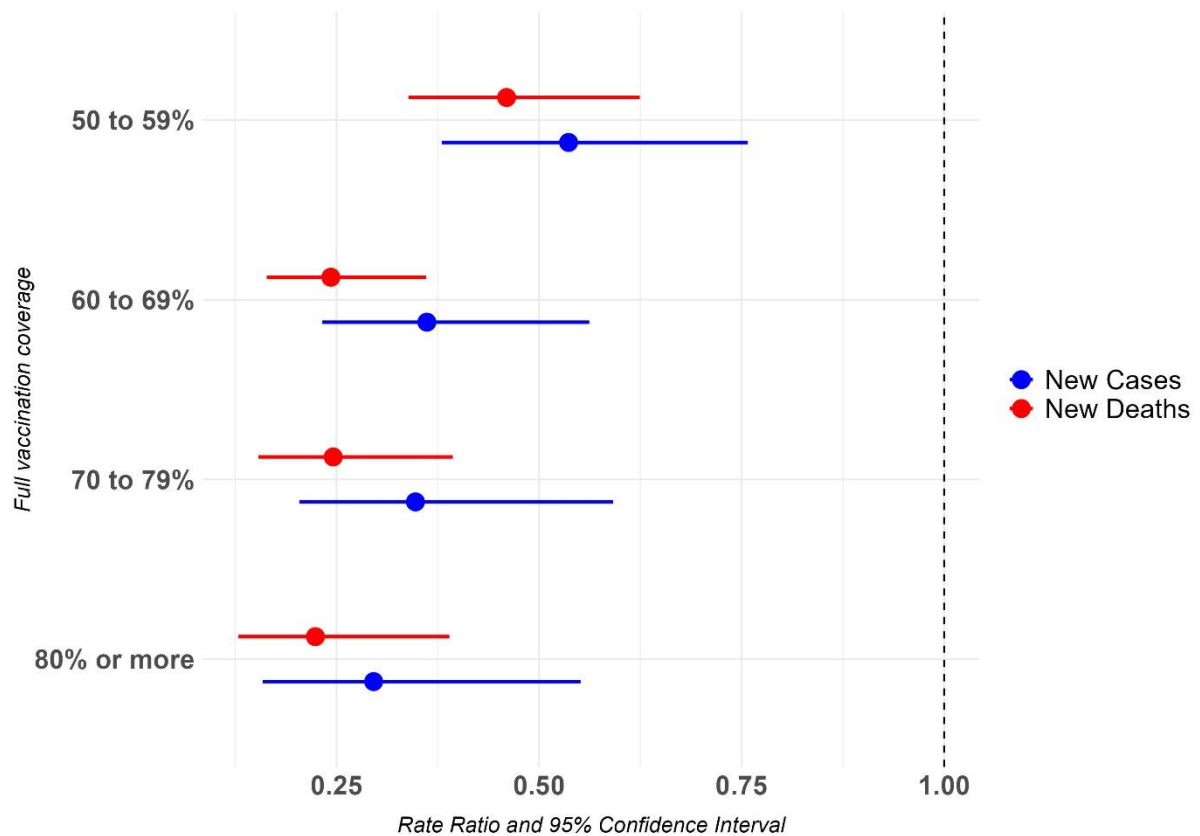


Figure S6: Adjusted regression estimates from two models assessing the association between two-month-lagged full vaccination coverage and COVID-19 cases and deaths across 110 countries for months between January 2022 and April 2023 (corresponding to the period of global dominance of the Omicron variant). Reference level is <50% vaccination coverage. The random effects models control for a wide range of country-level policy, sociodemographic and health factors, as well as for seasonality and continent. The standard errors are clustered at the country level.