Supplementary Results

Authors:

Xinyu Zhou,[a] Xu Zhang,[a] Heidi J. Larson,[b] Alexandre de Figueiredo,[b] Mark Jit,[b] Samah Fodeh,[c] Sten H. Vermund,[d] Sujie Zang,[a] Leesa Lin,[b] Zhiyuan Hou,[a]

Affiliations:

[a] School of Public Health, Global Health Institute, and NHC Key Laboratory of Health Technology Assessment, Fudan University, 130 Dong'an Road, Shanghai, 200032, China.

[b] Department of Infectious Disease Epidemiology, London School of Hygiene and Tropical Medicine, London, England.

[c] Department of Emergency Medicine, Yale School of Medicine, New Haven, USA.

[d] Department of Epidemiology of Microbial Diseases, Yale School of Public Health, New Haven, USA.

Correspondence to Zhiyuan Hou (email: zyhou@fudan.edu.cn).

Supplementary Results

Table of contents:

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Table S6. Distribution of X users by the number of COVID-19 vaccine-related tweets sent by one user during our study period.

Number of COVID-19 vaccine-related tweets sent by one X user	Number of X users	Percentage
1	2,320,786	69.40%
2	486,166	14.54%
3	192,091	5.74%
4	100,228	3.00%
5	59,471	1.78%
6	39,208	1.17%
7	27,188	0.81%
8	20,478	0.61%
9	15,341	0.46%
10	11,710	0.35%
11-20	47,437	1.42%
21-30	12,368	0.37%
31-40	4,908	0.15%
41-50	2,460	0.07%
51-100	3,450	0.10%
≥101	854	0.03%
Total	3,344,144	100%

Note: Totally, 7,047,223 human-generated tweets in this study were sent by a total of 3,344,144 X users.

Table S7. Associations between country-level characteristics and COVID-19 vaccine acceptance by univariate linear regressions (n=135 countries or territories).

- Only countries or territories with COVID-19 vaccination-related tweets from >100 X users were analysed.

Variables	Intent to accept COVID-19 vaccination				Intent to reject COVID-19 vaccination			
	Coefficient	95% CI [a]	p-value	R^2	Coefficient	95% CI [a]	p-value	R^2
Vaccine-related discourse on X								
Belief that COVID-19 vaccine is effective	*1.880****	*[1.523,2.237]*	*<0.001*	*44.9%*	*-0.497****	*[-0.733,-0.260]*	*<0.001*	*11.5%*
Belief that COVID-19 vaccine is not safe	*-1.351****	*[-1.678,-1.440]*	*<0.001*	*33.5%*	*0.376****	*[0.176,0.575]*	*<0.001*	*9.4%*
Distrust in government	*-0.591***	*[-0.995,-0.187]*	*0.004*	*5.9%*	*0.547****	*[0.351,0.744]*	*<0.001*	*18.6%*
Misinformation or rumours on COVID-19 vaccine	*-1.886****	*[-2.332,-1.353]*	*<0.001*	*34.5%*	*0.978****	*[0.744,1.212]*	*<0.001*	*33.9%*
COVID-19 vaccine accessibility	*0.810****	*[0.489,1.132]*	*<0.001*	*15.7%*	*-0.447****	*[-0.613,-0.280]*	*<0.001*	*17.5%*
COVID-19 vaccine equity	*0.667***	*[0.255,1.079]*	*0.002*	*7.2%*	*-0.243**	*[-0.462,-0.023]*	*0.031*	*3.5%*
Governance								
Government effectiveness	0.182	[-1.115,1.479]	0.782	0.1%	*-1.008***	*[-1.660,-0.358]*	*0.003*	*6.8%*
Control of corruption	0.098	[-1.207,1.404]	0.882	0.0%	*-1.012***	*[-1.667,-0.356]*	*0.003*	*6.8%*
State fragility	-0.124	[-0.638,0.391]	0.635	0.2%	*0.456***	*[0.199,0.712]*	*0.001*	*9.3%*
Pandemic preparedness								
Epidemic Ready Score	0.061	[-0.037,0.158]	0.217	2.5%	*-0.081***	*[-0.129,-0.033]*	*0.001*	*15.9%*
Global Health Security Index	-0.006	[-0.099,0.087]	0.906	0.0%	*-0.058**	*[-0.105,-0.010]*	*0.018*	*4.7%*
Doctors per 1000 people	0.001	[-0.072,0.073]	0.983	0.0%	-0.022	[-0.06,0.016]	0.257	1.1%
Trust								
Trust in government, %	*0.127***	*[0.039,0.216]*	*0.005*	*9.6%*	*-0.056**	*[-0.105,-0.007]*	*0.025*	*6.3%*
Trust in science, %	0.057	[-0.081,0.196]	0.413	0.8%	-0.024	[-0.096,0.048]	0.504	0.6%
Interpersonal trust, %	-0.059	[-0.246,0.129]	0.530	1.0%	-0.036	[-0.135,0.062]	0.460	1.4%
Culture-related index								
Individualism	0.002	[-0.086,0.089]	0.973	0.0%	-0.027	[-0.073,0.018]	0.235	2.6%
Uncertainty avoidance	-0.068	[-0.156,0.021]	0.131	4.3%	*0.088****	*[0.047,0.129]*	*<0.001*	*25.8%*
Social development status								
Socio-Demographic Index	0.419	[-6.830,7.668]	0.909	0.0%	*-5.268***	*[-8.911,-1.625]*	*0.005*	*6.1%*
Ln (GDP per capita)	-0.134	[-1.048,0.780]	0.772	0.1%	*-0.474**	*[-0.941,-0.007]*	*0.047*	*3.3%*
School enrolment, %	0.005	[-0.035,0.045]	0.806	0.0%	*-0.021**	*[-0.042,0.001]*	*0.042*	*3.3%*
Internet coverage, %	*0.140**	*[0.024,0.257]*	*0.020*	*10.6%*	*-0.067**	*[-0.133,-0.001]*	*0.048*	*7.8%*
Demographics								
Population density	0.001	[-0.000,0.003]	0.144	1.7%	*-0.001***	*[-0.002,-0.001]*	*0.002*	*7.3%*
Population ages 0-14, %	-0.029	[-0.157,0.099]	0.654	0.2%	*0.085**	*[0.018,0.151]*	*0.013*	*4.9%*
Population ages 65 and above, %	-0.160	[-0.343,0.023]	0.087	2.4%	-0.048	[-0.146,0.050]	0.338	0.7%
Urban population, %	0.008	[-0.054,0.071]	0.790	0.1%	-0.011	[-0.044,0.022]	0.508	0.3%

Note: [a] Confidence Interval. Significance level: *p<0.05; **p<0.01; ***p<0.001.

Table S8. **Country-level determinants of COVID-19 vaccine coverage by univariate linear regression in 135 countries and territories**

Variables	Coefficient	95% Confidence Interval	p-value	R²
Vaccine acceptance on X				
Intent to accept COVID-19 vaccination	1.007**	[0.389, 1.625]	0.002	7.50%
Intent to reject COVID-19 vaccination	-1.983**	[-3.166, -0.800]	0.001	7.90%
Governance				
Government effectiveness	19.916***	[16.979, 22.853]	<0.001	53.50%
Control of corruption	17.008***	[13.665, 20.352]	<0.001	39.30%
State fragility	-8.033***	[-9.199, -6.868]	<0.001	55.30%
Pandemic preparedness				
Epidemic Ready Score	1.161***	[0.955, 1.366]	<0.001	61.80%
Global Health Security Index	1.331***	[1.089, 1.573]	<0.001	44.40%
Doctors per 1000 people	0.973***	[0.779, 1.167]	<0.001	39.30%
Trust				
Trust in government, %	0.292**	[0.054, 0.530]	0.017	5.70%
Trust in science, %	1.294***	[0.972, 1.616]	<0.001	37.90%
Interpersonal trust, %	0.734***	[0.356, 1.113]	<0.001	23.70%
Culture-related index				
Individualism	0.292*	[0.035, 0.548]	0.026	7.50%
Uncertainty avoidance	0.195	[-0.077, 0.467]	0.157	3.10%
Social development status				
Socio-Demographic Index	106.417***	[88.687,124.146]	<0.001	47.60%
Ln (GDP per capita)	13.315***	[11.158, 15.472]	<0.001	50.00%
School enrolment, %	0.576***	[0.472, 0.680]	<0.001	43.70%
Internet coverage, %	0.548***	[0.257, 0.839]	<0.001	18.60%
Demographics				
Population density	0.007**	[0.002, 0.012]	0.003	5.50%
Population ages 0-14, %	-1.997***	[-2.284, -1.709]	<0.001	55.50%
Population ages 65 and above, %	2.24***	[1.702, 2.778]	<0.001	31.00%
Urban population, %	0.73***	[0.565, 0.896]	<0.001	32.90%

*p<0.05; **p<0.01; ***p<0.001

Figure S2. Trajectories in numbers of COVID-19 vaccine-related tweets, mortality, and vaccination

• Data on morality and vaccination were collected from Our World in Data.

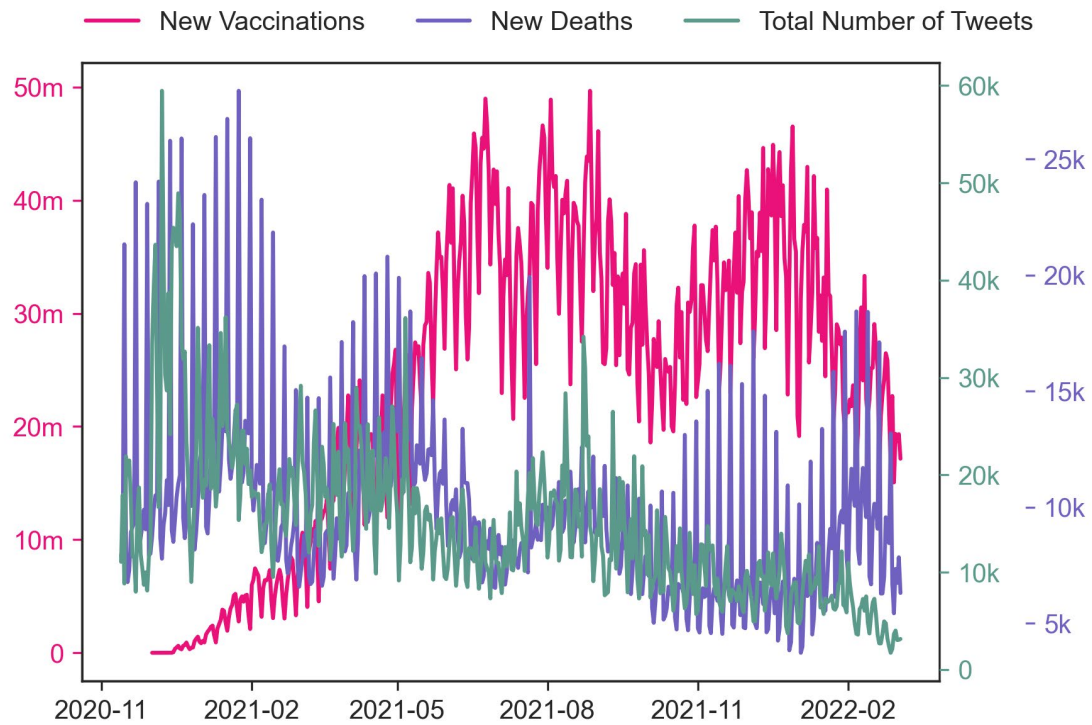**Figure S2a.** Global temporal trends at daily level.

Figure S2b. Country-level trajectories at monthly-level, in 50 countries with sufficient data.

- Countries with COVID-19 vaccination-related tweets from a total of over 2500 X users (and at least 30 users per month) were displayed.
- To supplement the trend in EMR and SEAR, countries with a total number of X users < 2500, but at least 30 users per month (Egypt and Nepal) were also displayed.
- Vaccination data were not available in selected countries. (Please refer to the graph for details.)
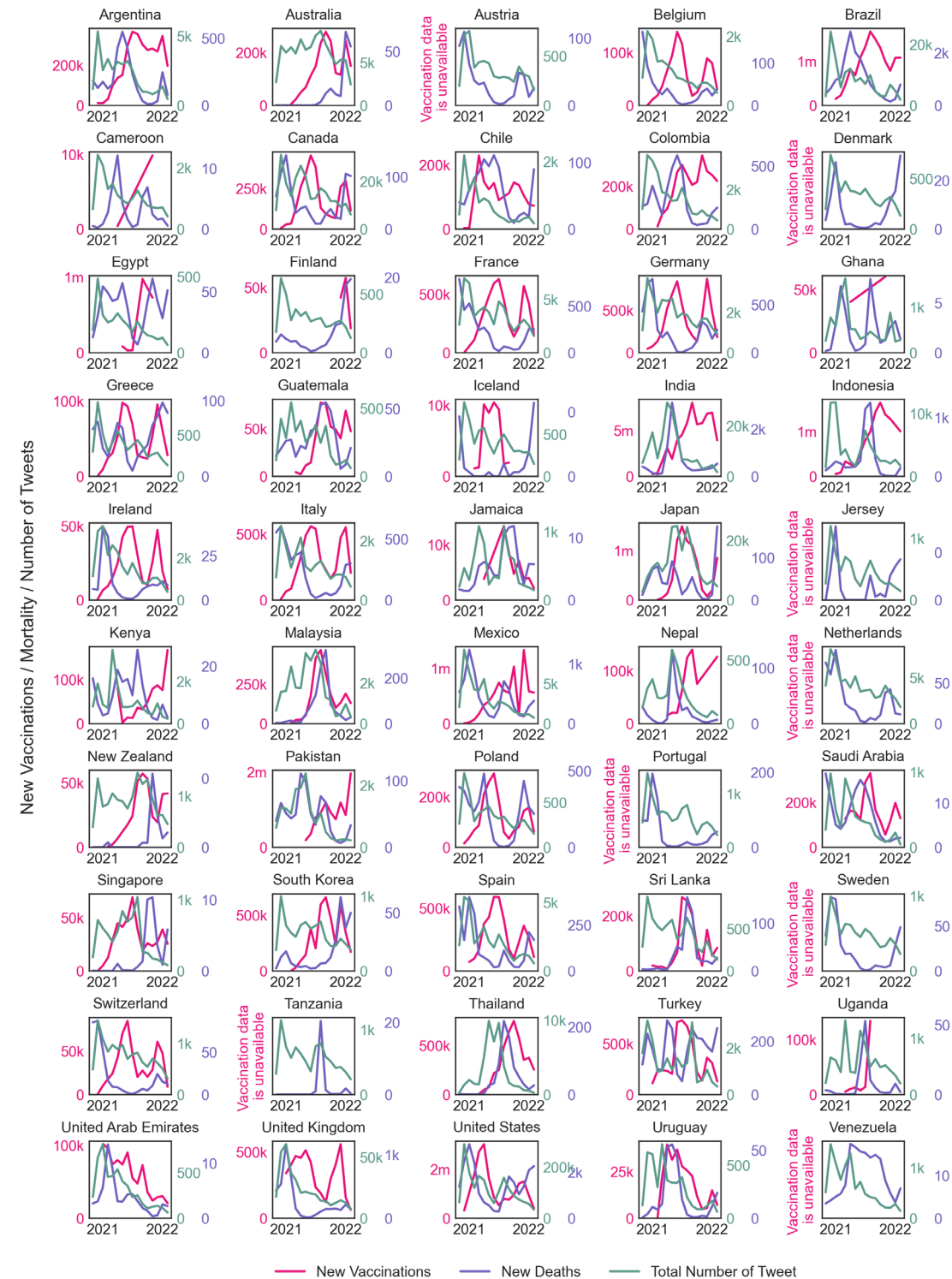

New Vaccinations — New Deaths — Total Number of Tweet

Figure S3. Regional variations in COVID-19 vaccine acceptance, vaccine confidence, information environment, and perceived barriers to accessing vaccines among X users, November 13, 2020 – March 5, 2022.

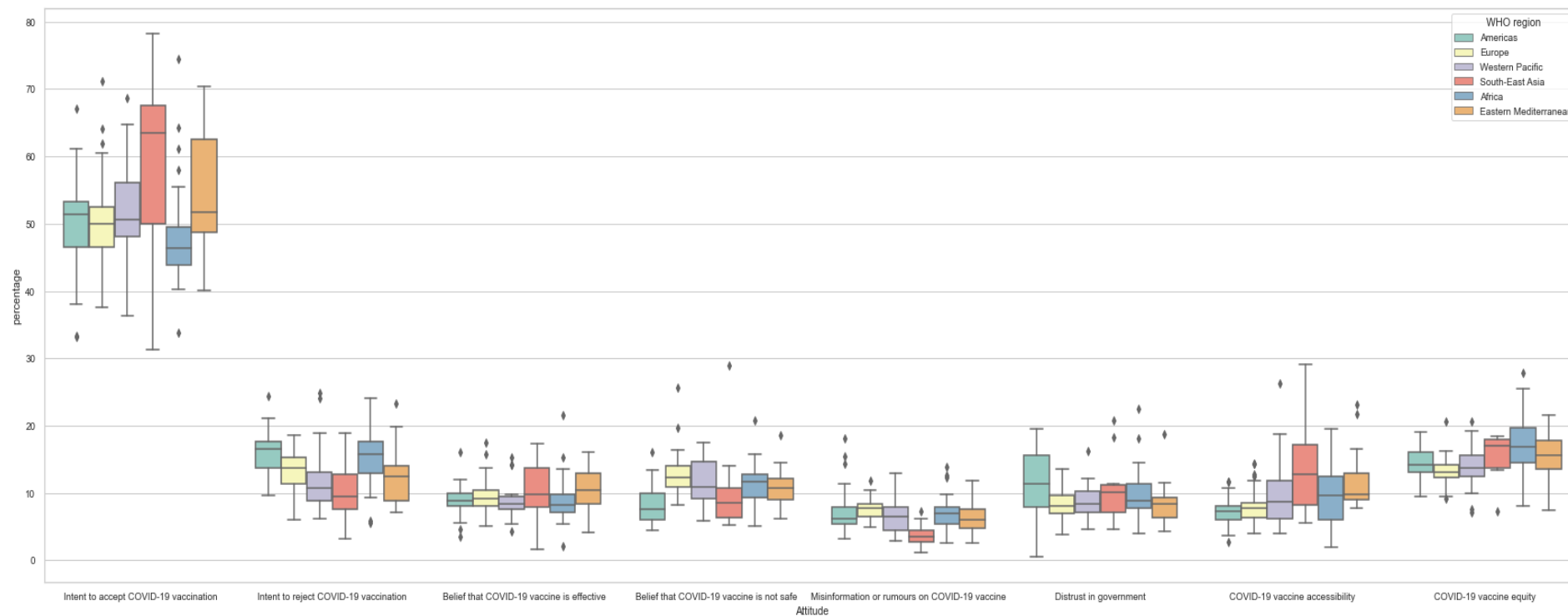- Each point in the plot represents a country or territory.

Figure S4. Regional weekly-level trends of COVID-19 vaccine acceptance, vaccine confidence, information environment, and perceived barriers to accessing vaccines among X users, November 13, 2020 – March 5, 2022

- Each point in the figure represents the weekly-level prevalence of a specific category among all X users in a given region.
- A point with a deeper colour suggests that a higher proportion of X users expressed a specific opinion.
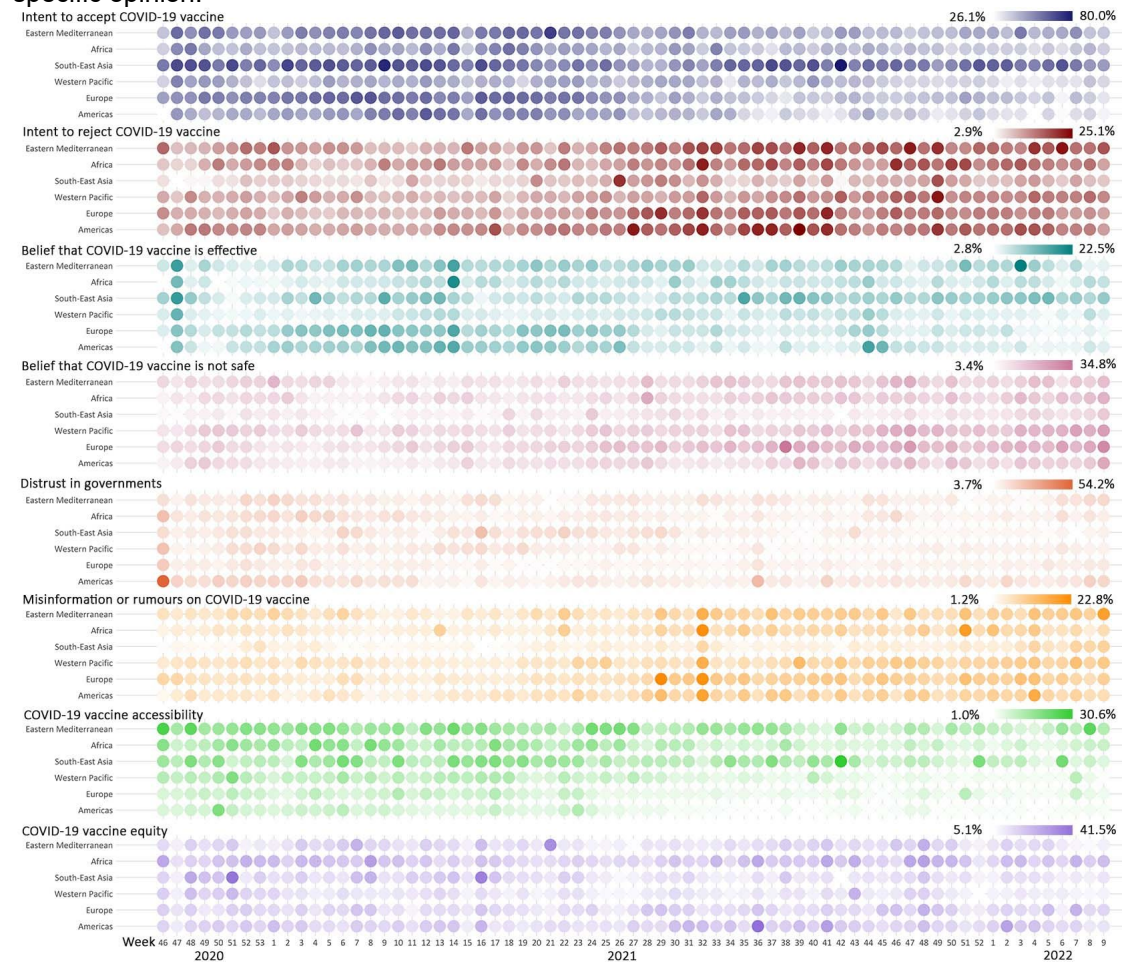
Figure S5. Weekly-level trends of weighted COVID-19 vaccine acceptance among X

users in 26 countries, November 13, 2020 – March 5, 2022

- Only the 26 countries or territories with sufficient X data (total number of X users mentioning COVID-19 vaccination >5000; weekly number >28 before and on the week of February 20, 2022, weekly number >18 after February 20, 2022.

Figure S5a. Weekly-level trends of weighted COVID-19 vaccine acceptance.

Figure S5b. Weekly-level trends of weighted COVID-19 vaccine refusal.