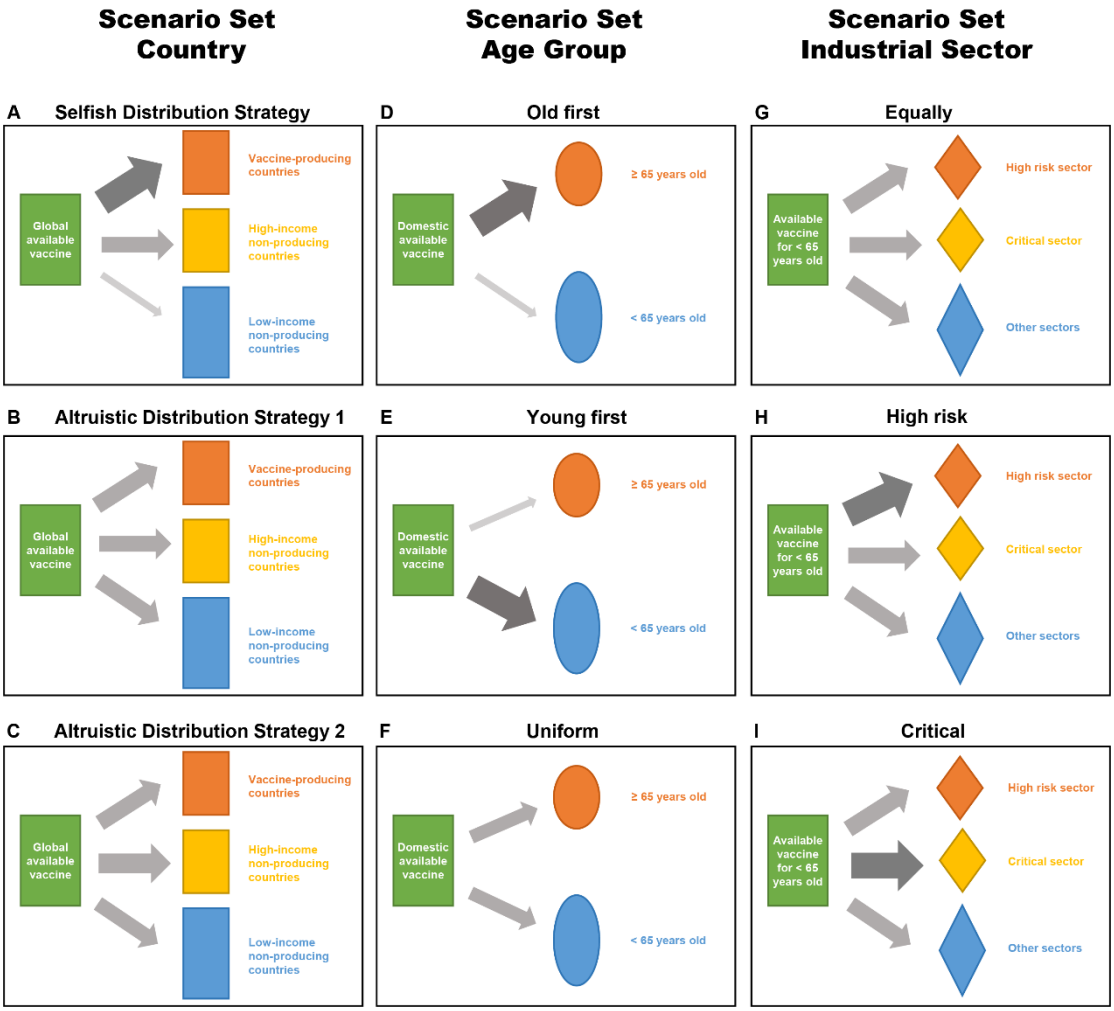
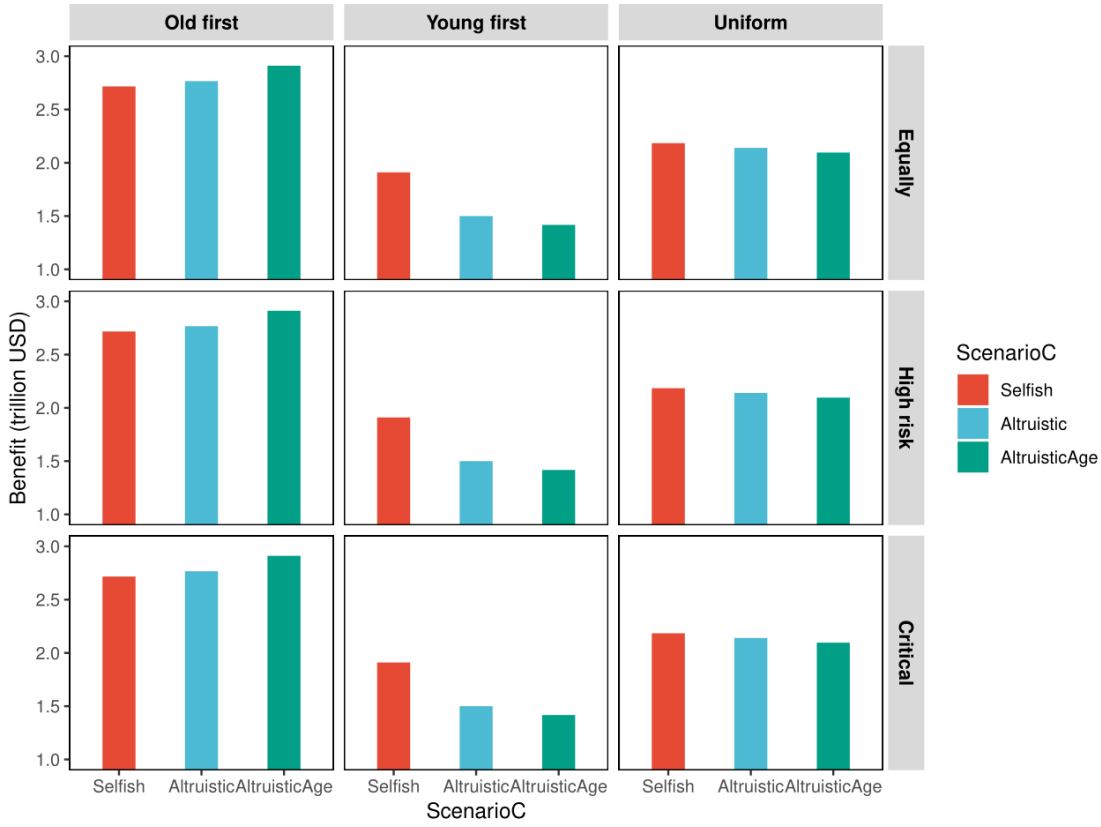
# Supplementary Figures

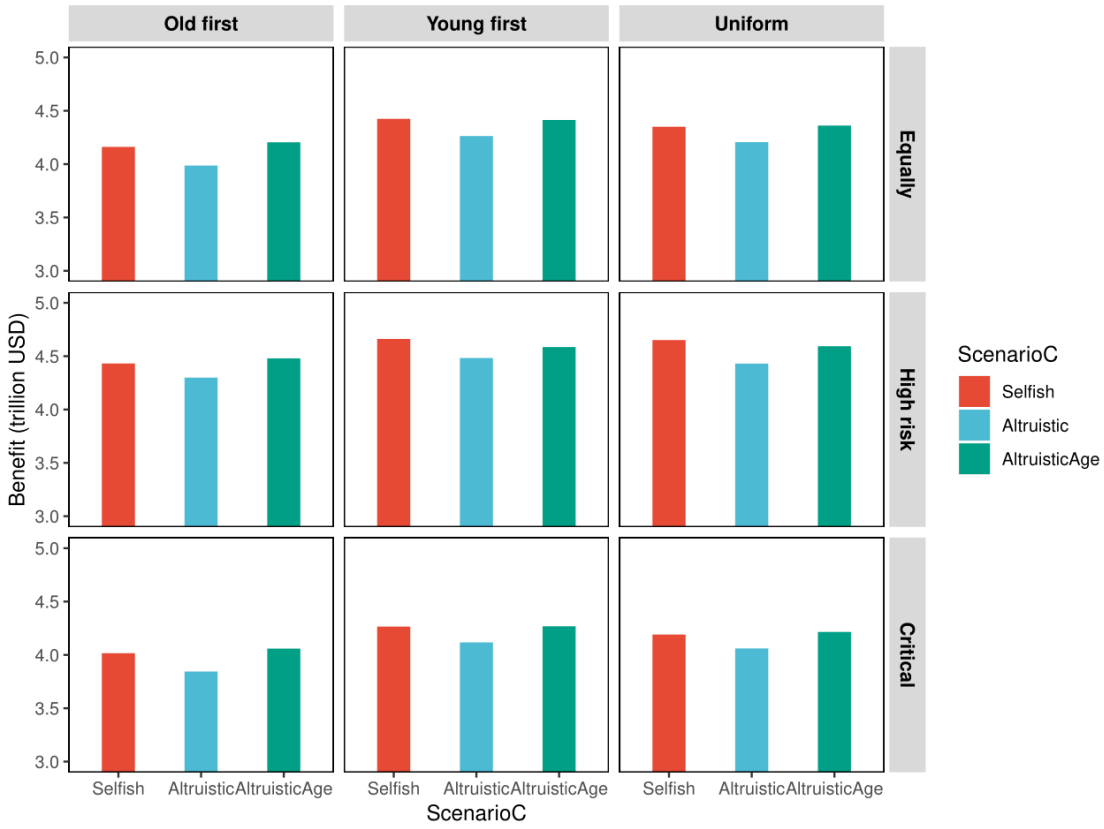



**Supplementary Figure 1. Schematic diagram of the scenario sets.**

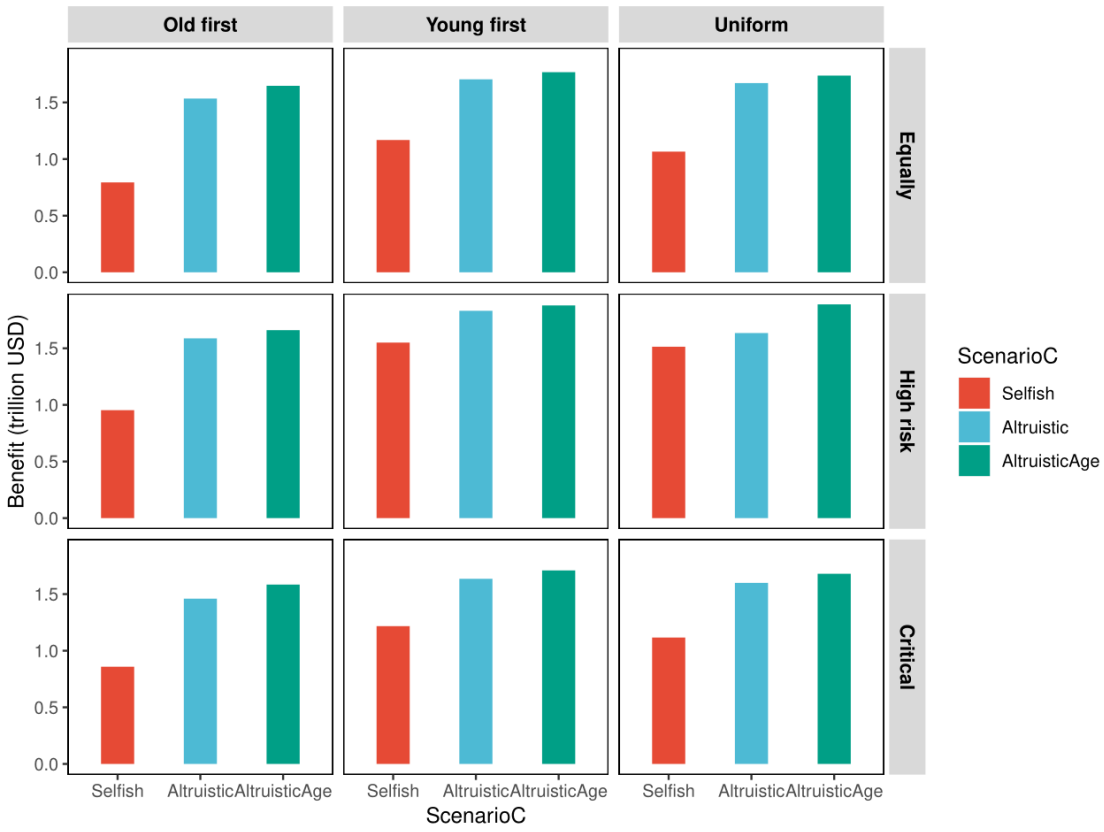
Scenario C represents to what extent the vaccine-exporting country is willing to share the vaccine with other countries (specifically, a Selfish Distribution Strategy vs two Altruistic Distribution Strategies). Scenario A defines the allocation of the received vaccines within destination countries by age group. And scenario S defines the allocation of the received vaccines within young groups in destination countries by industrial sectors.



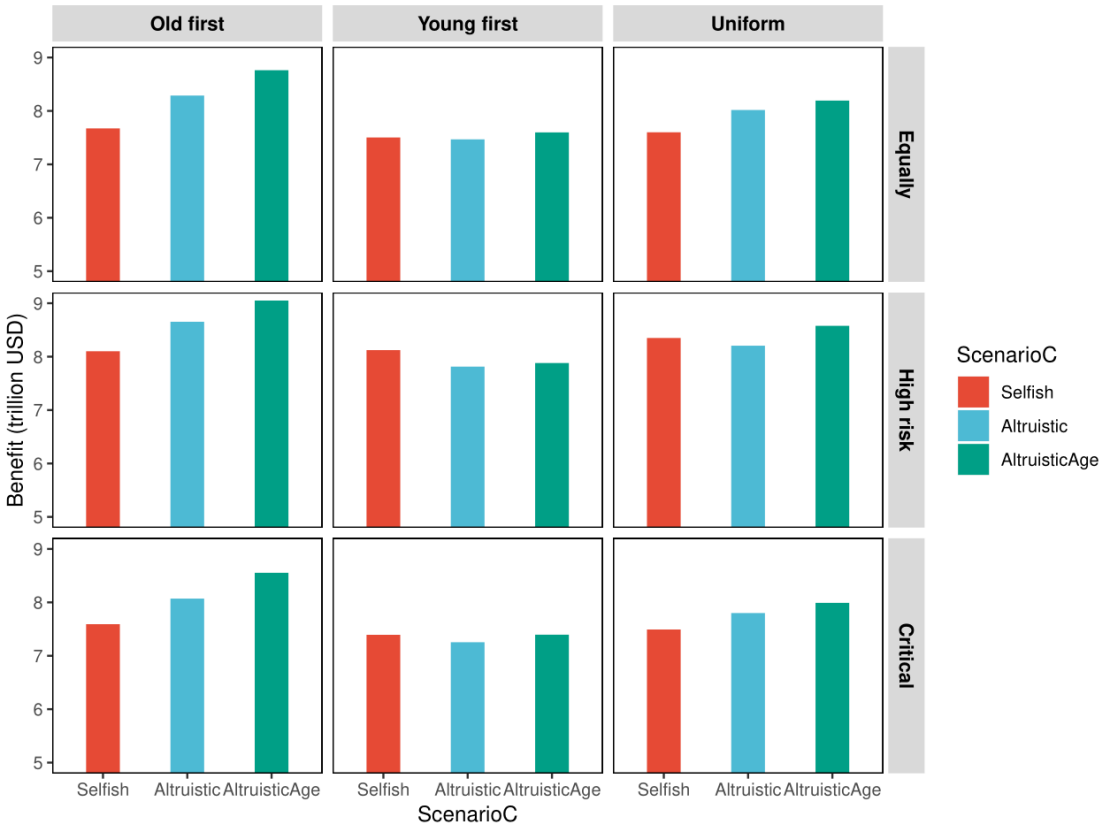

**Supplementary Figure 2. Global health gains under in 27 scenarios.**



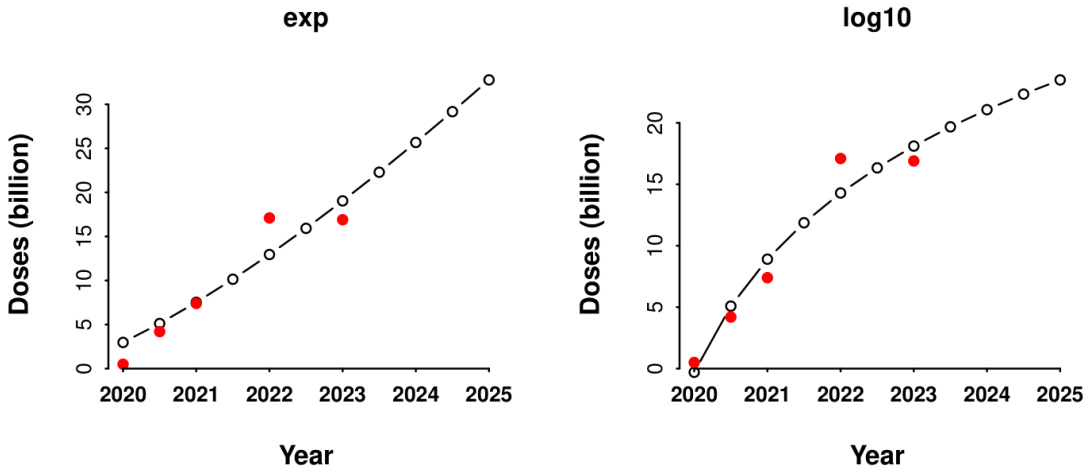

**Supplementary Figure 3 Global lockdown-easing effect under in 27 scenarios.**




**Supplementary Figure 4 Global supply-chain rebuilding benefit under in 27 scenarios.**

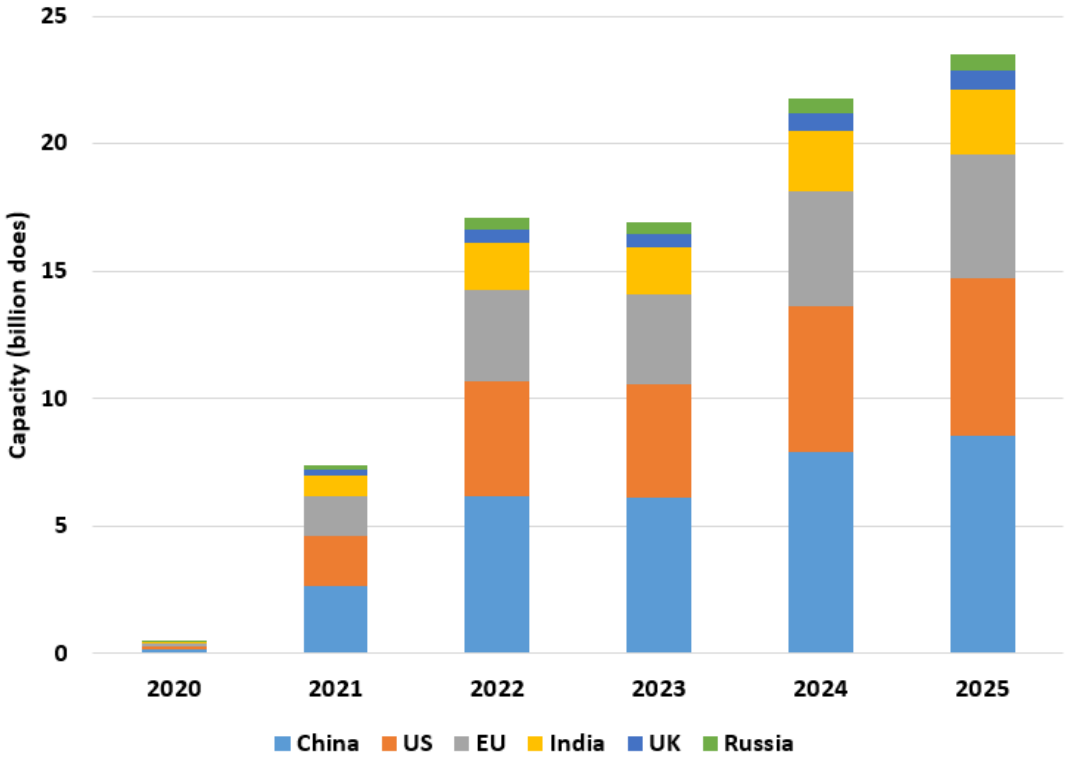



**Supplementary Figure 5 Global benefits under in 27 scenarios.**



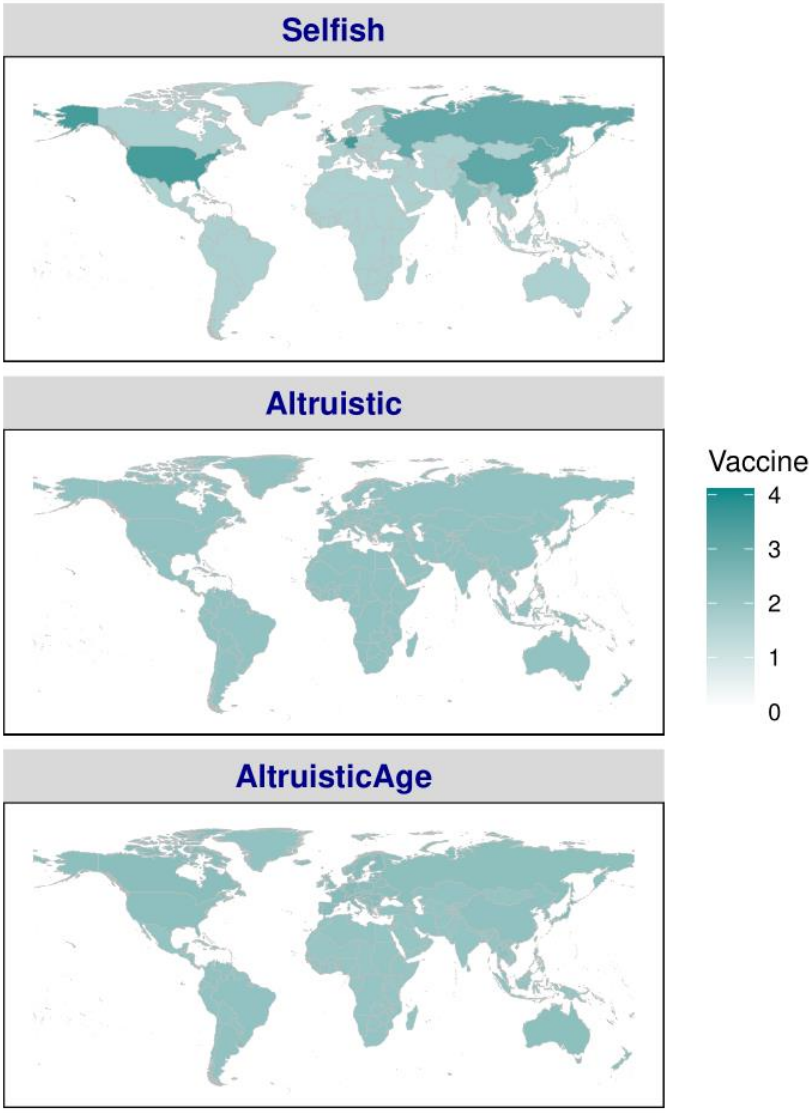

**Supplementary Figure 6 Fitting results of vaccine production capacity.**

It can be seen from the figure that the logarithmic function (right-hand side) fits better than exponential function form (lift-hand side). It is worth mentioning that there are too few sample points for fitting. If the estimated production capacity in 2024 and 2025 is too large or too small, it will have a certain degree of impact on the results of this study. We conducted +25% and -25% sensitivity tests, and find that the conclusions in the article will not change.



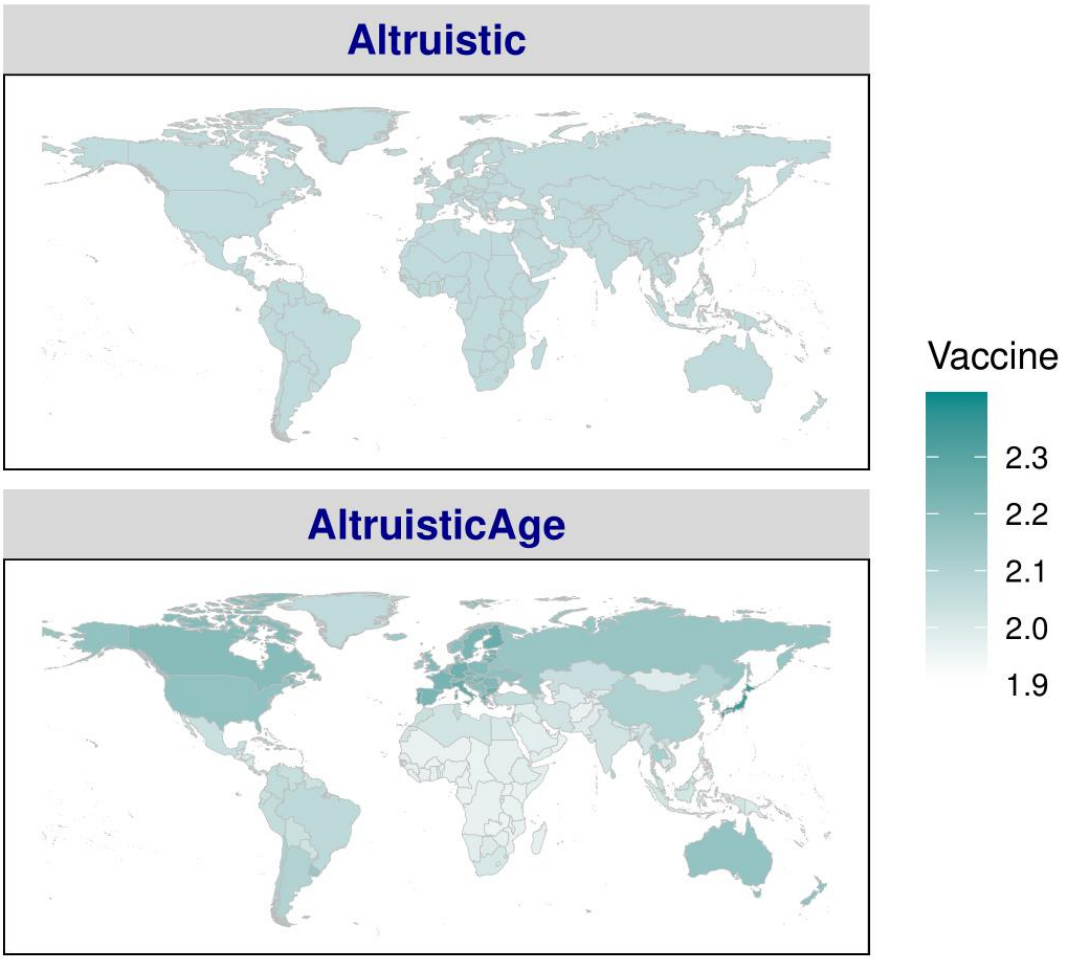

**Supplementary Figure 7. Projected vaccine production capacity in six regions.**

The data for 2020 to 2023 are from UNICEF[1], while the data for 2024 and 2025 are from estimates by the authors.



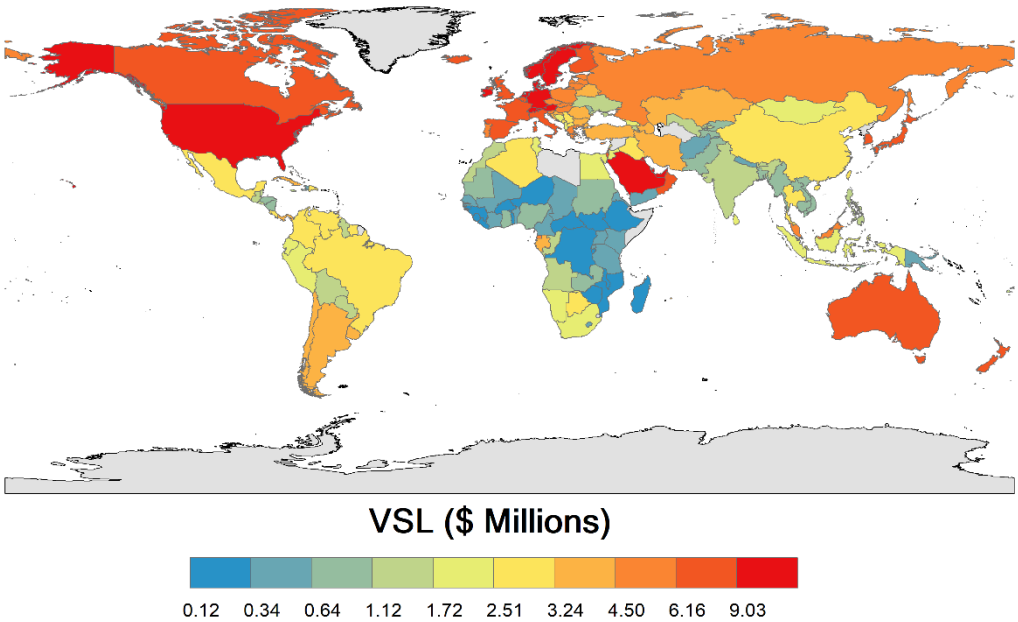

**Supplementary Figure 8. The average doses of vaccine available per capita per year in each country/region during 2020-2025.**

The panel on the top represents the number available under the Selfish Distribution Strategy; the panel on the middle represents the number available under the Altruistic Distribution Strategy; and the panel on the bottom represents the number available under the Altruistic Age Distribution Strategy.



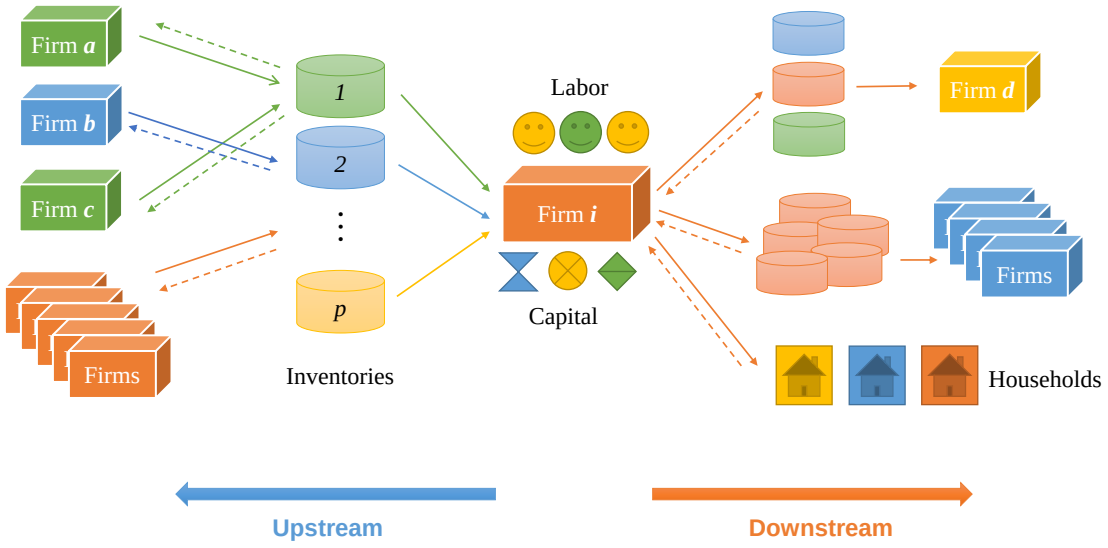

**Supplementary Figure 9. The average doses of vaccine available per capita per year in each country/region during 2020-2025. (A detailed display of Fig. S8)**

The panel on the top represents the number available under the Altruistic Distribution Strategy, while the panel on the bottom represents the number available under the Altruistic Age Distribution Strategy.




**Supplementary Figure 10. Estimated VSL for 175 countries in 2019$.**

The country based VSL estimation used in this research is adopted from the COVID-19 global health risks pricing study by Viscusi (Table 6) [2]. The estimation is based on the estimated VSL in the U.S. (11 million in 2019 US dollor), and coupled with an income elasticity of 1.0 to adjust the VSL to other countries using the fixed effects specification [3].




**Supplementary Figure 11. Overview of the backbone of the recursive dynamic disaster impact assessment model.**

Products flow from left to right (solid line), whereas orders flow in the opposite direction (dotted line). In each time step, firm *i* use the primary inputs (e.g., labour and capital) and inventories (i.e., intermediates) to produce a specific good, to meet the orders from its downstream clients (i.e., other firms and households). At the same time, firm *i* will issue orders to its upstream suppliers to restore its inventories, which is used in the production process, to a target level. In our model, some inventories of firm *i* may come from different firms (in practice, in the MRIO table for example, this refers to the same sector sourced from different regions). When one type of inventory has multiple suppliers, firm *i* will consider the order proportion of the equilibrium period and the current production capacity of each supplier when releases orders to them (the second improvement of our disaster footprint model on the ARIO model).

# Supplementary Tables

## Supplementary Table 1. Risk level of industrial sectors

| No. | Sector code | Description | Risk level |
|---|---|---|---|
| 1 | pdr | Paddy rice | Low |
| 2 | wht | Wheat | Low |
| 3 | gro | Cereal grains nec | Low |
| 4 | v_f | Vegetables, fruit, nuts | Low |
| 5 | osd | Oil seeds | Low |
| 6 | c_b | Sugar cane, sugar beet | Low |
| 7 | pfb | Plant-based fibers | Low |
| 8 | ocr | Crops nec | Low |
| 9 | ctl | Bovine cattle, sheep and goats | Low |
| 10 | oap | Animal products nec | Low |
| 11 | rmk | Raw milk | Low |
| 12 | wol | Wool, silk-worm cocoons | Low |
| 13 | frs | Forestry | Low |
| 14 | fsh | Fishing | Low |
| 15 | coa | Coal | Low |
| 16 | oil | Oil | Low |
| 17 | gas | Gas | Low |
| 18 | oxt | Minerals nec | Low |
| 19 | cmt | Bovine meat products | Low |
| 20 | omt | Meat products nec | Low |
| 21 | vol | Vegetable oils and fats | Low |
| 22 | mil | Dairy products | Low |
| 23 | pcr | Processed rice | Low |
| 24 | sgr | Sugar | Low |
| 25 | ofd | Food products nec | Low |
| 26 | b_t | Beverages and tobacco products | Low |
| 27 | tex | Textiles | High |
| 28 | wap | Wearing apparel | High |
| 29 | lea | Leather products | High |
| 30 | lum | Wood products | Middle |
| 31 | ppp | Paper products, publishing | Middle |
| 32 | p_c | Petroleum, coal products | Middle |
| 33 | chm | Chemical products | Middle |
| 34 | bph | Basic pharmaceutical products | Middle |
| 35 | rpp | Rubber and plastic products | Middle |
| 36 | nmm | Mineral products nec | Middle |

| | | | |
|---|---|---|---|
| 37 | i_s | Ferrous metals | Middle |
| 38 | nfm | Metals nec | Middle |
| 39 | fmp | Metal products | Middle |
| 40 | ele | Computer, electronic and optic | Middle |
| 41 | eeq | Electrical equipment | Middle |
| 42 | ome | Machinery and equipment nec | Middle |
| 43 | mvh | Motor vehicles and parts | Middle |
| 44 | otn | Transport equipment nec | Middle |
| 45 | omf | Manufactures nec | Middle |
| 46 | ely | Electricity | Middle |
| 47 | gdt | Gas manufacture, distribution | Middle |
| 48 | wtr | Water | Middle |
| 49 | cns | Construction | Middle |
| 50 | trd | Trade | High |
| 51 | afs | Accommodation, Food and servic | High |
| 52 | otp | Transport nec | High |
| 53 | wtp | Water transport | High |
| 54 | atp | Air transport | High |
| 55 | whs | Warehousing and support activi | High |
| 56 | cmn | Communication | Low |
| 57 | ofi | Financial services nec | Low |
| 58 | ins | Insurance | Low |
| 59 | rsa | Real estate activities | Low |
| 60 | obs | Business services nec | Low |
| 61 | ros | Recreational and other service | High |
| 62 | osg | Public Administration and defe | Low |
| 63 | edu | Education | High |
| 64 | hht | Human health and social work a | High |
| 65 | dwe | Dwellings | Low |

**Note: Please refer to [4-6] for more information about the risk classification.**

**Supplementary Table 2. Proportion of critical labor in each industrial sector.**

This table shows the Proportion of critical labor in each industrial sector. This table is documented in the compressed package “Supplementary Results.zip”. Please refer to Guan and Hallegatte [7] for more details of the critical labor.

## Supplementary Table 3. Health gains by country

This table shows the health gains for each country under all combinations of different sets of scenarios. This table is documented in the compressed package “Supplementary Results.zip”.

## Supplementary Table 4 Lockdown-easing effect by country

This table shows the lockdown-easing effect for each country under all combinations of different sets of scenarios. This table is documented in the compressed package "Supplementary Results.zip".

## Supplementary Table 5 Supply-chain rebuilding benefit by country

This table shows the supply-chain rebuilding benefit for each country under all combinations of different sets of scenarios. This table is documented in the compressed package “Supplementary Results.zip”.

**Supplementary Table 6. The 141 modeled regions and their demographic characteristics (2020).**

| RID | id | name | population | pop65+ |
|---|---|---|---|---|
| 1 | aus | Australia | 25687041 | 4164655 |
| 2 | nzl | New Zealand | 5084300 | 832214 |
| 3 | xoc | Rest of Oceania | 12310386 | 523874 |
| 4 | chn | China | 1402112000 | 167808567 |
| 5 | hkg | Hong Kong | 7481800 | 1361446 |
| 6 | jpn | Japan | 125836021 | 35733999 |
| 7 | kor | Korea Republic of | 51780579 | 8176623 |
| 8 | mng | Mongolia | 3278292 | 141370 |
| 9 | twn | Taiwan | 23694089 | 2207815 |
| 10 | xea | Rest of East Asia | 26428157 | 2487718 |
| 11 | brn | Brunei Darussalam | 437483 | 24368 |
| 12 | khm | Cambodia | 16718971 | 811346 |
| 13 | idn | Indonesia | 273523621 | 17129453 |
| 14 | lao | Lao Peoples Democratic Republic | 7275556 | 309879 |
| 15 | mys | Malaysia | 32365998 | 2325071 |
| 16 | phl | Philippines | 109581085 | 6039724 |
| 17 | sgp | Singapore | 5685807 | 759143 |
| 18 | tha | Thailand | 69799978 | 9044498 |
| 19 | vnm | Viet Nam | 97338583 | 7656664 |
| 20 | xse | Rest of Southeast Asia | 55728236 | 3449513 |
| 21 | bgd | Bangladesh | 164689383 | 8608320 |
| 22 | ind | India | 1380004385 | 90719952 |
| 23 | npl | Nepal | 29136808 | 1698136 |
| 24 | pak | Pakistan | 220892331 | 9605834 |
| 25 | lka | Sri Lanka | 21919000 | 2462130 |
| 26 | xsa | Rest of South Asia | 40240495 | 1098539 |
| 27 | can | Canada | 38005238 | 6880606 |
| 28 | usa | United States of America | 329484123 | 54796260 |
| 29 | mex | Mexico | 128932753 | 9822231 |
| 30 | xna | Rest of North America | 120270 | 11206 |
| 31 | arg | Argentina | 45376763 | 5157755 |
| 32 | bol | Bolivia | 11673029 | 873984 |
| 33 | bra | Brazil | 212559409 | 20389282 |
| 34 | chl | Chile | 19116209 | 2340332 |
| 35 | col | Colombia | 50882884 | 4610275 |
| 36 | ecu | Ecuador | 17643060 | 1339301 |
| 37 | pry | Paraguay | 7132530 | 485795 |
| 38 | per | Peru | 32971846 | 2876880 |

| | | | | |
|---|---|---|---|---|
| 39 | ury | Uruguay | 3473727 | 524105 |
| 40 | ven | Venezuela | 28435943 | 2267112 |
| 41 | xsm | Rest of South America | 1373193 | 96911 |
| 42 | cri | Costa Rica | 5094114 | 522305 |
| 43 | gtm | Guatemala | 16858333 | 850004 |
| 44 | hnd | Honduras | 9904608 | 492576 |
| 45 | nic | Nicaragua | 6624554 | 376109 |
| 46 | pan | Panama | 4314768 | 368429 |
| 47 | slv | El Salvador | 6486201 | 561118 |
| 48 | xca | Rest of Central America | 397621 | 19915 |
| 49 | dom | Dominican Republic | 10847904 | 816598 |
| 50 | jam | Jamaica | 2961161 | 268807 |
| 51 | pri | Puerto Rico | 3194034 | 665233 |
| 52 | tto | Trinidad and Tobago | 1399491 | 161146 |
| 53 | xcb | Caribbean | 24428517 | 2584149 |
| 54 | aut | Austria | 8917205 | 1712460 |
| 55 | bel | Belgium | 11555997 | 2225019 |
| 56 | bgr | Bulgaria | 6927288 | 1487145 |
| 57 | hrv | Croatia | 4047200 | 860120 |
| 58 | cyp | Cyprus | 1207361 | 173966 |
| 59 | cze | Czech Republic | 10698896 | 2155078 |
| 60 | dnk | Denmark | 5831404 | 1175844 |
| 61 | est | Estonia | 1331057 | 271179 |
| 62 | fin | Finland | 5530719 | 1247425 |
| 63 | fra | France | 67391582 | 13986082 |
| 64 | deu | Germany | 83240525 | 18052747 |
| 65 | grc | Greece | 10715549 | 2387895 |
| 66 | hun | Hungary | 9749763 | 1965855 |
| 67 | irl | Ireland | 4994724 | 728128 |
| 68 | ita | Italy | 59554023 | 13877215 |
| 69 | lva | Latvia | 1901548 | 393381 |
| 70 | ltu | Lithuania | 2794700 | 576211 |
| 71 | lux | Luxembourg | 632275 | 90989 |
| 72 | mlt | Malta | 525285 | 112011 |
| 73 | nld | Netherlands | 17441139 | 3494301 |
| 74 | pol | Poland | 37950802 | 7111772 |
| 75 | prt | Portugal | 10305564 | 2346811 |
| 76 | rou | Romania | 19286123 | 3708898 |
| 77 | svk | Slovakia | 5458827 | 911577 |
| 78 | svn | Slovenia | 2100126 | 435519 |
| 79 | esp | Spain | 47351567 | 9459712 |

| | | | | |
|---|---|---|---|---|
| 80 | swe | Sweden | 10353442 | 2104731 |
| 81 | gbr | United Kingdom | 67215293 | 12537902 |
| 82 | che | Switzerland | 8636896 | 1649435 |
| 83 | nor | Norway | 5379475 | 942838 |
| 84 | xef | Rest of EFTA | 404562 | 60797 |
| 85 | alb | Albania | 2837743 | 417278 |
| 86 | blr | Belarus | 9398861 | 1464361 |
| 87 | rus | Russian Federation | 144104080 | 22348998 |
| 88 | ukr | Ukraine | 44134693 | 7480452 |
| 89 | xee | Rest of Eastern Europe | 2617820 | 327045 |
| 90 | xer | Rest of Europe | 13212172 | 2333680 |
| 91 | kaz | Kazakhstan | 18754440 | 1482126 |
| 92 | kgz | Kyrgyzstan | 6591600 | 311644 |
| 93 | tjk | Tajikistan | 9537642 | 303274 |
| 94 | xsu | Rest of Former Soviet Union | 40263237 | 1926892 |
| 95 | arm | Armenia | 2963234 | 349747 |
| 96 | aze | Azerbaijan | 10110116 | 681586 |
| 97 | geo | Georgia | 3714000 | 566508 |
| 98 | bhr | Bahrain | 1701583 | 45112 |
| 99 | irn | Iran Islamic Republic of | 83992953 | 5513595 |
| 100 | isr | Israel | 9216900 | 1144218 |
| 101 | jor | Jordan | 10203140 | 403401 |
| 102 | kwt | Kuwait | 4270563 | 129646 |
| 103 | omn | Oman | 5106622 | 128228 |
| 104 | qat | Qatar | 2881060 | 48665 |
| 105 | sau | Saudi Arabia | 34813867 | 1217949 |
| 106 | tur | Turkey | 84339067 | 7574547 |
| 107 | are | United Arab Emirates | 9890400 | 125055 |
| 108 | xws | Rest of Western Asia | 99177839 | 3781731 |
| 109 | egy | Egypt | 102334403 | 5456144 |
| 110 | mar | Morocco | 36910558 | 2807655 |
| 111 | tun | Tunisia | 11818618 | 1048660 |
| 112 | xnf | Rest of North Africa | 50722330 | 3267826 |
| 113 | ben | Benin | 12123198 | 397455 |
| 114 | bfa | Burkina Faso | 20903278 | 503984 |
| 115 | cmr | Cameroon | 26545864 | 721027 |
| 116 | civ | Cote dIvoire | 26378275 | 760372 |
| 117 | gha | Ghana | 31072945 | 975799 |
| 118 | gin | Guinea | 13132792 | 387722 |
| 119 | nga | Nigeria | 206139587 | 5644234 |
| 120 | sen | Senegal | 16743930 | 520426 |

| | | | | |
|---|---|---|---|---|
| 121 | tgo | Togo | 8278737 | 240499 |
| 122 | xwf | Rest of Western Africa | 67082442 | 1823758 |
| 123 | xcf | Central Africa | 30621589 | 816553 |
| 124 | xac | South Central Africa | 122427672 | 3423816 |
| 125 | eth | Ethiopia | 114963583 | 4066140 |
| 126 | ken | Kenya | 53771300 | 1349222 |
| 127 | mdg | Madagascar | 27691019 | 858614 |
| 128 | mwi | Malawi | 19129955 | 505326 |
| 129 | mus | Mauritius | 1265740 | 158472 |
| 130 | moz | Mozambique | 31255435 | 894476 |
| 131 | rwa | Rwanda | 12952209 | 404019 |
| 132 | tza | Tanzania United Republic of | 59734213 | 1579127 |
| 133 | uga | Uganda | 45741000 | 908279 |
| 134 | zmb | Zambia | 18383956 | 391950 |
| 135 | zwe | Zimbabwe | 14862927 | 447995 |
| 136 | xec | Rest of Eastern Africa | 73589328 | 2436785 |
| 137 | bwa | Botswana | 2351625 | 106110 |
| 138 | nam | Namibia | 2540916 | 91113 |
| 139 | zaf | South Africa | 59308690 | 3267576 |
| 140 | xsc | Rest of South African Customs Union | 3302416 | 152566 |
| 141 | xtw | Rest of the World | 7983 | 744 |

Data source:

https://www.gtap.agecon.purdue.edu/databases/regions.aspx?version=10.211#:~:text=GTAP%20Data%20Bases%3A%20GTAP%2010%20Data%20Base%20Final,%20%20China%20%2082%20more%20rows%20

https://data.worldbank.org/indicator/SP.POP.TOTL

https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS

## Supplementary Table 7. GTAP sector classification and multiplier.

| SID | Code | Name | Short Name | Multiplier | Rational |
|---|---|---|---|---|---|
| 1 | pdr | Paddy rice | Rice | 0.5 | 1)Lower exposure risk of agricultural production activities. 2) Necessity |
| 2 | wht | Wheat | Wheat | 0.5 | |
| 3 | gro | Cereal grains nec | Cereals | 0.5 | |
| 4 | v_f | Vegetables, fruit, nuts | Veg & fruits | 0.5 | |
| 5 | osd | Oil seeds | Oilseed | 0.5 | |
| 6 | c_b | Sugar cane, sugar beet | Sugar crops | 0.5 | |
| 7 | pfb | Plant-based fibers | Fibre crops | 0.5 | |
| 8 | ocr | Crops nec | Crops nec | 0.5 | |
| 9 | ctl | Cattle, sheep and goats, horses | Livestock | 0.5 | |
| 10 | oap | Animal products nec | Poultry | 0.5 | |
| 11 | rmk | Raw milk | Milk | 0.5 | |
| 12 | wol | Wool, silk-worm cocoons | Animal fiber | 0.5 | |
| 13 | frs | Forestry | Forestry | 0.5 | |
| 14 | fsh | Fishing | Fishing | 0.5 | |
| 15 | coa | Coal | Coal | 1 | Ordinary setor |
| 16 | oil | Oil | Oil | 1 | |
| 17 | gas | Gas | Gas | 1 | |
| 18 | oxt | Other Extraction | Other extraction | 1 | |
| 19 | cmt | Meat: cattle, sheep, goats, horse | Red meat | 1 | |
| 20 | omt | Meat products nec | White meat | 1 | |
| 21 | vol | Vegetable oils and fats | Oil | 1 | |
| 22 | mil | Dairy products | Dairy | 1 | |
| 23 | pcr | Processed rice | Rice products | 1 | |
| 24 | sgr | Sugar | Sugar | 1 | |
| 25 | ofd | Food products nec | Food | 1 | |
| 26 | b_t | Beverages and tobacco products | Drinks & tobacco | 1 | |
| 27 | tex | Textiles | Textiles | 1 | |
| 28 | wap | Wearing apparel | Garments | 1 | |
| 29 | lea | Leather products | Leather | 1 | |
| 30 | lum | Wood products | Timber | 1 | |
| 31 | ppp | Paper products, publishing | Paper | 1 | |
| 32 | p_c | Petroleum, coal products | Petroleum | 1 | |
| 33 | chm | Chemical products | Chemicals | 1 | |
| 34 | bph | Basic pharmaceutical products | Medicament | 1 | |
| 35 | rpp | Rubber and plastic products | Rubber & Plastic | 1 | |
| 36 | nmm | Mineral products nec | Minerals | 1 | |
| 37 | i_s | Ferrous metals | Ferrous | 1 | |
| 38 | nfm | Metals nec | Metals | 1 | |

| | | | | | |
|---|---|---|---|---|---|
| 39 | fmp | Metal products | Metal products | 1 | |
| 40 | ele | Computer, electronic and optical products | Electronics | 1 | |
| 41 | eeq | Electrical equipment | Electrical | 1 | |
| 42 | ome | Machinery and equipment nec | Machinnery | 1 | |
| 43 | mvh | Motor vehicles and parts | Motor parts | 1 | |
| 44 | otn | Transport equipment nec | Trans. equip | 1 | |
| 45 | omf | Manufactures nec | Other manuf. | 1 | |
| 46 | ely | Electricity | Electricity | 0.1 | Lifeline |
| 47 | gdt | Gas manufacture, distribution | Gas | 0.1 | |
| 48 | wtr | Water | Water | 0.1 | |
| 49 | cns | Construction | Construction | 1 | Ordinary setor |
| 50 | trd | Trade | Trade | 1 | |
| 51 | afs | Accommodation, Food and service activities | Catering | 1 | |
| 52 | otp | Transport nec | Land transport | 1 | |
| 53 | wtp | Water transport | Water transport | 1 | |
| 54 | atp | Air transport | Air transport | 1 | |
| 55 | whs | Warehousing and support activities | Warehousing | 1 | |
| 56 | cmn | Communication | Communication | 0.1 | Work on line |
| 57 | ofi | Financial services nec | Finance | 0.1 | |
| 58 | ins | Insurance | Insurance | 0.1 | |
| 59 | rsa | Real estate activities | Real estate | 0.1 | |
| 60 | obs | Business services nec | Business | 0.1 | |
| 61 | ros | Recreational and other services | Tourism | 1 | |
| 62 | osg | Public Administration and defense | Administration | 0.1 | Special setor |
| 63 | edu | Education | Education | 0.1 | Work on line |
| 64 | hht | Human health and social work activities | Public health | 0 | Special setor |
| 65 | dwe | Dwellings | Dwellings | 1 | Ordinary setor |

Note: GTAP database classifies agriculture, food, resource extraction, manufacturing, and service activities (65 sectors in total) to describe all economic activities in each country/region. COVID-19 lockdown measures have different effects on labor supply in different sectors. We set a specific multiplier for each sector based on three factors, i.e., the exposure level of the sector's work, whether it is the lifeline, and whether it is possible to work at home. If a sector's work exposure level is low, or it is the lifeline sector, or it is easy to work at home, its' multiplier will be small, vice versa.

**Supplementary Table 8. People saved of vaccination under different scenarios.**

This table shows the number of people saved for each country under all combinations of different sets of scenarios. This table is documented in the compressed package "Supplementary Results.zip".

**Supplementary Table 9. Sectoral benefit of vaccination under different scenarios.**

This table shows the sectoral benefit for each country under all combinations of different sets of scenarios. This table is documented in the compressed package "Supplementary Results.zip".

## Supplementary Table 10 Sector aggregation scheme

| No | Code | Description | ID | Code | Sector Name |
|---|---|---|---|---|---|
| 1 | pdr | Paddy rice | 1 | GrainsCrops | Grains and Crops |
| 2 | wht | Wheat | 1 | GrainsCrops | Grains and Crops |
| 3 | gro | Cereal grains nec | 1 | GrainsCrops | Grains and Crops |
| 4 | v_f | Vegetables, fruit, nuts | 1 | GrainsCrops | Grains and Crops |
| 5 | osd | Oil seeds | 1 | GrainsCrops | Grains and Crops |
| 6 | c_b | Sugar cane, sugar beet | 1 | GrainsCrops | Grains and Crops |
| 7 | pfb | Plant-based fibers | 1 | GrainsCrops | Grains and Crops |
| 8 | ocr | Crops nec | 1 | GrainsCrops | Grains and Crops |
| 9 | ctl | Bovine cattle, sheep and goats | 2 | MeatLstk | Meat and Milk |
| 10 | oap | Animal products nec | 2 | MeatLstk | Meat and Milk |
| 11 | rmk | Raw milk | 2 | MeatLstk | Meat and Milk |
| 12 | wol | Wool, silk-worm cocoons | 2 | MeatLstk | Meat and Milk |
| 13 | frs | Forestry | 3 | Extraction | Extraction |
| 14 | fsh | Fishing | 3 | Extraction | Extraction |
| 15 | coa | Coal | 3 | Extraction | Extraction |
| 16 | oil | Oil | 3 | Extraction | Extraction |
| 17 | gas | Gas | 3 | Extraction | Extraction |
| 18 | oxt | Minerals nec | 3 | Extraction | Extraction |
| 19 | cmt | Bovine meat products | 2 | MeatLstk | Meat and Milk |
| 20 | omt | Meat products nec | 2 | MeatLstk | Meat and Milk |
| 21 | vol | Vegetable oils and fats | 4 | ProcFood | Food Manufacturing |
| 22 | mil | Dairy products | 4 | ProcFood | Food Manufacturing |
| 23 | pcr | Processed rice | 1 | GrainsCrops | Grains and Crops |
| 24 | sgr | Sugar | 4 | ProcFood | Food Manufacturing |
| 25 | ofd | Food products nec | 4 | ProcFood | Food Manufacturing |
| 26 | b_t | Beverages and tobacco products | 4 | ProcFood | Food Manufacturing |
| 27 | tex | Textiles | 5 | TextWapp | Textiles |
| 28 | wap | Wearing apparel | 5 | TextWapp | Textiles |
| 29 | lea | Leather products | 6 | LightMnfc | Light Manufacturing |
| 30 | lum | Wood products | 6 | LightMnfc | Light Manufacturing |

| | | | | | |
|---|---|---|---|---|---|
| 31 | ppp | Paper products, publishing | 6 | LightMnfc | Light Manufacturing |
| 32 | p_c | Petroleum, coal products | 7 | HeavyMnfc | Heavy Manufacturing |
| 33 | chm | Chemical products | 7 | HeavyMnfc | Heavy Manufacturing |
| 34 | bph | Basic pharmaceutical products | 7 | HeavyMnfc | Heavy Manufacturing |
| 35 | rpp | Rubber and plastic products | 7 | HeavyMnfc | Heavy Manufacturing |
| 36 | nmm | Mineral products nec | 7 | HeavyMnfc | Heavy Manufacturing |
| 37 | i_s | Ferrous metals | 7 | HeavyMnfc | Heavy Manufacturing |
| 38 | nfm | Metals nec | 7 | HeavyMnfc | Heavy Manufacturing |
| 39 | fmp | Metal products | 6 | LightMnfc | Light Manufacturing |
| 40 | ele | Computer, electronic and optic | 7 | HeavyMnfc | Heavy Manufacturing |
| 41 | eeq | Electrical equipment | 7 | HeavyMnfc | Heavy Manufacturing |
| 42 | ome | Machinery and equipment nec | 7 | HeavyMnfc | Heavy Manufacturing |
| 43 | mvh | Motor vehicles and parts | 6 | LightMnfc | Light Manufacturing |
| 44 | otn | Transport equipment nec | 6 | LightMnfc | Light Manufacturing |
| 45 | omf | Manufactures nec | 6 | LightMnfc | Light Manufacturing |
| 46 | ely | Electricity | 8 | Util_Cons | Construction |
| 47 | gdt | Gas manufacture, distribution | 8 | Util_Cons | Construction |
| 48 | wtr | Water | 8 | Util_Cons | Construction |
| 49 | cns | Construction | 8 | Util_Cons | Construction |
| 50 | trd | Trade | 9 | TransComm | Transportation |
| 51 | afs | Accommodation, Food and servic | 9 | TransComm | Transportation |
| 52 | otp | Transport nec | 9 | TransComm | Transportation |
| 53 | wtp | Water transport | 9 | TransComm | Transportation |
| 54 | atp | Air transport | 9 | TransComm | Transportation |

| | | | | | |
|---|---|---|---|---|---|
| 55 | whs | Warehousing and support activi | 9 | TransComm | Transportation |
| 56 | cmn | Communication | 9 | TransComm | Transportation |
| 57 | ofi | Financial services nec | 10 | OthServices | Other Services |
| 58 | ins | Insurance | 10 | OthServices | Other Services |
| 59 | rsa | Real estate activities | 10 | OthServices | Other Services |
| 60 | obs | Business services nec | 10 | OthServices | Other Services |
| 61 | ros | Recreational and other service | 10 | OthServices | Other Services |
| 62 | osg | Public Administration and defe | 10 | OthServices | Other Services |
| 63 | edu | Education | 10 | OthServices | Other Services |
| 64 | hht | Human health and social work a | 10 | OthServices | Other Services |
| 65 | dwe | Dwellings | 10 | OthServices | Other Services |

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**Supplementary Table 11. Total number of COVID-19 vaccine doses produced by country (March 03, 2021)**

| Country | doses | % |
|---|---|---|
| China | 141624000 | 0.362453019 |
| US | 103000000 | 0.263604057 |
| Germany/Belgium | 70534055 | 0.180515175 |
| India | 42390000 | 0.108487145 |
| UK | 12200000 | 0.031223005 |
| Netherlands/Belgium | 10496982 | 0.026864534 |
| Russia | 10492500 | 0.026853064 |

Source: https://www.statista.com/chart/24492/total-covid-19-vaccine-production-by-country/

**Supplementary Table 12. Parameters of epidemiological model**

| Parameter | Values | Details |
|---|---|---|
| Baseline reproduction number, $R_0$ | 3.5 | Assumed |
| Average duration of infection, $1/\gamma$ | 7 days | (3) |
| Immune duration, $1/\omega$ | 1year | Assumed |
| Average rate of aging, $a$ | 1 for all age classes | Assumed |
| Infection-fatality ratio | i.e. age-specific IFR | Estimated from (8) |
| Demography | i.e. age-specific proportion of population | (4) |
| Social mixing pattern, $C$ | i.e. age-structured number of contacts | (5) |

# Supplementary Text

## Current Distribution

Current COVID-19 vaccination status varies greatly among countries worldwide, with a range of 0 to 123.2% variation in vaccination rates. The countries with the highest vaccination rates globally are Seychelles (123.2%) and Israel (120.9%), both with rates of 120 percent or higher. Besides, the UAE is another country with a vaccination rate exceeding 100%, which has reached 103.7%. Other countries whose vaccination rates are relatively high (>40%) are mostly concentrated in Europe and the Middle East, and also including three American countries, the United States (79.9%), Chile (73.9%), Uruguay (55.8%) and the small Asian country of Bhutan (62.2%). In general, these countries with high COVID-19 vaccination rates fall into three categories: developed countries with more advanced health care systems, high-income energy-exporting countries, and developing economies with smaller populations.

Countries with moderate COVID-19 vaccination rates (10-40%) are mainly located in South America and East Asia, with Mexico and Russia, among others, also falling within this range. In contrast, vaccination rates in regions such as almost all of Africa, northwestern South America and Oceania are below 10%, that is very low. Moreover, the rates in less developed areas like Cameroon, Niger and South Sudan are even close to zero and can be ignored.

## Current Supply Agreements

Although many countries presently have low COVID-19 vaccination rates, they have reached a series of supply agreements with vaccine manufacturers that have resulted in massive increases in population coverage when involving the number of vaccines in the agreements. There are currently a total of 43 countries with the number of vaccines in the agreements to achieve full population coverage. For example, Canada's vaccination rate is 32.6% now, but with the agreements its coverage rate could reach a horrific 605.42%, equivalent to 6 doses of vaccine for every Canadian. Unlike the current distribution of vaccines, the countries with more agreements are absolute high-income countries, concentrated in Europe, North America and Oceania. However, the countries with less agreements are mostly low- and middle-income Asian countries such as Pakistan (1.03%), Georgia (1.25%), Iran (1.49%), and Uzbekistan (2.99%), whose

current vaccination rates are also relatively low.

## Current Price Information

Due to various factors, vaccine prices vary widely in different countries and groups. Currently, the most expensive vaccine in the world is available in Argentina, with a price of $40.00 per dose, which is Inactivated SARS-CoV-2 vaccine developed and manufactured by Beijing Institute of Biological Products (CNBG). On the contrary, the cheapest vaccine being sold is Covishield in India, developed by AstraZeneca and manufactured by Serum Institute of India, which costs only $2.06 per dose and just is 1/20 of the most expensive one. In summary, vaccine prices are currently higher in the more economically developed regions such as Argentina, the United States, the European Commission, and China, and the private markets of less developed countries like Thailand, Nepal, and Pakistan. Inversely, vaccine prices are relatively low in regions such as India, African Union, Latin America, and the COVAX AMC implementation region.

The price of COVID-19 vaccine also has a clear relationship with the vaccine manufacturer. Beijing Institute of Biological Products (CNBG) manufactures the highest average price of vaccines at $31.09, with even the lowest priced vaccine sold in Senegal is priced at $18.60. In addition, vaccines manufactured by companied such as Moderna, Bharat Biotech, and Sinovac are also more expensive, which are used in high-income countries and private markets in less developed countries. Serum Institute of India produces a large number of vaccines at low prices, with an average of only $4.88. The company’s most expensive vaccine, sold in the private market in Bangladesh, costs just $13.27, which is lower than most vaccine used currently. Other manufacturers such as AstraZeneca, Uniao Quimica Farmaceutica Nacional, and Fiocruz produce vaccines at relatively low prices, too.

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