terra nova
LE THINK TANK PROGRESSISTE

# A VACCINATION POLICY BY ZONES

By Miquel Oliu-Barton
and Bary Pradelski

2 OCTOBER 2020

# A vaccination policy by zones

**Miquel Oliu-Barton**, *associate professor at Paris-Dauphine University*
*and* **Bary Pradelski**, *associate professor at the CNRS, associate member of the Oxford-Man Institute*

2 october 2020

## Summary

Vaccination deployment should be dependent on the prevalence of the virus in a zone (i.e., a predefined geographical area). Red zones should focus on vaccinating people at risk and health workers to reduce fatalities and keep hospitals operational. On the other hand, green zones should also focus on vaccinating inter-zone travelers and highly central individuals to reduce the risk of re-importation and keep virus circulation near zero. This difference is motivated by the absence of community transmission in green zones. The efficacy of this policy relies on travel restrictions between red and green zones as have been introduced in and between several countries during the course of the pandemic.

With coronavirus vaccines on the horizon, attention is now on how to distribute them once they are available. This involves two different scales. On the one hand, how should vaccine doses be distributed between continents, countries, and regions.[1] On the other hand, how should the vaccine be allocated within a given region or zone?[2] The first question has received much attention, so we shall focus on the second one. How will vaccines be rolled out within a zone to minimize the number of severe cases of COVID-19?

[1] E Ezekiel, et al (2020), "An ethical framework for global vaccine allocation", Science Vol. 369, Issue 6509, pp. 1309-1312; and Kelland, K (2020), "How can the world ensure a fair distribution of COVID-19 vaccines?", World Economic Forum.
[2] A Babus, S Das and S Lee (2020), "The Optimal Allocation of Covid-19 Vaccines", Covid Economics, Issue 44.

## VACCINATING BY ZONES

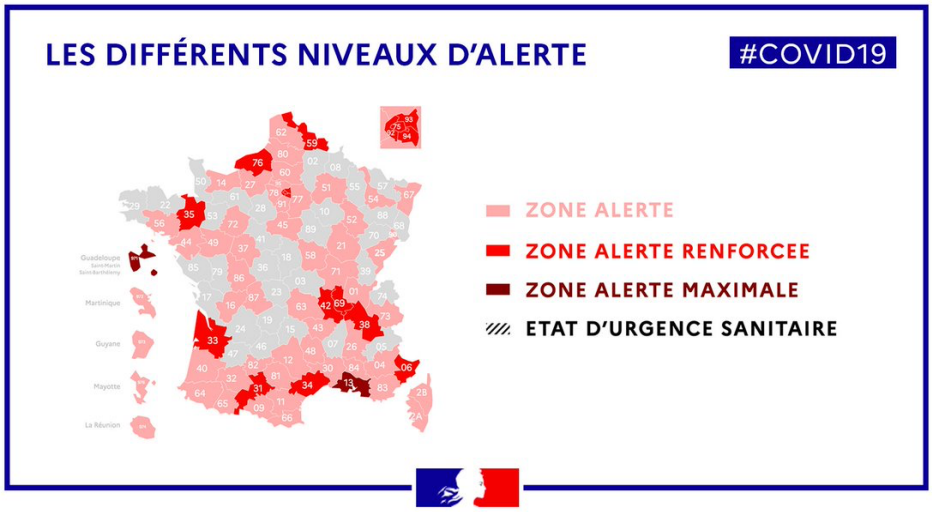
So far, the discussion on who to vaccinate first has focused on the characteristics of individuals or their environments of interaction. While the importance of this distinction is not questioned, we propose considering another fundamental aspect: the epidemiological status of each zone — which is constantly monitored and increasingly well understood. In *red* zones, the virus circulates actively among the population, whereas in *green* zones, this is not the case.[3] A more efficient vaccination policy can be implemented by considering not only the individuals' characteristics but also the color of zones. This is achieved by implementing travel restriction between zones, which considerably reduce the risk of re-importation to green zones.

Differentiating between red and green zones is a powerful tool during the pandemic. First of all, this distinction is *fair* — as long as the criteria for red and green are objective and pre-defined. Second, it provides a framework for flexible and intelligible policies, provided that the status of zones is clearly and periodically communicated. Third, the distinction is currently in place in many countries, including France where zones are identified to 'départements', and has proven to be politically acceptable. However, for this distinction to be effective, it is necessary to pair the different public health measures with mobility restrictions between and within red and green zones. This is most important for green zones, since the status "the virus does not currently circulate" loses all its meaning when mobility from red zones to green zones is unrestricted.

To illustrate the key insight of a color-dependent vaccination policy, let us consider two opposing epidemiological situations: a red zone with a particularly high incidence of the virus and a green zone where the incidence is close to zero. In the former, priority should be given to people at risk in order to minimize the number of severe cases of COVID-19 in the short run. For the latter, priority should also be given to incoming or returning travelers to reduce the risk of a future re-importation. Imposing a vaccine to travelers would thus build a protecting ring around the green zone.

[3] A more gradual scale is in place in most countries, including France, and in the EU. This further distinction, however, does not conflict with our proposal which we prefer to present in the simplest framework.

**Figure 1. The varying epidemiological situation of French 'départements' as of 24 September 2020.**




## VACCINATION POLICY PROPOSAL

### THE INDIVIDUALS' TYPE

The coronavirus is transmitted by physical proximity. Both the probability of transmission from one person to another and the risk of contracting a severe form of COVID-19 vary across the population. Furthermore, the physical proximity network — which is the relevant structure to study the spread of the virus — has a hierarchical structure, from households to communities, cities, countries, and even continents.

Considering these aspects, we can now discuss four categories under which an individual may belong :

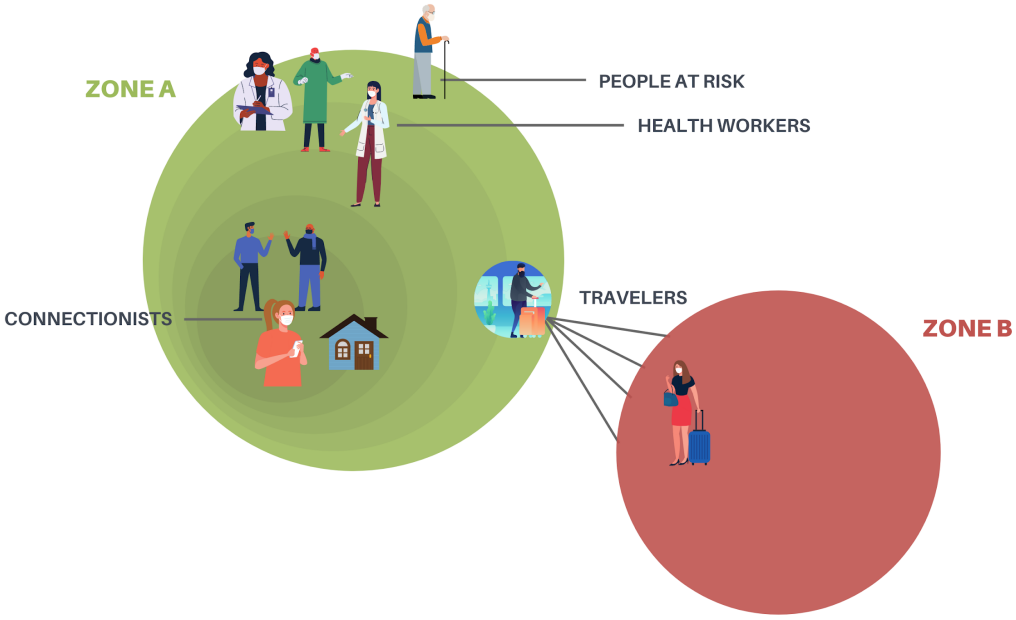
(1) *People at risk* are individuals with the highest risk of developing severe symptoms in case of infection (e.g., old people, people having pre-existing health conditions, people in extreme precarity);

(2) *Health workers* are individuals who are close to and connect people at risk ;

(3) *Connectionists* are individuals who are highly central within a zone with respect to profession (e.g., students, bar tenders) and environment of interaction (e.g., indoor, cold and dry air);

(4) *Travelers* are individuals who connect different zones (e.g., flight attendants, tourists, business travelers).

**Figure 2. The four types of individuals which are the focus of our vaccination policy.**




Terra Nova 2020 | "A vaccination policy by zones" by Miquel Oliu-Barton and Bary Pradelski

## DIRECT AND INDIRECT EFFECTS OF VACCINATION

Our proposal considers the heterogeneity of zones next to the heterogeneity of individuals. Because of time and resource limitations, two complementary effects of vaccination should be effectively balanced: (A) protecting vaccinated individuals from infection (direct protection) and (B) inhibiting them from passing on the virus to others (indirect protection). Remarkably, the vaccination of health workers provides both direct and indirect protection; not only are these workers highly exposed to the virus, but they are also in contact with people at risk. For this reason, regardless of the epidemiological situation of a zone, health workers and people at risk are the natural targets for direct protection, and prioritizing them is the consensus

among policymakers. By contrast, travelers and connectionists are particularly important for indirect protection, as their vaccination would considerably reduce the risk of re-importation.

Integrating the distinction between (A) and (B) in a potential vaccination policy is realistic, yet differs from the usual framework. In France, for instance, while the notion of indirect protection is present in the reports from the Conseil Scientifique[4] and the Haute Autorité Scientifique,[5] the priority for vaccination is established taking only (A) into account. The reason for such an omission may be the absence of a clear zoning strategy. Indeed, without mobility restrictions in place, the entirety of France should be considered as one single zone — a red zone, as long as the virus actively circulates somewhere in the country. This leaves green zones at an increased risk of re-importation, which could be avoided by combining mobility restrictions and an additional focus on (B).

## A VACCINATION POLICY FOR GREEN ZONES

Our proposal consists of the following steps:

1. Identification of zones and classification of individuals.

- Label zones green and red, as already done in several countries, to identify the presence of community transmission. (Community transmission is present if the virus is spreading in a zone even without new importations.)
- Classify individuals into four types: people at risk, health workers, connectionists, and travelers.

2. Dependence of the vaccination policy on the epidemiological situation.

- **Red zones.** Vaccinate people at risk and health workers to minimize the number of severe cases of COVID-19 and keep hospitals operational. In addition, mobility within, to, and from red zones should be restricted (e.g., seven-day quarantine or two negative tests), as the virus circulation is too high to allow an effective test-and-trace strategy.

[4] Vaccins contre le SARS-CoV-2: Une stratégie de vaccination, CARE – Comité scientifique COVID-19 – Comité Vaccin COVID-19 (July 2020).
[5] Stratégie de vaccination contre le COVID-19, Haute Autorité de Santé (July 2020).

- **Green zones.** Next to people at risk and health workers, vaccinate travelers and connectionists to reduce the risk of re-importation. In addition, travelers coming from red zones should be required to have been vaccinated (or go on a seven-day quarantine or present two negative tests).

Note that our vaccination policy is in line with the current consensus for red zones but introduces a new, important element for green zones.

## MAIN GOAL: REDUCE THE NUMBER OF SEVERE COVID-19 CASES

Given that the population at risk is large alternative vaccination policies need to be explored to protect larger parts of the population more quickly. (In France, more than 20M people are at risk due to their age or medical pre-conditions, according to a recent estimate.[6])

Our vaccination plan is intended to minimize the number of severe cases of COVID-19 and thus also the impact on the economy and the health system. By decreasing the probability of re-importation into green zones — where community transmission is close to zero — the likelihood that a person is infected within a green zone equally decreases, and so does the expected number of total infections. More importantly, our policy reduces the risk of contracting COVID-19 in green zones *for all* its inhabitants, vaccinated or not. We shall now explain the reasoning in more detail.

First, consider a vaccination policy which is not paired with strict travel restrictions and thus focuses fully on (A). Without a vaccine, an individual's probability of contracting COVID-19 in a green zone is $p$, and in a red zone is $q>p$. Vaccinating her will certainly reduce her chances of being ill, but not completely as vaccines are never 100% effective. For instance, the flu vaccine has reduced the risk of contamination by 44% on average between 2009 and 2018 according to the CDC.[7] If $e$ denotes the vaccination efficacy, then a person will get infected

[6] Vaccins contre le SARS-CoV-2: Une stratégie de vaccination, CARE – Comité scientifique COVID-19 – Comité Vaccin COVID-19 (July 2020).
[7] 'CDC Seasonal Flu Vaccine Effectiveness Studies' (2020).

with probability $p*e$ and $q*e$ respectively. The minimum efficacy required by the FDA to license a COVID-19 vaccine is 50%.[8]

Second, consider our vaccination policy, where zoning is in place. An individual's probabilities of contracting COVID-19 are $p'$ in a green zone and $q'$ in a red zone. Although mobility restrictions in red zones may imply that $q'<q$ (and thus the infection risk is also lower in a red zone) we assume that these two numbers are essentially equal and focus on green zones. Reducing the mobility to, from and within red zones reduces the virus re-importation most markedly in green zones, and thus $p'$ is significantly lower than $p$.[9] However, the priority on vaccination is now shared between four types of key individuals (people at risk, health workers, connectionists and travelers) and, as such, an individual's vaccine may be delayed. But as long as the inequality $p' < p*e$ holds the individual is more protected, even before her vaccination.

Last, let us explain why the inequality $p' < p*e$ likely holds. Recall that a key element of zoning are mobility restrictions. Reducing the mobility flows from red to green zones to a fraction $X$, will entail a similar reduction of the number of re-importations. As the virus then expands following an exponential pattern, the decrease in virus circulation in green zones will be larger than that. Thus, $p'$ is smaller than $p*X$. Consequently, everyone in the green zone is more protected (even without vaccination), than with vaccination and no zoning if $X < e$ holds. That is, as soon as the mobility restrictions outweigh the vaccine efficacy.

So far, we have argued that zoning protects all inhabitants of green zones. Now suppose that some travelers and connectionists are, in addition, vaccinated. On the one hand, vaccinating travelers will further reduce the risk of re-importing the virus to the zone.[10] On the other hand, vaccinating connectionists reduces the spread of the virus within the zone.

To summarize, the zoning policy is not only beneficial collectively, but also from the viewpoint of every individual. Further, as green zones will be much less likely to witness a resurgence of the virus, other health complications (e.g., rescheduling of routine treatments,

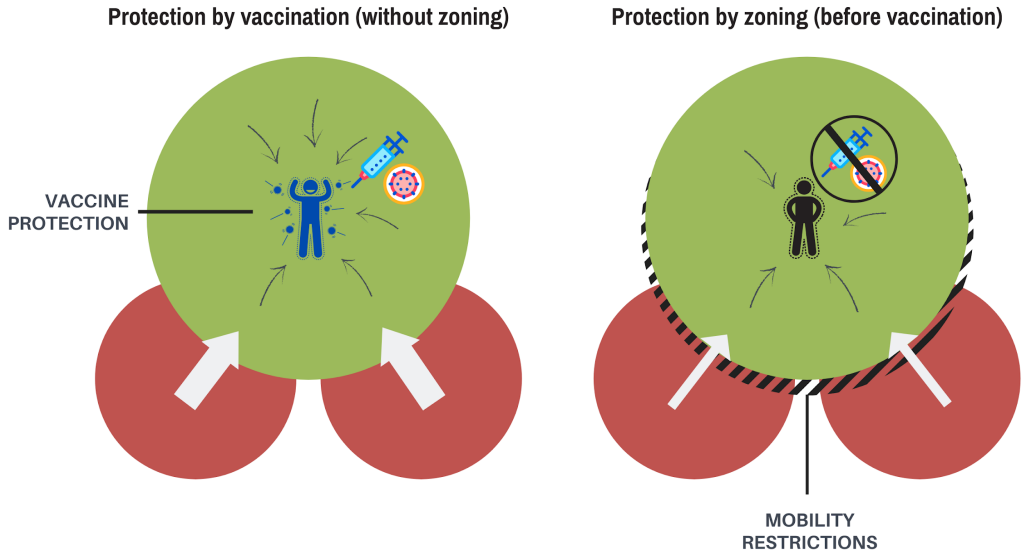
[8] U.S. Department of Health and Human Services Food and Drug Administration Center for Biologics Evaluation and Research (2020), 'Development and Licensure of Vaccines to Prevent COVID-19 - Guidance for Industry', June.

[9] See, for instance, S Vanderslott and T Marks (2020), 'Travel restrictions as a disease control measure: Lessons from yellow fever', Global Public Health.

[10] If, in addition to the mobility restrictions X, a fraction $v$ of travelers is vaccinated, the number of re-importatitions will drop to $X*(1-v*e)$. So, if for example $X = e = v = 50\%$, the number of re-importatitions will drop by 62.5%.

psychological impact), and social and economic hardship will be reduced. Allowing green zones to return to economic and social activity is essential to saving social cohesion and ensuring economic stability.

**Figure 3. Limiting the mobility from red zones reduces the risk of contracting COVID-19 in green zones. When the vaccine efficacy is outweighed by the mobility restrictions, everyone is more protected in green zones — including unvaccinated individuals.**




## IMPLEMENTATION

For the successful implementation of our proposal, several important points need to be deliberated and clarified in the months to come.

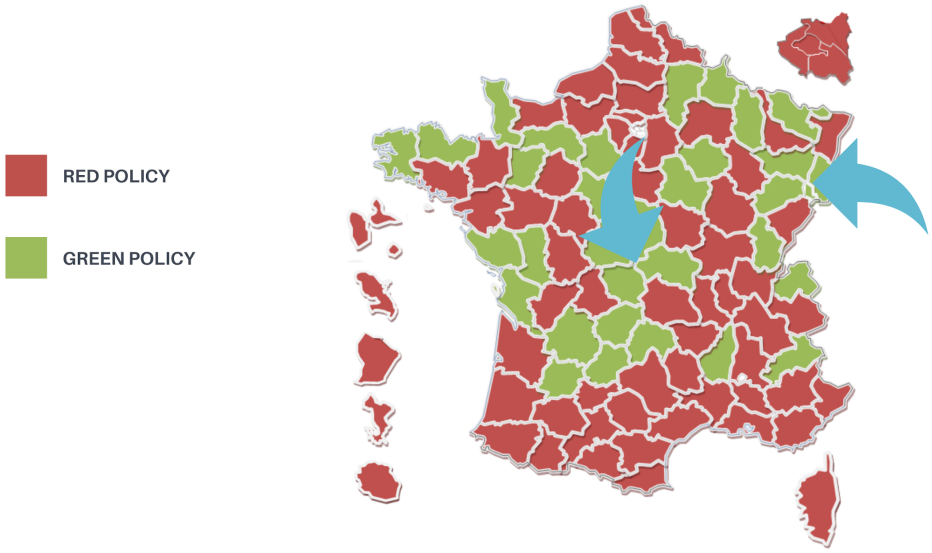
### ZONING AND TRAVEL RESTRICTIONS

Zoning has been implemented in many countries, with France and Spain being the first European nations to adopt this strategy.[11] It is thus natural, and politically acceptable, to use the current zoning as a basis for the vaccination policy. As already argued before, a

[11] M Oliu-Barton, B Pradelski and L Attia (2020), "Covid-19 exit strategy: from self-confinement to green zones", ESADE—Centre for Economic Policy & Political Economy, Policy insight No. 6, April.

vaccination policy that omits the mobility restrictions from red zones to green zones would be considerably less efficient.

**Figure 4. This map illustrates how vaccination by zones could be implemented in France. For simplicity, all alert zones in Figure 1 have been labelled as 'red', while other zones are 'green'.**




Terra Nova 2020 | "A vaccination policy by zones" by Miquel Oliu-Barton and Bary Pradelski

## INDIVIDUALS WITH PRIORITY

To establish the priority for vaccination, objective criteria need to be set in order to define people as (1) at risk, (2) health workers, (3) connectionists, and (4) travelers. While the definition of the first two categories is largely agreed upon already, that of the latter two requires careful consideration. Who is classified as a connectionist or as a traveler needs to be defined based on observable information, and in a way that is socially acceptable. In particular this entails that, although definitions may vary from zone to zone, a standardized logic must prevail.

(1) The population at risk due to age, medical pre-conditions or severe precarity may be too large to be vaccinated immediately. For this reason, it is crucial to find narrow criteria that identify those who are at highest risk.

(2) Health workers play a key role in the implementation of the vaccination policy as they prescribe and provide the vaccines to their patients. Their adherence to the policy proposal is thus of major importance.[12] As such, health workers should take a preponderant role in the discussion in the upcoming months, namely with regard to the definition of 'people at risk' and 'connectionists', and with regard to mandatory versus optional vaccination.

(3) Regarding connectionists, three factors should be taken into consideration, an individual's job, their place of work, and the efficacy of public health measures to protect them from contracting and passing on the virus. For example, a barman in an outdoor venue may not be considered a connectionist, whereas he would be considered as such if the venue was indoors, since the virus is known to transmit more easily indoors. Similarly, a concierge in a theatre may not be considered a connectionist as it turns out that public health measures such as the wearing of masks is adhered to in such venues. On the other hand, a concierge in venues where public health measures are poorly observed should be considered a connectionist.

(4) With regard to travelers we propose to build on definitions established during lockdown. Initially, those professionals for whom travel is essential should be prioritized (e.g., lorry drivers, people working in a different zone whose presence is necessary) along with imperative personal reasons (such as illness of close relatives or under-age children). In a second step the traveler category could be expanded based on applications by individuals or their employers.

**Some numbers**. France's total population is 67M. According to a recent report on priorities for vaccination,13 the population at risk due to age (above 65), medical pre-conditions or

[12] Concerning the vaccination hesitancy of French health workers we refer to the works of P Verger, e.g. Hésitation vaccinale dans la population et chez les professionnels de santé en France, 19 April 2019.

[13] Vaccins contre le SARS-CoV-2: Une stratégie de vaccination, CARE – Comité scientifique COVID-19 – Comité Vaccin COVID-19 (July 2020).

severe precarity is larger than 20M. In contrast, the number of health workers is estimated to be 1.8M. Finally, the number of connectionists is estimated to be 5M.[14]

## ATTITUDES TOWARDS VACCINATION

In 2019, the WHO named *vaccine hesitancy* as one of the top ten global health threats, which reflects the worries about under-vaccination and vaccine refusal in many countries across the world.[15] A recent study about vaccine hesitancy in 149 countries from 2015-2019 found low levels of vaccine confidence in Europe in particular.[16]

Prioritizing the vaccination of connectionists and travelers overcomes several implementation burdens. By leveraging the concept of *ring vaccination* — targeting those who are most likely to be infected — we can help reduce the spread of the virus despite limited vaccine doses and potential reluctance of vaccine uptake.

Vaccination is only required for people with certain characteristics (i.e., connectionists and travelers). Thus, the controversial and politically sensitive issue of mandatory vaccination is replaced by a *conditional obligation*. This is particularly important as research shows that making vaccination mandatory can be polarising and in fact reduce uptake.[17]

## NON-MEDICAL PUBLIC HEALTH MEASURES AND COMMUNICATION

As vaccination will reduce but not remove the risk of contamination, adhering to social distancing and other public health measures in place is important until vaccination is massively distributed. Otherwise, a too quick return to normality could endanger the benefits of vaccination.

---

[14] The term connectionist is not used; rather, the report estimates in 5M the number of 'people in contact with the population', 'people working in confined places' and 'people living in confined conditions'.

[15] WHO (2019), 'Ten threats to global health in 2019'.

[16] A Figueiredo et al. (2020), 'Mapping global trends in vaccine confidence and investigating barriers to vaccine uptake: a large-scale retrospective temporal modelling study', The Lancet Volume 396, Issue 10255, pp. 898-908.

[17] S Omer et al. (2019), 'Mandate vaccination with care' Nature Volume 571, Issue pp. 469-472; and A Gibuilini and S Vanderslott (2019), 'Is mandatory vaccination the best way to tackle falling rates of childhood immunisation?' Oxford Martin School blog.

Finally, as has become clear throughout the pandemic, the importance of clear and timely communication cannot be overstated. Being frank about unknowns, setting a timeline for implementation, and explaining the decision-making process and the frequency of policy reviews are all paramount for public adherence and support.

## INTERNATIONAL COORDINATION AND LOCAL REALITIES

A vaccination policy that accounts for the varying epidemiological situations of zones could be critical to achieve lower numbers of severe COVID-19 cases and thus a quicker return to normality. The question of how vaccines should be distributed within zones complements the question of international coordination to ensure a fair and efficient distribution. To achieve a coordinated and effective vaccination strategy, the realities of different countries need to be taken into account (e.g., different attitudes towards vaccination, or the fact that travel restrictions are easier to control for an island-state compared to a continental European country). The coming months are critical to address the above-mentioned implementation variables.

More broadly, opening the discussion on the *fairness* of vaccine distribution in light of the varying ex-ante characteristics of individuals, regions, countries, and continents is important. The mere fixing of quotas of vaccination doses per capita may be too simplistic for the exceptional moment we are currently in. Are we ready to consider a vaccination deployment that is dependent on a zone's social characteristics (e.g., density, precarity, average age), its centrality, or even its economic importance?

**Authors' note.** We are thankful to Thierry Pech and Mélanie Heard for their insight and support. A shorter version of this piece is concurrently published by VoxEU — the policy portal of the Centre for Economic Policy Research.

terra nova
LE THINK TANK PROGRESSISTE

@TerraNovaThinkTank

@_Terra_Nova

Terra Nova- think tank

*Terra Nova est un think tank progressiste indépendant ayant pour but de produire et diffuser des solutions politiques innovantes en France et en Europe.*