



COMMENT



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The radically unequal distribution of Covid-19 vaccinations: a predictable yet avoidable symptom of the fundamental causes of inequality

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The Covid-19 pandemic—and its social and economic fallout—has thrust social and health-related inequalities into the spotlight. The pandemic, and our response to it, has induced new inequalities both within and between nations. However, now that highly efficacious vaccines are available, one might reasonably presume that we have in our hands the tools to address pandemic-associated inequalities. Nevertheless, two prominent social science theories, fundamental cause theory and diffusion of innovation theory suggest otherwise. Together, these theories predict that better resourced individuals and countries will jockey to harness the greatest vaccine benefit for themselves, leaving large populations of disadvantaged people unprotected. While many other life-saving prevention measures have been distributed unequally in ways these theories would predict, the COVID-19 vaccines represent a different kind of case. As the disease is so highly infectious and because mutations lead to new variants so rapidly, any inequality-generating process that leaves disadvantaged individuals and countries behind acts to put everyone—rich and poor—at risk. It is time that we ensure the equitable distribution of this life-saving benefit. As the fundamental cause and diffusion of innovation theories help illuminate processes that regularly produce inequities, we turn to them to reason about the rollout of the COVID-19 vaccines. Specifically, employ them to suggest countermoves that may be necessary to avoid an irrational and inequitable vaccine rollout that ends up unfavorably affecting all people.

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Introduction

On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic. As of 6:36 p.m. CEST, 4 October 2021, there have been 234,809,103 confirmed cases of COVID-19, including 4,800,375 deaths, reported to WHO across the world. In response, at least 18 COVID-19 vaccines have been developed and implemented for human use globally (Holder, 2021). As of October 3rd 2021, a total of 6,188,903,420 vaccine doses have been administered (WHO, 2021). Nevertheless, the geographic distribution has not been equal. As of October 1st 2021, the highest-income countries—as classified by the World Bank—had a per-capita vaccination rate of 125.3 vaccinations per 100 people, representing nearly 3-fold higher than the rate for lower-middle-income countries of 45.3 per 100, and 30-fold higher than lower-income countries with 4.2 per 100 (Fig. 1). It is also important to consider that efficacy varies widely between vaccinations, for different variants. It may be the case that vaccines in lower-income countries are also more likely to be of lower efficacy on average, compounding the disparity. For instance, the Sputnik, Sinopharm, and Janssen vaccines have been used more widely in low and middle-income countries, and have lower efficacy against the Omicron variant compared to vaccines from Pfizer and Moderna—used more predominantly in higher-income locations (Cameroni et al., 2021; Holder, 2021). This represents an astoundingly unequal distribution of this critical public good. Furthermore, within countries large disparities have been observed along lines of income, race, ethnicity, and other contextually relevant markers of social class (cf. (Ndugga et al., 2021; Painter, 2021)). These international disparities in COVID-19 vaccination rates persist, although COVID-19 has had a profound epidemiological, social, and economic impact in every world region (Bollyky et al., 2021; Schellekens & Wadhwa, 2021).

Although these disparities are startling, we argue that they are not surprising. Indeed, vaccination rates between these groups of countries mirror numerous other outcomes such as the global accumulation of wealth, or average life expectancy. Similarities in inequalities between countries in these diverse indicators point to the idea that they may all simply be symptoms of the deeper, fundamental causes of inequalities between and within the world's societies.

Inequality has been named the “handmaiden of progress”. Throughout history, people have gained improved living standards guided by new knowledge and technological innovations. This has been an especially dominating narrative during the last decades, as we have seen a global decline in poverty, infant

mortality, and other health measures. However, this continuous improvement happens at different rates for different social groups. Evidence suggests that people of higher social positions are the first to take advantage of health-related progress, with increasing disparities in health outcomes as a consequence (Glied & Lleras-Muney, 2008). This is not to say that there exists a linear relationship between health inequalities and medical and technical development, but rather to demonstrate some unfortunate, mainly short-term, consequences that are nevertheless extremely relevant for the kind of rapid global implementation of vaccination schemes required to effectively stop a pandemic.

The Covid-19 pandemic represents a unique case where inequality may not simply represent a temporary and unwanted consequence of progress but may actually undo our efforts to defeat the virus. The disease is highly infectious, and transmission leads to new variants through mutation, which may be able to evolve the ability to escape the protective effects of the vaccine. Given these facts, any population where the virus is allowed to spread unchecked puts even fully vaccinated groups in jeopardy for subsequent rounds of infection. This collective nature of global outcomes in the Covid-19 pandemic compels us to search for solutions to the seemingly inevitable inequalities that have accompanied most major technological advances.

Here we draw on two theories from social science—*fundamental causes* (FCT, cf. (Link & Phelan, 1995)) and the *diffusion of innovations* (DoI, cf. (Rogers, 2010))—which show us that the current socioeconomic distribution of Covid-19 vaccinations is predictable, yet avoidable. These theories provide a useful lens for understanding the processes in place and identifying the structural issues that underlie them. They warn us that, *within* countries, the most disadvantaged segments of our societies will not benefit sufficiently from the Covid-19 vaccines, even as they become available to nations. Importantly, they can also provide us with guiding principles towards a more equitable distribution of the vaccine. These theories have existed separately as explanations for the persisting inequalities in health in modern societies, and in this paper, we make an attempt to combine and synthesize them in the context of Covid-19 vaccine inequalities.

Inequality and progress. There are numerous examples of how progress and the emergence of new knowledge and technology have not benefited population groups equally, but have rather contributed to increases in existing health inequalities. For example, prior to the Enlightenment, there was no health gradient between English aristocrats and ordinary citizens. However, a health gap between these groups quickly developed soon after

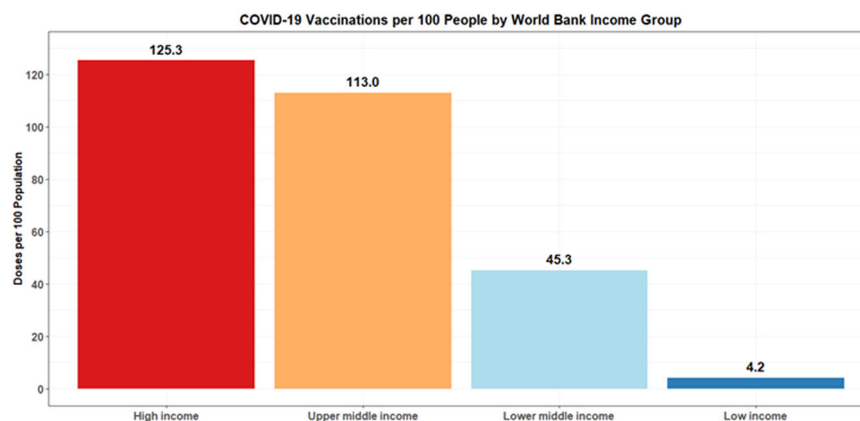


Fig. 1 Global distribution of covid-19 vaccinations by world bank country income groups. The rate of vaccination doses administered per 100 population is shown as of October 1st, 2021, separate by world bank county income groups, according to data from ourworldindata.org.

ideas of sanitation and nutrition started to spread (Harris, 2004). Similarly, a gap in infant mortality emerged between the children of physicians and those of non-physicians after the germ theory of disease was acknowledged in the nineteenth century (Cutler et al., 2006). Likewise, during the latter half of the twentieth century, smoking went from being a high-status to a low-status habit; people of high social position had been the first to start smoking but were also the first to quit when knowledge of tobacco's health damaging effects emerged (cf. (Giskes et al., 2005)). Cross-country comparisons have also demonstrated that countries reach the new epidemiological phases at different paces, with different patterns of inequality marking each phase (cf. (Pampel, 2002)).

However, it has also been argued that at a later stage, it is possible for this development to reach a point of saturation, where all socioeconomic groups benefit more equally, and inequality decreases (Clouston et al., 2016). At the same time this transition can take years to achieve and is highly dependent on the policies adopted to address the initial inequalities.

The distribution of key health determinants, such as access to goods and services, healthcare and education is skewed between and within countries, disfavoring the most disadvantaged. Within countries, Covid-19 is therefore hitting societies unequally, with higher rates of infection and short- and long-term morbidity and mortality among the most disadvantaged groups, both in high-income and low-income countries (cf. (Drefahl, 2020; Gu et al., 2020; Price-Haywood et al., 2020; Smith Jervelund & Eikemo, 2021; Williamson et al., 2020)). We are thus experiencing a *syndemic pandemic*, as the virus interacts with existing social inequalities in disease and the social determinants of health (Bambra et al., 2020). In all pandemics, socially marginalized groups are at higher risk of *exposure* to the virus, e.g., due to a demand for physical presence at work and inability to avoid public transportation. Once exposed, they are more *susceptible* and their disease is more *severe*, e.g., due to previous chronic conditions and healthcare availability. Finally, they are hit harder by the social and economic consequences of the pandemic, e.g., due to precarious employment. This means that unless we are able to provide vaccines to the most disadvantaged populations first, health inequalities will continue to increase. While these mechanisms are at play within countries, we have seen less evidence of a traditional socioeconomic gradient between countries in the infection and mortality rates of Covid-19. However, between-country inequality is very likely to occur for other pandemic-related consequences, such as overburdening of the healthcare services and financial recovery from the consequences of lockdown and various non-pharmaceutical interventions. Finally, an unequal distribution of vaccines may interact with all of the above, reproducing and strengthening existing health and socioeconomic disparities.

The theories of fundamental causes and diffusion of innovations. The theory of social conditions as the fundamental cause of disease seeks to explain health inequalities by looking upstream, beyond the proximate causes of risk and disease, to a fundamental set of causes that place individuals at risk of risk (Link & Phelan, 1995). The origins of this theory are in sociology and social epidemiology where the concept was named “fundamental causes” and the key characteristics of the theory codified in a 1995 publication by Link and Phelan. The theory has been further developed by many additional scholars who have elaborated, extended or tested the theory sometimes even creating new concepts that have become part of the theory (See (Clouston & Link, 2021) for a recent review of the theory's development). Central to the theory is that as contexts change, over time or

between countries, new mechanisms are triggered, which reproduce the association between a fundamental cause and disease. An example is how the lower social strata in prior decades led shorter lives due to diseases like diphtheria and tuberculosis, which could be traced back to poorer housing and working conditions. Such diseases have been nearly eradicated by medical advances and public health initiatives. However, inequalities in disease and death remain, now represented by diseases that previously did not have a social gradient, such as cardiovascular disease and lung cancer. A key concept within this theory is flexible resources—knowledge, money, power, prestige and beneficial social connections—which are unequally distributed and beneficial in many contexts. They function as means of achieving health goals through health-directed human agency. This agentic action can operate at the individual level as people use flexible resources to access circumstances beneficial to their health, whether that be a beneficial immunization or access to a neighborhood that facilitates healthy living. It can also operate at the contextual level through “collective agency” (Clouston & Link, 2021) in which hospitals, schools, work sites or communities use their relative resources to ensure the context they serve achieves the best health circumstances possible. The flexible nature of the resources, in turn, ensures that they can be beneficial in health-relevant circumstances that are diverse with respect to diseases and risk and protective actors for those diseases.

The *diffusion of innovations* theory is, on the other hand, very useful to explain how innovations are adopted by actors in a social system. Its application has included a vast array of innovations; the diffusion of hybrid corn to farms as well as beta-blockers to hypertension patients. The framework was first formulated in 1962 by Everett Rogers (Rogers, 2010). He built on decades of innovation and communication research when he developed concepts describing the different phases and actors in a diffusion process, such as communication channels, early adopters, early and late majority, and laggards.

The distribution and rate of adoption has often been illustrated as an s-curve, where the majority of a population adopts an innovation during the middle stages of the diffusion process, with early adopters and laggards making up the outliers. With regards to health and inequalities, this strand of research has focused on how medical innovations and new knowledge is hierarchically diffused across social segments, with inequalities in outcomes as a result.

One of the fundamental cause theory's strengths is its ability to explain the persistence of inequalities. Systematic social inequalities in health in the face of rapid social, medical, and technological progress have by many been labeled “ironic” or “paradoxical”. The fundamental cause theory turns this ironic connection into a causal relation: health inequalities persist not despite but because of these developments. This occurs because people who are propitiously situated with respect to flexible resources are better able to access and benefit from the new knowledge or technology thereby creating a new health inequality.

The diffusion of innovations on the other hand, is a theory more oriented towards change—how and why new technologies, knowledge and ideas spread over time. Integrating these two theories involve viewing the diffusion of health-beneficial innovations as fundamentally influenced by social conditions (Zapata-Moya et al., 2019). Diffusion can thus act as a mechanism in the fundamental cause framework, where individuals, regions and countries' benefit from medical and technological progress will be influenced by their position in the social hierarchy as well as the diffusion of relevant and beneficial innovations. It has been argued that with this integration of theories, diffusion process provides an inequality-generating mechanism to the fundamental cause theory, which can be

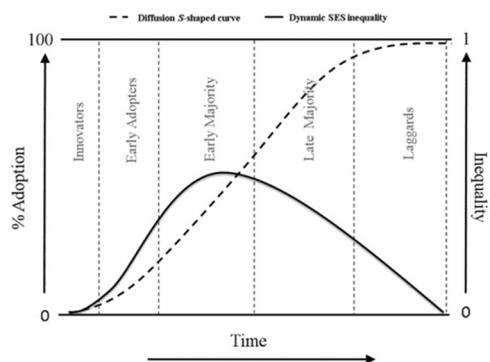


Fig. 2 Hypothetical relationship between technology diffusion and health inequalities. Retrieved from (Zapata-Moya et al., 2019).

repeated over time as new technologies and knowledge becomes available, thus contributing to enduring health inequalities (Zapata-Moya et al., 2019). Figure 2 illustrates how these theoretical perspectives can draw on one another. The x -axis displays time from the introduction of an innovation. The dotted line illustrates the rate of uptake across adopter categories, which can be read on the left y -axis. The solid line illustrates the rise and fall of inequality in use, which can be read on the right y -axis. This stylized figure—with an inverted U-shape that is similar to the well-known Kuznets curve—illustrates that inequality rises in the early stages of diffusion but falls as the early and late majority adopt the innovation. Thus, the relationship between the diffusion of an innovation and social inequality is first positive, then negative. Empirical research suggests that the social gradients in use and access are steeper for medical technologies in an early stage of diffusion, and that this pattern also is manifested as inequality in health outcomes (Glied & Lleras-Muney, 2008; Wang et al., 2012; Weiss et al., 2020; Zapata-Moya et al., 2019).

Following the same logic, we can also expect an unequal social distribution of vaccines within countries, with early adopters being those who have the resources to understand and appreciate the benefits of a vaccine. Early results from survey research indicate support for this notion, as both education and income has proved to be positively associated with vaccine acceptance (Lazarus et al., 2021). One reason for this inequality may be distrust in government and the health services—e.g., due to historical experiences of discrimination among African Americans in the United States (Doherty & Kenen, 2021). It will be important to monitor the socioeconomic distribution of vaccine uptake within countries, understand potential mechanisms, and specifically target vaccination campaigns.

Previous research integrating these two perspectives has focused on innovations requiring some individual agency, assuming that diffusion of innovations is a result of imitation of behavior. This article adds to this literature by emphasizing between-country inequalities, an area where such social modeling appears less likely. The COVID-19 pandemic and vaccine development provide a very relevant context to study inequality and innovation, and with this article we aim to explore how theories of fundamental causes and diffusion of innovations can inform these processes.

Making progress against innovation-induced inequalities. The negative population health impacts of inequalities are not natural, inescapable consequences of technological change and globalization, they depend on the policies we choose to implement (Case & Deaton, 2020). Previous findings suggest that the initial inequality consequences of technological and medical progress

seem to come with a long-term silver lining, as a more equitable distribution is reached later in the diffusion process (Cutler et al., 2006). This is, however, not a natural consequence of free diffusion, but more likely a result of thorough and systematic efforts by health policy makers to ensure that everyone can reap the benefits of medical innovation, regardless of the resources available to them. Additionally, in a global pandemic like Covid-19, short-term consequences are undoubtedly imperative: time is of the essence.

It has been argued that international pandemic preparedness plans have lacked an inequality perspective, possibly due to an idea that if medical risk factors are controlled for, everything else is socially neutral (Mamelund & Dimka, 2021). It is true that a virus does not take its host's social background into account, but history has taught us that pandemics tend to hit populations unequally, following and effectively reinforcing existing inequality structures. Although complete levelling of resource distribution appears utopian, policy makers should nevertheless be aware of how socioeconomic inequalities are fundamentally linked to inequalities in health. Further, policy implementations to differing degree can strengthen or weaken the suggested mechanisms for the persistence of health disparities. Policies which require or reward out-of-pocket payments, health literacy, self-efficacy and general personal agency should, as far as possible, be replaced with policies where personal resources are given less “wobble room”. For example, if governments impose regulations on health damaging products rather than merely encourage individuals to practice healthy behaviors, the resource distribution will be of less influence.

We argue that a national vaccine program should serve as a prototype of a more just form of medical innovation, which minimizes the influence of socioeconomic resources on health. Covid-19 vaccines are life-saving technologies in the early phase of adoption—when the influence of flexible resources is particularly powerful. Given the collective fate that the world's populations may share with respect to the Covid-19 pandemic, global leadership and coordination is needed. Below, we suggest guiding principles to ensure an equitable vaccine distribution. For each principle, a global as well as a national perspective is needed to identify the most vulnerable populations and measure success in diffusing critical interventions such as the COVID-19 vaccines.

Guiding principles

How can the theories of fundamental causes and diffusion of innovations inform us about the main determinants of successful and equitable diffusion of a medical technology? An important principle is to be aware of whether the innovation creates a context, which facilitates the use of flexible resources to obtain a health advantage, both within and between countries. In the following, we utilize theoretical expectations, as well as the research we have reviewed on technology diffusion and health inequalities, to formulate some guiding principles for the distribution of vaccines during a pandemic.

Price. Governments interested in decreasing within-country health inequalities should aim at weakening the impact of financial resources on access to vaccines. Very few countries are charging out-of-pocket payments from each individual patient, but the vaccines may put strains on national, regional, and local healthcare budgets, which vary dramatically in the resources available to them. If medical administrators consider the vaccines a limited resource like other medical technologies, they may, more or less deliberately, prioritize patients who appear competent and compliant—characteristics that have been associated with high social position (Øversveen, 2021). As for between-

country inequalities, Fig. 1 indicates that the global community indeed has let financial resources play a part in the distribution of vaccines. This could for one be an expression of how the means of vaccine production—research, manufacturing, and licensure—are concentrated. Big pharmaceutical companies such as Pfizer and AstraZeneca initially started their development and manufacturing in high-income countries, thereby providing these governments with beneficial social connections and subsequently giving them a “head start” in vaccinating their citizens. It is in line with the diffusion of innovation theory that innovators and early adopters rate high on different measures of social status, such as literacy, education, and wealth. Another theoretical expectation is that structural inequality in the social system where the innovation is introduced may lead to inequalities in the innovation’s consequences—which we can see reflected in the between-country inequality in socioeconomic as well as vaccine coverage.

The “insurance scheme” approach of the COVAX initiative could be regarded as an attempt to counteract this development, where wealthy countries pool their resources to ensure an equitable distribution of vaccines. Coordinated by Gavi, the Vaccine Alliance, the Coalition for Epidemic Preparedness Innovations (CEPI) and the WHO, the COVAX program is a platform supporting the research, development and manufacturing of a wide range of COVID-19 vaccine candidates, with the overall aim to ensure that people around the world have access to COVID-19 vaccines regardless of their wealth. Indeed, participating countries, regardless of income levels, will have equal access to vaccines once they are developed and pricing will be negotiated (Berkley, 2020). Nearly all countries in the world have signed into the COVAX initiative. However, the efficacy of the program is being jeopardized by supply shortfalls. As all countries have similar needs for vaccination, the price of vaccines will increase in the early stages, when supply is low. This effectively increases the importance of financial resources, and potentially produces inequalities, in accordance with the presented theories. It has been argued that the supply shortage is an inescapable consequence of COVAX’ governance structure, thus undermining the initiative’s equity goals (Storeng et al., 2021). Being a public-private partnership, COVAX includes actors with differing perspectives as well as different available resources: Donor-dependent lower-middle-income countries striving to cover as much of their populations as possible through limited means. Wealthier countries may have a short-term interest, fueled by the national political debate, to provide as many vaccines as possible to their citizens before being willing to share (*vaccine nationalism*), or using surplus vaccines to gain advantages in other fields (*vaccine diplomacy*). The partnership also includes pharmaceutical companies that ultimately operate in a profit-maximizing perspective, in some cases through price differentiation. Storeng et al. (2021) argue that there are unclaritys in the program’s structure and accountability, for instance are there not any safeguards to hinder countries from making bilateral agreements outside of the COVAX system. They further argue that these unclaritys, in combination with the aforementioned inequalities between participating actors, contribute to the pharmaceutical companies’ powerful position within the partnership, consequently increasing the importance of countries’ financial resources.

Access. Even in universal healthcare systems, socioeconomic status has been associated with receiving medically effective preventive medical care (cf. (Elstad, 2018)). Vaccines should therefore be implemented through channels that ensure sufficient access to the whole population, irrespective of individual- or area-level socioeconomic standing. In the US, we have seen that

disadvantaged groups who have higher incidence rates of disease are lagging behind in the vaccine rollout. In addition, there have been (anecdotal) reports of the difficulties associated with making vaccine appointments; not everyone has a stable internet connection nor the opportunity and ability to be online as coveted appointments become available (Cimons, 2021; Doherty & Kenen, 2021). These stories suggest that the US federal government has allowed for flexible resources like knowledge and social networks to impact the probability of receiving a vaccine. More active governance of vaccine appointments could be one solution. To support individuals’ potentially lost income when receiving vaccination could be another.

Acceptance. Equality in vaccine opportunity secured by price and access does not secure equality in outcome. If, as previous research has suggested, there is a socioeconomic gradient in acknowledging vaccines as safe, important, and efficient, the uptake may be lower among disadvantaged groups. One solution to this issue would be mandatory vaccination, a radical policy associated with both ethical and practical problems, while a “softer” approach would be to ensure the spread of information—the benefits, as well as the potential side effects, of vaccination. Experimental survey research has found that information on the collective benefits of vaccination—i.e., herd immunity—is a stronger predictor of vaccine acceptance than information on the individual benefits (Arnesen et al., 2018). Following these findings, one equity approach would be to actively promote the collective benefits of vaccination, both with regards to vaccine-skeptical individuals and to vaccine-hoarding countries: none of us are safe until all of us are safe.

Conclusions

Pandemic disease and its countermeasures—be that social distancing, complete lockdown, as well as the development and distribution of vaccines—exemplify how medical phenomena cannot be isolated from its social context. In order to promote an equitable distribution of vaccines, we need to ensure that price levels, access, and acceptability do not depend on the resources at hand among individuals and nations. This is only possible if we can raise awareness about the health protective effects of the vaccine among all citizens, if all citizens are regarded as equal partners in the eyes of the international community, and only if political decision-making processes about vaccine distribution strategies are made detached from traditional power structures. In this way, we will not only obtain reduced inequalities and healthier populations, but also reinforced trust in governmental institutions, a key building stone of modern democracies.

Data availability

Data used in Fig. 1 available at ourworldindata.org

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Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not deemed necessary, as this is an opinion piece, in which no individual-level data were applied. All research was performed in accordance with relevant guidelines/regulations and all co-authors have approved the content and submission of the article.

Informed consent

This was not relevant, as the article does not contain any studies with human participants performed by any of the authors.

Additional information

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