What matters the most in curbing early COVID-19 mortality? A cross-country necessary condition analysis

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Abstract

COVID-19 represents a turbulent problem: a volatile, uncertain, complex, and ambiguous crisis, in which bounded-rational policymakers may not be able to do everything right, but must do critical things right in order to reduce the death toll. This study conceptualizes these critical things as necessary conditions (NCs) that must be absent to prevent high early mortality from occurring. We articulate a policy-institution-demography framework that includes seven factors as NC candidates for high early COVID-19 mortality. Using necessary condition analysis (NCA), this study pinpoints high levels of a delayed first response, political decentralization, elderly populations, and urbanization as four NCs that have inflicted high early COVID-19 mortality across 110 countries. The results highlight the critical role of agility as a key dimension of robust governance solutions—a swift early public-health response as a malleable policy action—in curbing early COVID-19 deaths, particularly for politically decentralized and highly urbanized countries with aging populations.

Abstract (Chinese)

新肺疫情是动荡不安的公共政策难题的缩影。面对这场变化多端、飘忽不定、且又错综复杂、模棱不清的危机，有限理性决策者无法面面俱到，但必须做出关键决策以降低死亡率。本研究从必要条件视角出发，将这些“关键决策”界定

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The ongoing COVID-19 pandemic is emblematic of “turbulent problems” characterized by the surprising emergence of inconsistent, unpredictable, and uncertain events” (Ansell et al., 2021, p. 949). Policymakers at each country have an obligation to protect its people and save lives during the pandemic. However, the turbulent problems present a challenge, in that policymakers have neither available information to inform their decision-making in time nor the ability to obtain accurate information in order to “sit out the problem” (Boin & Lodge, 2021). Policymakers face a dilemma: should they act quickly without much knowledge about the virus or to wait until this knowledge is available?

With insufficient knowledge about the pathogenesis of COVID-19, countries in the early stages of the virus outbreak scrambled to combat virus transmission (Yan et al., 2020; Yarmol-Matusiak et al., 2021). It is unrealistic to expect policymakers with bounded rationality to do everything right, but they must do the most important things right. Many countries failed to curb early mortality rates not only because they did not know what to do, but also because they did not know what should be prioritized. It is particularly important to understand critical country-level factors that affected countries’ mortality rates when there were no effective vaccinations or treatments at the early stage of the pandemic (Jarman, 2021). A pressing question thus arises: what must have been done to prevent high early COVID-19 mortality from occurring?

This study goes beyond a traditional “average effect” regression-based approach to conceive of key or critical factors as necessary conditions. A necessary condition (NC) is defined as a factor that must be present for a specific outcome to occur; without it guarantees the absence of the outcome (Ragin, 2009). A necessary cause can be considered as a constraint or bottleneck that must be dealt with for the unfavorable outcome (e.g., high mortality) not to take place (Dul, 2016b). For example, if a delayed response were identified as an NC to incur high early COVID-19 mortality, its absence or opposite, that is, a quick response, would guarantee low mortality. No other alternative compensates for or substitutes this NC. The purpose of this study is to apply the necessary condition analysis (NCA) method (Dul, 2016b) to aiding the policymakers across countries in uncovering necessary country-level determinants of early COVID-19 mortality. NCA can perform both in-kind and in-degree necessity analysis. By employing this analytical method, we seek not only to locate NCs but also to quantitatively formulate the degree of conditions that are necessarily associated with the different levels of early COVID-19 mortality.

This study identifies high levels of a delayed first response, political decentralization, elderly populations, and urbanization, as four NCs for high early COVID-19 mortality. We further distinguish a delayed first response as a proximate condition from other three NCs as remote conditions. Proximate conditions are often the product of conscious and purposeful actions of human agency, whereas remote conditions are relatively outside the reach of the
conscious influence of agents. Turbulent problems call for robust governance solutions, defined as “the ability of one or more decision makers to uphold or realize a public agenda, function, or value in the face of the challenge and stress from turbulent events and processes through the flexible adaptation, agile modification, and pragmatic redirection of governance solutions” (Ansell et al., 2021, p. 952). Although crucial to the implementation, operation, and effectiveness of public policy, time has been neglected in the practice and research of public policymaking and management (Butler, 1995; Carter, 2019). This research highlights that, agility, defined as the speed of a quickly implemented response policy (Baran & Woznyj, 2021; Mergel et al., 2018), the opposite of a delayed first response as a proximate NC, is central to reduce early COVID-19 mortality.

The rest of the paper is organized as follows. Section 2 elaborates on the logic of NCs. After a systematic review of existing studies, Section 3 summarizes the potential necessary drivers of early COVID-19 mortality into a policy-institution-demography framework. Section 4 describes the research method and data, performs the analysis, and presents the results. Section 5 discusses the policy implications by delineating the NCs into either remote or proximate ones. Section 6 concludes the paper by reiterating the critical role of agile response to COVID-19.

2 | THE LOGIC OF NECESSARY CONDITIONS

Despite many contributing factors uncovered by extant studies, identifying factors that are necessary for mortality to occur is particularly important for policymakers looking to prioritize resources to combat the virus. An NC is a condition that must be present to enable a certain outcome; without the condition, the outcome will be guaranteed to be absent. The notion of NCs implies causality, as removing them will cause the outcome to disappear. In other words, an NC is considered as a constraint, barrier, or bottleneck that must be managed to achieve the desired outcome or prevent the undesired outcome from occurring (Dul, 2016b). Consequently, necessary condition statements have very specific policy implications: put and keep in place necessary condition X or else you will fail.

This study utilizes the NCA method developed by Dul (2016b) to identify NCs of early COVID-19 mortality. The NCA uses specific terminology: the word “condition” is used instead of independent variable, “outcome” instead of dependent variable, and “effect size” instead of coefficient. Different from traditional sufficiency-based analysis (for example, regression analysis), the NCA is a data analysis approach based on necessity logic (Dul, 2016b), referring to the way in which a certain level of X is necessary for a certain level of Y to occur (Hauff et al., 2021); if X is not in place, Y will not occur (Dul, 2016a).

The NCA can be applied to conditions that are dichotomous (i.e., whether or not a country has prior epidemic experience), but also to conditions that have multiple discrete levels or are continuous in nature (Dul, 2016b). The concept of NCs can be applied to single antecedents (a bivariate approach), or multiple antecedents (a multiple approach). In the multiple NCA approach, all NCs need to be put in place for the outcome (desired or undesired)—for example, high early COVID-19 mortality—to occur. The absence or a lower than required value for one NC guarantees the absence of high early COVID-19 mortality (that is, to guarantee the desired outcome of reducing death toll) because an NC cannot be compensated for by the presence or a higher value of another necessary factor. To prevent the undesired outcome from occurring, policymakers can work on any NC so that it does not meet its threshold level, regardless of the levels of any other NCs. By deploying NCA, we can pinpoint the relationships of necessity not only in kind but also in degree (Vis & Dul, 2018). The former makes qualitative statements about necessity (X is necessary for Y), while the latter formulates quantitative statements about necessity (a specific level of X is necessary for a specific level of Y) (Dul, 2016a).

As a rapidly emerging analytical method, NCA has been applied to a variety of research domains: to examine the necessity of top management support for the successful implementation of lean manufacturing (Knol et al., 2018); to analyze the necessity of intelligence for creativity (Karwowski et al., 2016); to uncover the necessary individual characteristics and behaviors for successful academic performance (Tynan et al., 2020); and to study the necessity of metacognition for motivation among schizophrenia patients (Luther et al., 2017).
3 | A POLICY-INSTITUTION-DEMOGRAPHY FRAMEWORK

While acknowledging many environmental factors, for example, daily temperature change, can contribute to influenza transmission (He et al., 2013), we pivot to policy, institutional, and demographic factors, focusing on three theoretical mechanisms associated with COVID-19 mortality. The first stream refers to a country’s policy responses enacted to mitigate the pandemic (Greer et al., 2021). The second stream concerns the institutional context through which policy responses are implemented. The third stream emphasizes the demographic comorbidities of each country that impact mortality. By reviewing existing studies, we formulate necessity hypotheses for high early COVID-19 mortality by identifying: (1) necessity statements; (2) “important” contributing causal factors from conventional methods; and (3) “critical,” “bottleneck,” or “must have” factors (Dul, 2021).

3.1 | Early pandemic responses

Policy response is a government’s willingness and ability to respond to public needs, a necessary dimension of government responsibility and capacity (Besley & Burgess, 2002). Three aspects of pandemic policy responses in each country can be scrutinized.

First, a delayed first response. Time is an important perspective that is necessary for a deeper understanding of public policy (Goetz & Meyer-Sahling, 2009). How fast a country can respond to containing the pandemic implies a difference in state agility in terms of managing a turbulent problem (An et al., 2021; Zheng et al., 2021). Some countries adopted a first response much earlier than others. Extensive studies have confirmed that the implementation of policy responses earlier during the outbreak was critical to flattening the curve of the epidemic and lower COVID-19 mortality during the subsequent months (Loewenthal et al., 2020; Middelburg & Rosendaal, 2020). Countries with high levels of early mortality tended to delay their first response. Earlier implementation of mitigation policies, even by just a few weeks, is critical to reduce the number of deaths from COVID-19 (Fuller et al., 2021). A comparative study of the Czech Republic, the Russian Federation, and the Slovak Republic that adopted the similar policy response measures also suggests that the timing of policy responses may be a critical factor in containing the pandemic (Tatiana et al., 2020). The countries that implemented stringent policies earlier might have saved several thousand lives relative to countries that implemented similar policies but later (Fuller et al., 2021). Dul and Verbeek (2020) also revealed the necessity of speed of social distancing policies for economic recovery among major U.S. cities amid 1918 Spanish flu. Thus, we expect that a high level of delayed first response is a necessary condition for high early COVID-19 mortality.

Second, first-response policy stringency indicates the extent to which a country mobilizes resources and implements coercive measures to prevent outbreaks. Understanding the linkage between the first-response stringency and COVID-19 death tolls is highly important for striking a balance between health, welfare, and economy (Loewenthal et al., 2020). Countries that suffered from high early mortality might have implemented less stringent first response. Previous studies reveal significant effects of more stringent measures in lowering the reproduction of virus transmission, and a significant shortening effect on the time to the epidemic turning point when stricter pandemic policies are applied (Jinjarak et al., 2020). Researchers also compared the efficacy of six policy instruments (mask mandates, domestic lockdowns, international travel bans, mass gathering bans, restaurant closures, and school closures) on reducing infection rates (An et al., 2021). Assuming that different policy instruments need to work together synergistically to control the spread of the virus, we focus on the overall stringency of all the policy instruments initially adopted. We examine a necessity logic: a low level of stringent first response is a necessary condition for high early COVID-19 mortality.

Third, prior epidemic experience may predict that countries’ relevant knowledge derived from prior epidemic experience can be useful in helping national governments to formulate and implement effective policy
responses. Without having experienced more pathogens in the past, countries do not have a more salient memory of the seriousness of a public-health crisis, such as SARS and MERS, and therefore are ill-prepared to the pandemic (Labib, 2021). Experience of handling epidemics in the past may better prepare a country in the face of the COVID-19 pandemic, which has been interpreted as “policy acumen” (Ang et al., 2021; Wu et al., 2015). The Asian countries that have performed well all had prior experience of failed responses to past epidemics. Fostered by experience, their governments overhauled their health care systems and put in place relevant institutional infrastructure, which has prepared them well to guard against the brunt of COVID-19 (An & Tang, 2020). We posit that the absence of prior epidemic experience is a necessary condition for high early COVID-19 mortality.

3.2 | Formal and informal institutions

The COVID-19 pandemic has prompted wide-ranging public debates about the challenges to the governance structure of each country (Ansell et al., 2021). Institutional context is important in determining a country’s response to turbulent problems, where higher levels of compliance from the public will be associated with lower mortality rates (Devine et al., 2021). We focus on central–local government relations as part of a country’s formal institutional structure and state–society relations as part of informal institutions. These two parts directly impact the effectiveness of enforcing a country’s decisions made to manage the COVID-19 crisis and related responses (Cheng et al., 2020; Park, 2021; Yan et al., 2020). The critical role of institutional infrastructure and cultural compatibility in the fight against COVID-19 is evident in East Asia (An & Tang, 2020). The compatibility of formal institution and informal culture is vital to fight against crisis (An & Tang, 2020; Porcher, 2021).

Political decentralization refers to the degree to which political power and authority are decentralized in a country. In the case of the COVID-19 pandemic, the worst performing countries have tended to be large, decentralized countries, including Brazil, the European Union as a whole, the United Kingdom, and the United States. It is rather difficult for a poorly-coordinated, fragmented, and decentralized array of central and local entities to address the urgent demands involved in mitigating a pandemic. Many studies have suggested that a more centralized institutional structure can adopt more aggressive containment policies (Trein, 2020; Yan et al., 2020). Unitary regimes tended to have stronger policy measures in place earlier on, relative to federalist states, but relaxed these restrictions sooner (Nelson, 2021). A more centralized political system can address intergovernmental conflicts and become more efficient in mitigating virus transmission through its centralized decision-making powers and strict top-down regulation enforcement (Bromfield & McConnell, 2021). In contrast, a high level of political decentralization is a necessary condition for high early COVID-19 mortality.

The success of a country in containing the pandemic depends on the extent to which society voluntarily adheres to restrictive measures from the state–society relations perspective (Moss & Sandbakken, 2021). In the case of Germany, control aversion is less common among those with greater trust in the government and among those who were brought up under the coercive regime of East Germany (Schmelz, 2021). Ecological and human-made threats increase the need for strong norms and the punishment of deviant behavior in the service of social coordination for survival (Gelfand et al., 2011). This implies that an individualistic national cultural orientation, rather than a collectivistic one, would result in high mortality, as interpersonal transmission of the virus could be more likely to occur in independent cultures than in interdependent cultures (Bavel et al., 2020). Some empirical findings have also confirmed that, on the one hand, the higher pandemic mortality rates often occurred in the individualistically-oriented countries (Ozkan et al., 2021); on the other hand, East Asian, African, and South Pacific societies with more collectivistic culture, are more likely to follow normative pressures to reduce the risk of ignoring public health advice and the human-to-human transmission of the virus (Yan et al., 2020; Yan et al., 2021). Thus, a high level of individualistic cultural orientation is a necessary condition for high early COVID-19 mortality.
Demographic comorbidities

Population demographical factors are considered to be decisive under the pandemic context (Goujon et al., 2021; Yarmol-Matusiak et al., 2021). Extant studies reveal that two demographic risk actors, elderly populations (≥65 years) and urbanization (percentage of the population living in urban areas), are major sources of mortality, with underlying biological and pathophysiological mechanisms (Pijls et al., 2021; Upadhyaya et al., 2022). The pandemic’s progression and impact are strongly related to the demographic composition of the population, which is crucial for protecting those at the highest risk of mortality both across and within countries (Dowd et al., 2020).

A meta-analysis of 59 epidemiological studies have affirmed that age is one of the most important factors in diminishing one’s chances of surviving COVID-19, especially for the elderly (Pijls et al., 2021). The elderly is the most vulnerable group and so differences in age structures put countries at different levels of risk (Estève et al., 2020). Researchers have emphasized population age structures in explaining the remarkable variation in mortalities across countries (Dowd et al., 2020; Sorci et al., 2020). Despite their well-developed healthcare infrastructure, higher COVID-19 mortality rates were observed in developed countries, due to their older populations, who have significant comorbidities such as diabetes, overweight, and obesity that subject them to mortality risk (Giang et al., 2020; Yarmol-Matusiak et al., 2021). Conversely, African countries, even with poor healthcare systems, generally have lower COVID-19 mortality rates, due to the lower population mean ages and lower life expectancies (Lawal, 2021). Therefore, a high proportion of elderly populations is a necessary condition for high early COVID-19 mortality.

The epidemiological risk increases with urban growth and dense populations (Coker et al., 2011; Connolly et al., 2021). The higher percentage of urban populations, the faster the urbanization in a country. People participating in social activities become more likely to aggravate the spread of the virus, increase the risk of infection, and reduce the chances of survival after COVID-19 infection (Lee et al., 2020). The mortality remains highly concentrated in highly urbanized countries. The pandemic is spreading more slowly in countries that are less urbanized. The transmission of COVID-19 may be slowed by urban–rural dynamics, particularly in countries where rural areas are disconnected from possible urban epicenters, where the pandemic would be expected to spread more swiftly (Schellekens & Sourrouille, 2020). However, the return-migration flows from megacities to rural hometowns also accelerated virus transmission (Sarkar, 2021). Therefore, higher urbanization rates may be very important in explaining the mortality variance across more and less urbanized countries. Thus, a high level of urbanization is a necessary condition for high early COVID-19 mortality.

Data, Measurement, Analysis, and Results

4.1 Data collection and measurement

With data collected from multiple sources, we constructed a cross-nation dataset of 110 countries due to the availability of data on the conditions of interest. Our study consists of “early COVID-19 mortality” as the outcome of interest and seven potential NCs: a delayed first response, first-response stringency, prior epidemic experience, political decentralization, individualistic culture, elderly populations (%), and urbanization (%). Table 1 presents the descriptive statistics of the seven conditions and the outcome.

Early COVID-19 mortality was computed as the number of cumulative total COVID-19 deaths per million population in a country as of January 1, 2021. Either fatality, excess mortality, or mortality can be used to measure the COVID-19 death toll. Fatality is the proportion of people who die among all diagnosed with COVID-19. With underreported infected cases in some countries (Lau et al., 2021), fatality is likely to be underestimated (Beaney et al., 2020). Excess mortality, expressed as a percentage of additional deaths in a given period compared to a baseline period, is a more comprehensive measure of the total impact of the pandemic on deaths. Yet amid the pandemic, it has limitations in data acquisition (Leon et al., 2020) and baseline measurement (Pifarré i Arolas...
et al., 2021). Most countries do not publish the statistics on excess mortality. Therefore, mortality (total cumulative deaths per million population) serves as a reasonable outcome measure (An et al., 2021; Fisher et al., 2020). The death toll of COVID-19 was obtained from the Oxford COVID-19 Government Response Tracker (OxCGRT) (Hale et al., 2021); the population of 110 countries was obtained from the World Bank. With a focus on early mortality, we chose January 1, 2021 as a cutoff point to isolate the effects of vaccination rollout (Wouters et al., 2021), the availability of more effective treatments, and the emergence of new virus variants on overall COVID-19 mortality.

A delayed first response refers to the number of days from January 1, 2020 (Teixeira da Silva & Tsigaris, 2020) until a country first implemented any of nine containment and closure policies. First-response stringency measures the scale and scope of the containment and closure policies implemented by the countries for the first time. The details of the nine policies and the calculation steps of stringency can be found in Table S1. Prior epidemic experience is a binary condition, showing whether or not a country has experienced one of four recent pandemics, including SARS, MERS, Zika, and Ebola (Reperant & Osterhaus, 2017). The information on prior epidemic experience was all obtained from the World Health Organization.

The political decentralization index was obtained directly from the World Bank, reflecting the level of home rule in local self-governance, which is examined using three criteria: local government legislative elections, local government executive elections, and direct democracy provisions (Ivanyna & Shah, 2014). Individualistic culture was defined as a preference for a loosely-knit social framework in which individuals are expected to take care of only themselves and their immediate families (National Culture, n.d.), obtained from Hofstede Insights.

Elderly populations (%) was computed as the population aged 65 years and above as a percentage of the total population in one country (World Bank, n.d.) Urbanization (%) indicates the ratio of urban population to total population (World Bank, n.d.).

### 4.2 Data analysis

We performed the data analysis with the R-based NCA package 3.1.0 (Dul, 2016b). The starting point of NCA involves drawing a scatterplot of data, plotting X (condition) against Y (outcome) for each case (Dul, 2016b).
Figures 1–7 visually present the scatterplots between each of the seven conditions and the outcome. In these scatterplots, NCA draws two ceiling lines—the Ceiling Envelopment-Free Disposal Hull (CE-FDH) and the Ceiling Regression-Free Disposal Hull (CR-FDH)—to separate the ceiling zone (empty zone in any of the four corners: upper-left, upper-right, lower-left, or lower-right) from the scope (full zone) as accurately as possible (Dul, 2016b). CE-FDH is a piecewise linear line (step function) that can be used when conditions or outcomes are discrete or when the pattern of points near the border is irregular, while CR-FDH is a straight trend line that can be used when conditions or outcomes are continuous or when the pattern of points near the border is approximately linear (Dul, 2020). We used the CR-FDH as the ceiling line for political decentralization and elderly populations (%) due to their linear pattern of points near the border, and CE-FDH as the ceiling line for the other five conditions because they are either binary or have irregular pattern of points near the border.

NCA provides a corner command when drawing ceiling lines. Corner 1 (upper-left corner) is used for an analysis of the necessity of the high level of X for the high level of Y, while Corner 2 (upper-right corner) is used for an analysis of the necessity of the low level of X for the high level of Y. Considering the expectations deriving from existing studies, we chose Corner 2 when analyzing the necessity of a low level of first-response stringency and absence of prior epidemic experience for the high COVID-19 mortality rate, whereas Corner 1 was selected when analyzing the necessity of the high level of the other five conditions for the high COVID-19 mortality rate.

The identification of the NCs is based on the effect size and p-value. Effect size represents how much X constrains Y. The p-value of the effect size indicates the probability that the effect size of the observed sample is equal to or larger than the effect size of random samples, drawing from permutation. After drawing the ceiling lines in scatterplots, NCA can calculate the effect size and p-value (see Table 2). The effect size is the size of the ceiling zone (i.e., the empty space above the ceiling line) as a fraction of the scope (i.e., the total space where cases are observed or could be observed) (Dul et al., 2020). Therefore, the effect size ranges from 0 to 1. To distinguish the magnitude of an effect size, a general benchmark is proposed: $0 < d < 0.1$ as a “small effect,” $0.1 \leq d < 0.3$ as a “medium effect,” $0.3 \leq d < 0.5$ as a “large effect,” and $d \geq 0.5$ as a “very large effect” (Dul, 2016b). In addition, the statistical significance test of an NC should be less than the threshold of 0.05 because the observed necessity empty space may be the result of random chance (Dul et al., 2020). Only if a condition satisfies the criteria of “effect size > 0.1” and “p < 0.05” at the same time can it be considered as an NC.

**FIGURE 1** Scatterplot for a delayed first response and early COVID-19 mortality
After identifying an NC $X$ for the outcome $Y$, the NCA method can further compute which level of $X$ is necessary for which level of $Y$ through the equation of $y = ax + b$ ($a$: slope of ceiling line; $b$: intercept). When the conditions are continuous in nature, the CR ceiling technique can add more detail to the analysis using a bottleneck table, by considering the levels of the conditions in combination and by identifying the required levels of each of the NCs, given the level of early COVID-19 mortality.

**FIGURE 2** Scatterplot for first-response stringency and early COVID-19 mortality

**FIGURE 3** Scatterplot for prior epidemic experience and early COVID-19 mortality
Taking political decentralization as an example, with a scope of 1,694.4, its ceiling zone is 556.8 for the CR-FDH. The computed effect size is $0.33 = \frac{556.8}{1,694.4}$ (p-value 0.014), indicating that a high level of political decentralization is an NC for high early COVID-19 mortality rate. For a given level of mortality, 500 deaths-per-million, for example, the necessary level of political decentralization can be obtained as 0.19 through solving the equation of $500 = 2,430.0x + 49.4$.

**FIGURE 4** Scatterplot for political decentralization and early COVID-19 mortality

**FIGURE 5** Scatterplot for individualistic culture and early COVID-19 mortality
In our study, four out of the seven conditions are identified as NCs, among which a delayed first response, political decentralization, and urbanization (%) have large necessity effects on COVID-19 mortality rate, whereas elderly populations (%) has medium necessity effects on COVID-19 mortality rate.

**FIGURE 6** Scatterplot for elderly populations (%) and early COVID-19 mortality

**FIGURE 7** Scatterplot for urbanization (%) and early COVID-19 mortality

### 4.3 Results

In our study, four out of the seven conditions are identified as NCs, among which a delayed first response, political decentralization, and urbanization (%) have large necessity effects on COVID-19 mortality rate, whereas elderly populations (%) has medium necessity effects on COVID-19 mortality rate.
| Condition                        | CE-FDH |     |     |     | CR-FDH |     |     |     |     |
|---------------------------------|--------|-----|-----|-----|--------|-----|-----|-----|-----|
|                                 | Ceiling zone | Scope | Effect size | p-value | Ceiling zone | Scope | Effect size | p-value | Slope | Intercept |
| A delayed first response        | 53,550.7 | 133,861.2 | 0.40       | 0.023   |         |      |      |     |     |
| First-response stringency      | 35,976.5 | 68,252.2 | 0.53       | 0.305   |         |      |      |     |     |
| Prior epidemic experience      | 441.4   | 1,694.4  | 0.26       | 0.165   |         |      |      |     |     |
| Political decentralization      |         |         |            |        | 556.8   | 1,694.4 | 0.33       | 0.014   | 2,430.0 | 49.4   |
| Individualistic culture         | 33,811.8 | 144,027.8 | 0.23      | 0.096   |         |      |      |     |     |
| Elderly populations (%)         |         |         |            |        | 13,393.0 | 45,487.4 | 0.29      | 0.003   | 84.7    | 90.1   |
| Urbanization (%)                | 64,560.6 | 140,344.1 | 0.46      | <0.001  |         |      |      |     |     |
A bottleneck table illustrates the minimum level of each of the four NCs that is required for various levels of early COVID-19 mortality. For example, Table 3 reveals that, to reach a mortality rate of 100 deaths-per-million, three NCs must be in place: a delayed first response of no less than 20 days, a political decentralization index of no less than 0.02, and an urbanization rate of no less than 34.5%. When the COVID-19 mortality rate increases to 1,000, all four NCs should be present, and a delayed first response should be at least 22 days, political decentralization at least 0.39, elderly populations at least 10.7%, and urbanization at least 42.7%. If any of these required levels of NCs were unmet, say, aging populations is less than 10.7%, the mortality rate would not reach 1,000, even when all 3 other NCs meet or exceed the required necessary levels. For example, Brazil exceeds the 3 required necessary levels for a mortality rate of 1,000 (a delayed response of 61 days, 0.83 on political decentralization, 86.8% on urbanization). Yet with a proportion of elderly populations at 9.3%, less than the necessary level of 10.7%, Brazil's early mortality rate is 919.3. Italy, a country with high levels of political decentralization (0.83), elderly populations (23.0%), and urbanization (70.7%), keeps its early mortality rate at 1,253.0 that otherwise would be 1,300, owing to its delayed response time of 22 days, less than the required threshold of 63 days.

We performed additional NCA analyses (available upon request). Instead of the number of days delayed from January 1, 2020, we used the number of days that it takes for a country to respond after the first confirmed case. This alternative measure turned out to be an NC. Two alternative measures to first-response stringency were analyzed: (1) average stringency during the first 30 days after seeing a first infection case; (2) maximum stringency until January 1, 2021, and neither is an NC. However, three additional demographic comorbidities that are highly correlated to elderly populations—national median age (coefficient = 0.92, \( p < 0.001 \)), overweight rates (coefficient = 0.48, \( p < 0.001 \)), and obesity rates (coefficient = 0.33, \( p < 0.001 \))—are NCs.

The presented results are based on the cross-sectional data until January 1, 2021. To test their robustness, we first run a longitudinal NCA. Among 110 countries, Malawi is the last country to adopt response policies (March 20, 2020). So, we pooled together 10-month data from April 1, 2020 to January 1, 2021 to generate 1100 country-month observations. The results are consistent with Table 2 in that high levels of a delayed first response, political decentralization, elderly populations, and urbanization are NCs for high early COVID-19 mortality. Second, we conducted an outlier analysis (Dul, 2021). It turns out that Belgium is the most serious potential outlier. We then did a sensitivity analysis and explored the influence of the potential outlier case—Belgium—both on the effect size and \( p \)-value. It shows that removing Belgium does not influence the evidence of necessity in the data or the results of NC hypothesis testing.

**Table 3** Bottleneck table of four necessary conditions for early COVID-19 mortality

| Early COVID-19 mortality | A delayed first response | Political decentralization | Elderly populations (%) | Urbanization (%) |
|--------------------------|--------------------------|---------------------------|-------------------------|-----------------|
| 0                        | NN                       | NN                        | NN                      | NN              |
| 100                      | 20                       | 0.02                      | NN                      | 34.5            |
| 300                      | 21                       | 0.10                      | 2.5                     | 42.7            |
| 500                      | 21                       | 0.19                      | 4.8                     | 42.7            |
| 700                      | 21                       | 0.27                      | 7.2                     | 42.7            |
| 1,000                    | 22                       | 0.39                      | 10.7                    | 42.7            |
| 1,100                    | 22                       | 0.43                      | 11.9                    | 42.7            |
| 1,300                    | 63                       | 0.52                      | 14.3                    | 98.0            |
| 1,500                    | 63                       | 0.60                      | 16.6                    | 98.0            |
| 1,600                    | 63                       | 0.64                      | 17.8                    | 98.0            |

Note: We used the CE-FDH as the ceiling line for a delayed first response and urbanization (%), and CR-FDH as the ceiling line for political decentralization and elderly populations (%). NN = not necessary.
5 | DISCUSSION: PROXIMATE VERSUS REMOTE NECESSARY CONDITIONS

This study provides insight into which conditions must be unmet when reducing early COVID-19 mortality, as well as the required levels of these conditions. Across 110 countries, high levels of a delayed first response, political decentralization, elderly populations, and urbanization stand out as being necessary for high early COVID-19 mortality rates. More specifically, the results show that different levels of mortality require different threshold levels in regard to each of the four NCs (see bottleneck table).

The NCA study enriches regression-based findings (An et al., 2021; Zheng et al., 2021) by further illustrating that it is not the stringency, but the speed of pandemic first-response policies that are critical to reducing the early death rate. Researchers found that neither the lockdown duration nor the lockdown strictness was significantly correlated with the mortality rates, suggesting that a tight lockdown may be unnecessary, but the immediate response was of utmost importance (Loewenthal et al., 2020). In terms of the stringency of pandemic responses, neither first-response, average response over 30 days, or maximum response, turns out to be necessary. The correlation coefficient between a delayed first response and its stringency is 0.58 ($p < 0.001$), indicating that countries tend to implement more stringent responses late. Prior epidemic experience is also not an NC, perhaps because the scale and scope of COVID-19 were so overwhelming that even the countries with prior epidemic experience were caught by surprise.

The findings highlight the criticality of agility with an emphasis on the speed of response to high-risk, uncertain, and turbulent challenges (Ansell et al., 2021). According to the bottleneck table (Table 3) and the data scatterplot (Figure 1), a 21-day delayed first response is a critical juncture in which early mortality rates jump from 300 to 700 deaths-per-million. This study echoes that a delay in policy response of even 2 or 3 weeks after its arrival can have substantial implications for containing the disease and minimizing causalities (Nelson, 2021).

If the initial response is delayed, the COVID-19 pandemic can spread explosively in local communities, making it difficult to control using subsequent social distancing strategies (Seong et al., 2021). Michael Lewis’ book The Premonition (2021) makes similar conclusions. The NCA analysis confirms the critical importance of an agile response to a pandemic even before sufficient data is available. The need to act quickly to implement stringent measures is paramount because otherwise infections and high mortality will be impossible to prevent and control.

Political centralization as part of formal institution proves to be important to reducing early mortality too, stressing a unified national rather than fragmented state and local approach to public health response to the pandemic (Lewis, 2021). Individualistic cultural orientation as an informal institution is not an NC. The overall influence of culture on combating the pandemic may be eroded over time.

Demographic comorbidities, such as elderly populations (other highly correlated measures) and urbanization, are also necessary in determining COVID-19 mortality. In the face of severe threats from COVID-19, vulnerable populations have greater risks of being infected, resulting in negative health and social consequences. In the same vein, from Table 3 and Figure 7, we identify 42.7% as a critical level of urbanization in which early mortality rates jump from 300 to 1100 deaths-per-million and below that level results in very low mortality, but above that there is not much effect difference.

From a policymaking perspective, the four NCs can be demarcated into either remote or proximate conditions according to their causal closeness to early COVID-19 mortality. Political decentralization, elderly populations, and urbanization are remote conditions that are relatively stable over time, whereas a delayed first response is a proximate condition that varies over time and originates not so far back in the past (Schneider & Wagemann, 2012). The conceptualization of remote and proximate conditions can be further expanded to account for structure and agency (Schneider, 2019). Remote conditions are also often considered as structural or contextual conditions, because their origins are often also remote on the time and/or space dimension from the outcome to be explained. As a result, remote conditions are usually completely outside the reach of the conscious influence of agents; thus, contexts and historical legacies are treated as exogenous conditions. In contrast, proximate conditions can vary over time and are subject to changes introduced by agents. Proximate conditions do not originate far in the past, but are the products of conscious and purposeful actions of human agency.
In responding to COVID-19, policymakers should prioritize resources on the most critical ones. Political decentralization, elderly populations, and urbanization as necessary remote conditions serve as the structural context within which pandemic response unfold and policymakers act as agents. They tend to be stable and cannot be subjected to purposeful changes. There is not much that policymakers can do to manipulate these institutional and demographic conditions in short term to reduce early COVID-19 deaths. A delayed first response as a necessary proximate condition, in contrast, originates closer to the outcome of COVID-19 mortality, both in time and space, is more volatile, and is often subject to conscious or purposeful manipulations by policymakers. It is more malleable because policymakers can respond to the virus more quickly or slowly.

An NC must be present for the outcome to occur; without it, the outcome will not occur. If any of these thresholds is not met, the high mortality outcome will not occur, despite the fact that the other thresholds are met or even exceeded. Such a unique quality of an NC further underlines agile responses as the most critical proximate condition to reduce early death tolls regardless of any other remote NCs. For example, Singapore and the United Kingdom have the same level of political decentralization (0.67), and similar levels of aging populations (12.4% vs. 18.5%) and urbanization (100% vs. 83.7%). Singapore has so far performed much better than the UK against the coronavirus on early mortality (5.1 vs. 1,102.8 deaths-per-million) because of its early adoption of restrictions and preparedness measures (a delay of 0 vs. 72 days). Japan, despite its high levels of political decentralization (1), aging populations (28.0%), and urbanization (91.7%), has kept an early mortality as low as 28.1 deaths-per-million, thanks to an agile response (a delay of 6 days). In comparison, with the same level of political decentralization with Japan but lower levels of aging populations (16.2%) and urbanization (82.5%), the United States delayed its pandemic response by 32 days and has encountered an early mortality rate as high as 1,075.2 deaths-per-million.

Three factors may undergird a country's agility in responding to public health crisis. First, caring and mindful leadership with precautionary principle are likely to take agile response (Parker & Stern, 2022). Some countries delayed initial responses because of their leaders' overconfidence in their healthcare capacity and/or fear of severe social and economic costs (Bel et al., 2021). Second, trust matters. The citizens' trust in government, compliance with rules and regulations, and acceptance of new norms and values are critical to the creation and implementation of agile solutions (Ansell et al., 2021). Third, resource redundancy is needed (Howlett et al., 2018). To achieve agility, we should also need a fundamental shift of policy paradigm from increasing efficiency in industry and society of the 20th century, to investment in more redundancy and contingency planning in the 21st century, a prudent hedge against future pandemic risks, even at some cost to efficiency.

6 CONCLUSION

COVID-19 has underscored the need for robust governance strategies to deal with a global disaster that threatens millions of lives among vulnerable people. Policymakers should focus on critical factors to reduce mortality. This study identified a high level of a delayed first response, alongside institutional and epidemiological factors of high levels of political decentralization, elderly populations, and urbanization, as NCs for high early COVID-19 mortality. When facing turbulent problems, policymakers should act early rather than wait until sufficient knowledge is available. What matters the most in curbing the early pandemic death toll was agility—how quickly countries could implement restrictive policy measures. The cost of a delayed response or policymaking procrastination is even more lives tragically lost. To protect us from future pandemics of this nature, a key lesson learned is to act as quickly as possible even before sufficient data is available, particularly in politically decentralized and highly urbanized countries with vulnerable elderly populations.

With the limit of scope, this study leaves a question unanswered for future research. Under a new normal of “living with virus,” robust governance has shifted from a “sprint” to a “marathon.” One needs to consider the social and psychological costs of introducing first response early, even in the absence of confirmed cases. More scholarly
attention should be paid to adaptability (flexible adjustment and modification in response to changing circumstances, such as the rollout of vaccinations and the arrival of new variants).

CONFLICT OF INTEREST
The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

DATA AVAILABILITY STATEMENT
The data used for this study are all publicly available. We provided the sources in either text or endnotes.

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ENDNOTES
1 Data from the World Health Organization, https://covid19.who.int/.
2 Indicator from the Hofstede Insights, https://hi.hofstede-insights.com/national-culture.
3 Indicator from the World Bank, https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS.
4 Indicator from the World Bank, https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS.
5 Our data indicates that as many as 56 countries took actions before, 8 countries acted on the date of, and 46 countries delayed their responses after the first confirmed case.

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**SUPPORTING INFORMATION**

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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