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Lives Versus Livelihoods: The Epidemiological, Social, And Economic Impact Of COVID-19 In Latin America And The Caribbean

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ABSTRACT During the COVID-19 pandemic, Latin American and Caribbean countries implemented stringent public health and social measures that disrupted economic and social activities. This study used an integrated model to evaluate the epidemiological, economic, and social trade-offs in Argentina, Brazil, Jamaica, and Mexico throughout 2021. Argentina and Mexico displayed a higher gross domestic product (GDP) loss and lower deaths per million compared with Brazil. The magnitude of the trade-offs differed across countries. Reducing GDP loss at the margin by 1 percent would have increased daily deaths by 0.5 per million in Argentina but only 0.3 per million in Brazil. We observed an increase in poverty rates related to the stringency of public health and social measures but no significant income-loss differences by sex. Our results indicate that the economic impact of COVID-19 was uneven across countries as a result of different pandemic trajectories, public health and social measures, and vaccination uptake, as well as socioeconomic differences and fiscal responses. Policy makers need to be informed about the trade-offs to make strategic decisions to save lives and livelihoods.

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Latin America and the Caribbean was one of the regions with the highest COVID-19-related death toll worldwide, despite stringent mobility restrictions that triggered large economic losses.[1] These policies, implemented early in the pandemic, had impacts on workers through the abrupt reduction of working hours in a sizable fraction of the working population. The short-term costs of these measures, mainly in terms of productivity losses and social isolation, often were so high that policy makers and individuals could not sustain them, which rendered them increasingly ineffective over time.

This study evaluated outcome measures such as deaths, hospitalizations, loss of gross domestic product (GDP), and the distributional impact according to sex and income level of public health and social measures implemented to mitigate the COVID-19 epidemic in Argentina, Brazil, Jamaica, and Mexico, taking into account vaccination rollout. We chose 2021 because that year produced the highest death toll in the region. In particular, we developed an integrated epidemiological-economic model to evaluate how the mitigation policies adopted by governments affected the trajectory of the pandemic and the economy as a whole.

Study Data And Methods

Our model, based on SEIR transmission models, where a population is divided into the noninfected and susceptible (S), the exposed (E), the infected (I), and the recovered (R), was designed to estimate the impact of COVID-19 in different settings.[2] Building on our previous models,[3,4] for this model we added the macroeconomic and social impact of public health and social measures, adjusted for the different vaccination strategies in each country. Specifically, we incorporated the economic rationale of DAEDALUS, a model that computes impacts on a wide range of SARS-CoV-2 control strategies on economic production, employment, infections, hospitalizations, and deaths,[5] as well as other models.[6] First, when the priority in a given country is to curb the case curve (a "safety-focused" or health-maximizing approach), the economy will have to endure a highly stringent and lengthy lockdown and a likely sizable decline in GDP. Second, if the policy maker has more of an "economy-focused" approach, attempting to minimize economic losses, the mortality rate will likely increase. Our model also incorporated "lockdown fatigue," or the degree of compliance with public health and social measures, to measure the economic impact of the pandemic at the sectoral level in a real-life setting.

DATA SOURCES We performed an exhaustive literature search that gathered demographic data and data on COVID-19 cases and deaths from the United Nations,[7] the World Health Organization,[8] national data sets,[9] and Our World in Data.[10] SARS-CoV-2 variant predominance in 2021 was estimated in Argentina,[11] Brazil,[12] Jamaica,[13] and Mexico.[14] Essential activities were obtained from the International Monetary Fund's policy responses to COVID-19[15] and from national governments' websites; labor-force shares and sex and income distribution across economic sectors were retrieved from household surveys for each country,[16–18] with the exception of Jamaica, for which such decomposition was not available. We used the International Standard Industrial Classification of All Economic Activities decomposition[19] and calibrated the share of each of the sixteen different economic sectors and categories per country, including the public sector, such as agriculture, manufacturing industry, wholesale and retail trade, transportation, education, and social security and health. The model's input and output matrices were calibrated using data from the Organization for Economic Cooperation and Development input and output matrix estimates for 2019.[20] The stringency of public health and social measures was calculated using the Oxford COVID-19 Government Response Tracker.[21]

METHODS Our model comprised an epidemiological and an economic framework. The former was an extension of the SEIR model, to which we added the impact of vaccination strategies and the differential impact of public health and social measures or immunization strategies on age groups. We incorporated specific age-strata mixing patterns matrices to represent the social interactions and effective contact rates at each of the four settings we included: home, school, work (including transportation), and community. The impact of public health and social measures, such as schools closing, staying at home, shielding the elderly, mandatory mask wearing, or public transport restrictions, was modeled as a modifier of these contact matrices. The impact of public health and social measures on the contact and effectiveness rates at each setting was based on the work of Nicholas Davies and colleagues.[22] More details on vaccination strategies and the impact of coronavirus variants are in online appendix 1.[23]

On top of the epidemiological framework, we developed an economic framework to capture two key features of the COVID-19 pandemic: the trade-off between the stringency of mobility restrictions and economic costs, and the economic impact of persistent lockdowns on the population. We focused on the dynamics of working-age adults, excluding school-age children and the population older than age sixty-five, who make a negligible contribution to the GDP.

On the basis of a similar conceptual framework and approach used in DAEDALUS,[5] we assumed that stringent mobility measures affected working hours at the intensive level—that is, how much active workers contribute to economic output. For this reason, we only considered people actively participating in the labor market (that is, formal, informal, and self-employed workers).

We assumed that the government determined, at the beginning of each period, the degree to which different economic sectors were exposed to mobility restrictions. For all of the nonessential sectors, the government decided whether they could operate at full or partial capacity or whether they should close. In the model, this translated into a certain proportion of the active workforce within each sector that may have been partially or fully prevented from working in any given period, depending on the extent to which specific sectors were closed as a result of the public health and social measures. Thus, the impact on the labor market was captured by adjusting working hours. This took into consideration the work-from-home capability of different sectors. At each decision period, the policy maker chose the degree of workplace closure, which could take one of the following values: no measures; recommended (discretionary) closure; closure of some activities; or closure of all activities except essentials. Crucially, the productive sectors were engaged both in economic production and in the spread of infection, as long as

An important concern of the postpandemic debate is how to calibrate public health and social measures to reduce economic and social costs.

production required working mobility. In this regard, more work hours increased the likelihood of getting infected, which meant a high rate of "work contacts" in the contact matrix of the epidemiological framework.

Because the economic costs were not evenly distributed across the population, we disaggregated the impact by sex and income level. To account for the impact on both poverty rates and sex, we leveraged the sectoral decomposition of the economy. We used data from household surveys to map the income and sex decomposition into each of the sixteen sectors of the economy. Then, conditioning on the "essentiality" of the sectors, we computed the income loss and the impact on the aggregate gender gap over time.

Finally, our integrated model accounted for lockdown fatigue[24]—a concept that helps explain why stringent lockdowns were unable to curb cases and deaths. The term conflates both the psychosocial aspects of isolation, including living conditions such as overcrowding and in-house amenities, and a growing necessity to earn that is particularly relevant for low-income and informal households without alternative sources of income. A consequence of lockdown fatigue was an increase in observed versus expected mobility before the stringent measures were relaxed, particularly among informal workers.

In this way, lockdown fatigue limits the capacity of the government to reduce mobility after a prolonged period of restrictions. In contrast, an increase in the rate of daily deaths, through a "fear factor," causes people to reduce their mobility and reverse lockdown fatigue. This self-regulation of people may reinforce the stringency of the measure or, alternatively, limit noncompliance. First, from the economic to the epidemiological frameworks, the economic framework determined the working hours that were an input to determining work-related contacts and, in turn, the spread of the virus. Thus, working hours, an output from the economic bucket, were an input for the epidemiological bucket, as a reduction of hours worked in the workplace affected the contact matrix (for example, work contacts or contacts in public transport). Second, from the epidemiological to the economic frameworks, lockdown fatigue was also related to the daily reported deaths through the fear factor: There was a greater adherence to public health and social measures when there were a greater number of deaths. The simulation of the two models ran recursively, as can be seen in appendix 2.[23]

Using this integrated epidemiological-economic model, we compared the actual number of deaths and GDP loss in each country studied with alternative counterfactual simulated scenarios of deaths and GDP loss that would have occurred if the government had implemented less stringent public health and social measures, reflecting the trade-offs of lives versus livelihoods.

CALIBRATIONS AND COUNTERFACTUALS First, to calibrate the model, we mapped the sequence of public health and social measures actually implemented at the country level in 2021. This sequence yielded both a path for cumulative deaths over this year and an estimation of the GDP loss. In general, the countries' governments imposed stringent measures earlier in 2021. Then, as vaccines became available and vaccination rates accelerated, governments were able to ease mobility restrictions in the second half of 2021. These measures determined benchmarks for deaths and GDP loss that we compared with alternative simulated scenarios.

Second, in the counterfactual scenarios, we compared deaths and GDP loss if the government had implemented less stringent public health and social measures. In this case, deaths would have increased and GDP loss would have been reduced.

To address uncertainty, we designed a series of scenarios shaped according to public health and social measure bundles that included variations in a key set of parameters. Thus, we displayed different scenarios for the public health and social measures implemented. The model was calibrated to reflect actual mortality curves in each country during 2021. In addition, we showed scenarios in which the public health and social measures were gradually eased.

Third, we were able to quantify the different impacts of these alternative scenarios (a "sacrifice ratio" reflecting epidemiologic and economic trade-offs), answering by how much less stringent public health and social measures would have reduced the GDP loss, but at a cost of an increasing death count, and by how much GDP loss each country would face to reduce daily deaths by a certain amount.

In other words, epidemiologic and economic trade-offs were determined by the sequence of public health and social measures actually implemented by the governments, computing the associated deaths and GDP loss. Then we simulated alternative scenarios for the public health and social measures, assuming less stringent (and more stringent) scenarios, and we estimated the associated outcomes in terms of deaths and GDP loss (see appendix 3 for more details on the economic component of the model).[23]

LIMITATIONS Our study had several limitations. First, the links between the epidemiological and economic frameworks could be further extended to capture other nuances. For instance, the epidemiological framework did not benefit from the sectoral disaggregation features in the economic framework, whereas the latter made several simplifications regarding age segmentations. Second, we assumed that the populations of preschoolers, students, retired people, and adults ages 20–64 who were not in the labor force, together with the unemployed, were not exposed to work contact. Third, we assumed that labor disruptions were fully reversible, which is a conservative evaluation of the actual economic impact of public health and social measures. Fourth, we did not account for differences in the social and economic structure of the countries, as well as in the fiscal response to contain the economic toll of the pandemic. Fifth, we did not consider reductions in labor due to sickness or death as a result of COVID-19, although we assumed that its impact was small. Finally, we did not perform sensitivity analyses related to single or multiple parameters, but all key parameters are customizable, allowing policy makers to explore the influence of uncertainty around them.

Study Results

The main economic indicators for Argentina, Brazil, Jamaica, and Mexico for the period 2020–21 are shown in appendix 4.[23] Note that the GDP per capita ranged between $23,737 (purchasing power parity) in Argentina to $10,938 (purchasing power parity) in Jamaica. Moreover, the share of informal workers ranged between 20 percent in Brazil and 43 percent and 45 percent in Mexico and Jamaica, respectively.

The results of the model are shown in exhibits 1–4. They should be interpreted as how much GDP loss a policy maker decides is bearable to reduce the death count. The ratio between those variables (change in the death count and GDP loss) constitutes a "sacrifice ratio." The counterfactual scenarios can be used as a benchmark. However, the current specification cannot be used to determine the optimal timing and intensity of the public health and social measures because those measures will ultimately depend on the preferences of users.

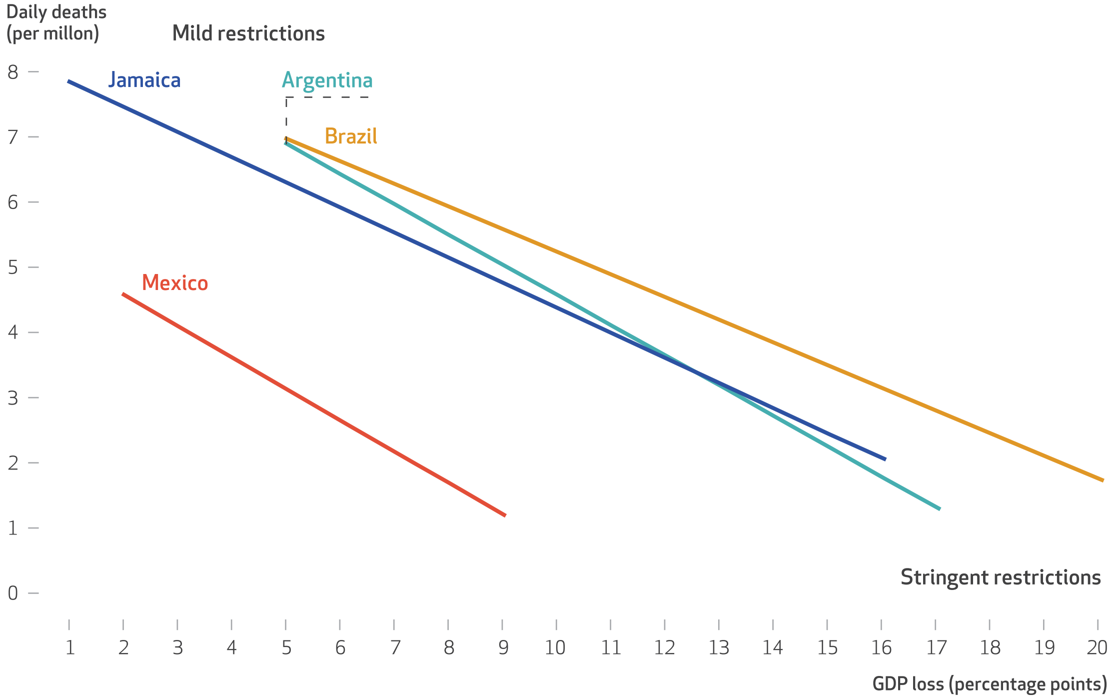
An important advantage of our model was to provide a unified framework to quantify the short-run trade-off between lives and livelihoods.

We analyzed the epidemiologic and economic trade-offs for Argentina, Brazil, Jamaica, and Mexico—that is, how much GDP loss each country would have to face to reduce daily deaths by a certain amount. The trade-off is shown in a scatterplot that depicts the simulated scenarios while keeping the degree of stringency to each of the possible values constant (exhibit 1). Although there was a wide range of uncertainty around this "sacrifice ratio," we found stark differences among the countries. In particular, reducing the GDP loss at the margin for Argentina and Mexico, by reducing the intensity of the mobility restrictions, would have increased the death count more compared with Jamaica and Brazil. These differences may reflect disparities in the economic structure (such as the relative shares of the manufacturing and informal sectors in each country), the strength of the health system, or the magnitude of the earlier COVID-19 wave, among other factors (see appendix 5).[23]

Exhibit 1 shows the comparison of trade-off slopes across countries. The trade-off is captured by the slope of the lines—the steeper the slope, the worse in terms of epidemiologic and economic trade-offs. In our study, the trade-off slope of Argentina was −0.51, whereas for Brazil the trade-off slope was −0.31. That is, reducing the GDP loss at the margin by 1 percent would have increased the daily death count by 0.51 per million in Argentina but only 0.31 per million in Brazil. To explore the magnitude of the trade-offs, we compared the actual scenario in each

EXHIBIT 1

Model results: trade-offs between daily death counts and economic performance associated with COVID-19-era mobility restrictions in 4 Latin American and Caribbean countries, 2021



SOURCE Authors' calculations based on data from the sources in notes 9–22 in text. **NOTES** The slope of the trade-off lines represents how much gross domestic product (GDP) a policy maker has to give up to reduce the death count. The steeper the slope, the worse in terms of trade-offs. R^2 statistics for each country are as follows: Argentina, 0.972; Brazil, 0.982; Jamaica, 0.944; and Mexico, 0.937.

country (base case) with the least-restrictive scenario in daily deaths per million saved. Daily deaths per million saved were 257 in Argentina (5.9 daily deaths per million), 1,180 in Brazil (5.5 daily deaths per million), 18 in Jamaica (6.3 daily deaths per million), and 465 in Mexico (3.7 daily deaths per million) (data not shown).

The cross-national differences between the trade-offs can be decomposed into two features: the slope and the origin of the lines. The slope of the trade-off lines represents how much GDP a policy maker has to give up to reduce the death count. Two factors increase the slope of the lines: the share of contact-intensive (services) sectors in the GDP and the share of informal workers. The origin of the lines may reflect disparities in the economic structure, strength of the health system, and magnitude of the earlier COVID-19 waves, among other factors.

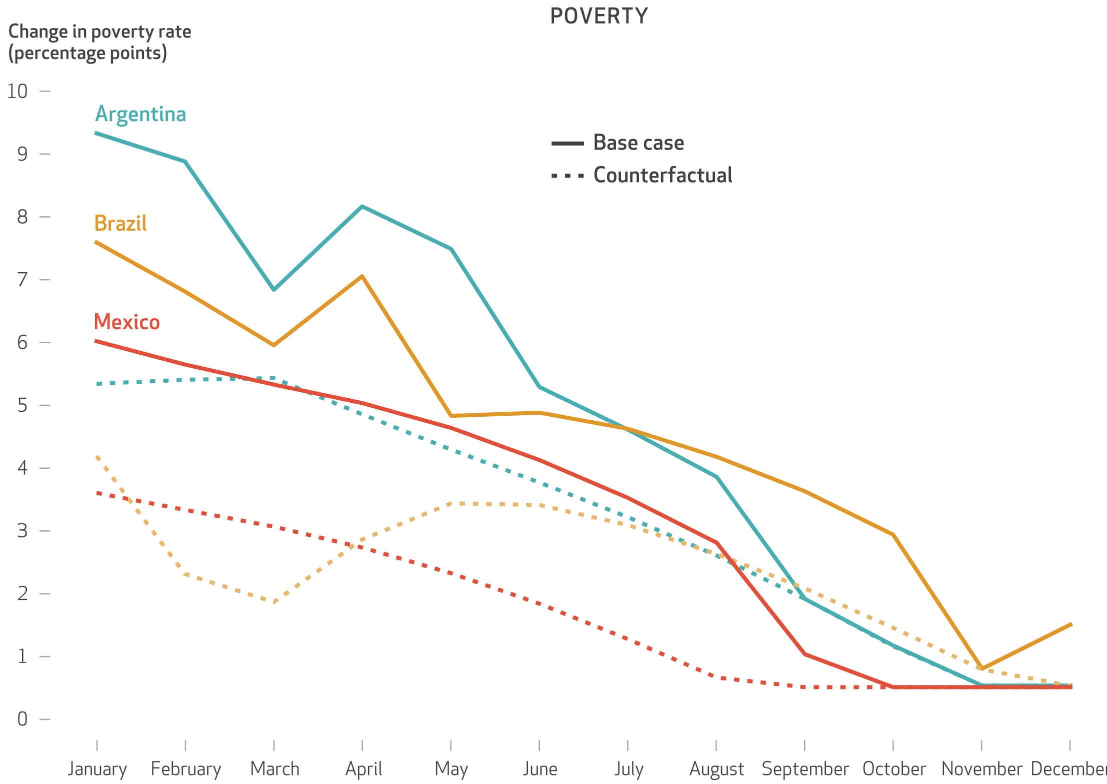
We also show the impact of trade-offs on various social indicators in three of the four countries (data for Jamaica were not available). For the poverty indicator, exhibit 2 shows that when public health and social measures were more stringent (as in January 2021), the gap between the base case and the counterfactual scenarios (less stringent restrictions) was wider. The gap narrowed as restrictions were eased toward the end of 2021. The initial gap in Brazil was partly driven by the lower mortality in the counterfactual scenario. For Argentina and Mexico, the convergence occurred around September and October 2021, reflecting the relaxation of public health and social measures.

Regarding impacts of public health and social measures on income by sex (exhibit 3), we observed similar income loss among women and men, particularly at the beginning of the year, when public health and social measures were more stringent. We found no significant difference by sex among countries, but we did observe a small difference between men and women in Argentina that could reflect the uneven sex composition of the labor force across sectors. This finding contradicts the belief that women work in sectors with a higher rate of informal employment and are more likely to lose their jobs or reduce their working hours compared with men.

We also examined the impacts of public health and social measures on income by income level (exhibit 4). Although the difference in the impact on upper- and lower-income workers was not significant, the results suggest that in the case of upper-income workers, the adverse effect

EXHIBIT 2

Model results: change in poverty rates during COVID-19 restrictions in 3 Latin American countries, actual and counterfactual scenarios, 2021



SOURCE Authors' calculations based on data from the sources in notes 9–22 in text. **NOTES** Data from Jamaica were not available. Poverty was defined by the share of the population that lay below the poverty line set by each country. Differences in poverty rates between the base case and the counterfactual scenario in each country are wider with greater stringency of public health and social measures. As the restrictions ease, the lines for each country tend to converge. The actual scenario (base case) was considered to be the simulation based on policies actually implemented by the countries. The "counterfactual" scenario considered the adoption of the lowest level of restrictions throughout the year.

was somewhat tempered by their lower exposure to contact-intensive sectors and their greater ability to transition to telework.

Discussion

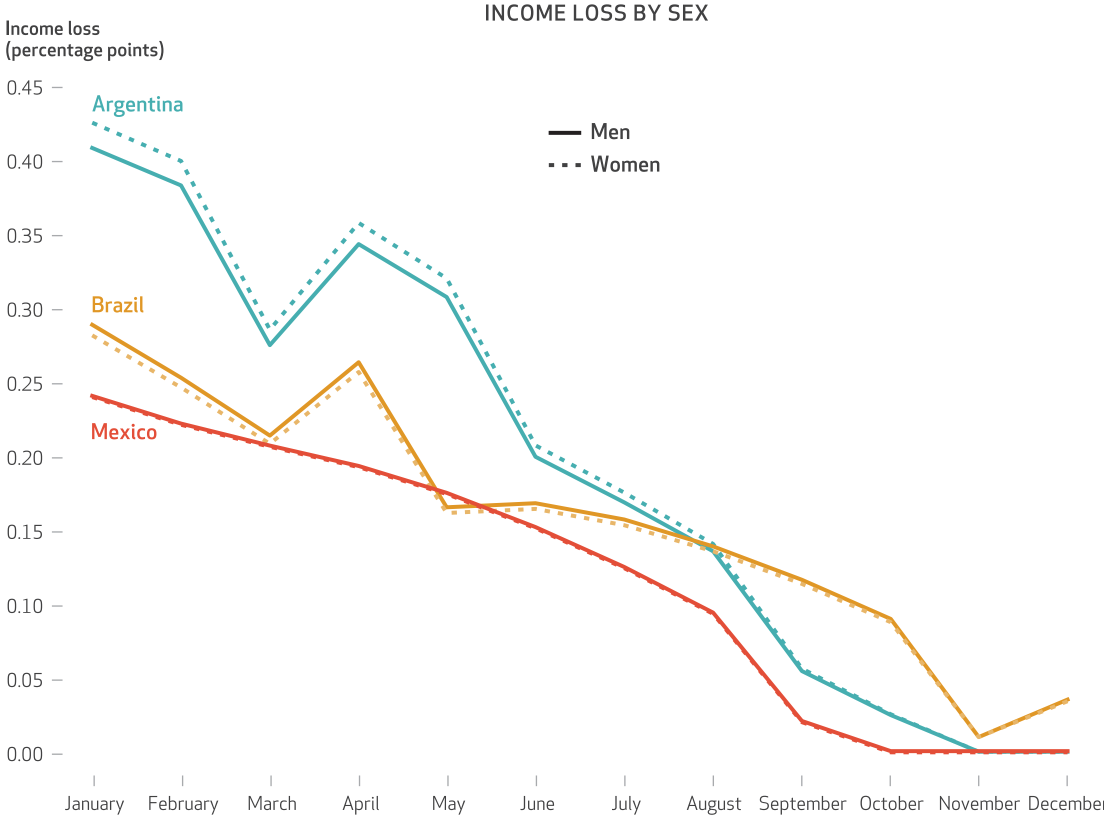
An important concern of the postpandemic debate is how to calibrate public health and social measures, in a context of unprecedented uncertainty, to reduce economic and social costs. This question is particularly relevant because public health and social measures were, until the vaccine rollout was more extensive, the only levers available to policy makers. At the same time, the measures' short- and long-term impacts were also uncertain in terms of their results, and arguments in favor of stringent restrictions were often rejected because of their collateral economic costs.

Among the four countries we studied, Argentina displayed a higher GDP loss and lower mortality compared with Brazil, Jamaica, and Mexico, highlighting the short-term trade-off in that country. We also observed a lesser impact on lower-income workers in Argentina, Brazil, and Mexico.

Other researchers have examined the economic and epidemiological trade-offs inherent in COVID-19 response. A similar SEIR model was used for establishing COVID-19 incidence in Dublin, Ireland, providing a framework for evaluating health intervention costs.[25] This model was able to characterize different forms of lockdown that may have affected specific age groups differently. Similar to our model, social interactions were represented through age group contact matrices, which could be modified using available data and were thus locally adapted. Social interactions show the different economic costs and impact on GDP for the country in each lockdown period. Sedona Sweeney and colleagues[26] created an economic model to simulate the impact of lockdown measures in Pakistan, Georgia, Chile, the United Kingdom,

EXHIBIT 3

Model results: COVID-19-related income loss in 3 Latin American countries, by sex, 2021



SOURCE Authors' calculations based on data from the sources in notes 9–22 in text. **NOTES** Data from Jamaica were not available. We observed important income losses in both men and women during 2021, particularly at the beginning of the year, when the public health and social measures were stricter. As restrictions are eased along the year, the income losses tend to decline. We estimated the differential weighted variation after public health and social measures between both sexes.

the Philippines, and South Africa. The researchers considered the impact of lockdown in terms of ability to socially distance, as well as income loss during lockdown. They found that people in lower-socioeconomic-status quintiles were consistently more likely to have been exposed to greater health or economic risk during lockdown across all of the countries studied. In a cross-national analysis, Mohamed Jalloh and colleagues found that higher public expenditure on health, rather than GDP per capita, was mostly associated with less stringency of public health and social measures throughout the pandemic.[27] Using a model to assess the economic impact of interventions, Jung Eun Kim and colleagues[28] estimated that the speed of vaccine supply was an important factor in offsetting the impact of the COVID-19 epidemic on GDP losses due to social distancing.

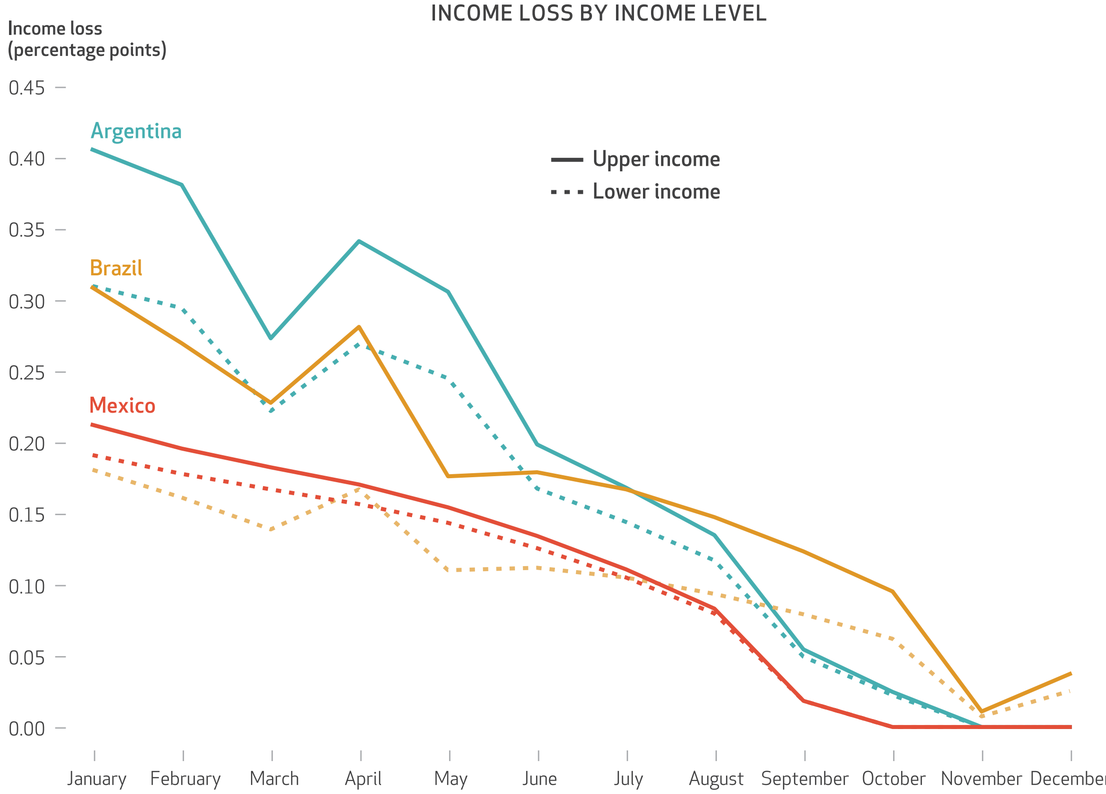
One of the key contributions of our model is allowing the comparison of different policies and how they influence trade-offs across countries. Our results showed that the economic impact and death toll were uneven across countries and that the differences were related not only to the pandemic trajectory, public health and social measures, and vaccination uptake but also to differences in the countries' socioeconomic structures, including health care systems, as well as in the fiscal responses to contain the economic toll of the pandemic.

It is important to consider the potential effect of differences in the demographic structures of the countries we examined. In this context, the dynamics of the epidemic may have been influenced by the different demographic structures of countries that may reflect different levels of interaction between age groups and therefore different patterns of social interaction (and thus different contact rates) that exist in the countries. In addition, different lethality by age and different vaccination strategies (according to age groups) should also be considered.

In this regard, an important advantage of our model was to provide a unified framework to quantify the short-run trade-off between lives

EXHIBIT 4

Model results: COVID-19-related income loss in 3 Latin American countries, by income level, 2021



SOURCE Authors' calculations based on data from the sources in notes 9–22 in text. **NOTES** Data from Jamaica were not available. Income levels were derived from household surveys for each country. We estimated the differential weighted variation after public health and social measures between upper- and lower-income earners.

and livelihoods—that is, the trade-off between the epidemiological and socioeconomic impacts of public health and social measures. In particular, the model could simulate the daily deaths and economic costs stemming from the COVID-19 pandemic and the policies imposed to contain its spread, and it included a focus on two more vulnerable groups: women and low-income households. Moreover, the model was flexible enough to allow for the effects of different SARS-CoV-2 variants and the impact of vaccination on the transmission and hospitalization of patients, which in turn affect the public health and social measures imposed by the countries.

In analyses not reported here, we found that the policy trade-off could be significantly improved with targeted pharmaceutical policies, such as increased vaccination coverage to reduce COVID-19 impact. Also, our intertwined analysis of the different policies explicitly incorporated the concept of lockdown fatigue[24] to capture the behavioral response of the population to stringent and persistent mobility restrictions, which became gradually less efficient. Indeed, one of the reasons that protracted stringent lockdowns did not stop the pandemic may be related to lockdown fatigue and the necessity for low-income households to engage in economic activity in low- and middle-income countries.

Finally, evidence shows that COVID-19's impact has exacerbated existing income inequalities.[28] Our model was able to account for the pandemic impact on poverty rates and reproduce the pandemic's regressive impact.

Policy makers were limited in making strategic decisions during the pandemic. By assuming a similar external context (that is, similar pandemic shock and availability and access to vaccines), our model allows for a comparison of the trade-off between lives and livelihoods. Indeed, the model could readily be adapted to other countries, based on data availability, allowing assessments of how the trade-off was influenced by country-specific aspects. Similarly, one could test whether the socioeconomic impact of COVID-19-related measures was higher for low-income countries. Finally, the model is amenable to simulations of alternative restriction policies, and, in particular, of different stringency-duration pairs that, through the presence of lockdown fatigue and vaccination uptake, may attain different epidemiological outcomes.

Our model is publicly available, and users can customize key parameters and set simulated scenarios for different combinations of policies.[29]

Conclusion

Policy makers need to consider not only the epidemiological impact but also the macroeconomic and social impact of strategic responses to pandemics and gauge their response and the calibration of their public health and social measures to protect both lives and livelihoods. Although COVID-19 is transitioning to an endemic stage, it will remain necessary to continue to adapt public health and social measures to occasional surges of this or other viral pandemics that may arise in the future. ■

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