The Socioeconomics of COVID and Lockdowns Outside Advanced Economies: The Case of Bogota

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ABSTRACT

Bogota is unique in recording and reporting the socioeconomic status of COVID-19 patients. As others in Latin America and Asia, the city imposed a blanket lockdown before contagion picked up in early 2020 and kept it in place for six months. We document that, during that period, being hospitalized or dying from COVID-19 was over eight times more likely for an individual in the lowest group of the socioeconomic classification, compared to one in the highest. We relate this to higher exposure to contagion, by presenting evidence that people at the bottom of this classification are: 1) Less likely to be in occupations fit for telework; 2) Disproportionately hit by the economic crisis; 3) Subject to more crowded environments; 4) Less likely to recognize a high risk of contagion. The pandemic has widened socioeconomic gaps, in one of the world's most unequal societies.

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INTRODUCTION

Researchers have followed with interest the differential incidence of COVID-19 and its impact among different socioeconomic groups in advanced economies. From the early stages of the crisis, they documented that people who live in poorer countries and neighborhoods in these countries were more likely to test positive or become seriously ill from the virus, as were people from disadvantaged racial origins (Adhikari et al. 2020; Magesh et al. 2021; Khan et al. 2022; de Lusignan et al. 2020; Williamson et al. 2020). Greater exposure to respiratory illness at these stages of the crisis was found for non-remote workers (Angelucci et al. 2020, for the US). Disadvantaged groups were also shown to be more exposed to the economic impacts of the crisis, with the inability to work remotely playing an important role (Adams-Prassl et al. 2020; Engzell et al. 2020; Davenport et al. 2020; Chang et al. 2020).

Inequality in the spread of COVID-19 and its impact is even more worrisome in less developed economies, typically also more unequal. We analyze the case of Bogota, Colombia's capital city, which is unique in having recorded directly the socioeconomic status of COVID-19 patients from the onset of the crisis. We focus on the early period of the crisis when the city (as the rest of Colombia) went through a strict lockdown that lasted for close to six months.

The Colombian strata classification of socioeconomic groups was used in the COVID-19 administrative data. The strata classification is widely used in the country to classify individuals along the socioeconomic dimensions, both in administrative datasets and surveys. We also take advantage of a number of these additional data sources.

In particular, after using the administrative data on COVID-19 patients to document that both hospitalizations and deaths were much more likely among individuals of low socioeconomic status, we use complementary data sources to show that the more serious presence of COVID-19 in these strata is consistent with their greater economic vulnerability rather than differential health access. We take advantage of the fact that the strata of individuals are recorded in the official household surveys (source for official employment statistics), administrative datasets on violations of sanitary measures, and surveys of attitudes and perceptions. Based on these sources, all representative of the city's population, we document that poorer individuals (i.e., those in lower socioeconomic strata) faced greater exposure to contagion as they were: 1) Less likely to be in occupations fit for remote work; 2) Likely disproportionately forced to work non-remotely because of being also disproportionately hit by the economic crisis; 3) Subject to more crowded environments; 4) Less likely to recognize a high risk of contagion.

Other researchers have analyzed inequalities associated with the COVID-19 crisis in Latin America, in general, focusing on the greater socioeconomic impacts of the crisis to those that were already disadvantaged. Some have documented differential economic impacts across socioeconomic groups or greater exposure due to inability to work remotely (Bottan et al. 2020; Delaporte and Peña 2020; Garrote-Sánchez et al. 2021). Others have modelled potential distributional consequences of the crisis based on differential exposure (Alfaro et al. 2020; Delaporte et al. 2020; Hevia et al. 2022; Lustig et al. 2020). In light of the expected negative distributional consequences, others have concentrated on policy options to address such consequences (Busso et al. 2020).

We add to these analyses by documenting the socioeconomic gap in the prevalence of serious COVID-19 cases in the region and its relationship to underlying socioeconomic conditions and economic effects of the crisis itself.[1] We do so in a descriptive manner, given the limitations of the data. This descriptive approach, however, allows us to document a wide variety of dimensions.

CONTEXT

Bogota is representative of main urban centers in middle-income countries, especially in Latin America (where urbanization is high and in levels similar to developed economies, almost reaching 80% of total population). Table 1 illustrates this fact comparing Bogota with three other large

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1   Using a Bogota sample of invited adults who were mostly over-exposed to the virus (taxi drivers, workers in delivery, first line health workers), Laajaj et al. (2021) also found that testing positive for the virus was most likely among those in lower socioeconomic strata.

cities in Latin America based on data from the respective official national household surveys. Bogota is in the middle of the group in terms of educational attainment, household income (PPP), and suitability of workers' occupations for remote work, with all these dimensions scoring badly by comparison to developed economies (Alfaro et al. 2020; IMF 2020). Informal labor, measured by the fraction of workers uncovered by labor regulation, is prevalent across these cities. Bogota displays the lowest informality rate of the group, but this is still a high 41 percent of the total employment, and it is combined with an unemployment rate on the high end (10.9%). The relatively poor economic and working environments of Latin American cities displayed in Table 1 imply high risks associated with the COVID-19 crisis, in terms of exposure to both the illness and the economic shocks associated with the pandemic.

	METROPOLITAN AREA OF			
	BOGOTA	BUENOS AIRES	LIMA	MEXICO CITY
Workers with some post-secondary education (% of total)	41.7	39.9	44.9	29.4
Median monthly labor earnings of the household (2019 USD PPP)	1,060	1,205	1,419	826
Informal employment (% of total employment)[1]	41.0	45.3	58.5	51.7
Unemployment rate (% of labor force)	10.9	11.0	6.2	4.9
Workers in occupations suitable for telework (% of total)[2]	32.3	29.9	35.5	36.0
Average age (years)	33.7	36.3	35.1	35.5
Population aged 65 and more (% of total)	9.2	14.1	11.4	11.7
Average size of a household (number of people)	3.1	3.0	3.8	3.5

Table 1 Socioeconomic characteristics: Bogotá vs. other large Latin American Cities, 2019.

Notes: The Table shows socioeconomic characteristics of Bogota and other metropolitan areas in Latin. America: Greater Buenos. Aires, Lima, and Mexico City, based on each country's household survey. Metropolitan areas are based on each survey's classification. (1) The definition of informality depends on the country. For Bogota, an informal worker is defined as a worker who is not contributing to the mandatory pension system. For Buenos. Aires, an informal worker is defined as a salaried worker who is not contributing to the pension system, is a non-profesional self-employed worker or is an unpaid worker. For Lima and Mexico City, the definition is based on the country's official measures of informality. (2) Occupations suitable for telework are obtained building concordances between the classification from Dingel and Neiman (2020) and each country's occupation classification. For each sub-major group in the country classification, we assign the share of US workers that are considered suitable for telework by Dingel and Neyman (2020). Source: Authors' calculations based on each country's household survey (GEIH for Colombia, EPH for. Argentina, EN.AHO for Peru, and ENOE for Mexico).

Although Latin American cities have young populations by comparison to cities in advanced economies, which attenuates COVID-19 related risks, households tend to have more members living in the same space. Bogota shares these characteristics, with mean age below 35 and average household size above 3 (compared to figures closer to 40 and 2.4 in North America and Europe).

Colombia registered its first COVID death on March 22, 2020, and went through a first wave of contagion between June 2020 and September 2020. The country imposed a long-lasting national level blanket lockdown on non-essential activities, which lasted from March 25, 2020 to the beginning of September 2020. This lockdown was similar in nature and duration to those in Argentina, Chile, and Peru. We concentrate in the period of this early lockdown.

Restrictions to mobility during the initial national lockdown were varied in nature. Stay-at-home orders stayed in place for the duration of the lockdown (May to September 2020) but exceptions changed over time. Grocery stores and other providers of essentials remained open for business, but different provisions were in place to keep low occupancy rates at these establishments. There were periods where the days or times of the day in which a person was allowed into a store depended on the last digit of his/her ID, and others in which the enabled times were gender-based. Gatherings of several people on the street were in general banned, as was alcohol consumption on the street. Masks were required. We take advantage of data regarding violations to these restrictions to characterize behavior by socioeconomic group.

By the time the initial national lockdown ended, on September 1, 2020, Colombia had recorded close to 391.1 COVID-19 deaths per one million inhabitants, well above Argentina's 195.6 but below the US 554, Mexico's 500 and South America's 574.9. To date (February 2022) all these countries record cumulative deaths in the range of 2,500–2,800 per million inhabitants.[2]

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2   Edouard et al (2020) Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/coronavirus' [Online Resource] Retrieved on February 22, 2022.

As has been the case for major cities in different countries, Bogota has recorded substantially higher COVID-19 deaths than the country as a whole. By September 1, 2020, the city had had close to 935.8 deaths per million inhabitants, compared to 391.1 for the country.[3] Throughout the pandemic, Bogota's normalized number of COVID-19 deaths have stood close to that of Buenos Aires, slightly below Mexico City, and substantially below Lima (Figure 1). During our period of analysis COVID-19 vaccines were still not available in any country.
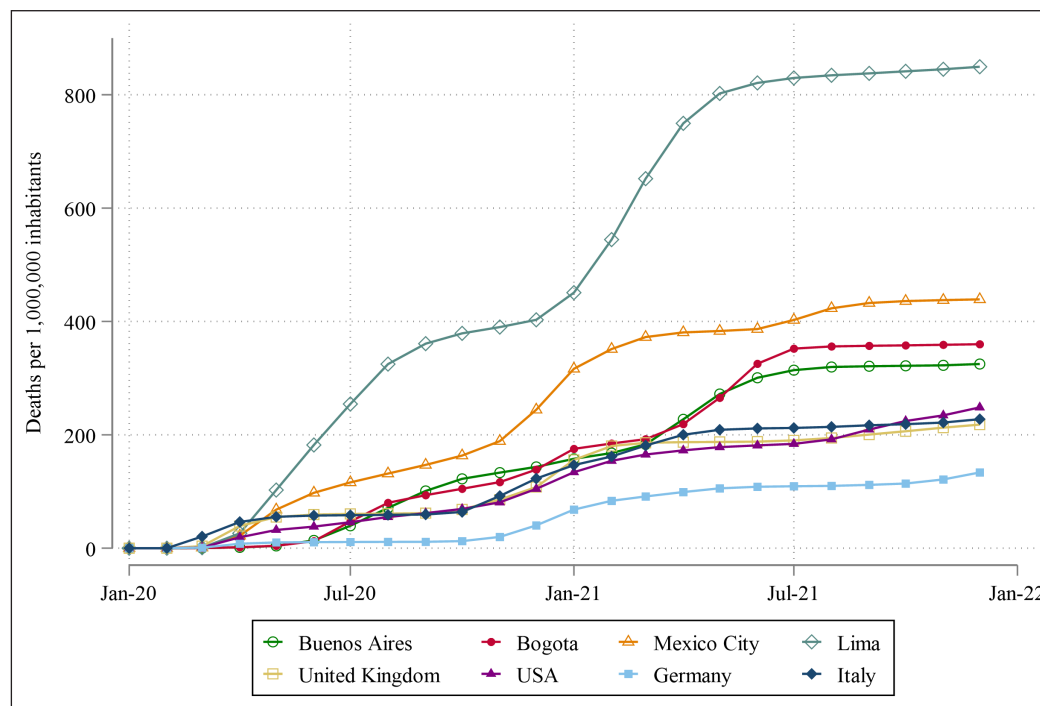
Figure 1 Cumulative number of deaths per one million inhabitants.

Source: Authors calculations based on data on cases from the Argentinian Ministry of Health, Colombian National Health Institute, Peruvian Ministry of Health, Mexican Ministry of Health, and Our World in Data. Population estimates taken from Household Surveys (Argentina, Colombia, Mexico, and Peru) and Our World in Data (United Kingdom, US, Germany, and Italy).

METHODS AND DATA

Our analysis is based on comparisons of how different socioeconomic groups in Bogota fared during the early lockdown period (March 2020 to September 2020) along the health and economic dimensions, and in behavioral terms. We take advantage of different data sources that share the characteristic of collecting individual level information and assigning individuals to socioeconomic groups according to the Colombian strata classification. These sources are all representative of the population of Bogota.

Because the different data sources we use cannot be inter-linked at the individual level, we use information that is aggregated by groups of the strata classification, or aggregate the individual information to this level in the case of sources for which we do have individual-level information, in particular the household survey (see below for detailed descriptions of the data we use). We then compare, for each of the outcome variables in our analysis, how the different socioeconomic groups performed. Our outcomes include: 1) COVID-19 hospitalizations and deaths; 2) Household size and age composition; 3) Labor market outcomes; 4) Compliance with pandemic-related restrictions; 5) Perceptions regarding COVID-19.

Since we have to work with data at the strata level, we are limited to comparing cross-strata patterns for each of these outcome dimensions. A decomposition of the contribution of each of these dimensions to the differential prevalence of serious illness is not possible with our data and approach, but the patterns we describe are crucial to understand the effects of the crisis and the stringent non-pharmaceutical interventions designed to deal with it at its onset. Subsequent policy analyses in modelling environments should be consistent with these sets of patterns, and some have already started to take some of them on board (e.g., Hevia et al. 2022).

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3   Edouard et al (2020). To date (February 2020) cumulative deaths in Bogota stand at close to 3,600 per million inhabitants, while the analogous figure for the country is 2,700.

While a fully linked individual level analysis would be desirable, our descriptive approach across a series of datasets allows us to overcome an important obstacle to the study of COVID-19 inequalities: administrative records of COVID-19 prevalence usually fail to record information on the socioeconomic status of the people affected. Studies for the early phase of the pandemic in developed economies have approached the differential prevalence of COVID-19 contagion or serious illness by focusing on gaps across geographical units and/or ethnic origins, which correlate with different underlying socioeconomic characteristics (e.g., Magesh et al. 2021). We take advantage of the direct socioeconomic classification used in the data for Bogota, and the fact that the same classification is used in a series of datasets that directly document other relevant dimensions of underlying economic characteristics and outcomes.

The strata system, which is the socioeconomic classification used in our analysis, was originally designed as a targeting tool for subsidies to water and energy consumption for low income households. The stratum is determined by the location of a person's residence, at the block level. It is widely used in Colombia to classify individuals in the socioeconomic dimension. Colombian residents know the strata that corresponds to their homes, and are frequently asked to report it in administrative datasets and surveys.

The system classifies blocks in residential areas according to the physical characteristics of dwellings, and assigns all homes in the block the same stratum. There are six categories, with stratum six corresponding to the most well-off blocks.

There is a positive association between strata and income groups, as illustrated in Figure 2, which supports the use of the strata as a proxy for socioeconomic groups. The association is not perfect, however, because of high inclusion errors in the low strata and an uneven distribution of households across strata (Figure 4 and Table 2). For instance, while households in strata 5 and 6 come almost exclusively from the top 40 percent, the lowest strata are a more mixed bag. Moreover, most households are concentrated in strata 2, 3, and (to a lesser extent) 1. Because of the large inclusion errors in the lower strata and the fact that most households are concentrated in the three lowest strata, the gaps between the low and high strata that we find are likely lower bounds for the true gaps between the individuals that are vulnerable and those that are well-off.
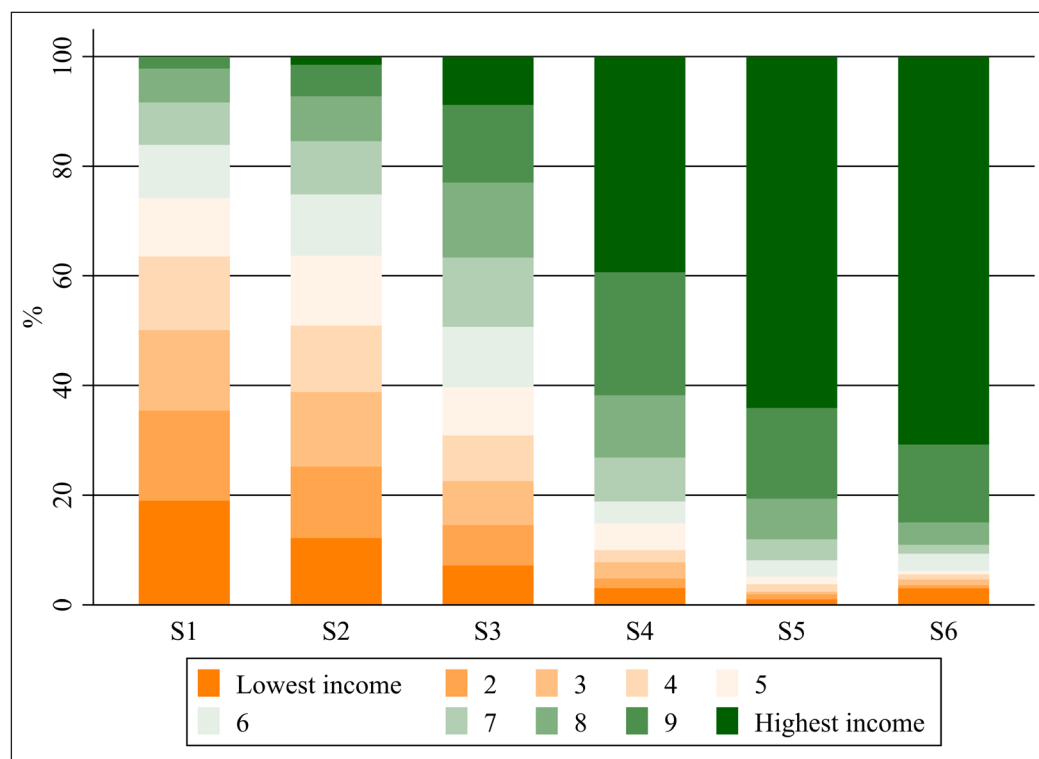

Figure 2 Correlation of deciles of household labor income and socioeconomic strata, Bogota (GEIH 2019).

Source: Own calculations based on National Household Survey (2019) data for Bogota.

While classifying individuals according to income, rather than strata, would probably deliver a more accurate picture of the unequal impacts of COVID-19, administrative records of COVID-19 prevalence do not record the income of the affected person. Bogota is unique in reporting COVID-19 incidence by socioeconomic groups using some sociceconomic classifications, in this case the strata system. Since strata are also recorded in a variety of datasources on income generation and behavior for Bogota, this fact allows us to match aggregate statistics along this variable and describe a variety of cross-strata patterns on COVID-19 related dimensions. Moreover, compared to income-based classifications, a person's stratum has the advantage of being predetermined for the vast majority of individuals and thus exogenous to the strong shocks of the period.

We now describe the data sources used for each set of outcomes that we analyze.

DATA ON COVID-19 DEATHS AND HOSPITALIZATIONS BY SOCIOECONOMIC GROUPS

These data come from Bogota's official Health Observatory, SALUDATA. The observatory reports COVID-19 deaths and hospitalization at specific points in time. Our focus is on the report for the second quarter of 2020, but we also report recent numbers for contrast. Unfortunately, SALUDATA stopped reporting hospitalization after the second quarter of 2020, so we can only keep track of COVID-19 deaths for the posterior period. The strength of this source of data is the fact that their reports discriminate COVID-19 outcomes by strata.

DATA ON EMPLOYMENT, INCOME, AND HOUSEHOLD COMPOSITION:

The data on economic shocks and household characteristics come from the National Household Survey (GEIH), the official source for labor market statistics. The GEIH is representative at the city level. Sample weights are provided to expand the survey to the whole population of the city. Table 2 presents basic descriptive statistics from the GEIH.

		MEAN	ST. DEV.	N (SAMPLE-WEIGHT-ADJUSTED)
Individual characteristics				
Gender (Male = 1)		0.48	0.50	8,264,019
Age		33.73	21.09	8,264,019
	All strata	9.36	5.32	7,949,489
	Stratum 1	7.08	4.50	1,006,121
	Stratum 2	8.26	4.76	3,406,461
Years of schooling	Stratum 3	10.25	5.20	2,676,493
	Stratum 4	13.66	5.35	522,682
	Stratum 5	13.35	6.19	145,772
	Stratum 6	14.14	6.04	175,691
Household characteristics (Totals)				
Household size		3.09	1.61	2,675,260
	All strata	2,296,383.00	3,562,733.00	2,675,260
	Stratum 1	1,243,194.00	992,488.70	305,532
	Stratum 2	1,543,917.00	1,454,298.00	1,100,169
Total labor income (current pesos)	Stratum 3	2,270,381.00	2,601,200.00	927,582
	Stratum 4	4,288,838.00	4,986,838.00	212,906
	Stratum 5	7,288,210.00	9,633,987.00	50,539
	Stratum 6	9,056,630.00	10,800,000.00	74,197

Table 2 Descriptive statistics.

Source: Own calculations based on National Household Survey (2019) data for Bogota.

We use the 2019 GEIH to characterize underlying socioeconomic characteristics of individuals in different strata, and some of their labor market outcomes during the 2020 lockdown period. We use information on households' pre-pandemic living conditions and age structure, as well as working conditions. Among the latter, we create a proxy for the individual's ability to work from home, based on Dingel and Neiman (2020). Our measure corresponds to the share of US workers that are considered suitable for telework in the occupational category of the individual (according to the GEIH's classification of occupations). To do this, we assign to each cateory in the GEIH's occupation classification the share of US workers that are considered suitable for telework in the same occupation group in the 2017 American Community Survey (ACS), following the definitions of Dingel and Neyman (2020).[4] We also use information on whether an individual lost his/her job during the lockdown period.

DATA ON VIOLATIONS TO SANITARY RESTRICTIONS IMPOSED DURING THE PANDEMIC

We use National Police data to report information on violations to sanitary restrictions imposed during the pandemic. This is an administrative dataset from the National Registry of Corrective Measures (RNMC for its acronym in Spanish) used by the National Police to record all fines imposed by the police due to violations to sanitary restrictions that were imposed during the strict lockdown period. These restrictions are described in Section "Context". The violations for which fines were imposed are: attending crowded meetings; failures to comply with stay-at-home orders; consuming alcohol in public spaces; violating rules on gender or ID numbers allowed to do a certain activity; not wearing a mask in public. Table 3 presents the number of fines imposed for each violation, by socioeconomic strata.

Table 3 Fine rates per 10,000 inhabitants by strata. Bogota, March 25, 2020 to September 1, 2020.

STRATUM	CROWDED MEETINGS	MANDATORY ISOLATION	ALCOHOL CONSUMPTION	GENDER RESTRICTION	ID RESTRICTION	WEAR-A-MASK ORDER	TOTAL
1	26.96	270.51	28.56	45.79	2.32	93.35	474.05
2	31.56	328.11	40.72	56.19	1.03	129.86	590.13
3	22.78	252.24	41.36	37.05	0.87	79.75	435.49
4	6.89	161.69	15.78	13.55	0.19	32.31	231.11
5	6.43	142.76	14.41	13.45	0.48	41.55	220.99
6	19.16	139.97	6.66	13.96	0.32	41.73	222.79

DATA ON HEALTH AND COVERAGE OF HEALTH SERVICES

We use the National Population Census of 2018 to measure the coverage of health services and pre-pandemic prevalence of health events. In particular, the Census asked citizens whether they experienced a given health event in the 30 days previous to the interview, with events categorized into illness, accident, dental emergency, or other. For those who experienced a health issue, the census asked whether they sought medical attention with healthcare specialists.

DATA ON ATTITUDES

To understand whether cognitive, informational, and cultural attributes shaping people's attitudes towards COVID-19 also differ across strata, we use data on the Citizenship Culture Survey conducted by Bogota Mayor's office. A total of 27.558 surveys were collected by phone and on

4   In particular, we first merge the information reported by Dingel and Neyman (2020) with the occupations reported in the ACS-2017, based on the SOC-10 classification. Next, we assign to each occupational category in the GEIH (ISCO-68 classification) the share of US workers that are considered suitable for telework by group. Given that the GEIH has a less granular classification than ACS-2017, we group the occupations in the US data intro larger categories that correspond to those in the Colombian data.

the streets in all localities or subdistricts of the city to monitor perceptions, opinions and attitudes by citizens when facing COVID-19 hardships.[5] During the first waves of the survey between March 2020 and April 2020, using a specialized survey company, they collected 8,536 responses based on a random sample stratified by locality (subdistrict), with a 95 percent of confidence. No factors of expansion were used in the data used here. These surveys included the following two questions we use in our analysis: "How likely it is that you get infected by COVID?" and "Do you think most people in the city will comply with the lockdown measures?"[6] Table 4 shows descriptive statistics for the data used.

SEX	PERCENT
Females	43.2
Men	56.2
No information	0.5
Age	
Less than 18	1.34
Between 18 to 25	2.55
Betwen 26 to 35	4.71
Between 36 to 45	3.35
Between 46 to 55	2.8
Between 56 to 65	2.33
More than 65	1.06
No information	83.17
Believe others will comply with lockdowns	
No	41.71
Yes	55.96
Did not answer	2.32
Believe will get infected by COVID	
Very likely	49.22
Rather unlikely	35.74
Not likely at all	12.34
Did not answer	2.7

Table 4 Descriptive statistics–Bogota's Citizenship Culture Survey.

Source: Citizenship Culture Survey.

We assigned subdistricts to strata based on information from the 2020 report by the Chamber of Commerce of Bogotá on numbers of blocks by strata and subdistricts. Because a stratum is defined at the block level, a locality has blocks belonging to more than one stratum. We compute the average stratum within a locality, weighted by the number of blocks in the locality. The average weighted strata for each subdistrict was obtained from the disaggregation by blocks reported in Table 5.

With the exception of Chapinero and Suba, subdistricts tend to be populated by relatively similar blocks in that most belong to two, sometimes three, contiguous strata.

5　The data were made publicly available online at https://bogota.gov.co/monitoreo-al-aislamiento-bogota.

6　"¿Qué tan probable es que usted se contagie de Coronavirus?" and "¿Usted cree que la mayoría de las personas en la ciudad van a cumplir con la medida de aislamiento?".

SUBDISTRICTS	NON REPORTED	STRATA 1	STRATA 2	STRATA 3	STRATA 4	STRATA 5	STRATA 6	TOTAL	WEIGHTED AVERAGE OF STRATA
Antonio Nariño	72	0	27	507	0	0	0	606	2.60
Barrios Unidos	145	0	0	791	269	26	0	1231	2.91
Bosa	286	348	2837	55	0	0	0	3526	1.75
Chapinero	145	102	141	58	208	130	338	1122	3.63
Ciudad Bolivar	689	3676	1156	105	0	0	0	5626	1.12
Engativá	605	36	1079	2519	142	0	0	4381	2.36
Fontibón	368	2	267	750	290	14	0	1691	2.37
Kennedy	550	64	2398	185	37	0	0	3234	1.72
La Calendaria	60	3	83	46	0	0	0	192	1.60
Los Márties	98	0	53	571	4	0	0	726	2.53
Puente Aranda	418	0	8	1453	0	0	0	1879	2.33
Rafael Uribe Uribe	328	414	1184	848	0	0	0	2774	1.92
San Cristobal	371	218	215	277	0	0	0	1081	1.37
Santa Fe	102	64	438	148	38	0	0	790	1.94
Suba	497	28	2153	1105	444	504	122	4853	2.61
Teusaquillo	151	0	0	137	688	50	0	1026	3.33
Tunjuelito	77	3	540	277	0	0	0	897	2.13
Usaquén	296	122	293	524	339	309	408	2291	3.33
Usme	585	1863	1127	0	0	0	0	3575	1.15

RESULTS

COVID-19 PREVALENCE AND DIRECT HEALTH RISK

Figure 3 shows cumulative numbers of COVID-19 hospitalizations and deaths by strata during the 2020 lockdown period. Both deaths and hospitalizations per capita decreased as the stratum increased. For instance, by July 2020 an individual in stratum one was 8.2 times more likely to have been hospitalized and 9 times more likely to have died from the virus than an individual in stratum six (Figure 3).[7] As noted, these already stark differences are likely lower bounds for the true gaps between the lowest and highest layers of the income distribution, because while a stratum six individual is surely a high income person, one in stratum one or two has a non-negligible probability of having relatively high income (see Figure 2 and the discussion around it).

The fact that there are stark gaps in deaths per capita between the low and high strata has persisted, although the magnitude of these gaps has diminished as the spread of COVID-19 has widened and touched the vast majority of the population. By November 2021 the number of COVID-19 deaths per capita was still 4.3 times larger among stratum one individuals compared to those in stratum six (Figure 3).

These gaps in serious COVID-19 outcomes between socioeconomic groups cannot be attributed to a worse age selection in the low strata. In fact, the elderly—who are at higher risk of serious COVID-19 outcomes—represent a much higher fraction of households' members in higher strata. While in strata 4–6 over 15 percent of the members of a household are aged over 65, the fraction falls to 11.4 percent in stratum 3, 8.7 percent in stratum 2, and 7 percent in stratum 1 (Figure 4).

Differences in access to healthcare and healthcare quality do not seem to be the underlying cause for gaps in COVID-19 deaths either. The relative rate at which individuals in lower strata are hospitalized for COVID-19, compared to people in higher strata, is similar to their relative fatality probability due to COVID-19 (Figure 3). This suggests that the quality of attention while at the hospital is similar. Moreover, according to data from the 2018 Census and consistent with the fact that Colombia has almost universal health insurance, in Census data individuals in the lower socioeconomic segments do not report higher prevalence of health issues or receive less

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7   By July 2020, the overall number of deaths per 100,000 inhabitants in Bogota was 47.1.

healthcare than individuals in higher segments. In fact, contingent on having suffered a health event, individuals in all strata report a probability of over 95 percent of having received health attention if they suffered a health issue (Figure 5). Additionally individuals in strata 1–2 are as likely as those in strata 5–6 to report the occurrence of a health problem.
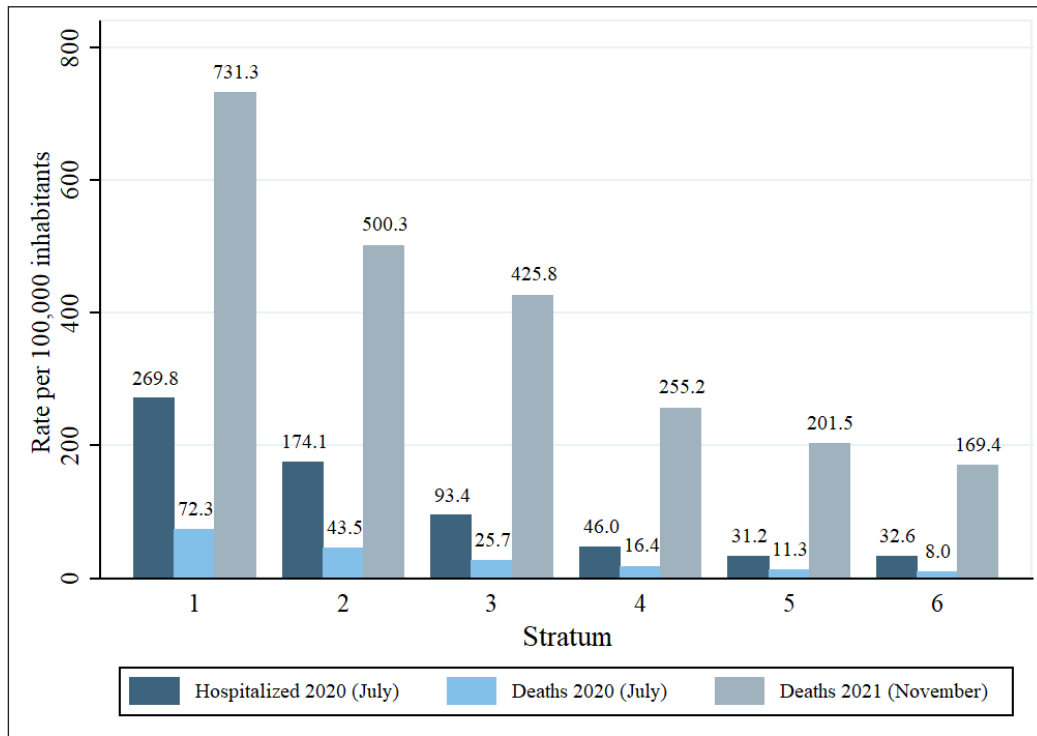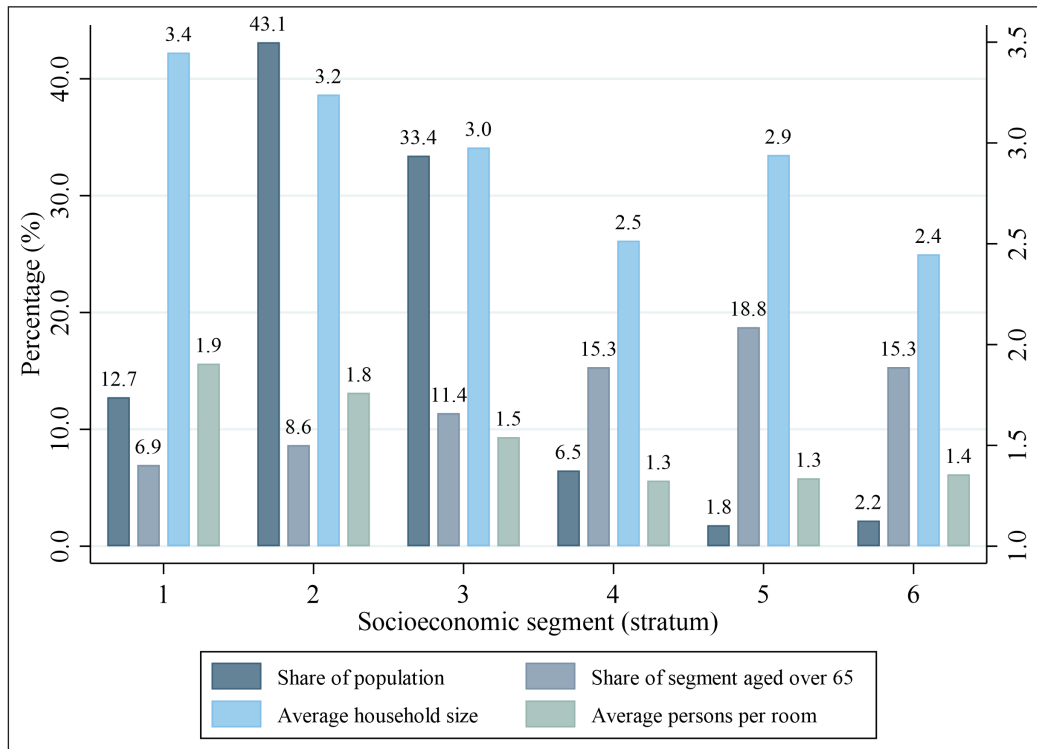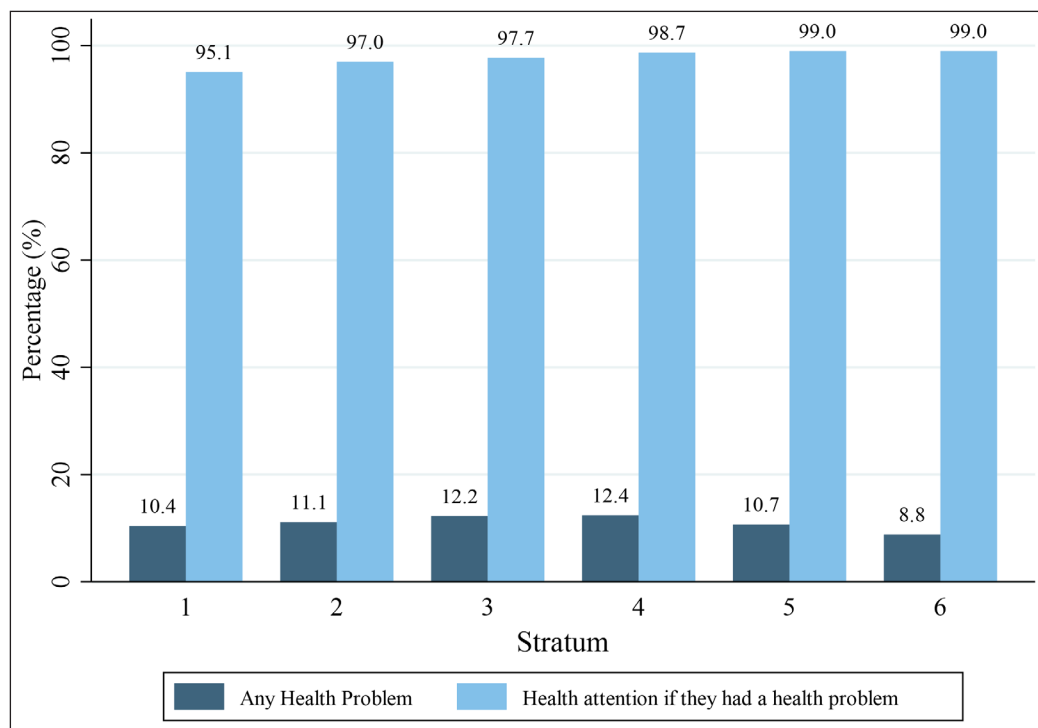
Figure 5 Fraction of people in Bogotá in 2018 who report having had, in the last 30 days.

Source: 2018 Population Census.

SOCIOECONOMIC CORRELATES

The presence of large gaps between low and high strata in the numbers of COVID-19 deaths and hospitalizations per capita, in a context where the underlying health conditions and age structure do not play an obvious negative role for the lower strata, suggest that the probability of COVID-19 infection is higher among poorer individuals compared to richer ones in similar age groups. We now explore whether the data are consistent with the hypothesis that socioeconomic conditions may themselves explain higher contagion in more vulnerable groups. We do it in the same descriptive fashion that we used in the previous section, that is, describing differences across strata.

Lower strata households are indeed exposed to more crowded environments, offering higher risk of in-home contagion (Chang et al. 2020). In Bogota, the average stratum 1 household has 3.4 members, compared 2.4 members on average in stratum 6 (Figure 4). The average number of people sleeping in a room in a household is also higher in stratum 1 (1.9 persons per room) than in strata 4–6 (about 1.33 persons per room).

Moreover, sheltering at home for protection from contagion requires a guaranteed livelihood, either because one can work from home, is covered by employment protection or social insurance, or can rely on savings. These conditions are ex ante less likely for people in Bogota's lower socioeconomic strata, as shown in Figure 6 for 2019 (i.e., before the pandemic hit). Among these groups, occupations not fit for telework are more prevalent, as are unemployment and informality, which also implies lack of social insurance (except for health) and of access to employment protection. In particular, Figure 6 indicates that people in Bogota's stratum 1 are more than twice as likely to be in an occupation not fit for working remotely as are people in strata 4–6. Not paying mandatory pension contributions (a common measure of labor informality) is four to five times more likely, and unemployment three times more likely in stratum 1 compared to stratum 6.

Not only were employment and income risks more prevalent in lower strata before the pandemic, but these groups were also, ex-post, more affected by the crisis during the lockdown period. We show that this is the case for employment outcomes. Methodological adjustments in the National Household Survey (GEIH) over the first months of the crisis make it impossible to directly classify employment outcomes losses by socioeconomic strata, because the strata field was not recorded during those initial months. However, it is possible to characterize differences in unemployment by education levels, which are highly correlated with strata. We show this in Figure 7. Among the unemployed, while in normal times (i.e., 2019) the probability that the employment loss occurred

recently is not higher for people with lowest vs. highest education (about 37% for both groups), in the first months of the crisis those with primary and secondary education were 16 percentage points more likely to have lost their job recently than those with higher education (83% versus 67%; Figure 7).
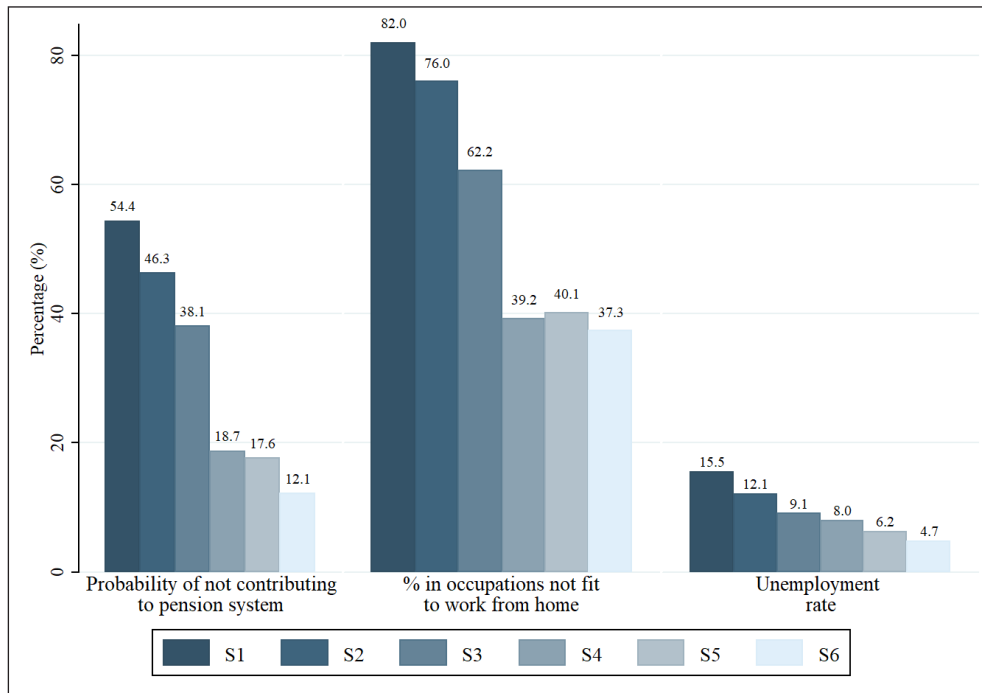

Figure 6 Underlying working conditions. Bogota 2019.

Source: Own calculations based on data from National Household Survey 2019.
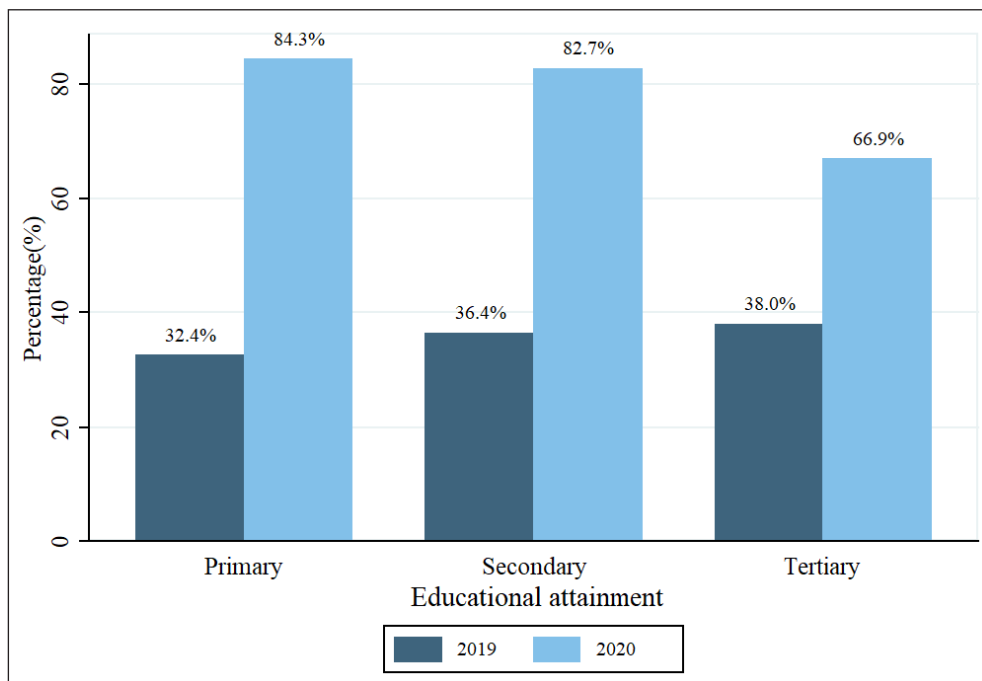

Figure 7 Fraction of unemployed people who lost their employment less than 12 weeks ago, May 2019 and May 2020, Bogota.

Source: Own calculations based on data from National Household Survey 2019.

Consistent with the hypothesis that economic hardship forced individuals in more vulnerable socioeconomic groups to expose themselves more to contagion, Figure 8 shows how the sanctions for not complying with sanitary regulations and restrictions were more prevalent among the lowest socioeconomic segments during the period of lockdown. The probability of being fined for violations to these regulations over the period of the strict lockdown (March 25, 2020 through September 1, 2020) was over three times as high in street blocks classified in strata 1–3 compared to those in strata 4–6 (Figure 8A). This holds also individually for specific violations to stay-at-home orders. Recidivism (recurrence of these violations) is also more likely in low strata neighborhoods (Figure 8B).
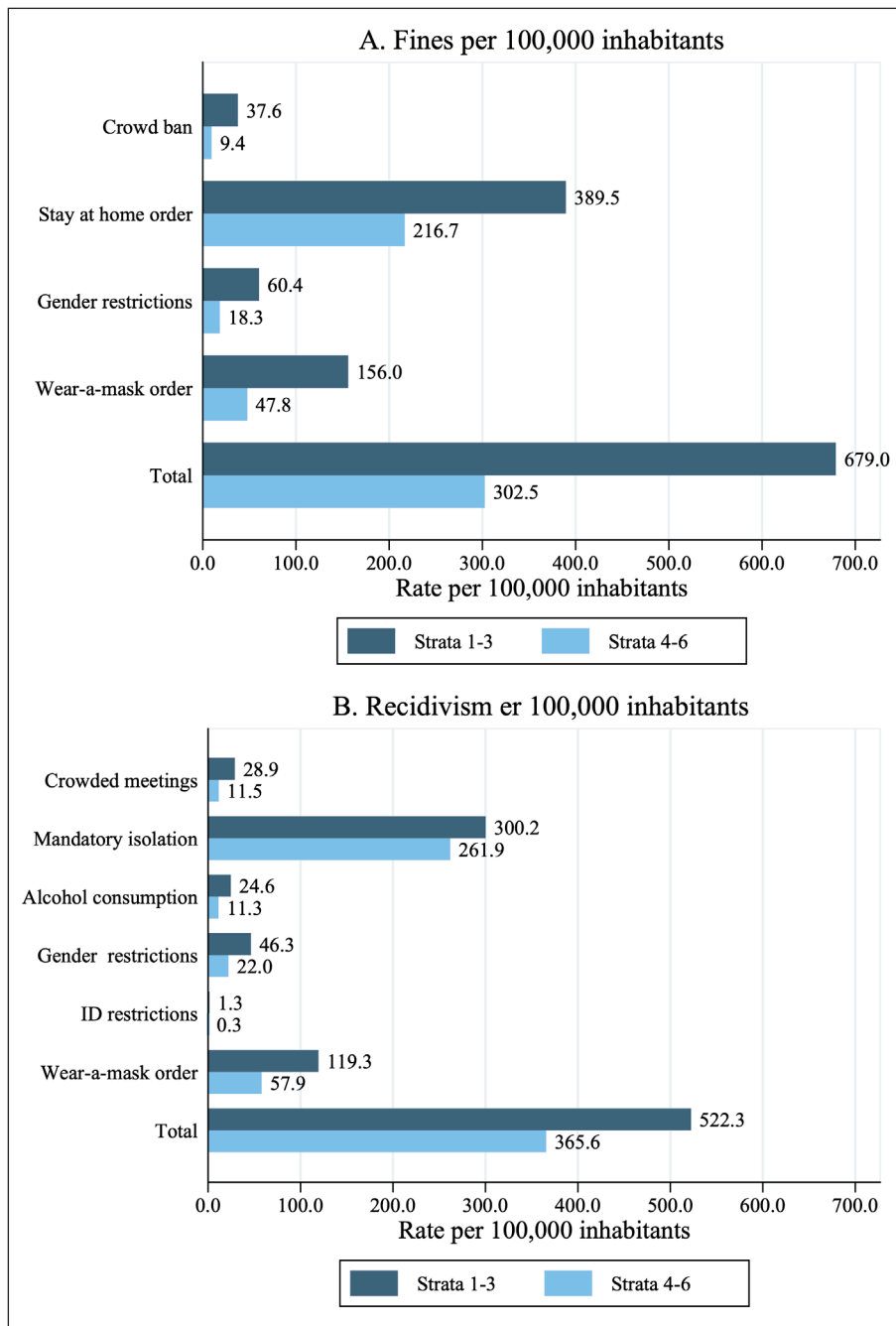
A. Fines per 100,000 inhabitants

Category	Strata 1-3	Strata 4-6
Crowd ban	37.6	9.4
Stay at home order	389.5	216.7
Gender restrictions	60.4	18.3
Wear-a-mask order	156.0	47.8
Total	679.0	302.5

Rate per 100,000 inhabitants

B. Recidivism er 100,000 inhabitants

Category	Strata 1-3	Strata 4-6
Crowded meetings	28.9	11.5
Mandatory isolation	300.2	261.9
Alcohol consumption	24.6	11.3
Gender restrictions	46.3	22.0
ID restrictions	1.3	0.3
Wear-a-mask order	119.3	57.9
Total	522.3	365.6

Rate per 100,000 inhabitants

Figure 8 Compliance with COVID sanitary regulations by strata. Bogota.

Notes: Violations for which fines were imposed are: attending crowded meetings (gatherings of many people); mandatory isolation (failures to comply compliance with the stay-at-home orders); consuming alcohol in public spaces; violating rules on gender and or ID numbers allowed to do a certain activity; restrictions to go out in specific days of the week and the order to not wearing a mask in public.

Source: Own calculations based on data from National Police.

Though greater hardship in low strata neighborhoods seems to partly explain the higher prevalence of fines and recidivism, it is interesting that sanctions for not wearing a mask were also more likely in lower strata neighborhoods, despite a facemask's low cost. It is therefore difficult to explain all these behaviors as originating solely in economic hardship and a consequent inability to comply in lower strata. A complementary hypothesis is that individuals in lower strata neighborhoods may also differ in average cognitive, informational, and cultural attributes, in a way that partly explains these behaviors. Figure 9A, where each dot represents a city subdistrict (among the 19 subdistricts in the city), shows that individuals in lower strata subdistricts report a lower perceived probability of becoming infected with COVID-19. This could be explained by either lack of information or psychological mechanisms, being cognitive dissonance a main suspect. By reporting and perceiving a lower probability of contagion one can go out to work reducing the cognitive costs of self-inconsistency. Lower strata also display lower levels of education which could also explain less access to reliable sources on the risks associated with the virus. Unfortunately, the Mayor's office survey did not collect the educational level of the respondents, but the correlation between strata and education levels and educational infrastructure by strata is strong. These data are consistent also with the *COVID-19 Beliefs, Behaviors & Norms Survey*

(MIT 2021) which collected data from August 2020 until February 2021 for several countries around the world. While the world sample average, showed a 6.37 percent of respondents evaluating the risk to their community as "not at all dangerous" and 14.09 percent as "slightly dangerous," those same numbers for Colombia were of 2.39 percent and 6.64 percent respectively.

Further, people in lower strata neighborhoods also have the perception that people around them are less likely to comply with lockdown measures (Figure 9B). Such reporting could imply a lower expected cost from social sanctioning by peers, implying higher personal and social licenses to expose to the virus out of homes. This is consistent with the reported data on fines imposed to low vs high strata groups reported before.
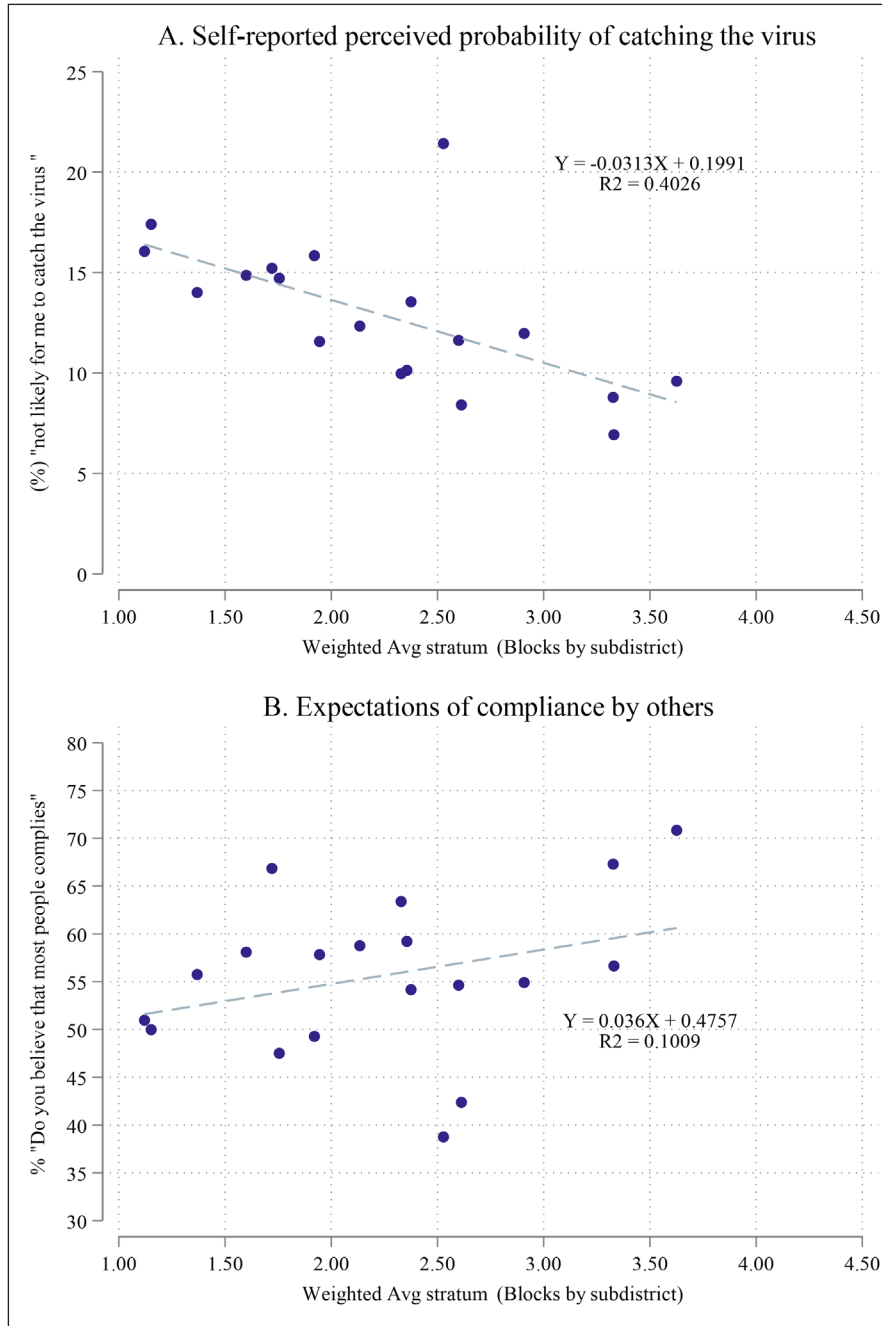
A. Self-reported perceived probability of catching the virus

$Y = -0.0313X + 0.1991$
$R2 = 0.4026$

(%) "not likely for me to catch the virus "

Weighted Avg stratum (Blocks by subdistrict)

B. Expectations of compliance by others

$Y = 0.036X + 0.4757$
$R2 = 0.1009$

% "Do you believe that most people complies"

Weighted Avg stratum (Blocks by subdistrict)

Access to education, subjective perceptions and psychological biases can create a cognitive poverty trap in which the more vulnerable groups construct an idea of lower probability of infection, while perceiving a lower rate of compliance by others. Economic hardship would be just one more layer of a larger economic cost for the poor, creating a vicious regressive cycle that generates the epidemiological results reported earlier.

FINAL REMARKS

For some time now, experts in the natural and health sciences have been warning society about the increase in the probabilities of pandemic events due to zoonotic causes just as SARS-CoV-2. More than 1,400 pathogens have been identified that cause diseases in humans, and two thirds of them live in non-human vertebrates (Molyneux et al. 2008). These ecosystem equilibria are being threatened by human forces pushing their frontiers into natural areas to expand agricultural activities, use of animal species for domestication, and consumption or land speculation. It is not unlikely that the planet will face far-reaching health crises at an increasing pace. Understanding the implications of the COVID-19 pandemic and the measures imposed to deal with it is crucial facing forward.

We have provided evidence that the complexity of economic, cultural, social determinants of exposure, and the impact of a pandemic such as this one has a rather regressive dynamic and that provides results that policy makers should not ignore in designing policy responses. The concentration of population in mega cities, such as Bogota, increases the demand for food, creates a riskier environment for the contagion of infectious diseases, while also including challenges regarding socio-economic forces that spread the vulnerabilities in a rather unequal manner as we have discussed in this text. The risks of future pandemic events grow and so the concern for how we adapt and attempt to disrupt in the least possible manner those equilibria in the human-environment relationships. Larger and more unequal cities such as Bogotá will have, therefore, larger fractions of the population exposed to the harms presented here. Our results highlight the need to work on multiple levels of the policy arena including information distribution, police enforcement, health provision, and social security attention with a special attention to the preexisting inequalities. They also warn that the high costs of extreme measures are not evenly distributed, less so in countries where economic activity and income distribution are poor to begin with. Policy makers in these countries must be especially careful in adopting such policies.

COMPETING INTERESTS

The authors have no competing interests to declare.

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REFERENCES

Adams-Prassl, Abi, Teodora Boneva, Marta Golin, and Christopher Rauh. 2020. "Inequality in the Impact of the Coronavirus Shock: Evidence from Real Time Surveys." *IZA Discussion Papers No. 13183*. Bonn: Institute of Labor Economics (IZA). DOI: https://doi.org/10.2139/ssrn.3594017

Adhikari, Samrachana, Nicholas Pantaleo, Justin M. Feldman, Olugbenga Ogedegbe, Lorna Thorpe, and Andrea B. Troxel. 2020. "Assessment of Community-Level Disparities in Coronavirus Disease 2019 (COVID-19) Infections and Deaths in Large US Metropolitan Areas." *JAMA Netw Open* 3(7): e2016938. PMID: 32721027. DOI: https://doi.org/10.1001/jamanetworkopen.2020.16938

Alfaro, Laura, Oscar Becerra, and Marcela Eslava. 2020. "EMEs and COVID-19: Shutting Down in a World of Informal and Tiny Firms." *NBER Working paper 27360*. DOI: https://doi.org/10.3386/w27360

Angelucci, Manuela, Marco Angrisani, Daniel M. Bennett, Arie Kepteyn, and Simone G. Schaner. 2020. "Work and the Heterogeneous Impact of COVID-19 on Employment and Health." *NBER Working Paper 27749*. DOI: https://doi.org/10.3386/w27749

Bottan, Nicolas, Bridget Hoffmann, and **Diego Vera-Cossio.** 2020. "The unequal impact of the coronavirus pandemic: Evidence from seventeen developing countries." *PloS one* 15(10): e0239797. DOI: https://doi.org/10.1371/journal.pone.0239797

Busso, Matias, Juanita Camacho, Julián Messina, and **Guadalupe Montenegro.** 2020. "The challenge of protecting informal households during the COVID-19 pandemic: Evidence from Latin America." *Covid Economics* 1(27): 48–73. DOI: https://doi.org/10.18235/0002388

Chang, Serina, Emma Pierson, Pang Wei Koh, Jaline Gerardin, Beth Redbird, David Grusky, and **Jure Leskovec.** 2021. "Mobility network models of COVID-19 explain inequities and inform reopening." *Nature*, 589: 82–87. DOI: https://doi.org/10.1038/s41586-020-2923-3

Davenport, Alex, Robert Joyce, Imran Rasul, and **Tom Waters.** 2020. "Spending and saving during the COVID-19 crisis: evidence from bank account data [Internet]." *Institute for Fiscal Studies Report*;. Available from: https://www.ifs.org.uk/publications/15146.

de Lusignan, Simon, Jienchi Dorward, Ana Correa, Nicholas Jones, Oluwafunmi Akinyemi, Gayatri Amirthalingam, Nick Andrews, et al. 2020. "Risk factors for SARS-CoV-2 among patients in the Oxford Royal College of General Practitioners Research and Surveillance Centre primary care network: a cross-sectional study." *The Lancet Infectious Diseases* 20(9): 1034–1042. DOI: https://doi.org/10.1016/S1473-3099(20)30371-6

Delaporte, Isaure, and **Werner Pena.** 2020. "Working From Home Under COVID-19: Who Is Affected? Evidence From Latin American and Caribbean Countries" *GLO Discussion Paper No. 528.* Essen: Global Labor Organization (GLO).

Dingel, Jonathan I., and **Brent Neiman.** 2020. "How many jobs can be done at home?." *Journal of Public Economics* 189: 104235. DOI: https://doi.org/10.1016/j.jpubeco.2020.104235

Edouard, Mathieu, Hannah Ritchie, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Joe Hasell, Bobbie Macdonald, et al. 2020. "Coronavirus Pandemic (COVID-19)". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/coronavirus' [Online Resource].

Engzell, P., A Frey, and **MD Verhagen.** 2020. "Learning Inequality During the COVID-19 Pandemic." SocArXiv. osf.io/preprints/socarxiv/ve4z7

Garrote Sanchez, Daniel, Nicolas Gomez Parra, Caglar Ozden, Bob Rijkers, Mariana Viollaz, and **Hernan Winkler.** 2021. Who on Earth Can Work from Home? *The World Bank Research Observer* 36(1): 67–100, DOI: https://doi.org/10.1093/wbro/lkab002

Hevia, Constantino, Manuel Macera, and **Pablo Andrés Neumeyer.** 2022. "Covid-19 in unequal societies." *Journal of Economic Dynamics and Control* 140: 104328. DOI: https://doi.org/10.1016/j.jedc.2022.104328

IMF, Western Hemisphere Division. 2020. "Latin American labor markets during COVID 19." Background paper for the Regional Economic Outlook. https://www.imf.org/~/media/Files/Publications/REO/WHD/2020/Oct/English/Labor.ashx?la=en.

Khan, Sadiya, Amy E. Krefman, Megan E. McCabe, Lucia C. Petito, Xiaoyun Yang, Kiarri N. Kershaw, Lindsay R. Pool, and **Norrina B. Allen.** 2022. "Association between county-level risk groups and COVID-19 outcomes in the United States: a socioecological study." *BMC public health* 22(1): 1–9. DOI: https://doi.org/10.1186/s12889-021-12469-y

Laajaj, Rachid, Camilo De Los Rios, Ignacio Sarmiento-Barbieri, Danilo Aristizabal, Eduardo Behrentz, Raquel Bernal, Giancarlo Buitrago, et al. 2021. "COVID-19 spread, detection, and dynamics in Bogota, Colombia." *Nature Communications* 12(1): 1–8. DOI: https://doi.org/10.1038/s41467-021-25038-z

Lustig, Nora, Valentina Martinez Pabon, Federico Sanz, and **Stephen D. Younger.** 2020. "The Impact of COVID-19 Lockdowns and Expanded Social Assistance on Inequality, Poverty and Mobility in Argentina, Brazil, Colombia and Mexico." *CGD Working Paper 556*. Washington, DC: Center for Global Development.

Magesh, Shruti, Daniel John, Wei Tse Li, Yuxiang Li, Aidan Mattingly, Sharad Jain, Eric Y. Chang, and **Weg M. Ongkeko.** 2021. "Disparities in COVID-19 outcomes by race, ethnicity, and socioeconomic status: a systematic-review and meta-analysis." *JAMA network open* 4(11): e2134147–e2134147. DOI: https://doi.org/10.1001/jamanetworkopen.2021.34147

MIT. 2021. "COVID-19 Beliefs, Behaviors & Norms Survey." Accessed: 07-2021 https://covidsurvey.mit.edu/index.html.

Molyneux, David H. 2008. "Ecosystem disturbance, biodiversity loss, and human infectious disease." *Sustaining life, how human health depends on biodiversity*, 287–323.

Williamson, Elizabeth J., Alex J. Walker, Krishnan Bhaskaran, Seb Bacon, Chris Bates, Caroline E. Morton, Helen J. Curtis, et al. 2020. "Factors associated with COVID-19-related death using OpenSAFELY." *Nature* 584(7821): 430–436. PMID: 32640463. DOI: https://doi.org/10.1038/s41586-020-2521-4

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