

1 **COVID-19, activity and mobility patterns in Bogotá. Are we ready for a ‘15-**
2 **minute city’?**

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15 **Abstract**

16 Social distancing and economic lockdown measures implemented in Global North countries
17 have been mimicked in the Global South to contain the spread of COVID-19. However, the
18 consequences of such measures on activity and mobility patterns among social groups in
19 Global South cities remain unclear. This paper seeks to provide reliable evidence from
20 changes in behaviors across income groups at the urban scale. We report a detailed
21 analysis from a web-based survey to understand the effects of the early and complete
22 lockdown adopted to contain the COVID-19 spread on activity and travel patterns in Bogotá.
23 We also performed a geographical proximity analysis of non-work services and facilities
24 located around surveyed households to challenge the rhetoric about the ‘15-minute’ city. We
25 found that low-income people are more socially exposed to contagion being forced to go out
26 to find their daily sustenance and having adverse economic and travel effects than other
27 income groups. However, even though Bogotá is not so far from meeting the goal of 15

28 minutes proximity, particularly for non-work-related activities, we found marked inequalities
29 among income groups regarding access to essential services in proximity. The paper's
30 findings serve as a reminder that travel behavior and accessibility are not the remit of only
31 urban transport planning and that land-use and urban planning play a determining role in
32 redressing social and spatial inequalities in a city.

33 Keywords: COVID-19; travel patterns; activity location; 15-minute city; Bogotá.

DRAFT UNDER REVIEW

34 **1. Introduction**

35 The global outbreak of the coronavirus COVID-19 has brought cities to a standstill in a matter
36 of months, imposing social distancing using isolation measures enforced by national and
37 local governments worldwide. Such measures have produced meaningful changes in the
38 world's urban population's daily activity and mobility patterns, causing differentiated and
39 frequently regressive effects, particularly in Global South cities. Social distancing and
40 measures to control local outbreaks are likely to deepen already large social gaps between
41 the poor and the rest of society in contexts dealing with acute poverty, lack of basic
42 connectivity to material and digital infrastructures, and limited access to formal livelihoods,
43 social security and safety nets (Renahy et al., 2018; Roelfs et al., 2011). Under such
44 conditions, it is not surprising that pandemic-related isolation force, a large share of low-
45 income citizens to engage in physical travel and exposure to contagion to maintain their
46 livelihoods and access to essential goods and services.

47 The international literature about the social and transport equality effects of the pandemic
48 has evolved rapidly, with an accent on Global North realities and those contexts where the
49 spread of the virus took place earlier (Cash and Patel, 2020; Sohrabi et al., 2020; Tsai and
50 Wilson, 2020). Among such recent literature, a relevant area for research has been the
51 observed changes in lifestyle behaviors in response to the pandemic and its associated
52 measures (Balanzá-Martínez et al., 2020). Many authors point to behavioral and social
53 sciences' role in addressing such changes to inform decisions in the short and medium term
54 (van Bavel et al., 2020). In this line, this paper recognizes that structural-demographic,
55 social, and economic differences set apart the challenges for understanding the effects of
56 the current crisis on behaviors in cities in the Global South compared to their Global North

57 counterparts. Spatial, functional and social characteristics typical of cities in Latin America
58 (Jauregui-Fung et al., 2019; Roberts et al., 2017) are likely to entail marked inequalities in
59 the social costs and benefits of isolation measures and social distancing. In the lowest-
60 income segment of the population, food insecurity and unemployment are suggested as
61 significant concerns in the face of restricted mobility and the incapacity to adapt to remote
62 working (Power et al., 2020; Roelfs et al., 2011).

63 Social distancing measures implemented in China, North America and Europe have been
64 mimicked in Global South cities responding to a rapidly evolving local crisis. However, in
65 countries without a robust social protection infrastructure, efforts to provide access to food,
66 protection of livelihoods, and social assistance to vulnerable populations pose a challenge
67 to already stretched public human and financial resources. With COVID-19's near-
68 ubiquitous presence across the globe, the consequences of social distancing and economic
69 shutdowns for the urban poor and socially vulnerable groups remain unclear (Barnett-Howell
70 and Mobarak Mushfiq, 2020). Available evidence suggests that social distancing benefits
71 are likely to be more limited and unequally distributed in low- and medium-income countries.
72 Moreover, the costs of economic shutdowns will pose challenges for precarious employment
73 and informal economies, as suggested by initial international reports (ILO, 2020). On the
74 other hand, overcrowding in public transport systems has been pointed at as a high-risk
75 factor in spreading COVID-19 (Sohrabi et al., 2020; Yang et al., 2020), with many public
76 transport authorities suspending or restricting services across the globe. Nevertheless, no
77 evidence was found of an additional effect of public transport closure when the physical
78 distancing measures were in place (Islam et al., 2020).

79 In Latin America, one of the unequal regions on the planet, labor informality of 53% implies
80 that nearly 140 million workers are in precarious employment (Salazar-Xirinachs and
81 Chacaltana, 2018). Many of these citizens do not have access to sick leave or
82 unemployment benefits and face inadequate healthcare system access. Such conditions
83 are no different in Colombia. In Bogotá, a highly segregated city responsible for 32% of the
84 country's GDP, nearly half of the labor market operates in the informal economy (42%)
85 (Guzman et al., 2017a).

86 Moreover, individuals faced isolation from family and friends and mental and physical health
87 problems. Even during this third and fourth epidemic peak, extending this policy seems
88 challenging even in the short term, rendering expectations of the situation lasting until the
89 widespread application of a vaccine unfeasible. Moreover, local press and anecdotal
90 evidence reflect large gaps between rich and poor in the city, sparking renewed debates
91 about how urban environments should be adapted to coexist with public health emergencies.

92 This paper seeks to provide reliable evidence from changes in behaviors across different
93 income groups at the urban scale during April and May 2020, caused by the mandatory
94 lockdown policies issued in Bogotá. We report an analysis of the COVID-19 effects on
95 activity and travel patterns resulting from a web-based survey distributed through social
96 media and other digital channels to capture geo-located quantitative and qualitative
97 information about individuals and their households. Seeking to reflect more structurally
98 about the changes brought up by the pandemic, our paper develops a spatial analysis that
99 questions whether the urban structure of a city such as Bogotá is ready to accommodate
100 the needs for local access and reduced mass mobility suggested by earlier publications
101 (Musselwhite et al., 2020) and which in the practice of urban transport policy and planning

102 has been informally addressed as the “15-minutes city”. Such vision of the city has as its
103 primary objective to provide access to essential opportunities within a walkable distance
104 around households, ensuring sustainable mobility and development.

105 **2. Background**

106 The social consequences of high rates of informal and often precarious employment in cities
107 in the Global South are compounded by high population densities and rapid urbanization
108 rates. Such consequences are particularly relevant for Latin American cities, where around
109 80% of the inhabitants in the region living in urban areas (Roberts et al., 2017).
110 Socioeconomic geographies in these cities are marked by spatial segregation driven by
111 differences in income, class and ethnicity, which also correlates with inequalities in access
112 to housing, infrastructure and local amenities. Almost a quarter of the population lives in
113 dense informal settlements (Inostroza, 2017). Moreover, the spatial concentration of
114 economic activities and the land value in a handful, often central areas coupled with
115 demographic increases contribute to the increase of the low-income population in the urban
116 peripheries. Overall, the urban structure of cities in Latin America leads to disproportionately
117 high travel times for a population that relies mostly on active modes and public transport
118 (68% see Estupiñan et al., 2018).

119 The Colombian National Government imposed a complete lockdown of population centers
120 from March 20, 2020, reducing all travel except for healthcare and other key workers.
121 Despite the lack of local evidence supporting such policies, Colombian national authorities
122 issued a decree on April 15, 2020, limiting public transport supply by reducing operating
123 fleets and capping occupation of public transport vehicles at 35%. From September 2020

124 the limitation will be 50%. This decision negatively affects mostly the low-income segment
125 of the population by lengthening their travel times due to the decrease in frequencies while
126 increasing congestion and social tensions in and around bus stops across the country
127 (Arellana et al., 2020). Despite the good intentions of the policy, perverse incentives
128 encouraging the use of private transport in the medium and long-terms are likely to ensue.
129 Notably, the promotion of the use of private motorcycles with its associated negative
130 externalities, which has been experienced in recent years in Colombia (Guzman et al.,
131 2020b) in correlation with observable decreases in public transport quality and availability in
132 some parts of the country (Hagen et al., 2016; Kopp, 2011) is worrying.

133 In addition to this, the rapid advance of climate change and the risk of contagion creates the
134 essential need to modify mobility habits in cities (Bashir et al., 2020; Nordbakke and Olsen,
135 2019; van Wee et al., 2019), as well as long-term transformations in the distribution of urban
136 land (Carter, 2018). It is time to consider urban transport, in all its dimensions, as an issue
137 of justice not only in urban areas. Lower-income populations often maintain strong ties with
138 home regions (Wilkinson et al., 2020). Thus, the mobility patterns, including urban-peri-
139 urban-rural relationships, promotion of local agriculture, and limiting the expansion of cities
140 must be considered to provide significant urban planning improvement. Urban space re-
141 distribution should be considered a facilitator of access for different transport modes,
142 including the more sustainable forms of transport that would support social distancing and
143 biosecurity protocols efforts.

144 Sustainable development concerns have highlighted the importance of diversity in the
145 distribution of land-use and the proximity of different urban amenities to residential areas in
146 urban development agendas. This proximity concept improves the urban environment and

147 increases accessibility (Banister, 2008), and it is more related to personal activities than
148 business ones (Marquet and Miralles-Guasch, 2015). The disruptions posed by COVID-19
149 in the short and medium-term can serve as an opportunity to challenge and redefine urban
150 development trajectories and the spatial distribution of land-use and transport in our cities
151 (Banister and Hickman, 2013). Caprotti et al., (2017) argued that the definition of urban
152 trajectories involves social and political consensus on the type of city that societies need,
153 which involves a complex negotiation of relationships of power, resources and regulations.

154 In this vein, in cases such as Bogotá, population densities and limited availability of public
155 space and sufficient infrastructure for non-motorized travel challenge maintaining a
156 minimum physical distance to reduce contagion between people, despite recent progress in
157 the provision of pavements and cycle lanes. Around 42.7% of daily trips are made by walking
158 or bicycle, and 20.5% by car, motorcycle, or taxi. For the first two transport modes, the
159 available street space is 37.8%, while for the second set, it is 55.8%. Therefore, the vision
160 for a '15 minute' city risks remaining in the local policy and academic rhetoric if it is not
161 accompanied by policies that address the high levels of socio-spatial segregation and
162 inequalities that the pre-COVID-19 patterns of development have consolidated. Examining
163 if the city is prepared to offer its residents a proximity city with fewer daily hours of transport
164 enables access to essential goods, services and opportunities for well-being, become a
165 relevant priority for research and practice.

166 The following sections illustrate such need through the localized analysis of a national
167 survey for Colombia in Bogotá, where the inequitable economic impact of complete
168 lockdowns on low-income residents is paramount. We highlight the importance of walkable

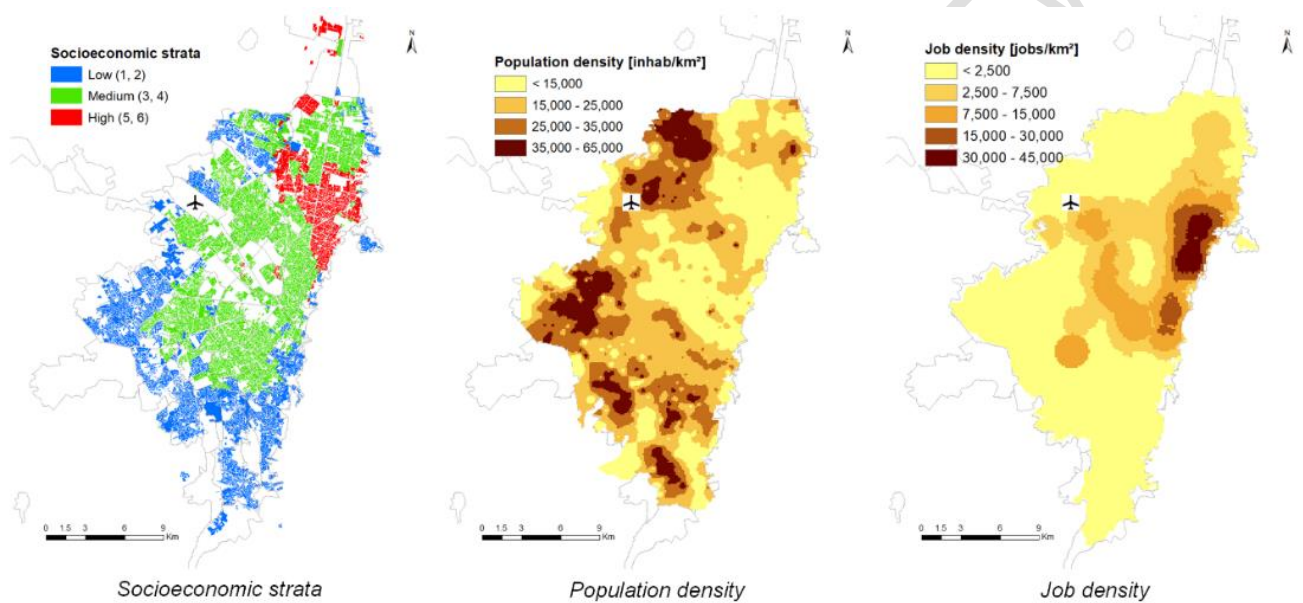
169 built environments and the neighborhood's livability and diversity to return the city to the
170 people.

171 **3. The vulnerability in Bogotá**

172 Population estimates for Bogotá place it at about 7.42 million inhabitants in 2018, with an
173 urban area of approximately 380 km². Bogotá is a compact and very dense city with high
174 degrees of socio-spatial segregation (Guzman and Bocarejo, 2017), high levels of public
175 transport use and walking (63.7%), low rates of car ownership (148/1,000 inhabitants), and
176 high congestion levels (Guzman et al., 2020a). Daily work-related trips are about 32%.
177 Study-related trips are mostly made by walking with 31.2%. Discounting the 'return home'
178 trips, around 68% of daily trips have different purposes. In this respect, walking is also the
179 primary mode for trips related to physical, social, and shopping activities. For trips up to 2
180 km, walking is the most used transport mode (Guzman et al., 2020c). Trips which purpose
181 is health care are made mostly by public transport.

182 In Bogotá (as well in Colombia), residential land is classified according to official household
183 socioeconomic strata (SES), which classifies households in six categories. SES one
184 corresponds to households with less quality and SES six to the best conditions. In Bogotá,
185 SES is considered an acceptable proxy variable for household income (Cantillo-García et
186 al., 2019). This classification by SES has encouraged spatial segregation in the city and has
187 made visible the invisible. The SES one and two are linked with poverty (i.e. low-income),
188 three and four with medium-income groups, while five and six with the wealthy population.
189 Also, the spatial distribution of activities, such as residence and job location in Bogotá
190 causes an unbalanced territory (see Figure 1), which causes inequality, particularly in lower-

191 income populations due to more prolonged and expensive trips (Guzman et al., 2017b).
192 Moreover, social and spatial segregation across the Bogotá region has led to marked
193 imbalances in public infrastructure investment and fragmented patterns of urban
194 development between central and urban peripheries, creating a self-reinforcing cycle of
195 exclusion and marginality of the lowest income populations (Oviedo and Dávila, 2016).



196
197 **Figure 1. SES distribution and activity locations (residence and work)**

198

199 Bogotá's social and economic structure encourages a higher risk of contagion among the
200 low-income population. Poverty and inequality play decisive roles in spreading the pandemic
201 and the vulnerability to its effects (Ahmed et al., 2020; Cash and Patel, 2020). COVID-19 is
202 hitting poor communities hardest than wealthier areas of cities in a pattern that has been
203 repeated throughout the world, and that has been hinted at by initial research in the
204 Colombian context (Amariles et al., 2020; Daniels, 2020).

205 Sociodemographic characteristics play a determining role, although not the only one. The
206 inability to carry out economic activities at home and limited access to devices and
207 connectivity enabling remote working for activities that can be conducted remotely are
208 common issues in low-income communities and informal workers (Katz et al., 2020; UN,
209 2020). As such, these groups face a higher probability of contagion, not only at work but in
210 transport. Residential densities, coupled with a limited supply of public spaces and
211 infrastructure and the imposition of physical travel, are likely to increase the level of
212 exposure.

213 To understand the city's level of exposure, we analyzed aggregated information from March
214 6, 2020, when the first COVID-19 case appeared in the city, to August 30. In this period,
215 authorities confirmed 209,250 cases in Bogotá. The most affected areas are traditionally
216 working-class zones and the most populated ones within the city. Consequently, considering
217 that the highest population densities are in the periphery, which spatially corresponds to low-
218 income zones, we can infer that low-income people are more socially exposed than other
219 income groups.

220 **4. Understanding the effects on activity and travel patterns and local access**

221 We aim to search for answers to understand changes in activities and travel patterns and
222 obtain additional information about local access to essential activities beyond work.
223 Therefore, we propose a mixture of spatial and quantitative methods to analyze data
224 obtained from a web-based survey applied during the first lockdown adopted in Bogotá to
225 prevent the spread of the COVID-19.

226 **4.1 Online survey**

227 We issued a web-based survey designed to uncover the influence of the pandemic on
228 people's daily habits. The survey comprised three sections. The first section gathered
229 socioeconomic information about the individual and their household. This section included
230 questions about age, gender, the number of household members, the presence of older
231 adults and children in the household, vehicle ownership, SES, education level, primary
232 occupation, and the household location. The second section collected information about
233 travel decisions and the time people spent on specific activities before and during the
234 pandemic. This section asked about the primary activity and other complementary activities
235 such as shopping, sports, leisure, family, home duties, and health. Specifically, we included
236 questions about the activity duration and the possibility to perform the activity from home,
237 before and during the pandemic. Whether individuals declared the necessity of traveling to
238 perform a specific activity, we asked about the transport mode, travel time, and trip cost.
239 Finally, the third section gathered perceptual and qualitative information about social,
240 economic, technological, and personal impacts derived from the government's measures to
241 contain the outbreak of COVID-19. In this section, we asked the respondents to express
242 their level of agreement with four statements related to time use satisfaction, financial
243 concerns, agreement with the government measures, and new technology adoption as a
244 product of the pandemic. We used a Likert scale ranging from 1 to 5, where 1 indicated
245 strong disagreement and 5, strong agreement.

246 We decided to use the Maptionnaire platform (<https://maptionnaire.com>), a participatory
247 map-based survey tool that allowed us to collect accurate information about respondents'
248 household location. We distributed the survey through social media (e.g. Twitter, email, and

249 web) during one month, collecting a sample of 1,597 respondents for Bogotá. During the
250 data cleaning process, we eliminated incomplete records, speedy responses -considering
251 that participants took 25 minutes on average to complete the full survey- and those with
252 inaccurate geographical household location (i.e. outside the Bogotá region). The final
253 working sample for the analysis comprises a total of 776 responses. Although the sample
254 collection was not representative of the Bogotá population, we weighted the survey to mimic
255 the distribution of age and gender in the city. Furthermore, surveyed households' location is
256 distributed across the city (Figure 4a), covering all socioeconomic levels. Then, we weighted
257 the sample using the raking iterative approach implemented in the *anesrake* package
258 (Pasek, 2018) in R, considering Bogotá's population by gender and SES, to deal with the
259 above. We also included a logit model to interrogate socioeconomic characteristics that were
260 more prone to perform activities outside the home during the pandemic.

261 **4.2 Estimating local access**

262 We propose a geographical analysis for analyzing local access to essential activities beyond
263 work. Specifically, we determined the number and the location of non-work essential
264 services and facilities around surveyed households from the 2017 Survey of Economic
265 Establishments of Bogotá. We performed a spatial count of visible economic units of
266 commerce and services located in fixed positions within the study area. This survey was
267 carried out on 44,009 blocks in Bogotá.

268 This proximity analysis was based on traditional contour measures (Geurs and van Wee,
269 2004) and includes health centers (hospitals and doctor's offices), educational centers
270 (daycares, schools, and universities), banks, local shops, and drug stores which could be
271 reached within a maximum 15-min walking threshold from survey respondents location (i.e.

272 the household location). We used the inverse distance weighted (IDW) tool in ArcMap to
 273 compute isochrones curves varying the walking time from the study area's household
 274 locations, assuming a walking speed of 3.16 km/h (Guzman et al., 2020c).

275 5. Findings

276 5.1 Are the poor more affected by the pandemic?

277 Table 1 shows summary statistics on the weighted sample describing the main
 278 characteristics of respondents considering income levels. We aggregated results using three
 279 groups: low-income (SES 1 and 2), medium-income (SES 3 and 4), and high-income (SES
 280 5 and 6). After the weighting, most of the respondents correspond to females (52%) and
 281 well-educated people (80% of them declared to hold undergraduate degrees). The average
 282 age of respondents was around 33 years old. The majority of respondents reported work as
 283 their primary activity (78%), and 91% self-considering as formal workers.

284 **Table 1. Descriptive statistics of the sample (Section 1)**

Variable	High-income	Medium-income	Low-income	Total
Age				
Average	36.79	34.67* ++	31.90***	33.40
Standard deviation	11.62	11.71	10.83	11.37
Gender				
Female	59%	56%+	48%*	52%
Male	41%	44%	50%	47%
Not declared	-	0%	2%	2%
Household members				
Average	2.92	3.06+++	3.58***	3.30
Cars per household				
Average	1.32	0.67*** +++	0.27***	0.51
Motorcycles per household				
Average	0.02	0.14*** +	0.22***	0.18
Primary Activity				
Work	81%	80%	75%	78%
Study	16%	14%	12%	13%
Other	3%	6%* ++	13%***	9%

	Informal worker				
	Yes	1%	4%** +++	15%***	9%
285	*** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10 (High-income vs Medium- or Low-income)				
286	+++ p-value < 0.01; ++ p-value < 0.05; + p-value < 0.10 (Medium-income vs Low-income)				
287					
288	Data in Table 1 mimics the inequalities regarding income groups in the territory. We decided				
289	to use multivariate techniques to explore the differences among mean values of the income				
290	groups' variables. Specifically, we ran a series of generalized linear models using the survey				
291	package (Lumley, 2010) in R. Nearly 19% of respondents live in low-income areas, while				
292	the remaining 64% and 17% live in middle- and high-income zones, respectively. We found				
293	significant differences among income groups regarding the percentages of workers in				
294	informality. About 15% of low-income workers self-declared as informal; while only 1% of				
295	high-income did. Also, high-income households declared car ownership rates of 1.32 cars				
296	per household on average, which contrasts with the 0.27 value for the lowest-income group.				
297	On the contrary, low-income groups have a high number of motorcycles per household.				
298	The mandatory preventive isolation measures adopted in Bogotá due to the pandemic have				
299	caused substantial changes in people's mobility and activity patterns. Furthermore, these				
300	changes have not been equally distributed across different income groups, negatively				
301	impacting the lowest-income inhabitants. Table 2 describes modal transport changes and				
302	different activity participation time changes due to implementing the mandatory lockdown in				
303	Bogotá.				
304	Overall, 40% of the weighted sample could not carry out their main activity at home. About				
305	58% of low-income respondents stated an impossibility to perform their activity from home,				

306 while 24% and 11% reported the same for medium- and high-income groups, respectively.
 307 Before the pandemic, nearly 84% of the weighted sample were developed their primary
 308 activity outside the home. However, after the lockdown implementation, this percentage falls
 309 dramatically. Around 38% of the respondents continue performing their main activities
 310 outside the home, mostly low-income people. Significant differences among percentages by
 311 income group suggest that the lowest-income group was the most resilient besides the
 312 lockdown because almost half of their respondents continue their activities outside the home
 313 (47%). In contrast, the percentages of people that continue traveling to perform their main
 314 activity were lower for higher-income respondents.

315 **Table 2. Activity participation by income group, before and during the lockdown**

Variable	High-income	Medium-income	Low-income	Total
Primary Activity				
Location (Before lockdown)				
From home	14%	15%	18%	16%
Outside home	86%	85%	82%	84%
Possibility to perform the activity from home				
Yes	89%	76%*** +++	42%***	60%
Location (During lockdown)				
From home	78%	60%*** +++	35%***	48%
Outside home	17%	31%*** +++	47%***	38%
Not performing	4%	9%** ++	18%***	13%
Duration (During lockdown)				
Increased	45%	40%+++	24%***	32%
Decreased	24%	28%	36%**	32%
Equal	31%	32%	41%	36%
Mode Change (lockdown)				
Yes	5%	22%***	28%***	25%
Shopping				
Yes (during a typical week)	84%	90%* ++	81%	85%
No	16%	10%* ++	19%	15%
Location (Before lockdown)				
Physical store	93%	97%+++	100%***	98%
Online	7%	3%+++	0%***	2%
Location (During lockdown)				
Physical store	47%	74%*** +++	88%***	79%
Online	53%	26%*** +++	12%***	21%
Duration (During lockdown)				

Increased	19%	24%+++	38%***	30%
Decreased	60%	54%+++	38%***	47%
Equal	21%	22%	24%	23%
Mode Change (lockdown)				
Yes	28%	25%	19%	22%
Sports				
Yes	70%	55%*** +++	36%***	47%
No	30%	45%*** +++	64%***	53%
Duration (During lockdown)				
Increased	14%	18%++	8%	14%
Decreased	64%	51%***	58%	54%
Equal	15%	17%	17%	17%
No sports	7%	14%*	17%**	15%
Leisure (61 observations removed because of non-response)				
Yes	92%	90%++	82%**	87%
No	8%	10%++	18%**	13%
Duration (During lockdown)				
Increased	21%	30%**	25%	27%
Decreased	65%	60%	63%	62%
Equal	14%	10%	12%	11%
Family time (99 observations removed because of non-response)				
Yes	87%	86%	87%	87%
No	13%	14%	13%	13%
Duration (During lockdown)				
Increased	66%	61%	60%	61%
Decreased	23%	22%	20%	21%
Equal	8%	14%**	18%**	16%
Lives alone	3%	2%	2%	2%
Home duties (108 observations removed because of non-response)				
Yes	45%	71%*** ++	82%***	74%
No	55%	29%*** ++	18%***	26%
Duration (During lockdown)				
Increased	80%	64%***	62%**	63%
Decreased	1%	6%**	10%**	8%
Equal	19%	30%*	28%	29%
Health (119 observations removed because of non-response)				
Yes	47%	54%	51%	52%
No	53%	46%	49%	48%
Location (Before lockdown)				
At home	2%	4%	7%	5%
Out of home	98%	96%	93%	95%
Location (During lockdown)				
At home	74%	51%***	44%***	49%
Out of home	26%	49%***	56%***	51%
Mode Change (lockdown)				
Yes	40%	39%	33%	36%

316 *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10 (High-income vs Medium- or Low-income)

317 +++ p-value < 0.01; ++ p-value < 0.05; + p-value < 0.10 (Medium-income vs Low-income)

318 Also, 13% of the respondents reported greater negative consequences as mandatory
319 quarantine prevents them from continuing performing their primary activity. Since the
320 measure was imposed, nearly 18% of the low-income respondents stop performing their
321 main activity, while for the high and medium-income groups, this percentage falls between
322 4% and 9%. The significance of the estimates in the generalized linear models suggests
323 that the percentages of people who stopped performing their main activity during the
324 pandemic are different among income groups. The above could be explained because
325 workers belonging to the low-income group tend to be employed in labor-intensive sectors
326 (formal and informal), that require most of the time physical attendance. In many cases,
327 even though they can remotely perform their activities, people in this group tend to have
328 fewer computers and less-stable internet access. This puts in evidence the reinforcing
329 effects of pervasive dependency from precarious employment and Colombia's income-
330 driven digital divide. The consequences of such redundant vulnerability imply higher
331 exposure to contagion because of the need for physically traveling to perform their primary
332 activity (i.e. low-income groups) and a high probability of income losses due to the
333 impossibility of carrying out such activities remotely.

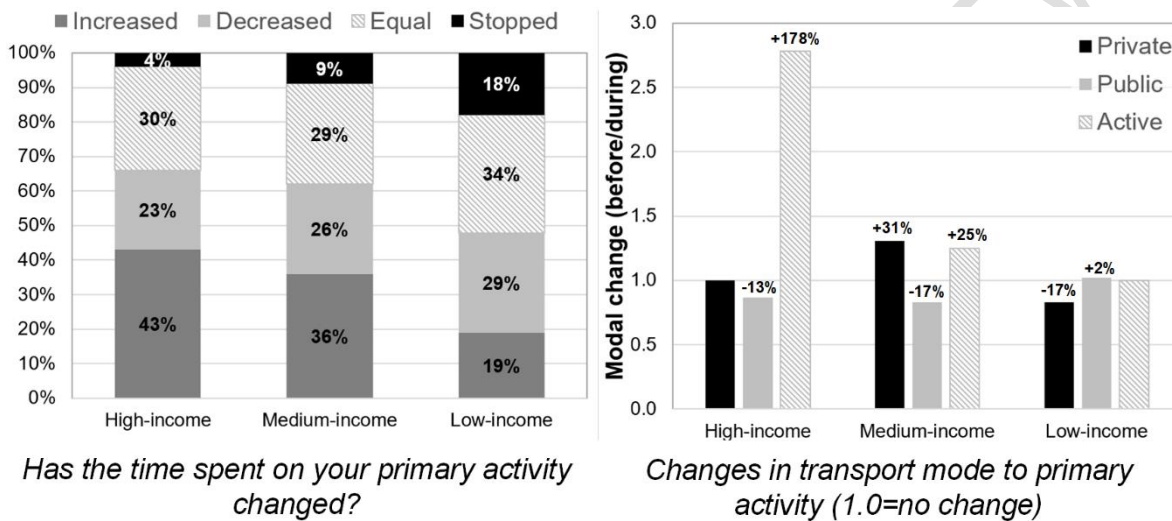
334 Accounting for those who can continue performing their primary activity, we identified that
335 participation times also change due to the lockdown implementation. Around 32% of the
336 sample reported that the time devoted to performing their primary activity increased, while
337 36% considered that not varied at all, and the remainder perceived that it decreased. Again,
338 there are marked differences among income groups. The percentages of time change
339 regarding the primary activity are similar between high- and medium-income groups (there
340 are no significant differences). In contrast, the lowest-income group has the highest
341 percentages of respondents considering decreasing participation times than other income

342 groups. This group includes the highest proportion of people who stopped their activity
343 during the pandemic (18%) (see Figure 2 left).

344 Regarding changes in individual mobility, 25% of respondents that traveled to reach their
345 main activity during the lockdown period changed their transport mode. High-income
346 respondents seem more prone to maintain their regular transport mode choices than other
347 income groups as only 5% of them reported transport mode changes. High-income
348 respondents travel mostly by private modes of transport (40% use the car), suggesting not
349 only the ability to remain mobile under lockdown but pointing to clear issues of injustice in
350 the distribution of access and its environmental impact as compared to lower-income
351 groups. We observed a decrease in public transport trips, which changed towards walking
352 and cycling. The separation between the main activities (i.e. work and study) and
353 households for high-income inhabitants, which is not as large as for other groups, explains
354 the increase in active transport use. Also, Bogotá heavily invested in expanding the cycle
355 paths network during the pandemic, which makes using the bicycle more attractive. In
356 contrast, the national government restricted the number of people allowed to ride on public
357 transport vehicles.

358 Meanwhile, medium-income individuals reported a higher modal change (22%) than the
359 high-income ones (5%). Notably, public transport modes declined their modal share in this
360 segment, favoring private and low-occupation public modes such as walking, cycling, taxi,
361 ride-sourcing, and the car. Finally, the lowest-income users seem to have fewer transport
362 alternatives available as they are often captive to public transport. Although the changes in
363 this group were the most substantial within all income groups (28%), most of them are due
364 to a decrease in trips by private transport towards a slight increase in the use of public

365 transport, as is shown in Figure 2 right, where a value of 1 in Y-axis means no changes
 366 before/during the pandemic. The current conditions for the demand for urban travel have
 367 questioned the current structure of the transport system of Bogotá, which has historically
 368 emphasized motorized transport, both public and private, only recently increasing
 369 investments in spaces for pedestrians and cyclists.



370

371 **Figure 2. Changes before/during the pandemic**

372

373 We also estimated a binary logit model (Ortúzar and Willumsen, 2011) to elaborate more on
 374 the analysis for identifying which socioeconomic characteristics make an individual more
 375 prone to perform activities outside the home during the pandemic. The model defines the
 376 possibility of carrying out the primary activity outside or from home as the dependent
 377 variable. Therefore, it does not consider those individuals who stopped performing their main
 378 activity due to the pandemic. We tested different specifications, including all the

379 socioeconomic characteristics in the survey as covariates. Table 3 shows the R *Apollo*
 380 package's estimation results (Hess and Palma, 2019).

381

382

383 **Table 3. Binary logit model results**

Coefficient	Estimate	Robust t-test
Alternative Specific Constant - Outside Home	-0.9175	-3.6***
Olders (age > 60 years old)	-2.5107	-2.4***
Minors (age < 18 years old)	-7.6268	-16.6***
Medium-income	0.7098	2.7***
Low-income	1.7882	5.6***
Informal worker	1.6215	1.7*
Not exempted activity	-0.7017	-2.9***
Non work activity	-2.6127	-4.9***
N: 709		
Adjusted Rho-square: 0.20		

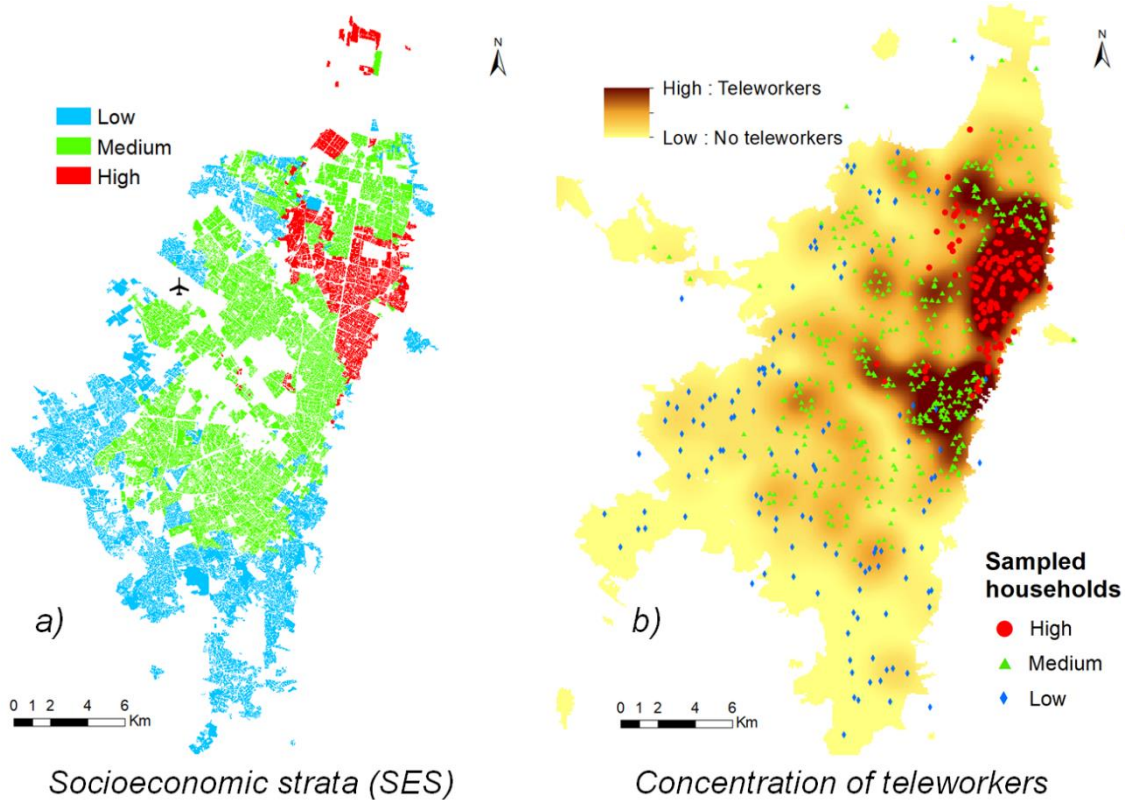
384 *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10

385

386 The negative sign of the alternative specific constant suggests that performing the main
 387 activity outside the home provides disutility compared to the base alternative, which refers
 388 to conducting the activity from home. Then, ceteris paribus, results suggest that individuals
 389 would prefer to carry out their main activities from home during the pandemic. Individuals
 390 between 18 and 60 years old are more likely to be performing their primary activity outside
 391 the home than those younger than 18 years and those over 60 years. In line with the
 392 previous findings, the lower the income level, the greater the probability of leaving home to
 393 conduct the main activity during the pandemic. The magnitude of the estimated parameter
 394 for individuals belonging to the lowest income group suggests that their probability is much
 395 higher than that of other groups. The situation even worsens for informal workers, depicting

396 those inequalities associated with the workforce. The model reveals that informal workers
397 are more likely to carry out their activity outside the home during the pandemic, which can
398 be due to having more significant financial problems than formal workers, who supposedly
399 have better income and more stable working conditions. The model also suggests that
400 individuals whose primary activity is not working (e.g. study, home duties) are more likely to
401 perform their activity from home than those who work as their primary activity. Finally, people
402 who work in sectors exempt from the mandatory quarantine (e.g. transport sector, health
403 care, supermarkets, banking, others) are more exposed to the virus as they have a higher
404 probability of working outside the home during the pandemic.

405 Maptionnaire enabled respondents to report on their home location, which informed mapping
406 the concentration of respondents who had the possibility of teleworking during the pandemic
407 (Figure 3). The highest income areas show the highest concentrations of teleworkers (i.e.
408 darker areas). Simultaneously, people who have more significant mobility needs due to not
409 having the possibility of performing their main activity from home are mainly located in low-
410 income areas. This gives an idea of the changes in mobility are also different according to
411 the income group. Wealthy people have low mobility levels in the pandemic since they have
412 less need and probability of going out, reducing their contagion risk. This situation
413 accentuates existing inequality patterns within the city, reinforcing conditions of both spatial,
414 social, and transport-related (dis)advantage where those that need to travel are in a worse
415 position to access relevant opportunities, while wealthier and better-located groups can
416 maintain essential and non-essential access via digital connectivity.



417
418 **Figure 3. The concentration of teleworkers during the pandemic**

419

420 We also found remarkable differences according to income groups when asking about
 421 participation in other activities. Regarding shopping, 85% of respondents reported regularly
 422 performing this activity weekly. Before lockdown, most of the shopping was done physically
 423 at the store, while only 2% usually place their orders from home. People regularly relying on
 424 online shopping mostly belonged to high- and medium-income groups, 7% and 3%
 425 respectively. Even though physical shopping remains the preferred option during quarantine,
 426 online shopping increased 1,050% on average compared to the pre-pandemic level. Home
 427 orders in the high- and middle-income groups showed increases of 757% and 867%,
 428 respectively. In the low-income group, 12% of the total shops were reported to be online
 429 during the pandemic, which contrasts with the regular shopping habits of this income group

430 that rely more on physical shopping. In particular, considering the boost of online shopping,
431 47% of the respondents reported that this activity's participation in their total available time
432 decreased during the pandemic. Before the lockdown implementation, this activity's average
433 duration was estimated to be around 1.7 hours per week. However, respondents reported
434 average time savings related to this activity because individuals invest approximately 1.0
435 hour per week during the lockdown period. Digital connectivity has been hinted at as a
436 relevant factor in redefining accessibility, findings in our survey suggest that inequalities in
437 access to digital connectivity and the required skills, abilities, and resources for its use can
438 deepen already marked inequalities between social groups (Velaga et al., 2012).

439 Another impressive result is the transport mode change associated with shopping activities
440 during the quarantine. Nearly 22% of the respondents reported changes in transport modes
441 for shopping activities. Even though there are no significant differences regarding income
442 groups, they share a similar pattern regarding the shift from private transport to active
443 transport modes. The prevalence of walking trips for shopping purposes highlights the
444 importance of local shops within households' close vicinity during the pandemic. High-
445 income respondents migrated their car trips to walking trips. We observed a 45% increase
446 in the active travel trips (e.g. walking and bicycle) in this income segment. Meanwhile, the
447 medium- and low-income groups reported more modest increases in walking and bicycle
448 trips, 20% and 9% respectively.

449 The analysis of different activities enables us to identify inequalities in the use of time and
450 capacity to carry out activities that support physical and mental health (Lebel et al., 2012).
451 Findings suggest that sports and leisure activities are among the most affected activities due
452 to the mandatory isolation measures. Around 47% of the respondents declared that they

453 regularly carry out sports activities and away from home (80%) before the pandemic.
454 Approximately 87% of the individuals reported performing leisure activities on a regular week
455 before the pandemic. However, most respondents stated that the time dedicated to both
456 activities decreased (i.e. 54% for sport and 62% for leisure activities). On average, we
457 observed decreases of 1.5 and 1.1 hours per week dedicated to sports and leisure activities,
458 respectively. Indeed, 12% of the respondents mentioned that they are not performing their
459 regular physical activities. Overall, we did not find significant differences in these activities
460 participation times among income groups. In contrast, the time spent on family activities and
461 home duties has increased. More than 60% of the respondents reported increases in these
462 activities, experiencing 7.2 additional hours per week in family time and 2.8 extra hours a
463 week on average for housework.

464 Additionally, most individuals (95%) that reported doing health care activities before the
465 mandatory lockdown did so outside the home. However, during quarantine, although people
466 continue to carry out most health activities outside the home, the pattern has been changing
467 because more people declared to receive medical care at home or shopping for medicines
468 or health care items from home. Considering those individuals that traveled for this purpose,
469 we also observed transport mode changes due to the pandemic. In particular, we identified
470 a 65% increase in walking trips for performing health activities in detrimental of trips by car,
471 motorcycle, taxi, and public transport. This situation suggests long walking times to access
472 healthcare facilities, mainly for the low-income population, due to health centers' location at
473 specific points in the city (see Figure 4f).

474 The above result reinforces the importance of urban planning to allocate an adequate land
475 use mix within the household vicinity to guarantee active transport access to shopping,

476 sports, cultural, recreational, and health opportunities. Also, as a consequence of all results,
 477 walking and cycling can be valuable ways to maintain satisfactory mobility levels as the
 478 economy gradually reactivates.

479 Finally, considering the third section of the survey, we observed that respondents perceive
 480 that the pandemic has brought financial problems, isolation from family and friends, and
 481 other mental and physical health issues. Table 4 shows the average responses to the four
 482 perceptual questions included in the survey to evaluate the pandemic's impacts on the
 483 household economy and activity patterns. Respondents declared neither marked
 484 satisfaction nor decided dissatisfaction regarding time spent on activities during the
 485 pandemic.

486 **Table 4. Average responses to perceptual questions (Section 3)**

Variable	High-income	Medium-income	Low-income	Total
Time Use Satisfaction	2.8	2.9+	3.2**	3.0
Financial concerns	2.6	3.1*** +++	3.8***	3.4
Agreement with the measures adopted by the government	4.3	4.1*	3.9***	4.0
New technology adoption	3.7	3.7	3.7	3.7

487 *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10 (High-income vs Medium- or Low-income)

488 +++ p-value < 0.01; ++ p-value < 0.05; + p-value < 0.10 (Medium-income vs Low-income)

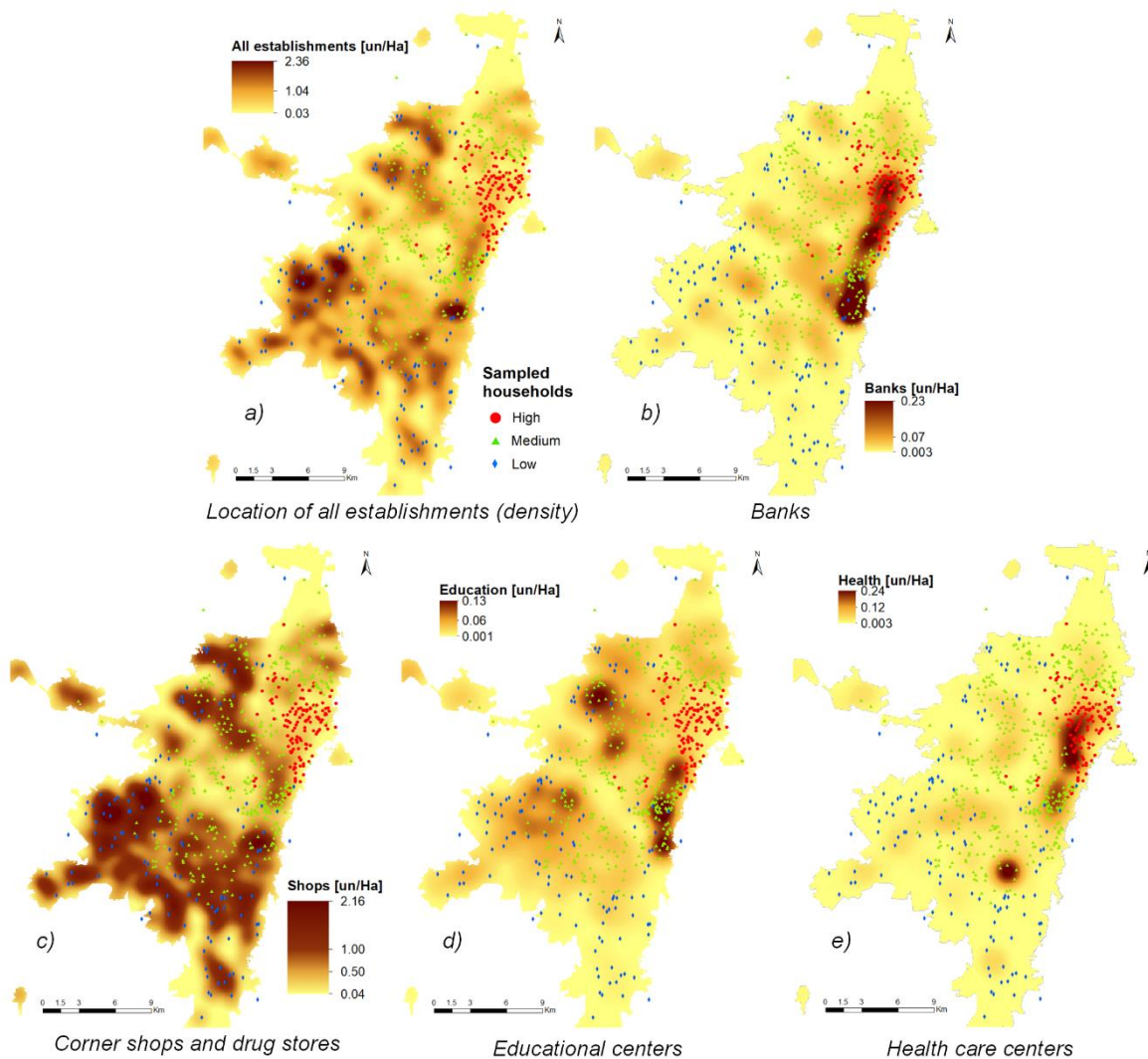
489 In line with previous analysis and research exploring poverty and inequality about the
 490 pandemic, low-income people seem to be more concerned about the pandemic's financial
 491 impacts than medium and high-income people. Overall, individuals agree with the measures
 492 adopted by the government to mitigate the outreach of the virus. This question's rating
 493 averaged 4.0 out of 5.0, which reflects agreement with top-down policies in the early months
 494 of lockdown. Specifically, the highest income group was the one that declared itself more in
 495 agreement with the government's measures during the pandemic. The middle- and low-

496 income groups declared themselves at a lower level of agreement, without there being a
497 significant difference between their perceptions. We also found significant differences
498 between the average time use satisfactions among income groups. Paradoxically, those
499 most affected regarding the possibility of performing their main activities during the
500 pandemic (i.e. the low-income group) are those who declared themselves the most satisfied.
501 Even though the above result seems counter-intuitive, recall that the poorer people also
502 spend a long time traveling to their main activities (i.e. on average, is twice as much time
503 traveling as wealthy people). Thus, those who can continue performing their main activity
504 from home will perceive more considerable time savings by not traveling to their usual
505 destination. They can use these time savings for more pleasant activities. On the other hand,
506 those who quit performing their main activity can now spend more time with their family, not
507 to mention that lower-income people tend to be more optimistic than wealthier inhabitants.
508 Moreover, and supporting earlier arguments about access to digital connectivity,
509 respondents acknowledge the importance and use of new technologies during the lockdown
510 period. Most of the respondents stated that the pandemic pushed them to use new
511 technology during the quarantine. In this regard, we could not find differences between
512 groups.

513 **5.2 Bogotá as a segregated 15-minutes city**

514 According to the available data, we found economic establishments in 73% of city blocks,
515 while in the rest, the predominantly land use corresponds to residential. The results show
516 that of the 471,904 establishments located in the study area, 88.8% were working places.
517 In commerce and services, there were 269,958 establishments in Bogotá, where the vast
518 majority were dedicated to the retail sector.

519 Using contour measures, also known as isochrone measure, we linked household and
520 establishments location, to estimate the cumulative distribution curves and establishments
521 by socioeconomic group (Figure 5). This measure represents the number of commercial
522 establishments and other relevant facilities and services around each surveyed household
523 according to their socioeconomic group. I.e., counts the number of establishments that can
524 be reached within a given average travel threshold, required to access a fixed number of
525 establishments (Guzman et al., 2018). Figure 1 shows the location of primary services in
526 Bogotá. As shown, key activities such as education, and healthcare services are highly
527 concentrated in the city's eastern edge (Figure 4), where wealthy people live. Besides,
528 commercial establishments such as local shops have the most substantial participation in
529 this economic category. We identified 1,591 educational centers, 1,459 health centers,
530 1,296 banks, and 34,513 local shops and drugstores, as shown in Figure 4.



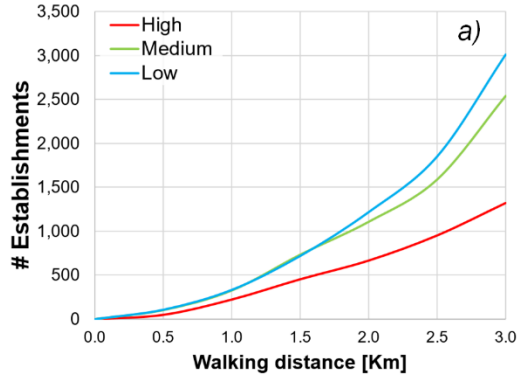
531
532 **Figure 4. Location of the sample of surveyed households and establishments by type**

533

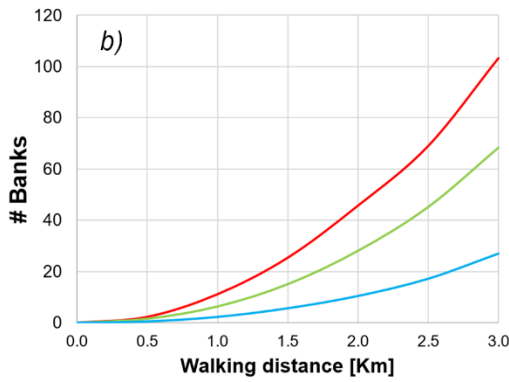
534 Figure 4c shows the local shops and drug stores are the most numerous establishments in
535 the city. Unlike other services, the city's southern and western parts concentrate this
536 economic activity, where the lower-income population resides. Now we will see what
537 implications this activity distribution has in access equity to these services, under the '15-
538 minutes city' framework.

539 Figure 5a summarizes the average walking distance from the surveyed households at the
540 city level in accessing the establishments. Here is the number of establishments that can be
541 reached within a specific range of distance. At a distance of 1 km (≈ 19 min walking¹) as the
542 travel threshold, results show that 0.9% of the establishments could be accessed. Although
543 it seems few, this means proximately 333 different establishments.

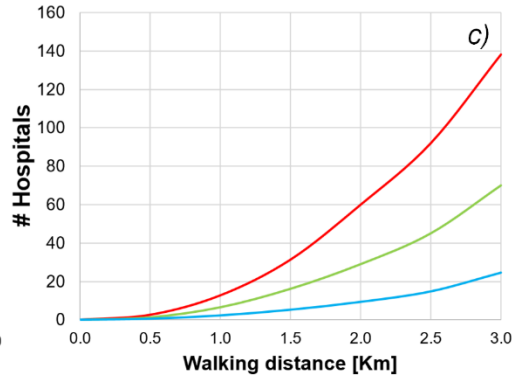
¹ Using an average walking speed of 3.16 km/h (Guzman et al., 2020c).



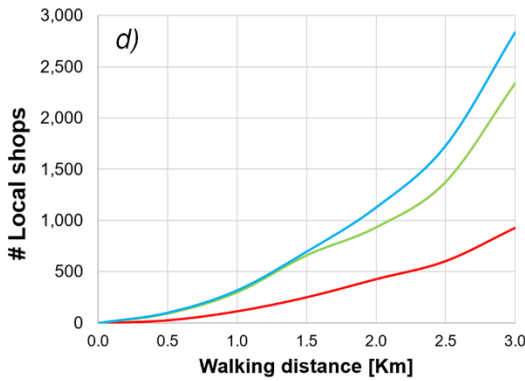
Establishments covered



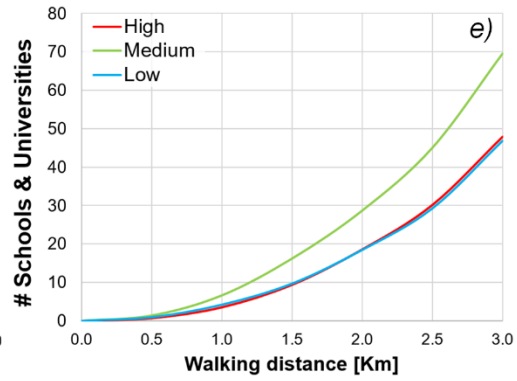
Banks covered



Healthcare centers covered



Corner shops and drug stores covered



Educational centers covered

544

545 **Figure 5. Curves of access of households and establishments covered by socioeconomic**
 546 **group**

547

548 Initially, it seems that low-income households have better access (more opportunities
549 nearby) to a large number of local shops. Although this is true, the total figure is inflated by
550 many local shops in the city. However, disaggregating access by type of establishment
551 shows notable differences. The former can be confirmed when comparing the distributional
552 curves in Figure 5. Although it is found that there is higher coverage of local shops in spatial
553 terms, there are substantial differences by socioeconomic group, particularly in banking and
554 medical services.

555 The city's eastern border seems to be related to better access regarding proximity to a
556 variety of services. This area has been traditionally the home of the wealthy population and
557 comprises a high concentration of employment and services. Although decentralization is
558 convenient, it is crucial to improve the coverage of more services in the periphery,
559 maintaining social interaction, precisely now that the fear of human contact is present. The
560 worst that could happen will be if the model of closed and isolated communities prevails,
561 more socially, and ecologically damaging.

562 As seen, Bogotá is not so far from meeting the goal of 15 minutes, particularly in retail
563 commerce. Analysis of non-mandatory accessibility in the city in pre-COVID-19
564 circumstances has suggested that local access inequalities can be more readily negotiated
565 and dealt with by lower-income populations than to mandatory travel and access to
566 livelihoods and human capital (Oviedo and Guzman, 2020; Vecchio, 2020). However,
567 according to the latest mobility survey, each *Bogotano* spends an average of 1 hour and 50
568 minutes per day traveling around the city. Two intense unidirectional flows are those
569 motivated by work and study (49%), with other travel purposes weighting on travel demand
570 distribution (51%). For residents in the lowest SES areas, long travel times and costs are a

571 permanent reality associated with the city's urban structure and the high dependency on
572 public transport. Local accessibility levels partially palliate these access inequalities to
573 essential services and amenities for non-work and education opportunities. The possibility
574 of meeting individual and household needs around low-income households presents itself
575 as an opportunity to redefine the city's current urban trajectory via new investments in public
576 space and non-motorized infrastructure that can support local mobility and accessibility.

577 **6. Discussion**

578 Unfortunately, the lockdown measures adopted have widened the gap between rich and
579 poor in Bogotá. Results also highlight the relevance of digital connectivity and local
580 opportunities within households' close vicinity during the pandemic. The gap between rich
581 and poor has widened in Bogotá due to isolation measures, as shown above. The gradual
582 opening of cities, considering possible fresh outbreaks, will be an opportunity for many
583 citizens to return to public spaces. However, many will avoid using public transport, and
584 others will continue to telework. In cities where most activities concentrate in central areas,
585 many will look for alternatives close to home, particularly in unbalanced territories. This
586 extraordinary situation can be a motivation to test the feasibility of proposals such as the
587 "15-minutes city". It is possible to find everything an individual needs, at most, 15 minutes
588 from home, walking or by bicycle. We argue that strategies for healthy built environments
589 (Megahed and Ghoneim, 2020) and also urban and behavioral transformation require
590 context-dependent considerations rooted in principles of social justice and equity, which play
591 an essential role in sustainable development (Keiner et al., 2004; Newman, 2015).

592 Our paper's value lies in interrogating findings from a spatialized behavioral survey vis-à-vis
593 insights from an accessibility analysis tailored to interrogate local access to essential
594 opportunities. By analyzing such complementary sets of information, it is possible to draw
595 relevant insights about the vast disparities associated with a health crisis such as the one
596 the world faces at the time of writing this article. On the one hand, the survey reflects that
597 although the attitude of a majority of *Bogotanos* towards the lockdown measures imposed
598 in response to the pandemic was mostly positive (in the beginning), their experiences
599 regarding the distribution of time, their exposure to risk, and their practices for access and
600 mobility are determined mainly by their spatial and socioeconomic position. On the other
601 hand, in a city marked by socio-spatial segregation and inequality in the availability of assets
602 for urban mobility (Oviedo and Guzman, 2020; Teunissen et al., 2015), findings such as
603 those presented in Figure 5 suggest that mobility-related inequalities are made more severe
604 by the inability of socially vulnerable populations to adapt to rapidly changing configurations
605 of the structure of access in the city.

606 The survey calls into attention the relevance of digital connectivity and access to
607 technologies that grant access to services such as home delivery of essential goods and
608 services. While it is positive that poor households and individuals have access to local shops
609 within walking distance, often in numbers that dwarf the available local opportunities of this
610 kind that even the high-income groups have shown in Figure 5, the opposite is true for all
611 other opportunities. Facilities for banking, education, and higher-level medical care such as
612 hospitals are spatially concentrated in some specific zones, forcing those that need to travel
613 to do so for longer distances. The survey reflects that a lower number of low-income people
614 access digital services. Much of the population in this segment needs to travel to facilities to
615 physically access relevant opportunities, increasing the level of contact and contagion risk

616 to which they are exposed. They also have a lower capacity for adaptation as inferred by
617 the comparatively high percentages of activities that people stop doing or dedicate less time
618 to, as shown in Table 2.

619 The implications of COVID-related lockdowns have far-reaching implications in urban
620 structures marked by spatial inequalities such as Bogotá's. 58% of the low-income
621 population report an impossibility to carry out their main activity from home and 18% have
622 stopped doing their main activity altogether. The distribution of those that can and cannot
623 access their livelihoods from home and the spatial distribution of opportunities across the
624 city make evident that for the poor immobility is not a choice. Even if you cannot work any
625 longer, there is still an imposition of physical mobility to the expanded city center that
626 concentrates most hospitals, universities, and other vital facilities. The consequences of
627 such imposition are suggested by the distribution of time reported in the survey. While
628 wealthier groups can maintain access to most relevant opportunities, including social
629 interactions and leisure, in some instances even decreasing time in certain obligations, for
630 the poor many activities need to be traded-off by longer working hours, more demanding
631 commutes and increased care responsibilities. Such findings suggest that the spatial
632 imbalances in accessibility may carry long-term decreases in quality of life and well-being
633 for those at higher risk of being negatively affected by the pandemic. By integrating a spatial
634 and a behavioral lens, our findings shed light on aspects not often considered from a
635 transport optic, highlighting the pandemic's social and distributional consequences as a
636 source of transport and social disadvantage.

637 7. Conclusions

638 In very dense areas, such as in the lower-income zones of Bogotá, people may spend more
639 time at home because they have no place to spend their time in the neighborhood and
640 because of fear of physical contact. This is consistent with earlier research examining
641 facilities dimension of transport-related social exclusion in the local context. Vulnerable
642 residents in peripheral neighborhoods in the Bogotá region endure near-immobility due to
643 the intersection between lack of local facilities and amenities and other transport and social
644 disadvantages. As seen in Figures 1 and 3, most of the activities in Bogotá except local
645 shops and drug stores are highly concentrated in the city center (eastern edge). The
646 shocking concentration of banking, health services, and a high percentage of educational
647 services, mainly university education, evidence the high levels of functional segregation of
648 Bogotá, a pattern too often found in other large cities in Latin America.

649 The exploration of urban mobility and activity behavior across income groups in the city of
650 Bogotá reflects marked inequalities in the ability of individuals and social groups to adapt
651 and respond to the restrictions imposed by the global COVID-19 outbreak. The examination
652 of Bogotá serves as an illustration of the challenges and potential opportunities for redefining
653 urban development trajectories and the practice of urban transport in cities facing similar
654 levels of social and spatial inequalities in the Global South. The research also speaks about
655 the relevance of digital connectivity and non-precarious employment as drivers of more
656 equitable accessibility, particularly under conditions that challenge urban structures
657 constructed around the assumption of physical travel as a precondition for access. From the
658 survey findings, it becomes clear that changes in behavior carry differentiated economic,

659 social and health consequences for communities that start from different positions of
660 disadvantage to adapt to rapidly changing conditions.

661 The research also highlights the role of digital tools and social networks in data collection
662 and the production of reliable and rigorous evidence for research and practice. In this
663 research, partnerships with organizations involved in sustainable development and transport
664 planning practice have proven essential in outreach and access to respondents and the
665 possibilities for transcending knowledge to practice.

666 Our paper challenged the recent rhetoric about the 15-minute city which has gained
667 popularity in mainstream media and professional circles in urban and transport planning,
668 highlighting the role of non-motorized travel and the provision of infrastructure and public
669 spaces for their support in constructing more equitable and inclusive cities. Findings of the
670 15-minute city and local access in Bogotá serve as a reminder that travel behavior and
671 accessibility are not the remit of only urban transport planning and that land-use and urban
672 planning play a determining role in redressing social and spatial inequalities that limit the
673 ability of particular income groups to accumulate social, economic and human capital. In
674 recent years, the local stores have been given little importance in Bogotá. Our findings serve
675 as evidence of the vindication of the local entrepreneurs and small businesses that play a
676 role in enabling access to goods and services in proximity, which is likely to reclaim the value
677 in post-COVID-19 realities. However, not all citizens have access to a park, a school, or a
678 health center close to home. In addition to adequate housing, to improve the quality of life
679 in the city, it is necessary to reduce the perimeter of access to a decent job, the ability to
680 obtain essential goods, education, health, and leisure.

681 Results show a high supply of several types of activities throughout the city. However, the
682 spatial availability of services and amenities finds itself restricted by temporal and economic
683 dimensions such as opening hours or people's ability to pay, highly relevant aspects of the
684 definition of transport-related social exclusion (Church et al., 2000; Jones and Lucas, 2012).
685 This is a limitation of the analysis. Therefore, further analysis should consider other
686 necessary accessibility components, such as an individual's spatial-temporal constraints
687 (Geurs and van Wee, 2004), to get a better-adjusted value in the number of opportunities
688 reached.

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