Science of the Total Environment 793 (2021) 148626

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Urban attributes and the spread of COVID-19: The effects of density, compliance and socio-political factors in Israel

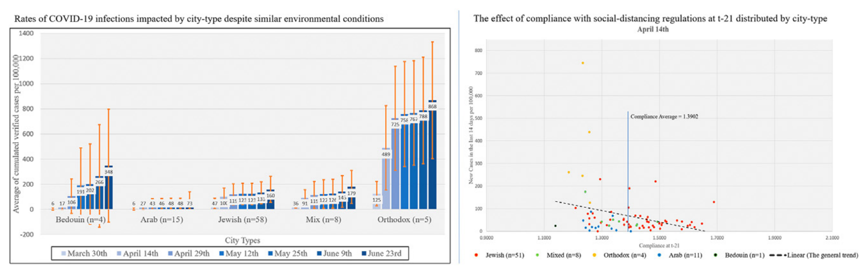
Nir Barak [a,*], Udi Sommer [b], Nir Mualam [c]

[a] Deparment of Politics and Government, Ben Gurion University of the Negev, Israel
[b] Political Science and the Center for Combating Pandemics, Tel Aviv University, Israel
[c] Faculty of Architecture and Town Planning, Technion, Israel Institute of Technology, Israel

HIGHLIGHTS

- Research on population density's effect on COVID-19 infection rates yields mixed results.
- Infection rates in cities vary according to their social and political attributes.
- Urban population density is defined and operationalized according to municipal land use.
- Population density's effect on COVID-19 infection rates is contingent upon socio-political variables.
- Compliance with social distancing regulations has a significant effect on infection rates.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 27 April 2021
Received in revised form 16 June 2021
Accepted 19 June 2021
Available online 23 June 2021

Editor: Jay Gan

Keywords:
COVID-19
Population density
Urban sustainability
Urban planning
Minorities
Cities

ABSTRACT

Current debates identifying urban population density as a major catalyst for the spread of COVID-19, and the praise for de-densification and urban sprawl that they entail, may have dire environmental consequences. Juxtaposing competing theories about the urban antecedents of COVID-19, our key argument is that urban political attributes overshadow the effects of cities' spatial characteristics. This is true even when considering levels of compliance with movement restrictions and controlling for demographic and socio-economic conditions. Taking advantage of Israel as a living lab for studying COVID-19, we examine 271 localities during the first 3 months of the outbreak in Israel, a country where over 90% of the population is urban. Rather than density, we find social makeup and politics to have a critical effect. Cities with some types of political minority groups, but not others, exhibit higher infection rates. Compliance has a significant effect and density's influence on the spread of the disease is contingent on urban political attributes. We conclude with assessing how the relationship between the politics of cities and the spread of contagious diseases sheds new light on tensions between neo-Malthusian sentiments and concerns about urban sprawl and environmental degradation.

1. Introduction: COVID-19, urban density, and city politics

Since the outbreak of COVID-19 in December 2019 and the World Health Organization's (2020) declaration of it as a pandemic, one question has repeatedly resurfaced by journalists (Krugman, 2021; Porter, 2020; Shenker, 2020) and urban scholars (Batty, 2020; Florida et al.,

* Corresponding author.
E-mail addresses: nirbarak@bgu.ac.il (N. Barak), udi.sommer@gmail.com (U. Sommer), nirm@technion.ac.il (N. Mualam).

https://doi.org/10.1016/j.scitotenv.2021.148626

2020)—*does COVID-19 spell the end of cities*? While the political, social, economic, and environmental ramifications of COVID-19 are not necessarily unique to cities, the heightened focus and concern for the future of cities is associated with one of their key characteristics—population density (Megahed and Ghoneim, 2020; Sharifi and Khavarian-Garmsir, 2020). A *New York Times* headline designated density as the city's 'big enemy' in its struggle with COVID-19 (Rosenthal, 2020). Likewise, Joel Kotkin (2020) argues that Los Angeles's sprawled urban design and car dependency contribute to comparatively lower viral infection rates.

These notions, identifying urban density as a catalyst for COVID-19 infections, echo anti-urban sentiments in environmental philosophy (de Shalit, 1996; Light, 2001; King, 2006; Kirkman, 2004; Booth, 2013; Barak, 2017) and neo-Malthusian concerns (Ehrlich, 1968; Tal, 2016). However, they may ignore certain critical political and social aspects. Cities' compactness, which correlates with high population density, is associated with urban resilience (Berkes and Ross, 2013; Leichenko, 2011; Meerow and Newell, 2019). Such compactness is pivotal for a transition towards more sustainable patterns of development (Barak, 2020a; Cannavò, 2007; Dagger, 2003; Light, 2003). In addition, increased urban density is advocated by planners and policymakers due to its contribution to fostering innovation and economic development, housing diversity, and urban cultural vitality (Whittemore and BenDor, 2019). Recent studies suggest that zoonotic diseases (such as COVID-19) proliferate in human-dominated ecosystems, highlighting the potential impact in densely populated cities (Frutos et al., 2020; Gibb et al., 2020). Intensive and proximate social interactions that characterize urban lifestyles have also been identified as catalysts for high rates of COVID-19 infections (Rocklöv and Sjödin, 2020). Thus, perceptions that urban density exacerbates COVID-19 contagion and the omnipresent ramifications of the pandemic might effectively lead to de-urbanization, sprawl, and consequently to more intensive environmental degradation.[1]

Such tensions between anti-urban sentiments and neo-Malthusian perceptions on the one hand and concerns about urban sprawl and environmental degradation on the other make it particularly important to assess the relationship between the spread of contagious diseases and key characteristics of urban life. The politics of the city, we contend, cannot be overlooked. Whereas density, a key structural characteristic of urban life, may be consequential, it should be analyzed in conjunction with socio-political variables such as trust in institutions, alienation from government, city identity, and city-state relationships.

This paper aims to juxtapose competing theoretical frameworks and to determine which better explains the spread of COVID-19. The questions driving this research are: do urban conditions, namely urban density, affect the spread of COVID-19? If not, are there other factors, such as social or political attributes, that better explain the spread of COVID-19 in cities? Furthermore, is there an interactive effect wherein the effect of density is contingent on urban political attributes? And, finally, what are the effects of compliance with social distancing on the spread of COVID-19, when we consider both urban political attributes and physical conditions?

To examine those questions, we conducted comprehensive cross-sectional research of 271 localities in Israel, covering over 8.3 million of the country's population of 9.1 million, over the first 3 months of the pandemic outbreak. Israel is a 'living lab' for studying how cities' political and structural characteristics impact the spread of COVID-19. The Israeli government system is unitary, with a centralized government system. As time passed, national policies gradually became differential based on the rate of local infections, and some cities have devised disparate municipal policies; however, these differences came into being only in late-August 2020, after the period examined in this paper. Therefore, our analysis covers a time-frame in which all local authorities were subject to unitary national policies, regulations, and containment measures.[2] Notably, over 90% of the country's population is urban, mostly concentrated in four main metropolitan areas. Given the country's relatively small size of 22,145 km^2, geographic, climate, and environmental factors are controlled for. For comparison, the area of Beijing is 16,808 km^2, and that of New York State is 141,300 km^2. Such a policy ecosystem that is nationally uniform plus the otherwise homogenous national environment mean that differences between localities should be mainly attributable to conditions at the level of the city.

We analyze infection rates based on cities' political attributes, urban density, demographic and socio-economic conditions, and compliance with mobility regulations. Previous studies yielded mixed results. Hamidi et al. (2020) and Sun et al. (2020) did not find a significant correlation between population density and rates of COVID-19 infections. Conversely, in several nations, Israel included, research did find an effect for density (Ahmadi et al., 2020; Birenbaum-Carmeli and Chassida, 2020; Coşkun et al., 2021; Han et al., 2021; Lee et al., 2021; Negev et al., 2021; Tsairi and Alon, 2020). However, explanatory models limited to cities' spatial and physical characteristics, with no consideration of socio-political variables fall short of comprehensively analyzing the spread of COVID-19. Instead, we suggest a typology of five city-types based on their communities' political identity and explain why other attributes are critical for the spread of COVID-19.

Our findings suggest that cities' socio-political makeup plays a key role. First, political minority groups and their unique political environments are key. Urban density is correlated with the spread of COVID-19 only in cities populated overwhelmingly by one type of minority group, namely Ultra-Orthodox Jews, but not by other minority groups. Additionally, greater compliance is correlated with fewer infections. When assessing compliance and density in a unified model, we find that urban attributes (type of city with a certain socio-political makeup) and compliance have a key influence, whereas density's effect is smaller by comparison and largely conditional.

2. Urban attributes: city politics, urban density and compliance

2.1. City politics: socio-political variables

While analyses of urban density often relate to cities' physical characteristics, they are often done at the expense of a vital focus on urban socio-political attributes. Articulating the intrinsic logic of cities, Löw (2012) contends that cities, besides being a distinct form of association (compared, for instance, to the state), also "behave" differently. This is so because of their political, social, spatial, temporal, and affective structures, which may often be implicit or hidden (Löw, 2012, p. 313). Accordingly, cities have the capacity to produce shared meaning for their city-zens (Löw, 2013, 2016). Along those lines, current research on cities highlights cities' distinction from the state, and from one another (Barak and de Shalit, 2021; Bauböck and Orgad, 2020; Blank, 2007). For example, Bell and de Shalit (2011) argue that some cities encapsulate *civicism* - a morally-thick collective identity and ethos distinct from nationalism, which varies between cities (Barak, 2020b; Barbehön et al., 2016). Different cities have similar problems, but how these problems are interpreted and the methods, legislation and regulations used to address them, vary according to the intrinsic logic and unique political landscape of each city (Molotch et al., 2000). Lastly, as Joy and Vogel (2021) have recently argued, while the outbreak of COVID-19 seemed to have universal impacts, it has, in fact, revealed socio-urban distinctions.

Cities in Israel offer a particularly appealing case to study the effects of urban politics. With the majority of the population concentrated in four metropolitan areas (Orenstein and Hamburg, 2009; Tal, 2016), Israeli cities exhibit significantly different characteristics. This variance is evident in a range of variables related to religious characteristics, degree of heterogeneity, and ethnic affiliations. The Israeli Central Bureau of Statistics and the government regulatory authorities define Israeli cities in quintessentially socio-political terms. In this typology, which we

[1] For a comprehensive review on compactness vs. sprawl see Ewing and Hamidi (2015).

[2] For elaboration and analyses on governmental responses in Israel see Maor et al. (2020).

largely emulate and further explain under Data and Methods below, localities are categorized as Jewish, Mixed, Ultra-Orthodox Jewish, Arab-Druze or Bedouin.

In the case of COVID-19, in unitary systems such as Israel, the key regulatory measures were normally passed by the national government. Orders concerning lockdowns, quarantines, limitations on movement, travel bans and social distancing emanated from that level of government. Yet, as cities have their own distinctive logic of governing and social makeup, those orders would translate into urban reality differently in dissimilar localities and thus, we argue, would have an uneven impact on infection rates.

As the regulation comes from the state but applies at the local government level, city-state relations are key. Those communities where trust in government institutions is lacking are more susceptible to be those where regulations are less effective (Kim, 2005). Where levels of alienation from the central government are high, governmental actions are less likely to hold, let alone accomplish their desired effect. Among minority groups, this level of trust is lower in general (Abramson, 1972; Pantoja, 2006) and in Israel (Hermann et al., 2019). According to the *Israeli Democracy Index*, 83% of Jews feel a sense of belonging to the state, nearly double the proportion of Arabs who share this sentiment (42%) and significantly more than Ultra-Orthodox Jews (69%). In terms of trust in institutions, only 19.6% of Jews report virtually no trust in the parliament, compared to 40.4% of Arabs. These national-level statistics map onto cities based on their socio-political attributes. Congruently, trust in government in Ultra-Orthodox cities, for instance, would be relatively low.

Based on disparate characteristics, our first key hypothesis is that city-types correlate with infection rates of COVID-19. Specifically, cities that are home to a minority group will be those where infection rates are higher. It is characteristic of those minority localities such as reduced levels of trust in institutions and a sense of alienation from central government that would be associated with undermining the effectiveness of policy measures aimed at preventing new COVID-19 cases.

H1. Ceteris paribus, city-types correlate with rates of COVID-19 infections, with minority localities (Jewish-Ultra-Orthodox, Arab and Bedouin), exhibiting higher infection rates.

2.2. Population density

Density is a key characteristic of urban life for two main reasons. Firstly, it is a spatial and physical characterization of the city, distinguishing it from other forms of human settlements such as villages and rural areas (Wirth, 1938). Secondly, it is a social and political characterization of normatively desired city life that is anchored in a densely populated public sphere. Density is associated with a sense of safety, heterogeneity, and tolerance in the city (Hall, 2012; Jacobs, 1992; Sennett, 2018; Tonkiss, 2013; Young, 2011); it is also associated with cities' economic capacities (Glaeser, 2011; Sassen, 2001). It is in the cities' densely populated public sphere where quotidian political and social life happens (de Certeau, 1984).

Despite the centrality of density to urbanism, its relationship with emerging infectious diseases is still underexplored. Former studies on seasonal pandemics have found mixed results considering the association between population density and the spread of disease. For example, with respect to the 1918–1919 Spanish Flu, some studies failed to find meaningful associations between death rates and population density measures or residential crowding, whereas other research found a moderate association (Bootsma and Ferguson, 2007; Chowell et al., 2008). Overall, when looking at the transmissibility of infectious diseases as a proxy for disease incidence, it appears to be invariant across population sizes and densities (Chowell et al., 2008; Mills et al., 2004).

Likewise, the picture emerging from early research into COVID-19 is convoluted at best (Sharifi and Khavarian-Garmsir, 2020). On the one hand, Hamidi et al. (2020) in the U.S. Sun et al. (2020) in China, Boterman (2020) in the Netherlands, and Khavarian-Garmsir et al. (2021) in Iran did not find a significant correlation between population density and rates of COVID-19 infections. Conversely, Ahmadi et al. (2020) in Iran, Coşkun et al. (2021) in Turkey, Cartenì et al. (2020) in Italy, Sy et al. (2021) in American counties, and Lee et al. (2021) in three American states contend that population density is correlated with higher rates of infections.[3]

As noted by Chowell et al. (2008, p. 507), when studying epidemics, "conflicting results may stem from the differences in the spatial scale considered (ranging from household to country) and the choice of socio-demographic indicators." How density is defined and analyzed in those studies varies and does not necessarily indicate the *actual* population density experienced in quotidian urban life (Teller, 2021). This is doubly true when freedom of movement is restricted, as was the case during COVID-19. Additionally, some of these studies span huge geographic and political areas (i.e., the U.S., China, India). Thus, either geographic and environmental factors or different policy tools employed invariably differently in disparate political units such as counties or states may obfuscate the true picture. Indeed, existing studies examine the spread of COVID-19 using a range of geographical units of inquiry: from examination at the country-level (Sirkeci and Yucesahin, 2020), counties (Jamshidi et al., 2020), metropolitan statistical areas (Angel et al., 2020), regions (Cartenì et al., 2020), to more focused examinations at the municipal scale (Boterman, 2020; Qiu et al., 2020) or even using smaller units such as neighborhoods (Khavarian-Garmsir et al., 2021) and urban blocks of 500 square meters (Feng et al., 2020).

Lastly, these studies relate to cities either only as spatial-physical entities or as a homogenous social unit, thereby overlooking crucially important differences. This is at odds with contemporary research that draws attention to the multitude of urban forms, city cultures, and identities. These differences are expressed in municipal governments' actions and how citizens of cities understand sociopolitical matters and the consequent individual behavior of those citizens (Barak, 2020b; Barbehön et al., 2016; Bell and de Shalit, 2011; Löw, 2012).

As the web of urban attributes is intricate, socio-political variables and density are not mutually exclusive in their effects on city life, and in the context of our discussion, in their effects on the pandemic. Indeed, those different types of variables may interact. Density's effect may depend on the characteristics of the community (Jamshidi et al., 2020) and on urban attributes (Whittle and Diaz-Artiles, 2020). Even cities with comparable population or density levels, but with dissimilar attributes at the levels of political institutions and their populations' characteristics, would exhibit different patterns in dealing with the pandemic. For example, some studies found that there is a statistically significant association between COVID-19 cases and race and income (Ibid). Likewise, the spread of the pandemics may be tied to compliance with social distancing regulations which itself depends on risk perception (Allcott et al., 2020; Barrios and Hochberg, 2020), poverty and economic dislocation (Wright et al., 2020), belief and trust in science (Briscese et al., 2020), political affiliation (Allcott et al., 2020; Engle et al., 2020), social responsibility and social trust (Bargain and Aminjonov, 2020; Brodeur et al., 2020).

When the characteristics of decision-makers and their political institutions differ between cities, and when the population of the city is dissimilar in terms of trust, economic conditions, and political characteristics, we expect a different effect for density. While in circumstances with certain social and political characteristics density may have less effect, in other circumstances, things may be different. Specifically,

[3] Additionally important is the role of household density, i.e., the number of people sharing a household. In addition, intergenerational households (i.e., households compromising of 2–3 generations) have been designated as additional catalysts of COVID-19 infections. While information on intergenerational households is limited, we have assembled data on household densities and have not found any statistically significant results regarding this component. See Appendix B.

communities of Ultra-Orthodox Jews had been identified as a 'risk factor' for COVID-19 infections (Schattner and Klepfish, 2020). Due to their unique characteristics, which include both a leadership and a public less trustful of the state (Hermann et al., 2019), we would expect to find an effect for density in Ultra-Orthodox localities. Regulatory measures aimed at fighting the spread of the disease would be of lesser effect in such socio-political settings. This is when density's effect would come to light. Accordingly, our second hypothesis contends that density's influence on the spread of COVID-19 is contingent on the type of city. This also means that we do not expect to find a main effect for density on the spread of COVID-19.

H2. Holding everything else constant, density's effect on COVID-19 is conditional on urban socio-political attributes of certain city types, in particular Ultra-Orthodox-Jewish cities.

2.3. Compliance

Preliminary research on COVID-19 highlights the role of compliance with social distancing, stay at home orders, travel bans, and quarantine (Courtemanche et al., 2020; Wilder-Smith and Freedman, 2020). In the context of urban life, once going into effect, restricting orders would be readily translated into reduced mobility in the city and between cities. Compliance can also relate to the level of trust between the citizens and the state. Low levels of trust would correlate with reduced compliance. Accordingly, and to further acknowledge cities' socio-political differences, we use the notion of compliance for assessing individual behavior therein.

As we explain in greater detail below, our measure for compliance is particularly appealing for several reasons. First, it is not a proxy, but the behavior itself. Rather than looking at the electronic footprints of a certain behavior, we examine the behavior directly. Furthermore, the measure for compliance is based on big data, and thus avoids any biases related to sampling. Along the lines of the preliminary findings in the literature, we would expect higher rates of compliance to correlate with lower infection rates.

H3. Greater compliance will correlate with lower rates of COVID-19 infections, controlling for everything else.

3. Data and methods

The first case of COVID-19 in Israel was verified on February 27th 2020, with gradually more restrictive containment measures put into force throughout March and April. Significant relief measures in early May indicated the end of the first wave of the disease. Infection rates remained relatively low throughout May and June, with signs of a new outbreak appearing by the end of June. Our research covers the entire timespan of the first wave until the beginning of the second outbreak in early July.

3.1. Outcome variable – rate of infections in cities

We measure infections in each city in intervals of 14 days. This interval takes into consideration the viral incubation period (Bar-On et al., 2020) and overcomes oscillations associated with weekly routines (e.g., weekends) and the number of available COVID-19 tests. Data are taken from the governmental reports issued by the Israel Ministry of Health.[4] In the first weeks of the outbreak in Israel, the reports focused on individual cases, and by March 31st, additional reports covered the distribution of infections at the level of local authorities.

Our data include 271 localities in 7 two-week intervals from March 31st (from the first formal Local Government Report issued by the Ministry of Health) to June 23rd. This covers the entire period of the first wave of COVID-19 in the country. This adds up to 7 observations over time for each of the 271 localities to a total of 1897 observations. 8.3 million out of the country's 9.1 million—that is, 91.2% of the population—reside in those 271 localities.

Our key outcome variable for the multivariate analyses is *New Verified Cases per 100,000 People in the Population in the Last 14 Days*. This variable is useful for analyzing antecedents of COVID-19 as it allows us to take advantage of variance over time. Compared to *Cumulated Cases per 100,000*, which we also refer to and used in some of the emerging literature on COVID-19, the measure for New Verified Cases per 100,000 in the Last 14 Days is more sensitive to temporal variance. Of our key predictors, this sensitivity to variance over time would be particularly crucial for compliance. City-types and density are time-invariant, but levels of compliance fluctuate over time.

3.2. Explanatory variables: city types, density and compliance

3.2.1. Political urban attributes: city-types

Israel has a high level of population density, with the majority of its population concentrating in four metropolitan areas (Orenstein and Hamburg, 2009; Tal, 2016). However, despite the physical proximity in these metropolitan regions, their urban subunits exhibit significant political and social variance.

Given the unitary and centralized government system in Israel, especially as far as COVID-19 containment measures are concerned, we offer a stringent test for the effect of city-types. The uniformity of central government policy could render city-types of diminished consequence. However, H1 contends the opposite. To test this, our first explanatory variable is based on a typology of cities related to their socio-political attributes. Data for city demographics are based on the Israeli Central Bureau of Statistics' most recent Local Government Report.[5] Moreover, this typology follows the lines of how those cities are defined and regulated by the national government:

1) **Jewish** – 149 localities consist of the state's majority population (approximately 79%) and are predominantly Jewish. They include cities, towns, and suburban settlements. The degree of religiosity varies from observant Jews to secular and atheist Jews spanning all socioeconomic classes. In political terms, these cities cover the ideological and partisan spectrum in Israel.
2) **Mixed** – These eight cities include Israel's four metropolitan cities and four other cities; their population is mostly Jewish but includes a significant share of Arabs (Muslim and Christian).
3) **Ultra-Orthodox** – These ten cities are also Jewish, though the vast majority of their population is Ultra-Orthodox Jews leading a religious, highly observant, way of life that had been identified as a 'risk factor' for COVID-19 infections (Schattner and Klepfish, 2020).
4) **Arab and Druze** – Arabs (Muslim and Christian) and Druze in Israel are a large ethnonational minority constituting 21% of the population. These 79 localities are identified as Arab and Druze by the Ministry of Interior.
5) **Bedouin** – The Bedouins are an ethnic Muslim minority in Israel (3.5% of the population) following a distinct way of life. These 25 localities include Bedouin cities, villages, and rural settlements, some of which are not formally recognized by the government.

3.2.2. Density

The standard measure for density is the ratio of population to a given area or jurisdiction (e.g., population per KM^2). For example, Hamidi et al. (2020) assess density in reference to counties and Sun et al. (2020) in reference to provinces. Given our focus on cities, our primary density variable is *Municipal Density*, defined as people living within the municipality's jurisdictional area of the municipality.

[4] https://www.gov.il/he/departments/ministry_of_health.

[5] The file relates to 2018 and was updated in February 2020. https://www.cbs.gov.il/en/mediarelease/Pages/2020/File-of-Local-Authorities-in-Israel-2018.aspx.

Preliminary evidence suggests that density's effect on rates of infection is convoluted. It is not simply that where there is higher density, we would also find higher infection rates. For instance, on March 31st, Bnei Brak, an Ultra-Orthodox city with the highest municipal density, had 287 cumulated cases per 100,000, which was the 3rd highest infection rate nationally. However, the second and third densest cities, respectively Givaatyim and Bat Yam (both Jewish), had only 36 and 59 cumulated cases per 100,000, respectively (ranked 68th and 36th in infection rates from a total 120 infected cities at the time).

Although local density as the share of population living in a jurisdictional area provides some indication regarding density's impact on rates of infection, it fails to account for differences in scale ranging, for example from the street level to the metropolitan region (Pafka, 2020) and discrepancies between cities in their urban land-use policies (e.g., open spaces, industry, agriculture). For instance, a city that includes agricultural land in its jurisdiction may seem to be less dense than it is in terms of livable space for its residents; alternatively, the density of a city that lacks urban amenities in its jurisdiction will not disclose the actual density of daily living conditions. Thus, whereas municipal density may provide some reference to the impact of density on rates of infection, given containment policies that include restrictions on movement, work, and use of public facilities (e.g., parks and playgrounds) we need a measure that accounts for these inter-city differences. For this purpose, and to ensure the findings' robustness for this critically important variable, we created three alternative measures for density based on land use, reflecting the various policy measures taken by governments ranging from somewhat permissive lockdowns to restrictive quarantine:

1) **Density for a lax lockdown**: local population per KM^2 (squared kilometer) of land used for dwelling, educational facilities, health services, public services, culture.
2) **Density for stringent lockdown**: local population per KM^2 of land used for dwelling, health services, and public services.
3) **Dwelling density**: is a restrictive measure. It is based on the local population per KM^2 of residential land used for dwellings only.

These measures focus on the inner-city level. They move beyond general density measurements at the country, county, or regional levels, and zero in on micro-level interactions between urban denizens. These measures also correspond with a growing body of literature that examines local densities concerning the pandemic. Thus, Feng et al. (2020) look at the total population per urban block (of 500 square meters), while others examine population density and the pandemic using zip code area (Whittle and Diaz-Artiles, 2020). Likewise, You et al. (2020) define population density in relation to the built-up area (ratio of residents to construction land area). This, and other similar indices, assume that urban areas cannot be treated as a whole and must be differentiated and sorted. The spread of the pandemics as a possible progeny of higher densities should be measured according to morphological (Teller, 2021) and micro-density conditions that look at scaled data, not on gross densities that overlook concentration of activities, residents, and population flows that affect interpersonal contacts.

Given these lessons, while municipal density often conceals gross variations in the use of land for residential purposes, dwelling density (i.e., people per KM^2 of residential land-use) provides a more accurate measure for comparison. It is the most common urban land-use, and the most important in times of restrictions on movement. Therefore, we used *Dwelling Density* as the explanatory variable in our multivariate analyses in the main body of the paper. We estimate models with the additional density measures in Appendix B; the findings are substantively indistinguishable.

Data for density include 193 localities (total population of 7.9 Million). The data source for municipal land-uses is based on the Central Bureau of Statistics most updated Local Government Report.

3.2.3. Compliance

We define compliance as following government regulations concerning limitations on movement. In Israel, restrictive measures were gradually put in place. In early March, restrictions on social gatherings of more than 5000 people; by March 11 these gatherings were limited to 100 people, with strong governmental recommendations for remote work and employing personal hygiene means; in March 12 all public and private schools were shut down; and by March 19 general restrictions on movement were adopted with a limit to a 100-meter radius from home (adopted March 25). As the rate of infections decreased in mid-April, relief measures were gradually adopted with a final relief of the 100-meter radius and re-opening of schools in early May. See Appendix A, which lists the complete timeline of main events and containment measures, for full details.

We scrapped our data for compliance from the public website operated by Kayma Labs LTD.[6] This website operated between March 1st and May 2nd (the entire timespan of the first wave) and provided information on the share of people who restricted their movement (i.e., stayed within a 100-meter radius) for Israel's biggest 76 cities (total population of 6.6 Million).[7] Based on these data, our *Compliance Index* is the ratio of mobility each week compared to baseline mobility in the first week of March, before the pandemic hit. To ensure the robustness of our findings, and in line with the epidemiological models for the lagged effect of compliance (Bar-On et al., 2020), we used multiple lags for our compliance measures. Those included compliance at t-14, t-21, t-28.

We control for three other variables. *Socio-economic scale* is specified to assess whether socio-economic inequalities impact infection rates. *Population size* was identified as a catalyst of infection rates for COVID-19 (Hamidi et al., 2020) and the Spanish Flu (Chowell et al., 2008). *Share of population over 60* years old was identified as a risk factor for COVID-19 related deaths and transmission (Davies et al., 2020; Williamson et al., 2020). Table 1 provides descriptive statistics for our variables.

3.3. Research design for multivariate models

In our research design, the outcome variables, measuring infection rates, are continuous variables. Accordingly, we estimated Ordinary Least Squares regression models, specifying density levels, city-type, and the interaction between city-type and density as their key predictors. Control variables included a Socioeconomic Scale, Population, % over 60 years old in the population in addition to time fixed effects. City-types were specified as a series of dummy variables, with the excluded category being Jewish. The interaction effect with density was specified for ultraorthodox*density in the models presented in the paper. For robustness, in the Appendix we present the results for models specified with interaction terms also with all other city-types.

We estimated three prototypes of models according to the following specifications:

Density models

$$Y=\alpha+\beta_1{}^*Density+\beta_2{}^*Arab+\beta_3{}^*Mixed+\beta_4{}^*Bedouin+\beta_5{}^*UltraOrthodox+\beta_6{}^*Ultraorthodox^*Density+\beta_7{}^*SocioeconomicScale+\beta_8{}^*Population+\beta_9{}^*\%\ over\ 60+\beta_{10}{}^*time\ fixed\ effects$$

Compliance models

$$Y=\alpha+\beta_1{}^*Compliance+\beta_2{}^*Arab+\beta_3{}^*Mixed+\beta_4{}^*Bedouin+\beta_5{}^*UltraOrthodox+\beta_6{}^*SocioeconomicScale+\beta_7{}^*Population+\beta_8{}^*\%\ over\ 60+\beta_9{}^*time\ fixed\ effects$$

Mixed models – including density and compliance

$$Y=\alpha+\beta_1{}^*Density+\beta_2{}^*Compliance+\beta_3{}_*Arab+\beta_4{}^*Mixed+\beta_5{}^*Bedouin+\beta_6{}^*UltraOrthodox+\beta_7{}^*Ultraorthodox^*Density+\beta_8{}^*SocioeconomicScale+\beta_9{}^*Population+\beta_{10}{}^*\%\ over\ 60+\beta_{11}{}^*time\ fixed\ effects$$

[6] Kayma Labs is a private company operating in Israel; it is directed by Prof. Dan Arieli, and specializes in behavioral economics. https://kayma.com/kayma-home-eng.html.

[7] https://hamadad-haleumi.co.il/.

Table 1
Descriptive statistics.

Variable	Mean	Standard deviation	Minimum value	Maximum value
Outcome variables				
New cases in the last 14 days per 100,000	23.06	71.72	0	1109.4
Cumulative cases per 100,000	104.34	176.05	0	1636.81
City spatial attributes				
Density #1 (municipal)	3281.14	3438.65	68	27,204
Density #2 (lax lockdown)	10,227.42	6482.7	1569	45,611
Density #3 (stringent lockdown)	11,145.52	7787.92	1600	57,145
Density #4 (dwelling)	11,597.54	8216.77	1620	62,339
Compliance				
Compliance average	1.35	0.1	1.12	1.61
Compliance at T-28	1.39	0.12	1.1	1.76
Compliance at T-21	1.31	0.18	0.97	1.76
Compliance at T-14	1.39	0.12	1.1	1.76
Demographic and socioeconomic controls				
Socioeconomic scale	−0.14	1.01	−2.312	2.59
Population	30,460	74,125.75	99	919,438
Percent over 60	9.6	8.21	1.2	41.2

Table 2
Political urban attributes and density.

Variables	Model 2.1	Model 2.2
Density	−0.0001 (0.0003)	0.0001 (0.0004)
Arab	−15.58** (5.74)	−25.16** (8.15)
Mixed	−8.05 (10.24)	−9.61 (7.94)
Bedouin	−5.04 (11.91)	3.9 (14.05)
Ultra-Orthodox	4.8 (19.28)	−115.9*** (34.1)
Ultra-Orthodox * Density	0.002*** (0.0006)	0.004*** (0.0008)
Socioeconomic scale	−2.54 (2.93)	−5.65 (3.36)
Population	0.00004 (0.00003)	0.00005* (0.00002)
% over 60	−0.63 (0.45)	−0.69 (0.5)
Constant	26.58** (8.41)	27.58** (9.93)
	$N = 1351$	$N = 623$
	$F(12, 1338) = 16.51$	$F(12, 610) = 24.53$
	Prob > F = 0.0	Prob > F = 0.0
	$R^2 = 0.13$	$R^2 = 0.33$

Time fixed effects are not reported.
Standard error in parentheses.
* <0.05.
** <0.01.
*** <0.001 (one tailed tests).

4. Results

In the graphical abstract figure, the distribution of cumulated verified infections per 100,000 people is charted for each city-type at each of the points in time in the database. On the X-axis, the five different city types appear, with 7 bars for each. Each bar represents the cumulative number of cases for this city from March 30 to June 29 in 2-week intervals, chronologically sequenced from left to right in bright to dark blue. Orange lines represent standard errors. As the measure is proportional to the size of the population, comparisons over time and between city types shed important light on the relationship between infection rates and urban socio-political attributes.

Lending support for H1, patterns are markedly different between city types. First, as time goes by and the share of infections in the population grows as well, the share is significantly higher in Ultra-Orthodox cities. For instance, on April 14, at the height of the first wave of COVID-19 in the country, the share in Ultra-Orthodox localities is 489 per 100,000 in the population. This figure far surpasses the Jewish (100 per 100,000), Arab (27), Mixed (91) or Bedouin (17) rates. Furthermore, while the rate of increase is linear in Jewish, Arab and Mixed cities, it is curvilinear with an increasing rate of growth in Bedouin cities and curvilinear with a decreasing rate of growth in Ultra-Orthodox cities. Standard errors are particularly high in Bedouin and Ultra-Orthodox cities, partly due to the small number of data points in each. Support for H1 is mixed. While one of the minority groups (Ultra-Orthodox) exhibits higher levels of infections in their cities, the same cannot be said for the other major minority group, the Arabs. Indeed, compared to Jewish cities, Arab localities have lower levels of cumulated cases per 100,000 at any point in time in our data.

In Table 2, multivariate models estimated show the effects of urban attributes and density. The main effect of density does not reach standard levels of statistical significance. Conversely, the dummy for Arab cities is negative and highly significant. Echoing the results in the graphical abstract figure, the dummy for Arab cities indicates that in comparison to Jewish cities, Arab cities show consistently lower rates of infection during the period studied. Furthermore, in support of H2, the interaction effect between density and the Ultra-Orthodox dummy is highly significant and positive. This suggests that the effect of density is contingent on urban socio-political attributes. It is in Ultra-Orthodox cities that density's effect is felt. Interaction terms specified for density and other city types (see Appendix C) were not statistically significant. The results remain substantively the same when the same model is estimated for a subsample of cities with population size greater than 20,000 (Model 2.2). While population size significantly correlates with higher infection rates in cities with population over 20,000, percent over 60 years old and socio-economic conditions have no statistically significant effects on rates of COVID-19.

In Fig. 1, the compliance trendline for all 76 cities for which data are available indicates that more compliance at t-21 days is negatively correlated with new cases in the last 14 days. Each of the graphs shows the compliance index in 2-week intervals for the full duration of the first wave in Israel. On the X-axis are compliance index scores. City-types are depicted in different colors. Lending preliminary support for H3, higher compliance scores are negatively correlated with rates of COVID-19 infections. March 31st is still a relatively early stage in the outbreak and the compliance at t-21 refers to the second week of March when early containment measures were devised. Accordingly, the average compliance score is relatively low (1.057), indicating virtually no change over the baseline. This depiction dramatically changes on April 14th. At this stage, containment measures at t-21 already include general restrictions on movement, including limitation to a 100-meter radius from the household. While the general average increases (1.3902), the conglomeration of clusters distributed according to city-types is clear. Most minority city-types (Ultra-Orthodox, Bedouin, and Arab) are below the general average, whereas most Mixed and Jewish cities are above. This clustering according to city-types continues throughout the rest of the first wave. Cities with high levels of compliance show relatively low infection rates. Conversely, cities with below-average compliance scores exhibit variations in infection rates. Although minority group clusters are below average, most Arab and Bedouin cities show a relatively low infection rate. Ultra-Orthodox cities have exceedingly high levels of infection.

Corroborating the preliminary evidence in Fig. 1, multivariate models analyzing infection rates based on compliance and socio-economic index in Table 3 suggest that complying with lockdown regulations at t-21 has a statistically significant negative impact on new cases in the last 14 days. See Model 3.1 for all cities, and Model 3.2, for cities with a population greater than 20,000. Even when controlling for the type of city, its socio-economic and demographic conditions, and time, the effect of compliance is significant and negative. Ceteris paribus, more compliance is significantly correlated with decreased infection rates. Controlling for alternative effects, for each additional unit of compliance (i.e., decreased levels of mobility compared to pre-pandemic levels), we expect to see a decrease of over 160 new cases in the locality in the last 14 days. Analyses of compliance at t-28 yielded similar results (see Appendix D), with an effect of the same magnitude.

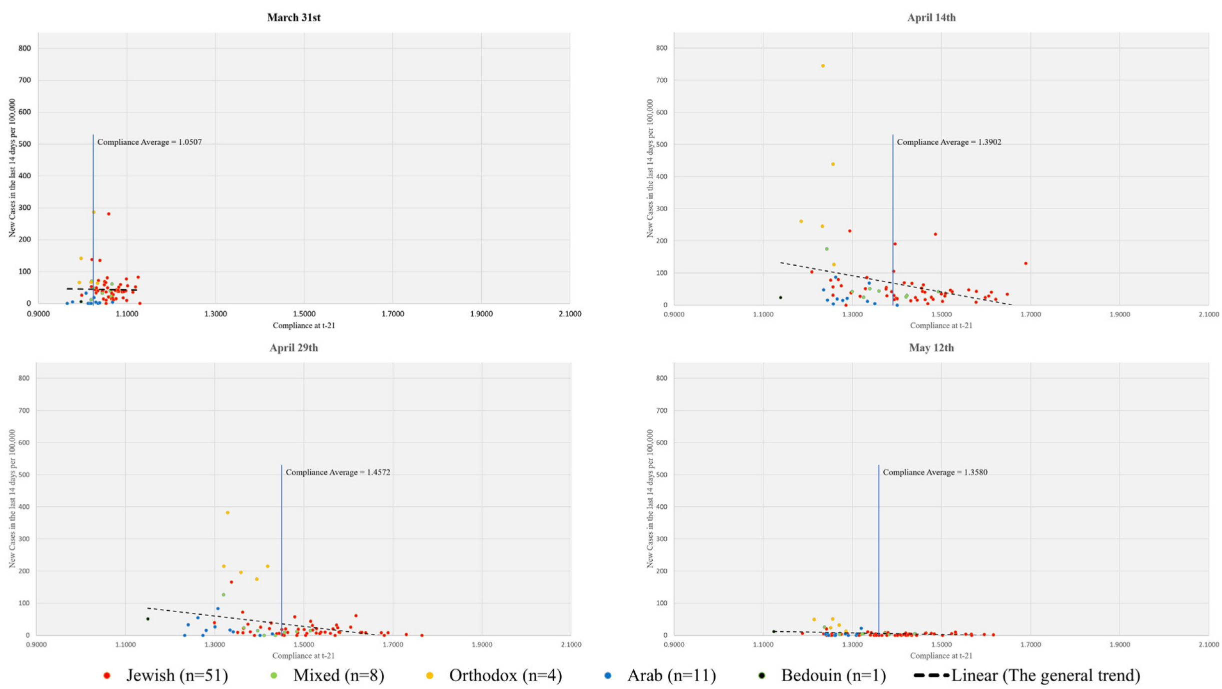


Fig. 1. The effect of compliance at t-21 in 2-week intervals (March 31st, April 14th, April 29th, and May 12th).

Let us now examine multivariate models that combine our full gamut of explanatory variables. This would allow us to juxtapose the different theoretical accounts empirically. Estimating a model for infection rates based on urban socio-political makeup, density, compliance and socio-economic conditions lends further support to our overall conclusions. In support of H2, in Table 4 (all cities in Model 4.1 and those with population greater than 20,000 in Model 4.2), the coefficient on the interaction term between density and the Ultra-Orthodox dummy is positive and significant. In Ultra-Orthodox cities, more density is correlated with higher infection rates. What is more, in support of H3, controlling for everything else, the effect of compliance is negative and significant. Ceteris paribus, compliance with containment measures decreases the rate of infections over time in a statistically significant manner. Controlling for alternative effects, for each additional unit of compliance (i.e., decreased levels of mobility compared to pre-pandemic levels), we expect to see a decrease of over 150 new cases in the locality in the last 14 days. We find no statistically significant main effect for density. Indeed, a comparison to the results in Table 2 prove that density's marginal and statistically insignificant main effect remains unchanged when compliance is also specified in the model.

Table 3
Political urban attributes and compliance.

Variables	Model 3.1	Model 3.2
Compliance at T-21	−161.56** (52.36)	−170.46** (53.22)
Arab	−26.79* (12.63)	−30.08* (12.86)
Mixed	−21.92 (11.55)	−23.15* (11.65)
Bedouin	−33.26 (30.11)	−37.99 (30.45)
Ultra-Orthodox	146.95*** (18.62)	143.43*** (18.86)
Socioeconomic scale	8.86 (7.75)	8.71 (7.84)
Population	0.00008** (0.00002)	0.00008** (0.00002)
% over 60	−0.39 (0.81)	−0.45 (0.81)
Constant	209.88*** (57.67)	222.27*** (58.78)
	$N = 304$	$N = 296$
	F (11, 292) = 23.86	F (11, 284) = 23.59
	Prob > F = 0.0	Prob > F = 0.0
	$R^2 = 0.47$	$R^2 = 0.48$

Time fixed effects are not reported.
Standard error in parentheses.
* <0.05.
** <0.01.
*** <0.001 (one tailed tests).

Table 4
Political urban attributes, density and compliance.

Variables	Model 4.1	Model 4.2
Compliance		
Compliance at T-21	−152.79**	−161.85***
	48.28	48.99
City spatial attributes		
Density	−0.000001	−0.0002
	0.0007	0.0007
Political urban attributes		
Arab	−30.71**	−34.69**
	11.79	12.04
Mixed	−18.86	−20.45
	10.69	10.78
Bedouin	−37.41	−42.39
	27.76	28.03
Ultra-Orthodox	−166.02***	−171.91***
	46.45	46.79
Ultra-Orthodox ⁎ Density	0.007***	0.007***
	0.001	0.001
Demographic and socioeconomic controls		
Socioeconomic scale	9.55	9.29
	7.16	7.22
Population	0.00007*	0.00007*
	0.00002	0.00003
% over 60	−0.89	−0.89
	0.77	0.77
Constant	210.54***	225.07
	53.43	54.48***
	N = 304	N = 296
	F (13, 290) = 27.90	F (13, 282) = 27.67
	Prob > F = 0.0	Prob > F = 0.0
	R2 = 0.56	R2 = 0.56

Time fixed effects are not reported.
Standard error in parentheses.
* <0.05.
** <0.01.
*** <0.001 (one tailed tests).

5. Discussion and conclusions

The questions driving this research concerned the socio-political aspects of COVID-19, that while understudied, have major implications for the current pandemic as well as for its aftermath. To consider the underlying issues at the core of our investigation—which pertain to broad questions of sustainability and cities—our empirical investigation examines the impact of density on the spread of COVID-19; the role of urban attributes in explaining the spread of the pandemic; how compliance with restrictive measures influenced infection rates; and, potential interactions between those theoretical accounts. Our first hypothesis wins mixed support. Conversely, the support for H2 and H3 is robust in various model specifications and based on different subsamples. Infection patterns over time are consistently dissimilar between different city-types.

Furthermore, we find no main effect for density. In the analyses presented here, we use *Dwelling Density* (the most restrictive density measure). For robustness, we estimated models with the additional density measures in Appendix B. Findings remain the same. As such, this structural-spatial variable is not correlated with infection rates as such. However, when considering the urban socio-political attributes, we find in support of H2, that there is a conditional effect for density. It is in Ultra-Orthodox cities that higher density translates into higher infection rates. In cities with other political urban attributes, we did not find either a conditional or a main effect for density. As expected, compliance with policy measures concerning restrictions of movement correlated with reduced levels of infection. This dynamic, where socio-political variables have more impact in comparison with spatial-structural variables (i.e., population density) may be explained in analogy to Bronfenbrenner's (1994) socio-ecological system model. According to this model, individual behavior is impacted by multiple levels of the surrounding environment from the microsystem (e.g., family, school, neighborhood) to the macrosystem (e.g., cultural values, laws and customs), and a mesosystem that mediates between these two, and the other, levels. By analogy, it may be argued that in COVID-19 cases, microsystemic features such as political urban attributes, may have a higher impact on individuals than the macro and mesosystems.[8]

How come we find partial support for H1? Why, despite our theoretical expectations and relatively low compliance scores, Arab cities did not show higher levels of infections, at least around the outbreak? Two accounts help explain why these cities, in which minorities, who are equally less trustful of government, live, do not show increased infections. The first has to do with the tense, somewhat volatile, general elections on March 2nd 2020. In these elections, the Joint-List (a political alliance of four dominant Arab parties in Israel, and the only Arab list) gained its most significant political achievement ever and won 15 of the 120 seats in the Israeli parliament. Moreover, during the negotiations over coalition formation, it was the first time that an Arab party recommended appointing a Zionist premier. Accordingly, it was the first time in Israeli politics that pragmatic negotiations regarding the inclusion of Arab parties in the coalition were held. Arab leadership at the national and local levels paid close attention to the spread of COVID-19 and took precautionary containment measures so that public attention is paid to the dramatic political affairs and that growing infections in the Arab community would not overshadow these affairs.

Secondly, at an early stage of the COVID-19 outbreak in Israel (March 17th), Arab religious leaders (Muslim and Christian alike) put in place severe restrictions on all places of worship due to the close social interactions within. These measures were self-adopted. The national government put forward no compulsory regulatory measure. Conversely, in the Ultra-Orthodox community, these forms of cautionary restrictions on places of worship were devised only at a later stage (March 31st) and after intense negotiations with government officials.[9] Overall, in the Jewish-Ultra-Orthodox community, local leaders were reluctant to postpone or ban religious events in which many people participated without social distancing.

Although both minority groups exhibited low levels of compliance, the Arab cities did adopt lifestyle changes requisite for containing COVID-19 infections. Conversely, Ultra-Orthodox Jews were reluctant to do so. While Arab leadership autonomously adopted restrictive measures such as shutting places of worship, the Ultra-Orthodox leadership insisted that their religious practices be safeguarded, the greater risk of infection notwithstanding. It is possible that issues of integration also played a role. The Ultra-Orthodox community is less connected to the main information channels of Israeli news media, where important information on the nature of the pandemic and restrictive measures was relayed to the public. While the aspects above played a significant role during the first wave, with shifting political realities, the rates of infection have changed with increased infection rates in Arab cities at later stages of the pandemic in Israel (Muhsen et al., 2021). Future research should further explore the underlying mechanisms explaining why cities with certain minority groups, and not others, exhibit higher levels of infection rates.

Our comparison of different theoretical accounts produced crucially important findings for the understanding the spread of COVID-19. While density is key to urbanity, analyzing density alone does not disclose the full dynamics of COVID-19 infections in cities. As our findings indicate, density's effect on rates of infection is contingent on socio-political attributes. As the descriptive statistics in Table 1 indicate, variance levels in density measures were high, in particular in comparison with our indicator for compliance. To address possible limitations, we took several precautions to ensure such discrepancy has no bearing on our results. Firstly, the fact that we have multiple measures for density, all yielding substantively similar results when specified in our multivariate models (see Appendix B), adds to the robustness of our findings, even in light of different levels of variance in the predictors. In addition, we estimated models for the whole sample as well as for a split sample of cities with population over 20,000 (e.g., Model 2.2 in Table 2 and Model 4.2 in Table 4). The ratio of standard errors of the different predictors remains approximately the same in the sub-sample for big cities (population > 20 K). Likewise, the results in models with the split sample remain substantively unchanged, which is another indication that even when the divergence in variance between predictors is smaller; the conclusions are unaffected.

5.1. Suggestions for future research

Our findings suggest several venues for future research. Density's conditional effect might be applicable not only to cities but also at other urban scales. In larger metropolitan areas, far bigger than those in Israel, such as New York City, London, or Beijing, it would be interesting to conduct similar analyses juxtaposing political accounts against structural ones. Instead of cities, however, the units of analysis in such studies would be metropolitan regions, neighborhoods, or boroughs. This would introduce new levels of complexity into the analysis, as those units are different from cities and the interactions between them may be particularly consequential (Hamidi et al., 2020).

Another aspect of studying density and COVID-19 infection rates would be to look at other types of density. Our findings in Appendix B suggest that household density (i.e., the number of people living in the same house), is uncorrelated with our other density measures all of which are strongly correlated with each other (see Table 1B). That said, household density may be consequential particularly for pandemics given restrictions on movement and home quarantines. While

[8] While this analogy is useful for understanding why the effect of density on contagion is contingent upon socio-political variables, it is important to note that the analogy is incomplete: while Bronfenbrenner's theory analyses individual behavior, our unit of analysis is city-type.

[9] See Timeline of main events and containment measures in Appendix A.

we failed to find a significant effect for infection rates, this question warrants further research.

5.2. Takeaways for practice

The findings add important input to the growing public debates regarding various antecedents for COVID-19. Our findings concerning the conditional effect of density on socio-political city characteristics parallel critiques of neo-Malthusian analyses of overpopulation as cause for environmental collapse. Neo-Malthusians argue that exponential population growth overshadows sustainable development goals. The larger the population, the harder it becomes to supply public amenities (e.g., food supply) or to maintain human affairs within ecosystemic carrying capacity. Conversely, their critics indicate that inequalities are key causes of environmental degradation and argue that any analysis of population growth must be reflected in socio-political factors. Our findings indicate that it is not population density per-se that exacerbates infections. Instead, it is urban socio-political circumstances, cultures and lifestyles that influence the dynamic realities of pandemics.

The takeaway for practitioners is quite clear: instead of embracing suburbanization and low-density developments, planners and decision-makers should look for ways to increase compliance and trust in governance. The pandemic highlights tensions regarding these issues especially among minorities. Thus, the findings accentuate distributional and environmental justice issues and highlight the vulnerabilities to which preemptive measures could and should be applied. Such preemptive measures may include (1) special attention to needs of minority communities; (2) two-way exchanges between minority population and decision-makers; (3) establishing different modes of interaction between communities and politicians; (4) identifying local leadership and appointing qualified personnel, trusted by local communities, to communicate information, needs and guidelines and alleviate possible tensions that reduce trust in government.

In addition, the findings suggest that decision-makers should improve the use of existing dense urban environs in a manner which reduces risk of infection. Indeed, in this regards cities' action worldwide is encouraging. Cities are already breathing new life into their public spaces, rapidly adapting to the changing reality via tactical urbanism (i.e., low cost temporary spatial interventions) and dynamic place-based policies such as expanding pedestrian and cycling spaces, and expanding outdoor seating for restaurants. These interventions enable people to continuously interact in dense built environments without exposing themselves to the virus. The variance in those measures reflects the range of circumstances emanating from the unique logic of each city. The notion that densification and sprawl are due in light of the COVID-19 pandemic (Kotkin, 2020), underestimates the importance of city politics and social makeup and is thus insufficiently informed and may potentially vitalize environmentally and socially destructive policies.

CRediT authorship contribution statement

Nir Barak: Conceptualization, Formal analysis, Data curation, Writing – original draft, Project administration, Visualization. **Udi Sommer:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Supervision. **Nir Mualam:** Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A–D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2021.148626.

References

Abramson, P.R., 1972. Political efficacy and political trust among black schoolchildren: two explanations. J. Polit. 34, 1243–1275. https://doi.org/10.2307/2128934.

Ahmadi, M., Sharifi, A., Dorosti, S., Jafarzadeh Ghoushchi, S., Ghanbari, N., 2020. Investigation of effective climatology parameters on COVID-19 outbreak in Iran. Sci. Total Environ. 729, 138705. https://doi.org/10.1016/j.scitotenv.2020.138705.

Allcott, H., Boxell, L., Conway, J., Gentzkow, M., Thaler, M., Yang, D., 2020. Polarization and Public Health: Partisan Differences in Social Distancing During the Coronavirus Pandemic (Working Paper 26946 No. w26946). National Bureau of Economic Research, Cambridge, MA https://doi.org/10.3386/w26946.

Angel, S., Blei, A.M., Lamson-Hall, P., Salazar, M.M., 2020. The Coronavirus and the Cities: Explaining Variations in the Onset of Infection and in the Number of Reported Cases and Deaths in U.S. Metropolitan Areas as of 27.

Barak, N., 2017. Hundertwasser - inspiration for environmental ethics: reformulating the ecological self. Environ. Values 26, 317–342. https://doi.org/10.3197/096327117X14913285800689.

Barak, N., 2020a. Civic ecologism: environmental politics in cities. Ethics Policy Environ. 23, 53–69. https://doi.org/10.1080/21550085.2020.1746005.

Barak, N., 2020b. Ecological city-zenship. Environ. Polit. 29, 479–499. https://doi.org/10.1080/09644016.2019.1660504.

Barak, N., de Shalit, A., 2021. Cities and political theory. In: Aust, H., Nijman, J. (Eds.), Research Handbook on International Law and Cities. Edward Elgar.

Barbehön, M., Münch, S., Gehring, P., Grossmann, A., Haus, M., Heinelt, H., 2016. Urban problem discourses: understanding the distinctiveness of cities. J. Urban Aff. 38, 236–251. https://doi.org/10.1111/juaf.12206.

Bargain, O., Aminjonov, U., 2020. Trust and Compliance to Public Health Policies in Times of COVID-19 (No. IZA Discussion Paper 13205). IZA Institute of Labor Economics.

Bar-On, Y.M., Flamholz, A., Phillips, R., Milo, R., 2020. SARS-CoV-2 (COVID-19) by the numbers. eLife 9, e57309. https://doi.org/10.7554/eLife.57309.

Barrios, J.M., Hochberg, Y.V., 2020. Risk Perception Through the Lens of Politics in the Time of the COVID-19 Pandemic. (Working Paper NO. 2020-32). Becker Friedman Institute for Economics at UCHICAGO, Chicago.

Batty, M., 2020. The coronavirus crisis: what will the post-pandemic city look like? Environ. Plan. B Urban Anal. City Sci. 47, 547–552. https://doi.org/10.1177/2399808320926912.

Bauböck, R., Orgad, L. (Eds.), 2020. Cities Vs States: Should Urban Citizenship Be Emancipated From Nationality? EUI RSCAS, Global Governance Programme-386, [Global Citizenship], GLOBALCIT, [Global Citizenship Governance]. European University Institute Research Repository Retrieved from Cadmus. at.

Bell, D.A., de Shalit, A., 2011. The Spirit of Cities: Why the Identity of a City Matters in a Global Age. Princeton University Press, Princeton, N.J.

Berkes, F., Ross, H., 2013. Community resilience: toward an integrated approach. Soc. Nat. Resour. 26, 5–20. https://doi.org/10.1080/08941920.2012.736605.

Birenbaum-Carmeli, D., Chassida, J., 2020. Covid-19 in Israel: socio-demographic characteristics of first wave morbidity in Jewish and Arab communities. Int. J. Equity Health 19, 153. https://doi.org/10.1186/s12939-020-01269-2.

Blank, Y., 2007. Spheres of citizenship. Theor. Inq. Law 8, 411–452. https://doi.org/10.2202/1565-3404.1156.

Booth, K.I., 2013. Deep ecology, hybrid geographies, and environmental management's relational premise. Environ. Values 22, 523–543. https://doi.org/10.3197/096327113X13690717320829.

Bootsma, M.C.J., Ferguson, N.M., 2007. The effect of public health measures on the 1918 influenza pandemic in U.S. cities. Proc. Natl. Acad. Sci. 104, 7588–7593. https://doi.org/10.1073/pnas.0611071104.

Boterman, W.R., 2020. Urban-rural polarisation in times of the corona outbreak? The early demographic and geographic patterns of the SARS-CoV-2 epidemic in the Netherlands. Tijdchr. Econ. Soc. Geogr. 111, 513–529. https://doi.org/10.1111/tesg.12437.

Briscese, G., Lacetera, N., Macis, M., Tonin, M., 2020. Compliance With COVID-19 Social-Distancing Measures in Italy: The Role of Expectations and Duration (No. w26916). National Bureau of Economic Research, Cambridge, MA https://doi.org/10.3386/w26916.

Brodeur, A., Grigoryeva, I., Kattan, L., 2020. Stay-At-Home Orders, Social Distancing and Trust. p. 32.

Bronfenbrenner, U., 1994. Ecological models of human development. International Encyclopedia of Education. Pergamon Press and Elsevier Science, Oxford, pp. 1643–1647.

Cannavò, P.F., 2007. The Working Landscape: Founding, Preservation, and the Politics of Place, Urban and Industrial Environments. MIT Press, Cambridge, Massachusetts.

Cartenì, A., Di Francesco, L., Martino, M., 2020. How mobility habits influenced the spread of the COVID-19 pandemic: results from the Italian case study. Sci. Total Environ. 741, 140489. https://doi.org/10.1016/j.scitotenv.2020.140489.

Chowell, G., Bettencourt, L.M.A., Johnson, N., Alonso, W.J., Viboud, C., 2008. The 1918–1919 influenza pandemic in England and Wales: spatial patterns in transmissibility and mortality impact. Proc. R. Soc. B Biol. Sci. 275, 501–509. https://doi.org/10.1098/rspb.2007.1477.

Coşkun, H., Yıldırım, N., Gündüz, S., 2021. The spread of COVID-19 virus through population density and wind in Turkey cities. Sci. Total Environ. 751, 141663. https://doi.org/10.1016/j.scitotenv.2020.141663.

Courtemanche, C., Garuccio, J., Le, A., Pinkston, J., Yelowitz, A., 2020. Strong social distancing measures in the United States reduced the COVID-19 growth rate: study evaluates the impact of social distancing measures on the growth rate of confirmed COVID-19 cases across the United States. Health Aff. 39, 1237–1246. https://doi.org/10.1377/hlthaff.2020.00608.

Dagger, R., 2003. Stopping sprawl for the good of all: the case for civic environmentalism. J. Soc. Philos. 34, 28–43. https://doi.org/10.1111/1467-9833.00163.

Davies, N.G., Klepac, P., Liu, Y., Prem, K., Jit, M., Eggo, R.M., 2020. Age-dependent effects in the transmission and control of COVID-19 epidemics. Nat. Med. 26, 1205–1211. https://doi.org/10.1038/s41591-020-0962-9.

de Certeau, M., 1984. The Practice of Everyday Life. University of California Press, Berkley.

de Shalit, A., 1996. Ruralism or environmentalism? Environ. Values 5, 47–58.

Ehrlich, P.R., 1968. The Population Bomb. Sierra Club/Ballantine Books.

Engle, S., Stromme, J., Zhou, A., 2020. Staying at Home: Mobility Effects of COVID-19 (SSRN Scholarly Paper No. ID 3565703). Social Science Research Network, Rochester, NY https://doi.org/10.2139/ssrn.3565703.

Ewing, R., Hamidi, S., 2015. Compactness versus sprawl: a review of recent evidence from the United States. J. Plan. Lit. 30, 413–432. https://doi.org/10.1177/0885412215595439.

Feng, Y., Li, Q., Tong, X., Wang, R., Zhai, S., Gao, C., Lei, Z., Chen, S., Zhou, Y., Wang, J., Yan, X., Xie, H., Chen, P., Liu, Shijie, Xv, X., Liu, Sicong, Jin, Y., Wang, C., Hong, Z., Luan, K., Wei, C., Xu, J., Jiang, H., Xiao, C., Guo, Y., 2020. Spatiotemporal Spread Pattern of the COVID-19 Cases in China (Preprint). In Review. https://doi.org/10.21203/rs.3.rs-32520/v1.

Florida, R., Rodríguez-Pose, A., Storper, M., 2020. Cities in a post-COVID world. Papers in Evolutionary Economic Geography #20/41. Utrecht University, Utrecht, the Netherlands, p. 29.

Frutos, R., Lopez Roig, M., Serra-Cobo, J., Devaux, C.A., 2020. COVID-19: the conjunction of events leading to the coronavirus pandemic and lessons to learn for future threats. Front. Med. 7. https://doi.org/10.3389/fmed.2020.00223.

Gibb, R., Redding, D.W., Chin, K.Q., Donnelly, C.A., Blackburn, T.M., Newbold, T., Jones, K.E., 2020. Zoonotic host diversity increases in human-dominated ecosystems. Nature, 1–5 https://doi.org/10.1038/s41586-020-2562-8.

Glaeser, E., 2011. Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier and Happier. Penguin Books, New York.

Hall, S., 2012. City, Street and Citizen: The Measure of the Ordinary. 1st ed. Routledge https://doi.org/10.4324/9780203118597.

Hamidi, S., Sabouri, S., Ewing, R., 2020. Does density aggravate the COVID-19 pandemic? J. Am. Plan. Assoc. 0, 1–15. https://doi.org/10.1080/01944363.2020.1777891.

Han, Y., Yang, L., Jia, K., Li, J., Feng, S., Chen, W., Zhao, W., Pereira, P., 2021. Spatial distribution characteristics of the COVID-19 pandemic in Beijing and its relationship with environmental factors. Sci. Total Environ. 761, 144257. https://doi.org/10.1016/j.scitotenv.2020.144257.

Hermann, T., Anabi, O., Cubison, W., Heller, E., 2019. The Israeli Democracy Index 2019.

Jacobs, J., 1992. The Death and Life of Great American Cities. Vintage Books, New York.

Jamshidi, S., Baniasad, M., Niyogi, D., 2020. Global to USA county scale analysis of weather, urban density, mobility, homestay, and mask use on COVID-19. Int. J. Environ. Res. Public Health 17, 7847. https://doi.org/10.3390/ijerph17217847.

Joy, M., Vogel, R.K., 2021. Beyond neoliberalism: a policy agenda for a progressive city. Urban Aff. Rev., 1078087420984241 https://doi.org/10.1177/1078087420984241.

Khavarian-Garmsir, A.R., Sharifi, A., Moradpour, N., 2021. Are high-density districts more vulnerable to the COVID-19 pandemic? Sustain. Cities Soc. 70, 102911. https://doi.org/10.1016/j.scs.2021.102911.

Kim, I.C., 2005. A sense of alienation towards government: an anatlyic framework. Int. Rev. Public Adm. 9, 55–64. https://doi.org/10.1080/12294659.2005.10805049.

King, R.J.H., 2006. Playing with boundaries: critical reflections on strategies for an environmental culture and the promise of civic environmentalism. Ethics Place Environ. 9, 173–186. https://doi.org/10.1080/13668790600694576.

Kirkman, R., 2004. Reasons to dwell on (if not necessarily in) the suburbs. Environ. Ethics 26, 77–95.

Kotkin, J., 2020. Angelenos Love Their Suburban Sprawl. The Coronavirus Proves Them Right. Los Angel. Times.

Krugman, P., 2021. Opinion|The Pandemic and the Future City. N. Y. Times.

Lee, W., Kim, Honghyok, Choi, H.M., Heo, S., Fong, K.C., Yang, J., Park, C., Kim, Ho, Bell, M.L., 2021. Urban environments and COVID-19 in three Eastern states of the United States. Sci. Total Environ. 779, 146334. https://doi.org/10.1016/j.scitotenv.2021.146334.

Leichenko, R., 2011. Climate change and urban resilience. Curr. Opin. Environ. Sustain. 3, 164–168. https://doi.org/10.1016/j.cosust.2010.12.014.

Light, A., 2001. The urban blind spot in environmental ethics. Environ. Polit. 10, 7–35. https://doi.org/10.1080/714000511.

Light, A., 2003. Urban ecological citizenship. J. Soc. Philos. 34, 44–63. https://doi.org/10.1111/1467-9833.00164.

Löw, M., 2012. The intrinsic logic of cities: towards a new theory on urbanism. Urban Res. Pract. 5, 303–315. https://doi.org/10.1080/17535069.2012.727545.

Löw, M., 2013. The city as experiential space: the production of shared meaning. Int. J. Urban Reg. Res. 37, 894–908. https://doi.org/10.1111/1468-2427.12022.

Löw, M., 2016. The Sociology of Space. Palgrave Macmillan US, New York https://doi.org/10.1057/978-1-349-69568-3.

Maor, M., Sulitzeanu-Kenan, R., Chinitz, D., 2020. When COVID-19, constitutional crisis, and political deadlock meet: the Israeli case from a disproportionate policy perspective. Polic. Soc. 39, 442–457. https://doi.org/10.1080/14494035.2020.1783792.

Meerow, S., Newell, J.P., 2019. Urban resilience for whom, what, when, where, and why? Urban Geogr. 40, 309–329. https://doi.org/10.1080/02723638.2016.1206395.

Megahed, N.A., Ghoneim, E.M., 2020. Antivirus-built environment: lessons learned from Covid-19 pandemic. Sustain. Cities Soc. 61, 102350. https://doi.org/10.1016/j.scs.2020.102350.

Mills, C.E., Robins, J.M., Lipsitch, M., 2004. Transmissibility of 1918 pandemic influenza. Nature 432, 904–906. https://doi.org/10.1038/nature03063.

Molotch, H., Freudenburg, W., Paulsen, K.E., 2000. History repeats itself, but how? City character, urban tradition, and the accomplishment of place. Am. Sociol. Rev. 65, 791. https://doi.org/10.2307/2657514.

Muhsen, K., Na'aminh, W., Lapidot, Y., Goren, S., Amir, Y., Perlman, S., Green, M.S., Chodick, G., Cohen, D., 2021. A nationwide analysis of population group differences in the COVID-19 epidemic in Israel, February 2020–February 2021. Lancet Reg. Health Eur. 7, 100130. https://doi.org/10.1016/j.lanepe.2021.100130.

Negev, M., Dahdal, Y., Khreis, H., Hochman, A., Shaheen, M., Jaghbir, M.T.A., Alpert, P., Levine, H., Davidovitch, N., 2021. Regional lessons from the COVID-19 outbreak in the Middle East: from infectious diseases to climate change adaptation. Sci. Total Environ. 768, 144434. https://doi.org/10.1016/j.scitotenv.2020.144434.

Orenstein, D.E., Hamburg, S.P., 2009. To populate or preserve? Evolving political-demographic and environmental paradigms in Israeli land-use policy. Land Use Policy 26, 984–1000. https://doi.org/10.1016/j.landusepol.2008.12.003.

Pafka, E., 2020. Multi-scalar urban densities: from the metropolitan to the street level. Urban Des. Int. https://doi.org/10.1057/s41289-020-00112-y.

Pantoja, A.D., 2006. Descriptive representation, political alienation, and political trust: the case of Latinos in Connecticut. In: Torres, A. (Ed.), Latinos in New England. Temple University Press, Philadephia, PA, pp. 225–236.

Porter, E., 2020. Coronavirus Threatens the Luster of Superstar Cities. N. Y. Times.

Qiu, Y., Chen, X., Shi, W., 2020. Impacts of social and economic factors on the transmission of coronavirus disease 2019 (COVID-19) in China. J. Popul. Econ. 33, 1127–1172. https://doi.org/10.1007/s00148-020-00778-2.

Rocklöv, J., Sjödin, H., 2020. High population densities catalyse the spread of COVID-19. J. Travel Med. 27. https://doi.org/10.1093/jtm/taaa038.

Rosenthal, B.M., 2020. Density Is New York City's Big 'Enemy' in the Coronavirus Fight. N. Y. Times.

Sassen, S., 2001. The Global City: New York, London, Tokyo. 2nd ed. Princeton University Press, Princeton, N.J.

Schattner, A., Klepfish, A., 2020. Orthodox Judaism as a risk factor of Covid-19 in Israel. Am J Med Sci https://doi.org/10.1016/j.amjms.2020.05.037.

Sennett, R., 2018. Building and Dwelling: Ethics for the City. Penguin Books.

Sharifi, A., Khavarian-Garmsir, A.R., 2020. The COVID-19 pandemic: impacts on cities and major lessons for urban planning, design, and management. Sci. Total Environ. 749, 142391. https://doi.org/10.1016/j.scitotenv.2020.142391.

Shenker, J., 2020. Cities After Coronavirus: HOW COVID-19 Could Radically Alter Urban Life. The Guardian.

Sirkeci, I., Yucesahin, M.M., 2020. Coronavirus and migration: analysis of human mobility and the spread of Covid-19. Migr. Lett. 17, 379–398. https://doi.org/10.33182/ml.v17i2.935.

Sun, Z., Zhang, H., Yang, Y., Wan, H., Wang, Y., 2020. Impacts of geographic factors and population density on the COVID-19 spreading under the lockdown policies of China. Sci. Total Environ. 746, 141347. https://doi.org/10.1016/j.scitotenv.2020.141347.

Sy, K.T.L., White, L.F., Nichols, B.E., 2021. Population density and basic reproductive number of COVID-19 across United States counties. PLoS One 16, e0249271. https://doi.org/10.1371/journal.pone.0249271.

Tal, A., 2016. The Land Is Full: Addressing Overpopulation in Israel. Yale University Press, New Haven.

Teller, J., 2021. Urban density and Covid-19: towards an adaptive approach. Build. Cities 2, 150–165. https://doi.org/10.5334/bc.89.

Tonkiss, F., 2013. Cities by Design: The Social Life of Urban Form. Polity Press, Cambridge.

Tsairi, Y., Alon, T., 2020. How population density contributes to COVID-19 infections in Israeli citiess. Ecol. Environ. J. Sci. Environ. Policy [Hebrew] 11, 1.

Whittemore, A.H., BenDor, T.K., 2019. Exploring the acceptability of densification: how positive framing and source credibility can change attitudes. Urban Aff. Rev. 55, 1339–1369. https://doi.org/10.1177/1078087418754725.

Whittle, R.S., Diaz-Artiles, A., 2020. An ecological study of socioeconomic predictors in detection of COVID-19 cases across neighborhoods in New York City. BMC Med. 18, 271. https://doi.org/10.1186/s12916-020-01731-6.

Wilder-Smith, A., Freedman, D.O., 2020. Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. J. Travel Med. 27. https://doi.org/10.1093/jtm/taaa020.

Williamson, E.J., Walker, A.J., Bhaskaran, K., Bacon, S., Bates, C., Morton, C.E., Curtis, H.J., Mehrkar, A., Evans, D., Inglesby, P., Cockburn, J., McDonald, H.I., MacKenna, B., Tomlinson, L., Douglas, I.J., Rentsch, C.T., Mathur, R., Wong, A.Y.S., Grieve, R., Harrison, D., Forbes, H., Schultze, A., Croker, R., Parry, J., Hester, F., Harper, S., Perera, R., Evans, S.J.W., Smeeth, L., Goldacre, B., 2020. Factors associated with COVID-19-related death using OpenSAFELY. Nature 584, 430–436. https://doi.org/10.1038/s41586-020-2521-4.

Wirth, L., 1938. Urbanism as a way of life. Am. J. Sociol. 44, 1–24.

World Health Organization, 2020. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 [WWW Document]. World Health Organ URL. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020 (accessed 8.18.20).

Wright, A.L., Sonin, K., Driscoll, J., Wilson, J., 2020. Poverty and Economic Dislocation Reduce Compliance With COVID-19 Shelter-in-Place Protocols (WORKING PAPER · NO. 2020-40). Becker Friedman Institute for Economics at UCHICAGO, Chicago.

You, H., Wu, X., Guo, X., 2020. Distribution of COVID-19 morbidity rate in association with social and economic factors in Wuhan, China: implications for urban development. Int. J. Environ. Res. Public Health 17, 3417. https://doi.org/10.3390/ijerph17103417.

Young, I.M., 2011. Justice and the Politics of Difference. Princeton University Press.