Chapter 9
Decongesting Global Cities as Part of Health Reform in the Era of COVID-19: Impacts and Implications for Zimbabwe

Isaac Nyambiya and Lawrence Sawunyama

Abstract Since the year 2000, eight major disease outbreaks, including COVID-19 involving zoonosis of viruses, have occurred. Increasing population density, high mobility and economic activity make cities hotspots for the spread of infectious diseases. COVID-19 has exposed the vulnerability of nations regardless of the development index. This paper reviews and analyses the literature on the effect of population density on the morbidity and mortality of COVID-19 since the outbreak of COVID-19. Literature reveals that 7 months into COVID-19, 95% of the infections came from urban centres around the world (Mizutori and Sharif, OPINION: COVID-19 demonstrates urgent need for cities to prepare for pandemics. *UN-Habitat*. https://news.trust.org/item/20200615120207-y321f, 2020). This could be because of a skewed economic model in which 55% of the world's population resides in cities which occupy 1–3% of the landmass while concentrating 85% of the world's economic activity. Cities are a constant magnet for huge numbers of people, making the chances of spreading disease relatively high. Current studies reveal a significant correlation between population density and the number of infections. The paper recommends a health reform plan centred on decongesting cities and a systematic reorganisation of settlement patterns, recognising efficient social distancing to limit illicit human-wildlife interactions. This should ensure less vulnerability to disease pathogens while guaranteeing environmental, food security, and good health for all.

Keywords Decongestion; health reform · SARS-CoV-2 · Cities · Zoonosis

I. Nyambiya (✉) · L. Sawunyama
Department of Physics, Geography & Environmental Science, School of Natural Sciences, Great Zimbabwe University, Masvingo, Zimbabwe
e-mail: inyambiya@gzu.ac.zw; lsaunyama@gzu.ac.zw

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9.1 Introduction

The COVID-19 pandemic has to date infected about 562 million people (17 July 2022) (John Hopkins University, 2022) and killed nearly 15 million (World Health Organization, 2022). Scientists admit to the unprecedented nature of the spread of COVID-19 (Jefferson et al., 2020). Within a few months of the outbreak, questions were already being asked about the role population density has on the spread of the pandemic (Carozzi et al., 2020). Seven months into the pandemic, it was also observed that 95% of cases emanated from the urban centres (Mizutori & Sharif, 2020). Notably, 55% of the world's population now resides in cities which occupy up to 3% of the entire land mass (Lucertini & Musco, 2020). As such cities which concentrate 85% of economic activity have become global hotspots of all kinds of pollution including pandemic diseases (Landrigan et al., 2017).

Population density is one of the major variables which determine the duration of impact of a pandemic (Reyes et al., 2013). Density has historically always been contentious when referencing the spread of infectious airborne diseases because of the dichotomy of thought among scholars. Modelling studies published early into the pandemic suggested how population density affects the basic reproduction number, R_o, through the number of contacts in crowded areas (Joacim Rocklöv & Sjödin, 2021). This is reflected in the raft of protocols of social distancing measures which have been implemented globally to reduce human contact since the outbreak (Yin et al., 2021).

At least 4.5 billion of the world's population were put on lockdown by decrees from various governments acting in concert (Cresswell et al., 2020; Sheikh et al., 2020). A study of 49 countries has shown that lockdowns effectively reduce the spread of the COVID-19 (Atalan, 2020). A physical separating distance of at least 1 meter is associated with lower transmission of SARS-CoV-2 with better protection accorded when the distance is increased (Chu et al., 2020).

However, being able to social distance is also a function of population density (Wong & Li, 2020). The built environment is known to promote crowding (Sharifi & Khavarian-Garmsir, 2020) which leads to more contacts between persons and hence the spreading of infectious diseases. The debate on the role of cities spreading of COVID-19 as they attract large numbers of residents has meant that some have questioned the sustainability of the sanitation particularly so, the dense model for development. Both sides have weighed in on the 'compact versus sprawl' debates (Sahasranaman & Jensen, 2021). This paper uses an integrative and semi-systematic literature review approach with the aim of analysing the current correlation between COVID-19 infections and mortality as a function of population density.

9.2 Literature Review

9.2.1 Cities and Outbreaks of Pandemics in the Twenty-First Century

The rate at which disease outbreaks are happening has been alarming in the past few years, while crowded cities have acted as chambers for global spread. In the twenty-first century alone, the world has experienced at least eight major disease outbreaks beginning with SARS of 2002 (Cherry & Krogstad, 2004; LeDu & Barry, 2004). Coronavirus are known to undergo a zoonotic spill over into secondary hosts such as civet cats for SARS-CoV-1 (Parashar & Anderson, 2004; Widagdo et al., 2017), dromedary camels for MERS (Sharif-Yakan & Kanj, 2014), (Ji, 2020) and pangolins for SARS-CoV-2 (Liao et al., 2020) (T. Zhang et al., 2020). A 22.8% incidence of MERS-CoV in camels is regarded as an occupational hazard (Ji, 2020). Figure 9.1 shows some of the outbreaks which have happened with increasing frequency and severity during the past 20 years. Table 9.1 also provides more detail on the epidemiology of these infectious diseases of the past 20 years.

Concomitantly with the outbreak of polio (Akil & Ahmad, 2016; Okiror et al., 2021), Ebola Virus Disease (EVD) spread globally from West Africa with a case fatality rate of more than 40% (Cenciarelli et al., 2015; Gatherer, 2014). The African bats have been implicated as primary hosts in the spread of Ebola (Letko et al., 2020). Before the emergency of COVID-19 in December 2019, the world had been grappling with containing another Ebola epidemic which started in West Africa (see Fig. 9.1) and spread to a host of countries in the West (Kalenga et al., 2019; Rugarabamu et al., 2020). Most of the diseases have had their epicentres in urban areas.

Despite the outbreaks occurring in distant countries, the spread of these diseases to become global epidemics and pandemics has been facilitated by global connectivity and population density associated with some jurisdictions especially the mega cities of the world.

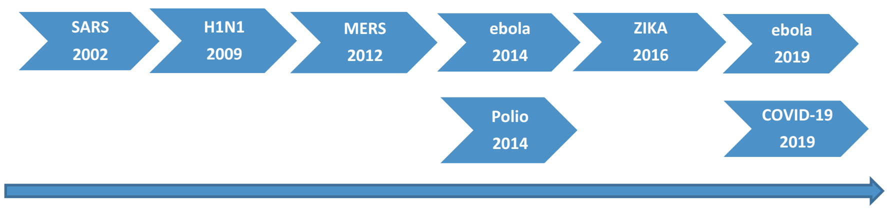

Fig. 9.1 The trajectory, frequency and prevalence of major disease outbreaks since 2000. (Source: Authors)

Table 9.1 Statistics relating to the pandemics of the twenty-first century

Year	Disease outbreak	Causative agent	Duration	Total infections	Total deaths	Estimated CFR (%)	Number of countries affected	Reference
2002	SARS	SARS-CoV-1	2002–2004	8000–8422	774–916	9.7–11.0%	29 on five continents	Peiris et al. (2014), Chan-Yeung et al. (2003), Lam et al. (2003)
2009	H1N1	H1N1pdm09	2009–2010	18,449 (lab confirmed); 700 million-1.4 billion (estimated)	284,500	0.16–4.48%	214	CIDRAP Dawood et al. (2012), Monamele et al. (2019), WHO (2010), Nishiura et al. (2009)
2012	MERS	MERS-CoV	2012–2021	2583	889	34.4%	27	WHO (2021), Alyami et al. (2020)
2014	Ebola Virus Disease (EVD)	Ebola virus	2014–2016	28,652	11,325	39.5%	7	WHO (2021)
2014	Polio	Wild Poliovirus (WPV), cVDPV	2014–2016	359	ND	(5–10%)-theoretical	9	Hagan et al. (2015)
2016	ZIKA	Zikavirus	2016–2019	84,276	51	0.06%	84	Bhargavi et al. (2020), Cardona-Osipin et al. (2019)
2019	Ebola Virus Disease (EVD)	Ebola virus	2019–2020	3462	2267	65.4% (as of 25 March 2020)	2	WHO (2021), Barbiero (2020)
2019	COVID-19	SARS-CoV-2	2019-ongoing	448,028,910	6,008,426	1.3%	224	John Hopkins dashboard (as of 8 March 2022)

Source: Authors' compilation

9.2.2 COVID-19 and the City Connection

Many cities with large population densities have particularly borne the brunt of COVID-19 and there is a tacit realisation of the need to reconfigure the way the city is designed (Sharifi & Khavarian-Garmsir, 2020). Authors such as Hazarie et al. (2021) have posited the existence of a strong interaction between mobility and population density and spread of infectious diseases. An indictment of the city has always been that in extraordinary circumstances such as pandemics, there is the so-called (urban) death penalty associated with urban development (Martínez & Short, 2021).

While the conclusion of population density as driver of infection may be considered intuitive (Federgruen & Naha, 2021), empirical studies have demonstrated that under forced circumstances, population densities are 'quite pathogenic' (Levy & Herzog, 1974). A countrywide study conducted in the USA concluded that counties with larger population densities produced greater reproductive numbers (R_o) hence greater rates of transmission of COVID-19 and as such larger infection cases. Evidence from other studies in the USA reached similar conclusions suggesting a 0.14 increase of R_o with every unit log increase in population density. There are further arguments by the researchers that the value of R_o was not mediated by transportation (Sy et al., 2021) which contradicts the observations in New York (Hamidi et al., 2020; Hamidi & Hamidi, 2021). The evidence of density as a persistent predictor of COVID-19 severity and death appears overwhelming from most of the studies conducted in the USA (Desmet & Wacziarg, 2021)

A study conducted in Brazil revealed that initially smaller cities were impacted more by COVID-19 infections. However, this trend called an urban advantage is reversed in the long term with major cities showing that a 1% increase in the susceptible population being associated with 0.14% increase in infections (Ribeiro et al., 2020). With some of the largest population densities, the difficulty to contain the virus has been compromised by the prevalence of slum urban development with as many as 205,415 people /km^2 in Bangladesh (Islam & Kibria, 2020). Further studies of environmental factors in Bangladesh also reveal a positive correlation between the number of cases and the population density (Alam, 2021). Research done in Malaysia showed that districts with greater population densities were more affected by the COVID-19 pandemic (Ganasegeran et al., 2021). In India where large population densities are realised through very close contact between individuals in public spaces also gave positive correlations between population density and infections (Bhadra et al., 2021). Concerns were expressed at the beginning of the pandemic for cities such as Manila which are known to have very high densities as much as 71,263 persons/km^2 (Salva et al., 2021). Moderate positive correlations have been observed in some Indian cities contrary to the information released by John Hopkins University (Bhadra et al., 2021).

Researchers investigating the effect of household size among other parameters have observed a positive correlation between the size of the household and the rate of infection (Federgruen & Naha, 2021). While one Italian study showed that

COVID-19 exhibited more severity in households with single occupancies for people aged more than 80 years (53.1% of the 25 million Italian families in Italy are composed of less than two people) (Liotta et al., 2020), other research done in Italy showed a positive correlation between population density as a function of the number of infections and deaths further indicating how the proximity of household exacerbates the spread of COVID-19 (Ilardi et al., 2021). An IZA Institute of Labour Economics report often quoted in the debate on population density versus COVID-19 spread categorically finds no evidence that greater population density is linked with more COVID-19 cases and deaths (Carozzi et al., 2020). This demonstrates the divergent views and positions among scholars, and as such the need for further investigation into population density as risk factor of COVID-19.

On the other hand, a largely rural community (Diop et al., 2020) and a younger population in Africa (Chitungo et al., 2020) are some of the reasons proffered for the lesser number of infections and mortalities in Africa compared to West. The United Nations has thus far realised and deplored the roles cities have played in the spread of the COVID-19 pandemic especially as they have been heavily impacted on by the outbreak (UN-Habitat, 2021). There is also a realisation of the need for reconfiguration of the settlement patterns especially in urban centres to a model which provides social and economic equity (Sharifi & Khavarian-Garmsir, 2020).

9.3 Methodology

In this paper, we mostly surveyed literature which has been published since the outbreak of COVID-19 and how the spread of the disease has been influenced by population density. A combination of integrative and semi-systematic literature review approach (Snyder, 2019) is used to search for literature and provide an overhead review and qualitative analysis of information available regarding the influence of population density versus COVID-19 infections and fatalities. A continuous search of literature was done on databases such as PubMed, Google Scholar using search criteria using words such as ‘COVID-19 and population density’. Other literature relating to similar infectious diseases such as, SARS, H1N1, Ebola, polio and ZIKA was also consulted. A number of ‘cause and effect’ or correlation models used by various authors globally were identified. Fifteen studies which provide various models showing the correlation between population densities against the total number of infections and in some cases the number of fatalities due to COVID-19 were selected within the last 2 years of published data. A compilation was done of the model used, the place or cities studied, the correlation coefficients obtained and the time limits within which the study was considered and conducted. Table 9.2 shows the different models which have been used to arrive at the correlation between population density and the number of infections and fatalities around the world.

Table 9.2 Models for predicting the effect of population and population density in the spread of COVID-19

Model used	Place/City	R^2 (infections)	R^2 (mortality)	Date of consideration	Reference
Linear regression	India	0.58 (10 September 2020)	0.64 (10 September 2020)	10 September 2020	Bhadra et al. (2021)
		0.67 (5 July 2020)	0.57 (5 July 2020)	5 July 2020	
Multiple regression models	2814 US counties	0.447 ($F = 219.437$, $p < 0.001$)	0.391 ($F = 174.656$, $p < 0.001$)	1 May 2020	Zhang and Schwartz (2020)
Simple linear regression	50 states andthree US territories	0.55	ND.	Not stated in the paper but estimated here to be between 1 January 2020 and 8 July 2020 (a month before submission)	Yin et al. (2021)
	17 cities in Hubei province, China	0.62	ND: positively associated with the disease mortality.		
Quantile regression	Global study across 84 countries	Population density initially (Week 10) had a strong positive influence at the mean, and at the 25th, 50th, and 75th quantiles that waned with time.		Six (6)-week period: from 10th week (ending March 4th) until the 15th week of 2020 (ending 8 April 2020)	Sigler et al. (2021)
Simple linear regression	Malaysia countrywide ecological survey	($r = 0.912$; 95% CI 0.911, 0.913; $p < 0.001$)	ND	22 January 2021 and 4 February 2021	Ganasegeran et al. (2021)
Multiple linear regression, Pearson correlation	All 64 Bangladesh districts	$r = 0.876$, $p < 0.001$	ND	Data obtained on 18 September 2020	Alam (2021)
		($r = 0.802$, $p < 0.001$)	ND		
Spatial regression models	USA counties	Population density alone 76% in the spatial models	ND	March to late May 2020	Wong and Li (2020)
Spatial lag models	New York counties	Population density not significant with rate of infection after controlling for crowding	ND	1 April and 25 May 2020	Hamidi and Hamidi (2021)

(continued)

Table 9.2 (continued)

Model used	Place/City	R^2 (infections)	R^2 (mortality)	Date of consideration	Reference
SIRD 1 epidemiological model	USA	$R^2 = 0.88$	$R^2 = 0.74$	15 March to 30 November 2020: Density is a persistently important determinant of disease severity across space	Desmet and Wacziarg (2021)
Ordinary Least Squares (OLS); Negative BinomialRegression (NBR) model	South Korea	Only net population density strongly associated with the number of cases (coefficient = 29.38 for the OLS model and coefficient = 0.31 for the NBR model)	ND	20 January 2020 until 17 September 202 Density plays an important role in the proliferation of theCOVID-19 outbreak in South Korea	Jo et al. (2021)
Extreme boundsanalysis (EBA) and variable addition tests (VAT)	172 countries	Bmin = 0.28 Bmax = 0.56 Population density considered robust when there is not sign change from one variable to another when considering infections rather than deaths. As such robustness is 100%	Bmin = −0.01 Bmax = 0.003 A change in sign of the B coefficient interpreted to mean no significant correlation and as such the robustness is 0%	From disease outbreak up to 11 May 2020	Moosa and Khatatbeh (2021)

Nonparametric Spearman's correlation analysis	Italy	$r_{rho} = 0.67$ PD & number of cases at $p = 0.0001$	$r_{rho} = 0.69$, PD & deaths at $p = 0.0001$	From outbreak to 1 April 2020	Ilardi et al. (2021)
Spearman's rank correlation coefficient	Sergipe state, Northeast Brazil	$r_s = 0.326$, CI 95%0.106–0.514, $p = 0.005$; effect size = weak) 5% significance level	($r_s = 0.518$, CI 95% 0.329–0.666, $p < 0.001$; effect size = moderate) 5% significance level	From outbreak to l January 2021	Martins-Filho (2021)
Regression model (not specified)	Three majorcities in Turkey	Population weighted density vs. number of cases $r = 0.97$ with p – value <0.0001	ND	April 2020	Baser (2021)
Spearman's correlation coefficients	Eight cities in Bangladesh	$r_s = 0.712$ of a city	$r_s = 0.678$	07 March 2020 to 14August 2020	Sharif and Dey (2021)

Source: Authors' compilation

9.4 Results

Researchers have used various tests of goodness of fit and statistical significance to assess the validity of the claims of population density as a function of morbidity and mortality. These models range from the simple standard linear regression, and the Quantile regression which is an extension of linear regression method. Others have applied multiple linear regression and cluster analysis to derive Pearson coefficients to measure levels of correlation or association. The other models captured in Table 9.2 are spatial regression models, spatial lag models, the Susceptible-Infected-Recovered-Deceased (SIRD) epidemiological model, the Ordinary Least Squares (OLS), and Negative Binomial Regression (NBR) models, Extreme Bounds Analysis (EBA), Variable Addition Tests (VAT), nonparametric Spearman's correlation and negative binomial regression (NBR). Each of these models have been used to calculate the corresponding correlation coefficient or another size effect parameter such as extreme values coefficients (β) to measure the effectiveness of population density in influencing the COVID-19 epidemiology. Other methods used including econometric methodologies such as random-effects models and Hausman–Taylor models (Kaicker et al., 2020) and the Generalised Linear Model (GLM) combined with the Geographically Weighted Regression (GWR). It is not the scope of this paper to exhaust all the models which have been utilised but highlight how several tools have been utilised to measure the size effect of population density on COVID-19 severity. The heterogeneity of the models makes it difficult for comparisons to be made between the various models. However, what is clear is that from most (about 80%) of the models which have been sampled for this paper, a statistically significant correlation has been established between population density and with the number of infections.

What is also clear is that a number of researchers have predicted that population density including other parameters such as the total country population, the age of the population and family sizes living within the same households correlate strongly with the quick diffusion of COVID-19 within countries (Sigler et al., 2021). In Malaysia, the strongest correlation was observed in the central region of the country, being greater in urbanised districts and cities (Ganasegeran et al., 2021). A study in the Gauteng region of South Africa assessed that the 'ward' areas which have more than average risk to COVID-19 and more than average population density were in the so-called townships with denser settlements patterns (Maree & Ballard, 2020).

In studying the disparate jurisdictions, researchers chose a variety of approaches which include the investigation of many countries grouped together such as the 172 country study by Moosa and Khatatbeh (2021) or the 84 country quantile regression analysis by Sigler et al. (2021). An analysis of data from 140 countries undertaken by Murányi et al. (2021) between 18 April and 4 July 2020 quantitatively reveals very high infection rates as a function of population density after ranking the 140 countries into four categories according to infection rates of very high, high, medium, and low (Murányi et al., 2021).

Comparative and quantitative studies have also been undertaken at country level across the world with a view to recommending the best possible options for in-country containment of COVID-19. In most cases of the literature surveyed, the data reveals a higher severity of the pandemic associated with high population densities. For instance, while studies undertaken in India by Bhadra et al. (2021) reveal a moderate correlation between population density and the number of infections and mortalities ($r = 0.58$ for infections; $r = 0.64$ for mortality) for the four major states in India, the authors are careful to mention that the worst effects of the pandemic have been experienced in the megacities of the four states (Bhadra et al., 2021). These studies in India have been corroborated by other researchers who have reached similar conclusions on the spread of COVID-19 in that country (Sengupta et al., 2021; Tamrakar et al., 2021). In the three states of Maharashtra, Jharkhand and Meghalaya, a large association between urban population density as a function of daily and cumulative severity ratios was established (Kaicker et al., 2020).

Multiple linear regression analysis on 2814 US counties done by Zhang and Schwartz (2020) characterises metropolitan cities in the USA as hotspots for COVID-19, although counterintuitively some smaller cities and counties have been similarly affected. This has been attributed to a more aged population found in some of smaller cities. In the US eastern states, a positive association between population density and transmission or fatalities between the 1 March and 16 November 2020 was observed. In this study, New York City leads in the figures (Lee et al., 2021).

A comparison of 18 cities in the Hubei province of China and 50 states and counties in US arrived at an $r = 0.55$ for the Chinese cities compared to $r = 0.62$ for the US when applying simple regression analysis. The assessment and conclusion from this study is that of a positive association between population density and morbidity (Yin et al., 2021). However, the level of analysis seems not as robust to include other parameters such as connectivity, crowdedness, household sizes which could have influenced the spread of the disease. Spatial regression models have predicted correlations as high as 84% for infections in the United States (Wong & Li, 2020). However, Hamidi and Hamidi (2021) have projected contrary results for New York regardless of the large population densities experienced in the city. A globalised world with increased mobility and connectivity between points of interests (POI) has been used to explain the apparent heterogeneity of the associations between density and vulnerability to COVID-19 especially in more developed countries such as the USA (Hazarie et al., 2021). For cities in South Korea which have similar development indices as the United States, connectivity has a greater impact in the spread of COVID-19 (Jo et al., 2021). This is understandable as travelling has the effect of bringing people into more contact with each other and hence increasing the probability of infection to a susceptible population. Despite the mathematical rigor associated with this conclusion, in our opinion this does not override the intuitive effect of population density on the spread of communicable diseases.

A study conducted in Oman using GLM combined with the GWR yielded an adjusted $R^2 = 78.77\%$ between COVID-19 infection and the population density variable. Other parameters such as the number of households, and spatial interactions have also been used as proxies for population density giving greater effect to the impact of population as a measure of close interaction between individuals during a pandemic leading to infection (Al Kindi et al., 2021).

For the 265,000 cases reported by the end of the August 2020 in Turkey, 60% of these were recorded in Istanbul the capital city with a very strong correlation (r = 0.97) between population density and number of infections (Baser, 2021). Interestingly within a similar timeframe, 60% of infections were also recorded in Dhaka the capital of Bangladesh which has a population density of about 46,997 persons/km^2 (compare New York = 34,338.5 persons/km^2 (Lee et al., 2021)). In this study, the largest correlation was detected between the population density and number of infections (Sharif & Dey, 2021). Alam also finds a strong positive correlation between population density and infection accounting for 60% countrywide variability in Bangladesh, and similar a strong correlation between COVID-19 and prevalence of urban centres (Alam, 2021). Similarly a Z-score analysis performed for the regions of the Philippines yielded the second highest correlation for population density against COVID-19 infections (0.93) and deaths (0.92) after the number of ICU beds at the regional level (Talabis et al., 2021).

The situation in South Korea, however, offers an interesting middle of the ground position in which both population density and connectivity (both leading to crowdedness) have been observed to be positively correlated to the number of infections in the country. However, there is a greater emphasis on the effect of connectivity rather than density as predictor of the number of infections (Jo et al., 2021).

9.5 Discussion

There is a clear existential crisis of novel infections and pandemics happening with increasing rapidity and severity. Coupled with the benefits of globalisation these airborne infections are spreading around the world once they have been triggered from a single location. Research has revealed that infectious diseases such as measles and COVID-19 spread more quickly in densely populations areas (Tarwater & Martin, 2001).

The cases of the cruise ships have been investigated over long periods of times as the environments within these confined spaces offer unintended but conducive conditions for disease causation and spread and study (Carling et al., 2009; Kak, 2007). The Diamond Princess cruise ship provided valuable opportunity and information for epidemiologists to analyse the dynamics of COVID-19 (Russell et al., 2020) revealing basic reproduction numbers which were four times higher on the crowded ship than was found in Wuhan (J. Rocklöv et al., 2020). While some studies in countries such as Italy seem to suggests that social connectedness is negatively correlated with spread of COVID-19 (Liotta et al., 2020), high population densities have been observed to catalyse the spread of COVID-19 (Joacim Rocklöv & Sjödin, 2020). A study conducted in China suggests that population density is not a factor in the spread of COVID-19 under strict lockdown conditions (Sun et al., 2020), but observations from Brazilian cities have confirmed a positive correlation between population density with number of cases (Pequeno et al., 2020). Among other reasons, the high population densities in the cities Sao Paolo and Rio de Janeiro are blamed for the higher number of infections of COVID-19 compared to other states in Brazil (Baqui et al., 2020). The increase of infections with population density has been corroborated by other studies within Brazil controlling for metrological factors such as rain, radiation, humidity and radiation (Pequeno et al., 2020). Apparently the number of infections are reduced by lockdowns conditions where there is a greater number of symptomatic cases as observed in an Indian analysis of the spread of the pandemic in its states (Sardar et al., 2020). Observations carried out in US cities from 14 March through 19 March 2020 have also realised that the worse attack rate of COVID-19 is to be expected in cities with larger population sizes (Stier et al., 2020). Regardless of social distance, measures such as lockdowns are more effective where the population density is low among other parameters (Verhagen et al., 2020). In the UK, hospital capacities have been found to be highest along the Cardiff coast, a place with higher levels of population density in the UK (Verhagen et al., 2020).

Unsanitary conditions emanating from over-crowdedness which induce breeding conditions for pathogens (Amoo et al., 2020) and a high concentration of germs in confined places such as experienced in the Cook County jail in Chicago are examples of how adversely the spread of any infectious disease can be exacerbated by lack of social distance (Reinhart & Chen, 2020). Rural Africa is characterised as sparsely populated, and along with a young population, with fewer comorbidities; this seems to have contributed to a far a smaller number of infections (Oleribe et al., 2021; Wamai et al., 2021) (Diop et al., 2020).

Hamidi et al. have recommended denser urban development as the basis for inducing lower death rates in case of infectious outbreak of disease (Hamidi et al., 2020). This is counter-intuitive to the principles of epidemiology of airborne infections. Unless this is accompanied by the concomitant and commensurate health facilities and adequate infrastructure, a denser model of development becomes a very dangerous proposition especially for countries in the global south. This is because the larger populations residing in the countryside with a better natural phenomenon of social distancing through sparse populations may be encouraged into city dwelling.

Arguments which dismiss the role of population density in large cities appear to have forgotten the importance of this geographical and demographic factor in the spread of infectious diseases (Nathan, 2021). The positions taken by researchers as to whether infectious pandemics spread as function of compactness (dense) or sprawling urban appear to be driven by vested interests amongst scholars of urban planning, with each camp favouring its own theories ahead of intuition and objectivity. Conclusions arrived for compact development in relation to COVID-19 are derived from a persuasion which argues that there is significant reduction in trips to POIs such as grocery stores, pharmacies and transit points during lockdown periods (Hamidi & Zandiatashbar, 2021). As such this would curtail the spread of disease. The data is used to definitively recommend the continued adoption of compact model of development in the face of ever-increasing infections airborne infections

(Hamidi et al., 2020). Based on the findings in New York, the question remains to be answered as to whether the significant effect of POIs in the greater proportion of the spread of infections can be positively correlated with bigger population sizes within smaller geographical spaces and hence with an effective population density.

The disparity between the United States, which has a comparatively lower population size and densities, compared to China and yet the US has recorded the largest infections and mortalities to date points to other socio-economic factors between the two countries other than demographic parameters. A greater prevalence of co-morbidities in North America and a larger proportion of an older population has been used to explain the higher cases and fatalities in North America and other western countries (Badawi & Vasileva, 2021). On the other hand, China has implemented a rapid response 'zero COVID' policy which is not very popular in the western nations for its seeming harsh stringency (Mallapaty, 2022) and possible violation of individual rights of citizens (Watkins, 2020). However, the Chinese policy has been viewed as success model despite the misgivings (AlTakarli, 2020).

Population size and population density which lead to crowdedness are positively correlated to COVID-19 morbidity and mortality. The effects of these are exacerbated by the 'benefits' of globalisation such as better connectivity which unfortunately guarantees the importation of viral infections and their variants from one distant place to another. However, the detrimental effects of higher population densities can be mediated by better health facilities, infrastructure and rapid response governance policies which ensure better chances of survival for a populace. Considering the inequitable distribution of land and the attendant rapid spread of COVID-19 in the urban centres, this paper proposes a calculated and unemotive policy of decongestion of cities as part of a first principles approach to the health reform agenda.

9.6 Conclusion

This paper sought to establish the role of population density on the spread and severity of COVID-19 by surveying the literature which has been published for the last 2 years. Disparate models have been used by researchers around the world to arrive at several conclusions ranging from positive association to high correlations. In most cases, population density has a significant effect on the proliferation of COVID-19. Two main scenarios emerge as follows: (1) High population densities found in conjunction with inadequate health (and connectivity) infrastructure means population density is found to be significantly positively correlated with more infections and may be deaths. This has been the experience in less developed countries such as Bangladesh, India and the Philippines. This represents the classic scenario in which population density is generally expected to influence the spread of infectious diseases; (2) On the other hand, developed countries with larger metropolitan and better connectivity facilities establishments appear to reverse the effect of population density on the spread of infectious disease. The effect of population density seems to be transferred to crowdedness as encouraged by mobility. As such this becomes a proxy for population density. A typical example is that of North Korea which revealed a similar phenomenon to New York where great neural networks are associated with higher infections and mortality. This situation could be mediated by better medical facilities which help in reducing the impact of COVID-19. However, even the best medical facilities can be overwhelmed as has already been experienced during COVID-19.

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