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Study on the Influential Factors of COVID-19 pandemic in Urbanisation in Chinese Cities

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The world has witnessed an unprecedented event, COVID-19, which has profoundly affected all aspects of human existence. As the initial spread of the virus was more prevalent in densely populated urban areas, this has introduced a fresh perspective to urban and town planning. This study investigates the various micro and macro-level urbanization indicators in the context of the virus spread in seven main Chinese cities with varying degrees of urbanization. Using simple log-linear regression, the relationship between the explanatory variables and the number of confirmed cases of COVID-19 is determined, along with the statistical significance of the influential factors. In addition, a comprehensive correlation analysis will be performed to reveal the relationships and associations between the variables. Results indicate that population density, temperature, air quality, medical infrastructure, and age positively correlate with virus transmission in urban areas as they increase the number of cases. Shortly, the scope of the endeavor can be expanded to include an exhaustive list of variables.

Key words: Urbanization, confirmed cases, COVID-19, urban planning, simple log-linear regression, correlation analysis.

1. Introduction

COVID-19 pandemic, a global pandemic, has wreaked havoc on the world and claimed countless lives. The world is destined to confront unprecedented challenges concerning food systems, public health, lifestyle changes, economic disruptions, and even work (Verma et al., 2020). In addition to people who are malnourished, the socioeconomic disruption has pushed tens of millions of individuals into extreme poverty. According to estimates, the numbers may reach 132 million by the end of the year (Maital et al., 2020). On the business front, millions of enterprises are threatened with extinction, posing a danger to 3,3 billion workers. Most informal economic employees lack social protection, access to healthcare facilities, and productive assets, making them more vulnerable (Shrestha et al., 2020). As a result of lockdowns and other restrictions, many families are left without food, jobs, and access to necessities. Figure 1 depicts the demographic effects of COVID-19 pandemic on the Chinese population.

Border closures, trading restrictions, and confinement actions have severely impacted all social classes, preventing farmers and other producers from accessing markets for purchasing and selling, thereby disrupting global supply chain management (Bloom et al., 2020). The new crown disease has decimated employment, jeopardizing millions of livelihoods. This has significantly impacted the livelihoods of women and men, particularly in low-income countries. The marginalized and disadvantaged populations, such as small-scale farmers, daily wage earners, indigenous people, and laborers, will be hardest affected (Yeyati et al., 2021). Figure 2 depicts the proportion of the global population living below the poverty line.

Many low- and middle-income people, including farmers, rely on predatory loans, the sale of assets, and even child labor to make up for income losses. As Asmorojati et al. (2020) note, migrant laborers have endured a great deal of hardship due to obstacles such as living conditions, transportation, access to support mechanisms, and employment. Governments across the globe, particularly China, reacted swiftly to the negative effects of the pandemic by implementing various forms of relief measures for the underprivileged, such as cash transfers, free food, child allowances, shelter, employment support, financial aid, and business loans, etc. (Pan et al., 2020). Figure 3 depicts the change in GDP throughout the COVID-19 period. Several sophisticated technologies are used to extract data from various sources to learn more about the topic (Rismawaty Arunglabi et al., 2022; Carhuancho et al., 2023).

2. Urbanisation and Pandemic in China

China was the location of the earliest known case of COVID-19, discovered in Wuhan (Liu et al., 2020). This respiratory disease has spread nationwide, creating a national and international public health emergency. McKibbin et al. (2021) and Guan et al. (2020) report that an increasing number of individuals with the same disease symptoms have been observed and documented in many other nations. On January 30, 2020, the World Health Organization (WHO) proclaimed COVID-19 a public health emergency of international concern, and its status was upgraded to a global pandemic (Jeet et al., 2020). However, since March 19, 2020, Wuhan has not reported any new cases of the pandemic for nearly five days in a row, thereby transferring the status of the epicenter to countries such as Italy, the United States, Spain, and even Germany.

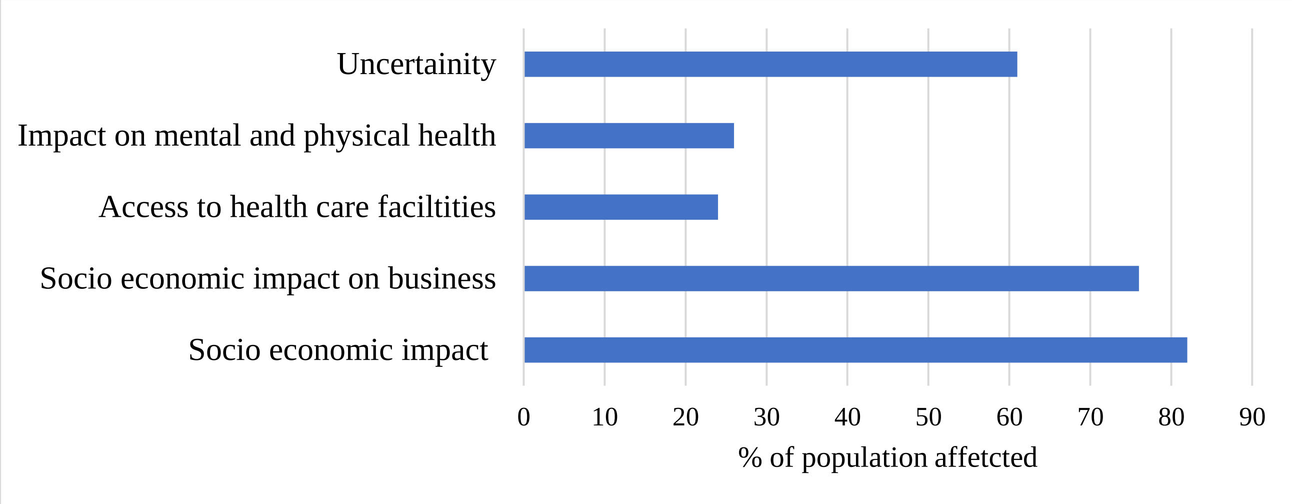

Figure 1: Impact of COVID-19 on society

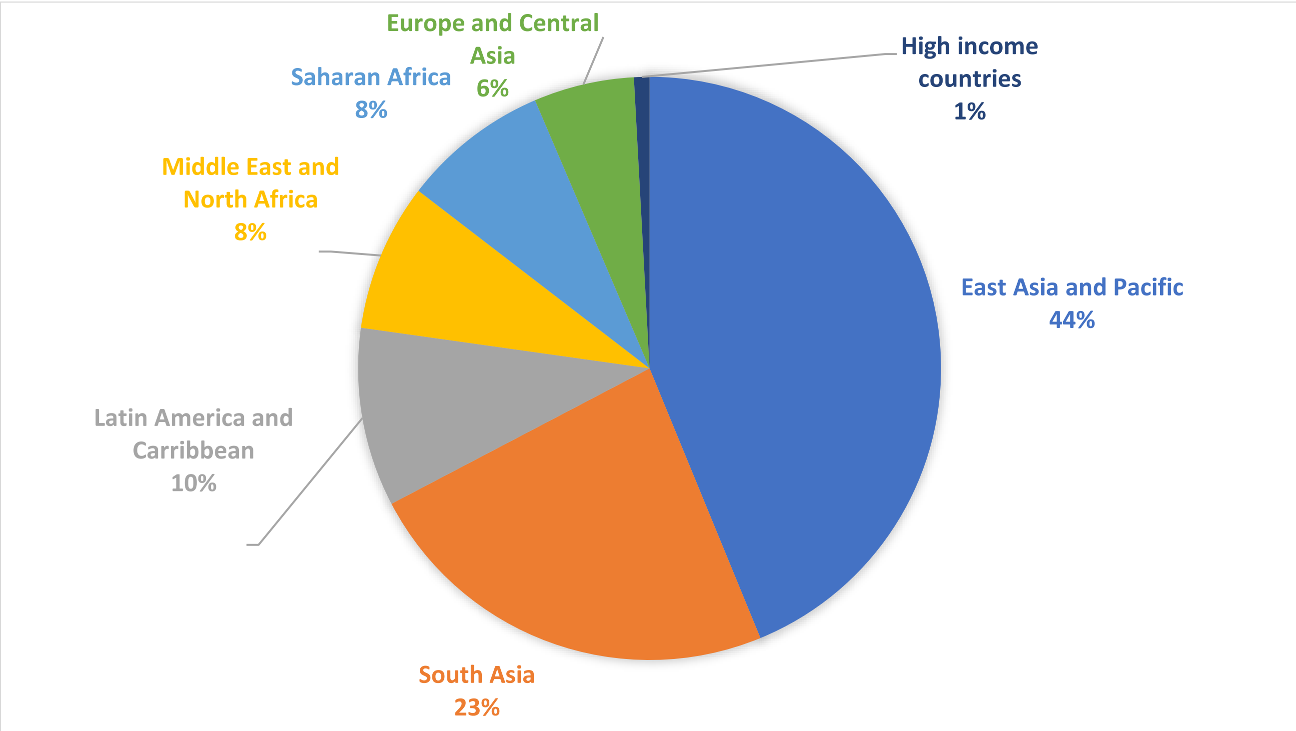

Figure 2: Percentage of population pushed below the poverty line in 2030.

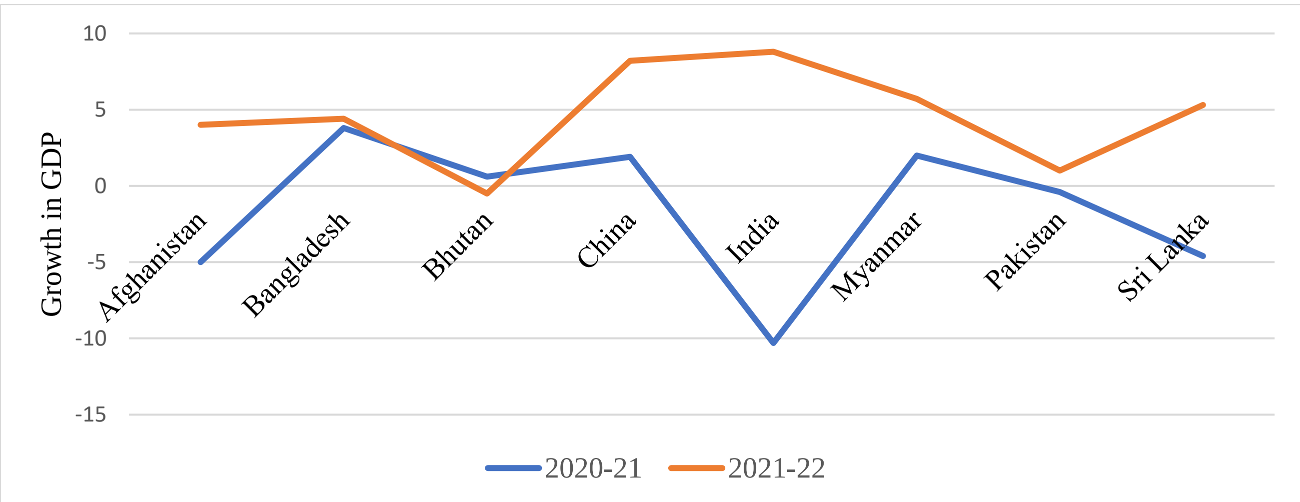

Figure 3: Change in GDP in Asian countries due to the pandemic

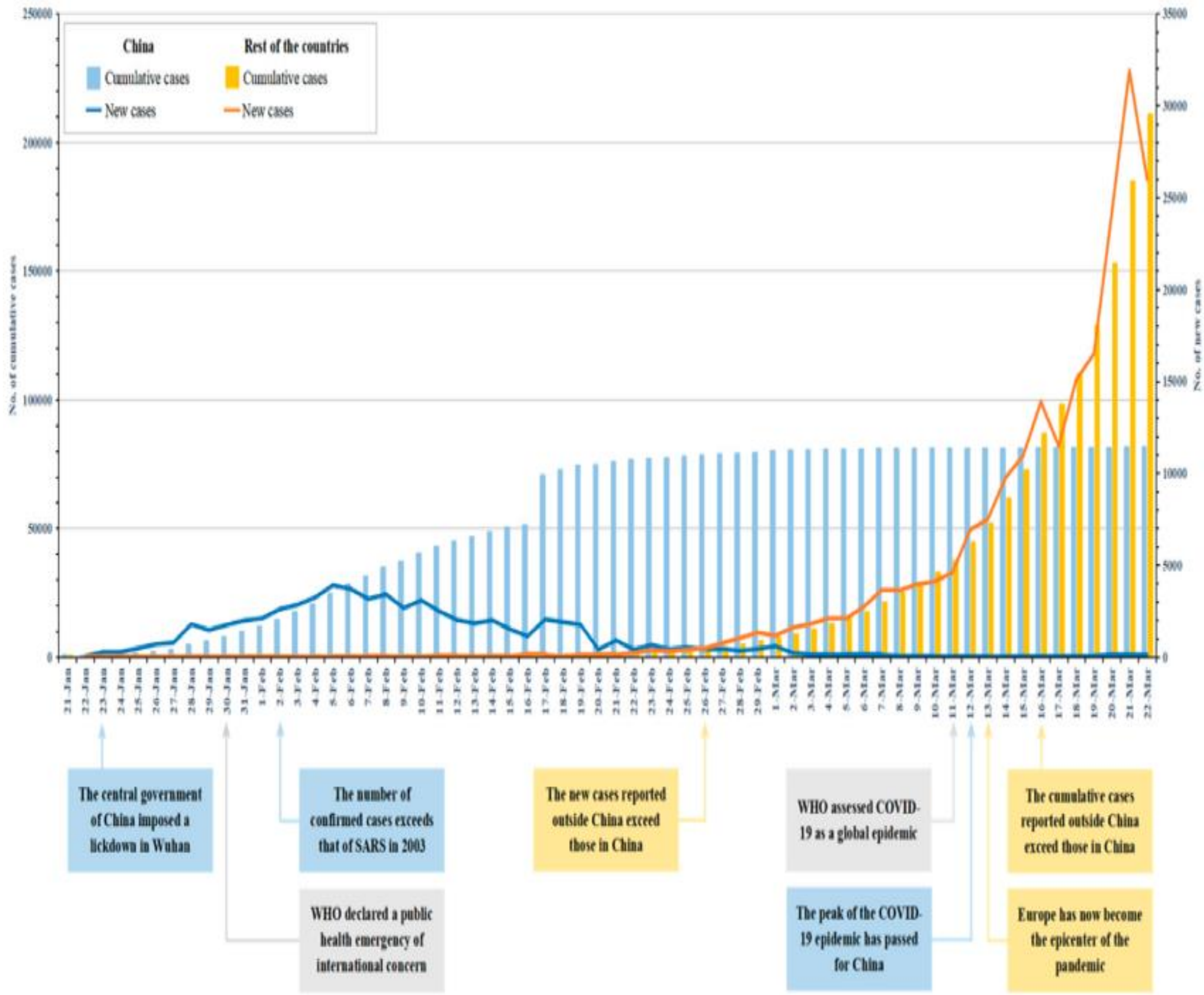

Figure 4: Status of COVID-19 in China and other countries by WHO (Liu et al., 2020)

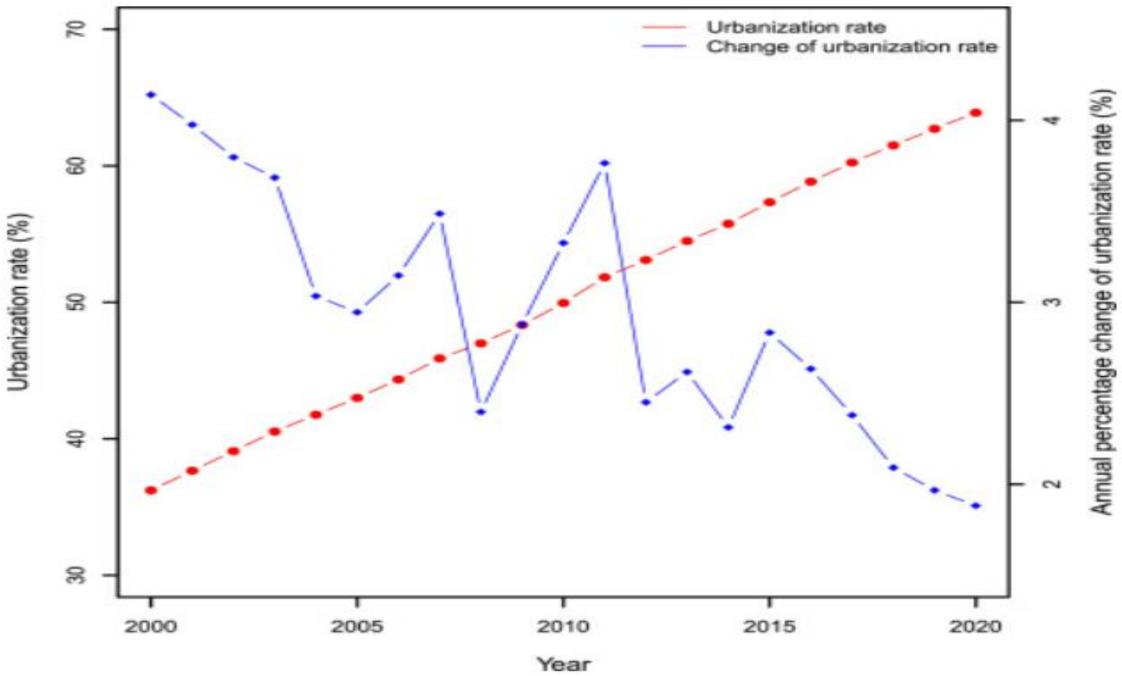

Figure 5: Urbanization rate in China

The cumulative verified cases in China and other countries are depicted in Figure 4. Wei et al. (2018) found that the number of confirmed cases skyrocketed during the Spring Festival Travel Rush when a significant proportion of the population returned home. Numerous unrecorded infections in this mobile population contributed to the rapid dissemination of the virus (Li et al., 2020). The epidemic circumstance caused a nationwide chain reaction of population movement. Population flow is China's most significant geographical process after its reforms (Zhu et al., 2014), which subsequently evolved into a social phenomenon that facilitated urbanization. Population movement on a larger scale influences the system of transportation networks, social culture, and industrial development. Figure 5 depicts China's urbanization.

During the pandemic, rural laborers have two options: move to large cities from their hometowns or move to small towns close to their hometowns (Li, 2015). This behavior represented two models: urbanization nearby and urbanization at a distance. In the former model, rural residents move to communities that serve as regional service hubs but are still close to their homes. People with non-agricultural occupations fall into this category as they seek new employment and business opportunities (Su et al., 2016). In contrast, remote urbanization refers to rural residents' permanent or temporary migration to larger cities far from their hometowns. They become permanent residents of new cities and are the new community of rural residents who have moved to the city (Long et al., 2009). Due to COVID, urbanization at a distance became the primary conversion mode at a larger mobility scale. However, a development gap exists between metropolitan and rural areas due to a dual urban-rural structure. In 2020, the per capita income of China's urban residents was 43,834 yuan. At the same time, the income of rural residents was significantly reduced up to 17,131 yuan. This created a disparity between less established and developed regions.

During the initial phase of the pandemic, the largest cities in China, such as Beijing and Wuhan, were hardest affected per capita. The epidemiological models predicted that if adequate and timely control measures were not implemented, the disease would swiftly spread in urban and metropolitan areas (Stier et al., 2020). Therefore, many severely affected regions were subjected to stringent containment measures such as trade and commerce closures and travel restrictions. In addition, adherence to social distance contributed to declines in mobility by various modes of transportation in major cities (Hudecheck et al., 2020). With a comparatively low incidence of disease infections, only a few dense cities could control the pandemic. Most Chinese cities rely on public transportation and serve as a significant transmission agent (Florida et al., 2020). The efforts to track down the contract confirm this. Disease transmission was found to be lower in trains than in other modes of transportation due to ventilation systems. People in the OECD avoided public transportation, resulting in less congested travel. In addition, it is a fact that contact tracing has not identified a significant number of transmissions in the transportation system due to its dispersed nature. Due to their connectivity, large Chinese cities encountered more cases during the initial phase of the pandemic.

3. Literature Survey

This section overviews the relevant studies and factors associated with epidemic urbanisation. Wuhan (Lu Liu, 2020) investigates the primary factors that influence the proliferation of virus transmission in the context of urbanization. The results of the study indicate that distance from the pandemic's epicenter has a significant negative correlation with its spread. Urbanization and population density are also negatively associated with early-stage dissemination. Based on prevalence, fatality, trends, and incidence, epidemiological data from 17 countries during the first 90 days of closure were analyzed (Shivam Gupta et al., 2020). The study revealed that the fatality rate has a positive correlation with the ratio of the geriatric population but a weak correlation with the urban population.

Due to control measures such as quarantine, isolation, and social distancing, the pandemic has challenged urban planning and thought (Avetisyan et al., 2020). The study focuses on the urban economy, design, and planning. Moreover, constructing smart cities may also mitigate the pandemic's effects. Also, lock-down significantly impacts the spread of the pandemic in globalised cities, financial hubs, and political flashpoints (Hesse et al., 2020). Case studies of Dublin and Luxembourg are presented in this work. Their urban development is uncertain, and the emergence of a 'new normal' poses a challenge to these cities governed by the market. The conflict between covid-capitalist urbanization and the prioritization of rentiers over workers has emerged as a potential study area (Madden, 2020). Unlike the landlords, the active community was most affected by the transformation of work during confinement and other safety protocols. Another area of decline is the distressed investment firms and the debt-ridden real estate market. The catastrophe capitalism is then normalized and rephased.

Chiris et al. (2020) conducted a comprehensive survey on the redefinition of humanity and operational and conceptual realities during the pandemic. The urban poor were unable to adhere rigorously to safety measures. There was a choice between being famished and susceptible to infection. This work emphasizes the lack of appropriate planning response at all levels. The COVID-19 infection data indicates that the disease predominantly spreads in urban and congested areas, with more infections and a higher mortality rate (Pethe et al., 2002). Expanding cities are more vulnerable, highlighting the need for improved and increased investments in city planning, public health, and enhancing the lifestyle of ghetto dwellers, among other areas.

Patidar et al. (2020) comprehensively analyze the pandemic's dissemination and urbanization patterns. As a result of high population density, increased urban encroachment, and intra-urban commuting in large slum populations, the pandemic spread considerably more quickly. According to the study's findings, enhancing health infrastructure and adherence to safety protocols are necessary. The comprehensive assessment of urbanization and covid spread identifies three improvement areas: infrastructure, demographic change, and governance (Connolly et al., 2020). These were the three most important factors controlling the disease's urban spread. The study also emphasizes the role of the landscape political ecology framework in bringing about socio-ecological changes in peri- and suburban areas.

Diop et al. (2020) examines applying a deterministic Susceptible-Infected-Recovered model to forecast pandemic spread under containment measures. The work focused on analyzing people of various age structures, urbanization, and health comorbidities, among other factors, to determine that the peak due to urbanization may reach very quickly compared to the other two. Global evidence demonstrates that urban dwellers have greater contact and exposure (Biswas et al., 2020). Due to today's relatively high urban population, the pandemic was particularly severe in these areas. The investigation focused on determining the relationship between the spread of the infection and uneven urbanization. Tammaru et al. (2023) conducted a comprehensive investigation of the origin, intensity, and destinations of urban migration in Estonia during the new crown pandemic. According to the results, urbanization has caused a migration trend, and counter-urban transitions were prominent during the economic downturn caused by the pandemic. This counter-urbanization increased family migration to rural areas outside of metropolitan areas.

During the COVID-19 phase, research was conducted on the determinants of in-migration and net migration into non-metropolitan New South Wales (Argent et al., 2020). The results indicated that non-metropolitan areas rely less on anti-urbanization mechanisms and are projected to experience greater net migration gains. High population densities are closely related to out-migration, but these changes only affect net migration.

4. Research Methodology

The data for this study was collected from a variety of data sources, including Worldometer, Kaggle, and other internet-sourced data, between the years 2020 and 2021, as this is the worst COVID-19 affected period, from seven cities with varying degrees of urbanization, namely Anhui, Hubei, Hinan, Guangixi, Gansu, Xinjiang, and Shandong.

In addition, urbanization data is gathered from various sources, including the China Statistical Yearbook, the Statistical Yearbook of Provinces and Cities, the China Health Statistical Yearbook, the National Economic and Social Development Statistical Publication, and the National Research Network Database. Table 1 displays descriptive statistics for a small number of explanatory variables.

Table 1: Descriptive statistics of the dependent and independent variables used in the study

Variables	Mean	Standard deviation	Minimum	Maximum
Mortality rate	0.593	0.457	0.067	5.679
Population density	0.5	0.134	0.004	3.104
Age	54	14	15	75
GDP	9.035	0.682	0.057	0.563
Expenditure for health	0.063	0.02	0.03	0.172
Medical facilities	1.62	0.361	0.589	0.256
Building density	0.167	0.102	0.004	0.902
Length of roadways	15.928	58.92	0.002	702.3
Wastewater disposal	14,927	24,972	258	29,387
Solid waste management	56.826	101.927	16.86	875
Greeneries	15.108	5.975	3.862	56.932
Temperature	5.872	6.926	-10.027	26.93
Urban area	503.76	1102.4	4.976	17.0892
Air	5.826	0.235	3.918	6.903

The units for measuring the explanatory variables, along with their definition or mode of measurement, are mentioned in Table 2.

Table 2: Description of the variables

Variable	Description	Unit
Mortality rate	Death rate	percentage
Population density	Number of people living per unit area	Person/km^2
Age	Age	Number
GDP	Gross Domestic Product	-
Expenditure for health	Health expenditure of the residents	Yuan
Medical facilities	The logarithm of the number of health technicians per 1,000	number
Building density	Built up area	Square meter
Length of roadways	Length of built roadway lines	Km
Wastewater disposal	Yearly wastewater disposed	10,000 cubic meters
Solid waste management	Yearly Solid and municipal waste	10,000 tons
Greeneries	Public green space	Square meter
Temperature	Celsius	C
Urban area	Urban area	Km
Air quality	Measure of air quality	ppm

It is a technical issue that many laboratory-confirmed patients are not recorded, particularly in the early days of the pandemic (Lui et al., 2020). The data is gathered from the seven locations mentioned above. Many patients in the epicenter, such as Wuhan, race to the local health centers, which are inadequately staffed. This study does not consider these factors. In addition, the literature demonstrates that the proportion of urban and total populations are direct indicators of urbanization (Hao et al., 2018). This reflects the rise in population due to urbanization. This paper investigates whether the increase in population proportion has exacerbated the spread of disease.

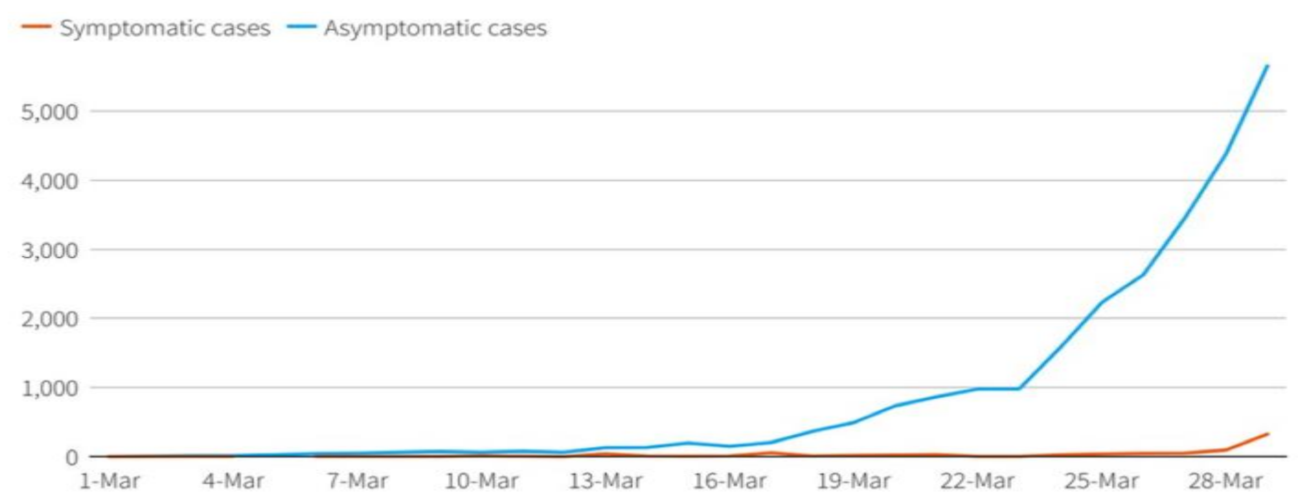

Figure 7: Covid-19 cases in Shangai

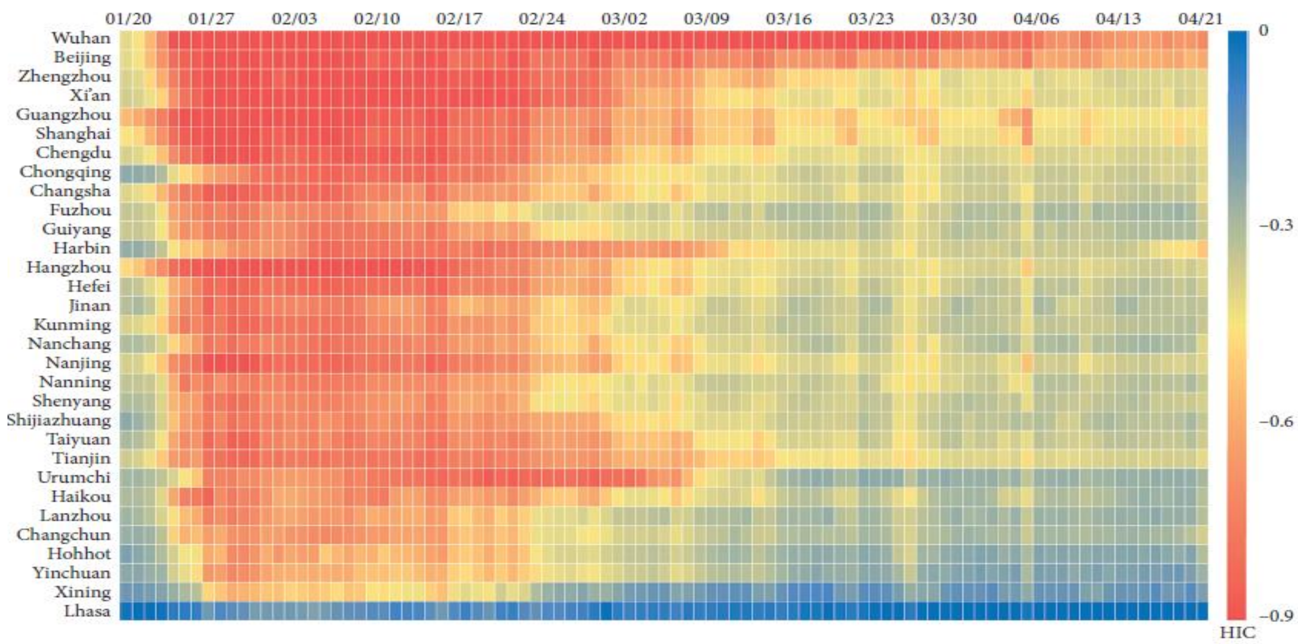

Figure 8: Heatmap of Covid spread in various Chinese cities

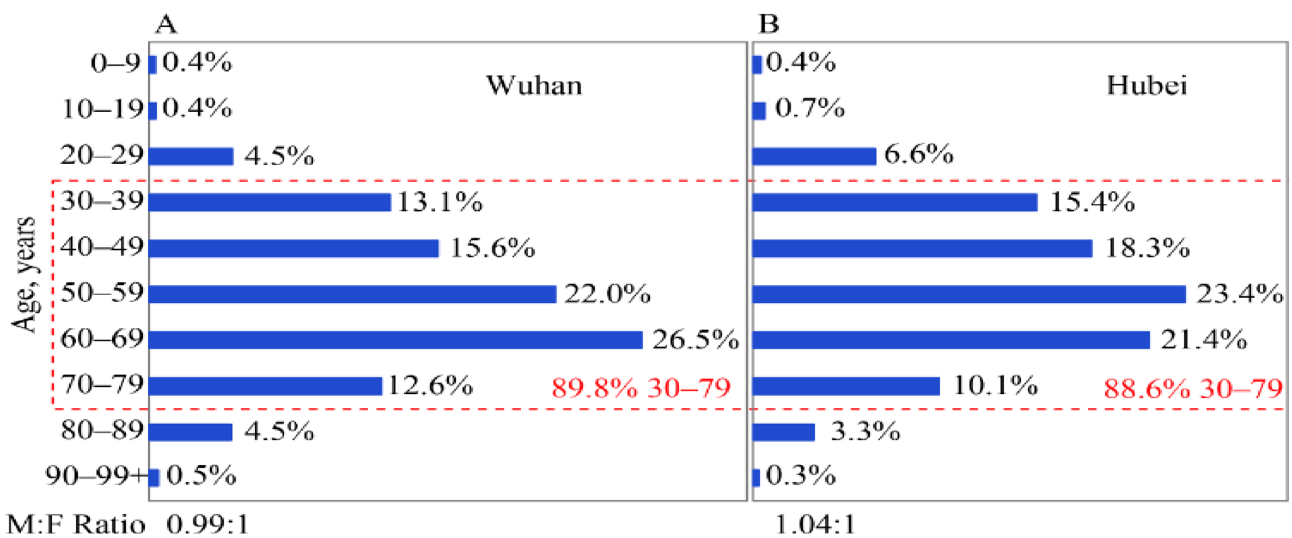

Figure 9: Age as a major factor of disease spread in two main cities of China

It implies that urbanization leads to overpopulation per unit area but does not include the claim that it leads to more densely packed built areas or buildings. Consequently, this is assessed using the ratio of the built-up area in the cities mentioned above to the city's total land area. This refers to the density of the building. Age is evaluated as the dependency ratio of the elderly population in the provinces mentioned above because they are more susceptible to disease transmission (Bai et al., 2020).

As shown in Figure 9, individuals in the middle and older age groups are more susceptible to the pandemic, with a high death rate among the elderly. China's aging population has had a significant impact on regional economic growth. Consequently, they have greater access to medical consumption, as measured by the city's Gross Domestic Product (GDP) during the COVID-19 period (Cheshmehzangi et al., 2022). This indicates the significance of public health: the ratio of health expenditures to total economic expenditures represents medical facility expenditures. This is the approximated logarithm of the number of healthcare professionals per 1,000 residents in the city. In addition, the logarithmic value of the number of days with good air quality is included as an explanatory variable. COVID-19 is not an exception to the relationship between air quality and virus transmission.

5. Methodology

This study employs a simple log-linear regression model in which the number of laboratory-confirmed COVID-19 patient cases is the dependent variable and other factors are the independent variables. The model is represented by Equation 1.

$$Ln\,Y = \beta_0 + \sum_{i=1}^{n} \beta_i\ X_i + \epsilon \qquad (1)$$

In the above equation, Y is cases of COVID-19 cases. The association between factors considered is indicated as variable X and is enumerable in Table 1. ε denotes the stochastic error. Though the above model appears simpler, it must be accepted that multiple factors affect the spread of the virus. Research illustrates that many influential factors are yet to be discovered and explored.

To effectively explore the hidden relationship between factors enumerated in Table 1 and the disease spread, the work includes estimating the correlation (Cor) among the variables as mentioned in Equation 2.

$$= \frac{n(\sum py) - (\sum p)\,(\sum y)}{((n\sum p^2 - (\sum p)^2)(n\sum y^2 - (\sum y)^2)\hat{}\ 0.} \qquad (2)$$

Here y indicates the number of confirmed COVID-19 cases, and the value of p is the explanatory variable considered in this study.

6. Empirical Analysis

The computation of the log-linear model's relation between is done more intuitively in this work between various explanatory variables and the number of confirmed pandemic cases. Table 3 displays the results of the estimation.

The results indicate that the highly urbanized cities of Hubei, Xinjian, and Shangai show a positive relationship between the urbanization factors and the spread of COVID-19. Thus, urbanization has a positive impact on the spread of the virus. To drill down further, not all factors play a prominent role in spreading the virus. The explanatory variables like greeneries, wastewater management, building density, and GDP do not show statistically significant results in most cities. But in highly urbanized cities, the air quality influences the spread of the virus with good statistical significance. Solid waste management positively impacts faster virus spread in urban cities. The medical expenditure did not turn out to be a deciding factor of urbanization which is not coupled with the pandemic spread.

Further, the correlation analysis between the variables is done according to Equation 2. The results are tabulated in Table 4.

According to the table's correlation analysis, there is a strong correlation between the mortality rate and the number of confirmed cases. Additionally, there is a strong correlation between the following pairs: population density and medical facilities, urban area and several cases, and building density and wastewater disposal. In addition, it can be observed that factors such as temperature, medical facilities, population density, urbanization, and air quality have a stronger correlation than the other variables. In contrast, the urbanization measures examined in this study, such as Greenery, solid waste management, roadways, and building density, do not demonstrate a significant correlation. These variables cannot be decisive in analyzing the impact of urbanization and COVID-19 pandemic in China.

7. Conclusions and Future Works

This multidisciplinary study investigates the effect of urbanization on the proliferation of the new crown disease in Chinese cities. Cities are complex organisms with a large migratory population, making it extremely challenging to study dynamic phenomena such as migration caused by the new crown pandemic. This study examines the relationship between numerous urbanization factors and the spread of the virus in seven major cities with varying levels of urbanization: Anhui, Hubei, Hinan, Guangxi, Gansu, Xinjiang, and Shangai. The explanatory variables considered in this study are derived from a vast body of research. Using a straightforward log-linear regression model, the relationship among the factors of urbanization is revealed. Detailed empirical studies and statistical significance of the factors indicate that variables such as temperature, air quality, age, population density, and the availability of medical facilities are positively associated with the spread of the virus. Other urbanization characteristics, such as roadways, waste management, and vegetation, have no significant implications. Also, correlation analysis is performed between the variables to investigate their connectivity. This analysis also yields a few additional significant findings, such as that urbanization and air quality are strongly correlated. Nonetheless, this research employs data from seven major cities with extensive explanatory variables. This work can be expanded in the future to incorporate additional variables.

Table 3: Empirical Estimation Results with Dependent Variable Log (Average Number of Confirmed COVID -19 Cases the year 2020-2021)

Variables	Anhui	Hubei	Hinan	Guanigxi	Gansu	Xinjiang	Shangai
Mortality rate	0.673 (-0.02)	0.862 (0.04)	0.527 (-0.03)	0.552 (-0.03)	0.569 (-0.002)	0.756 (0.12)	0.801 (0.013)
Population density	0.845(-0.002)	0.836 (0.02)	0.634 (-0.01)	0.664 (-0.03)	0.701 (0.002)	0.724 (0.001)	0.847 (0.01)
Age	0.056 (-0.003)	0.673 (0.012)	0.602 (-0.01)	0.473 (-0.01)	0.476 (-0.042)	0.563 (-0.36)	0.678(-0.01)
GDP	0.023(-0.001)	0.243(-0.003)	0.351 (-0.02)	0.346(-0.03)	0.263(-0.032)	0.342 (0.001)	0.546 (0.002)
Expenditure for health	0.452 (-0.27)	0.562(-0.25)	0.528 (-0.025)	0.372(-0.023)	0.432(-0.032)	0.521(-0.023)	0.534 (0.001)
Medical facilities	0.452(-0.002)	0.375(-0.002)	0.398 (-0.051)	0.273 (-0.02)	0.345 (-0.023)	0.356(0.001)	0.456 (0.005)
Building density	0.037 (-0.028)	0.028(-.001)	0.367 (-0.001)	0.345 (0.001)	0.341 (0.001)	0.0452 (0001)	0.563 (0.002)
Length of roadways	0.035 (<0.001)	0.352 (0.001)	0.054 (-0.23)	0.046 (-0.034)	0.062(-0.023)	0.531 (0.001)	0.672 (0.001)
Wastewater disposal	0.36 (<0.001)	0.45 (0.002)	0.342 (<0.001)	0.262 (<0.001)	0.356 (<0.001)	0.572 (0.001)	0.621 (0.002)
Solid waste management	0.256 (<0.001)	0.535 (0.002)	0.432 (-0.011)	0.382 (0.031)	0.406 (<0.001)	0.576 (0.001)	0.702 (0.001)
Greeneries	0.345 (-0.01)	0.335 (-0.023)	0.026 (-0.023)	0.452 (-0.93)	0.392 (-0.025)	0.244 (-0.0123)	0.302 (-0.01)
Temperature	0.534 (0.045)	0.567 (0.075)	0.673 (0.052)	0.782 (0.002)	0.832 (0.014)	1.076 (0.001)	1.028 (0.001)
Urban area	0.453 (0.014)	0.563 (0.001)	0.473 (<0.001)	0.376 (0.014)	0.482 (<0.001)	0.592 (0.001)	0.473 (0.001)
Air	0.344 (0.001)	0.465 (0.001)	0.452 (0.013)	0.354 (0.002)	0.342 (0.001)	0.453 (<0.001)	0.520 (0.001)

Table 4: Correlation Analysis between the Explanatory Variables

Variable	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1	0.764	0.43	-0.76	-0.45	0.478	-0.63	-0.034	-0.043	-0.45	-0.45	0.442	-0.98	-0.46	0.825
B	.*	0.054	-0.98	0.054	0.0432	0.653	0.032	-0.742	-0.25	-0.532	-0.032	0.456	-0.345	-0.53	0.35
C	*	*	1	-0.034	-0.735	0.432	-0.043	-0.675	-0.76	-0.064	-0.456	-0.754	0.421	-0.064	0.543
D	*	*	*	1	0.563	0.456	-0.56	-0.563	-0.452	-0.452	-0.53	0.452	-0.35	0.242	0.364
E	*	*	*	*	1	-0.36	0.026	0.034	-0.271	0.034	0.24	-0.24	-0.38	-0.532	0.23
F	*	*	*	*	*	1	0.002	0.023	-0.043	0.034	0.234	-0.341	0.345	-0.24	0.245
G	*	*	*	*	*	*	1	0.035	0.462	-0.47	-0.25	-0.87	0.229	-0.441	0.451
H	*	*	*	*	*	*	*	1	0.003	0.035	-0.341	-0.46	0.346	-0.461	0.34
I	*	*	*	*	*	*	*	*	1	0.28	0.026	0.124	0.043	0.036	0.24
J	*	*	*	*	*	*	*	*	*	1	0.0234	-0.023	0.021	-0.024	0.21
K	*	*	*	*	*	*	*	*	*	*	1	-0.27	0.024	-0.27	0.324
L	*	*	*	*	*	*	*	*	*	*	*	1	0.56	-0.756	0.137
M	*	*	*	*	*	*	*	*	*	*	*	*	1	-0.46	0.73
N	*	*	*	*	*	*	*	*	*	*	*	*	*	1	0.45
O	*	*	*	*	*	*	*	*	*	*	*	*	*		1

***A- Mortality rate, B- Population density, C- Age, D- GDP, E- Expenditure for health, F- Medical facilities, G - Building density, H- Length of roadways, I- Wastewater disposal, J- Solid waste management, K- Greeneries, L- Temperature, M- Urban area, N- Air quality, O- Number of Confirmed cases (O)

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