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IS COVID-19 A PANDEMIC OF INEQUALITY AND URBANIZATION?

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ABSTRACT

***Aim of the study**: The aim is to determine whether inequality and urbanization are factors influencing the development of this pandemic.*
***Design/methodology**: The methodology of the study is to analyse infection data of eight individual countries that are available from the World Health Organization and determine if per capita GDP, population, population density, air travel and population size of the capital cities are factors affecting the spread of the pandemic.*
***Findings**: The study results show that socioeconomics and air travel are factors which enhance the spread of infection.*
***Originality/value**: The study is an important contribution to understanding the development of the pandemic and factors enhancing the spread of infection and can assist governments to plan control measures for future pandemics.*

***Key words**: Social inequality, urbanization, infection control, infection rates, disease transmission*
***Paper type**: Research paper*

INTRODUCTION

Viruses account for about 60% of all infectious diseases (Campbell, Scadding, & Roberts, 1979). Viruses can be transmitted (Shors, 2017) from one species to another species and pandemics occur periodically (Morens and Fauci, 2007) .For a viral infection to occur, there has to be a reservoir/pool of virus and a mechanism for the transmission to a susceptible host. There has to be a convenient portal of entry to and exit from the host. Some viruses can stay intact and be active for a considerable time outside a host cell.

There are both inborn and acquired mechanisms that enable us resist infection. Firstly, there are surface factors such as intact skin or mucous membranes plus secretions such as sweat and sebaceous secretions. The effect is to inhibit the host cells adsorbing the virus or destroying attachment sites. Viruses need susceptible cells, it is not able to infect every cell it encounters. It must come into contact with a host cell that can support its replication. Host cells do have some molecular constraints on virus attack.

The spread of disease is usually linked to poor urban living conditions and socioeconomic status (Braveman and Gottlieb, 2014; Wang and Geng, 2019). The aim of this work is to highlight that the spread of the virus is faster in less affluent societies and the impact in large cities are greater and that air travel in modern society which is more beneficial to the wealth off enhances the severity of the pandemic. Secondly, in the pre-industrial revolution era Europe the most serious pandemic was the Black Death or great plague. During the Black Death it was also much more dangerous living in a rural district than in cities (Kelly, 2005). This work also aims ascertain the consequence of increased urbanization on the pandemic.

METHOD

The World Health Organization publishes Situation Reports (2020, 2021, 2022) on daily and total cases by country up to August 2020. Data quoted in the WHO Situation Reports are used for this work. It is possible that on any day, a value is misreported and amended in the next day's report. When daily infections are small, figures can appear as fluctuations on a plot and can disguise the true trend of the curve. To smooth out the spikes on the curve moving averages (average value for three consecutive days) are used in the plots and calculations.

Growth of an epidemic sometimes resembles a typical growth curve (Chatfield,1989). However, plots of total infections versus time for France, Germany and Italy and Spain, which are similar countries, do not show any smooth curve. On close inspection, with the exception of the start of the plots, each plot emerges as a series of straight lines following the relationship of $y = mx+c$ (each with a different gradient) linked together. The gradients m and the constant c can be calculated using any two points on the line by applying a mathematical calculation (Wilson, 1973). Analysis shows that each line represents a different stage of the pandemic. Eight European countries are used to evaluate infection rates and correlation between population density, age and wealth where per capita GDP (World Bank, 2020) provides a good indicator. Air transport statistics are analysed to evaluate correlation between infection and international air travel.

RESULTS

Up to the mid July, six stages of the pandemic were identified. Table 1 shows the start date of each stage. For convenience, the day when the average total number of confirmed cases as reported in the WHO Situation Reports approaches a hundred of total cases is taken as the beginning of the pandemic in each of the countries.

Table 1. Dates showing the start of each stage of the pandemic in each country

Stage	France	Germany	Italy	Spain
I	March 2	March 2	February 25	March 4
II	March 22	March 24	March 16	March 23
III	April 18	April 13	April 6	April 9
IV	May 10	April 28	April 26	April 27
V	May 18	May 13	May 17	May 9
VI	June 4	June 2	June 2	May 28

During the first stage, the number of infections is small but grows rapidly until there is a critical mass of infected individuals. In the second stage enough of the population are infected and can carry on infecting a bigger proportion of the population until the whole is infected or some control is put in place to check the growth. It is almost inevitable an epidemic will take place in this stage and the number of infections continues to increase. In the third stage, some of the infection protection measures (i.e. restrictions such as social distancing and shutting non-essential shops) have started to take effect and the number of new daily infections becomes steady. In the fourth stage the number of new daily infections begins to slowly reduce.In the next stage, the fifth stage, the population are now educated to protect themselves with prevention measures such wearing masks and washing their hands. In the sixth stage, the wave of virus attack begins to subside and if there is no new source of virus the pandemic should begin to come under control. This has not happened partly because in the later stages governments have relaxed infection control measures too soon probably for economic reasons and the virus has begun to mutate to a new variant.

Each stage of the pandemic is defined by a mathematical expression shown in Table 2 (Expression defining the mathematical characteristic of each stage of the pandemic). The total number of infections on any day in any stage can be calculated using the mathematical expressions given in Table 2.The value of T is the number of days from the start of the pandemic beginning from day one of stage I. European governments responded to the seriousness of the pandemic and took similar control measures starting at a similar time.

Table 2 Expressions defining the mathematical characteristic of each stage

Stage	**France**	**Germany**	**Italy**	**Spain**
I	86x1.29T	81x1.3T	143x1.34T	103x1.34T
II	3770T-67500	4830T-82500	5090T-84000	7250T-118000
III	1230T-52000	2360T+21400	3250T-15500	4140T-40000
IV	720T+85500	1070T+94000	1350T+114000	840T+165500
V	580T+94000	550T+131500	640T+171000	825T+167300
VI	350T+115500	440T+140500	230T+210500	350T+208000

The gradient of each line segment reveals the speed of the growth of total infections in each stage.We know the actual total number of infections at the end of stage IV. Assuming from the beginning of stage II of the epidemic the total number of infections increases linearly, by substituting in the value of the last day of stage IV for T in the expression for stage II, the total number of infections up to the end of stage IV without the lock down can be calculated. Take France for example, the expression is 3770T – 67500. The last day of stage IV is 17th May which is day 77 of the epidemic, by substituting in 77 for the value of T, the total number of infections is equal to (3770x77 – 67500) which is 222790. Subtracting the (moving average) value of the total infections reported on 17th May (which is 139897) we obtain the extra number of infections should no restrictions have been applied. Table 3without control measures, i.e. not action taken by the authorities,the number of total infections is higher than with control measures (the actual total infections with restriction are taken from the WHO Situation Reports) by 45% or more.

Table 3 Total infections at the end of stage IV (no action vs restrictions)

Category	France	Germany	Italy	Spain
a. no action	222790	265260	333380	353250
b. restrictions	139897	170508	223914	220367
c. difference	82893	94797	109466	132883
c/b	0.45	0.56	0.49	0.60

Eight European countries are used to compare the infection rates and assess the correlation between population density, age and per capita GDP. Tables 4 and 5 show the population of each the individual country's capital (population within the capital's commuting zone) which in all cases is the largest city in the whole country, percentage of the population by age group, population density per square km, the 2019 per capita GDP and the number of infections as at 16thJune 2022. Values shown are rounded and the percentages by age group may not add to exactly 100%. In addition, the percentage population over the age of 65 (marked *) living in functional urban areas (defined by Eurostat as a city and its commuting zone) with populations over half a million are shown in Tables 4 and 5.

Table 4 Infections, population, population distribution and per capita GDP (US$)

Categories	Belgium	Sweden	Netherlands	Norway
Population (million)	11.5	10.2	17.3	5.3
Population density	375.7	22.7	416.6	16.3
GDP percapita US$	46117	51610	52448	75420
Population of capital(M)	2.6	1.6	2.6	0.7
Total infections	4225222	2515769	8171396	1445034
Infections/ 000 population	367	246	472	272
*City population age 65+	17.3%	16.3%	16.9%	16.3%
Age 0-14	16.9%	17.8%	15.9%	17.5%
Age 15-24	11.4%	11.3%	12.3%	12.4%
Age 25-49	32.7%	32.9%	31.8%	34.1%
Age 50-64	20.1%	18.1%	20.9%	18.7%
Age 65 and over	18.9%	19.9%	19.2%	17.2%

Table 5 Infections, population, population distribution and per capita GDP (US$)

Categories	France	Germany	Italy	Spain
Population (million)	67.0	83.0	60.4	46.9
Population density	121.4	232.5	200.5	92.9
GDP percapita US$	40494	46259	33190	29614
Population of capital(M)	12.8	5.1	4.4	6.6
Total infections	29901085	28048190	18343422	12734038
Infections/ 000 population	446	338	304	272
*City population age 65+	20.6%	20.6%	21.8%	17.7%
Age 0-14	18.0%	13.6%	13.2%	14.8%
Age 15-24	11.7%	10.4%	9.8%	11.8%
Age 25-49	31.0%	31.6%	32.4%	35.3%
Age 50-64	19.2%	22.8%	21.9%	20.7%
Age 65 and over	20.1%	21.6%	22.8%	19.4%

Norway and Sweden have the highest percentage of the population within the age group 15-49 and Sweden has lowest percentage within the age group 50-64 and shows the lowest infection rates. Probably the part of the population within the age group 15-49 are more immune to the virus or even being infected show few symptoms.

There is correlation between the size of capital cities and infections rates. Norway has no cities with populations of over a million and the population of the other capital cities are larger than that of Sweden. France has higher infections than Italy, Spain and Germany because the populations of Rome, Madrid and Berlin are so much smaller than those at Paris. So the overall infections in Italy, Spain and Germany are lower. The tables also show a correlation between infection rates and per capita GDP. Agricultural workers and the rural population are in general less well paid than industrial and city workers and more likely to live in cities. Most the infections occur in cities where the population density is higher.
There were few restrictions in air travel for most of 2020. Table 6 lists the number of cases as at 16th May 2021 and the number of air passengers in the years 2019 and2020.

Table 6 Comparison of number of cases with thousands of air passengers in 2019 and 2020

Country	**Total infections**	**Air passengers 000s in 2019**	**Air passengers 000s 2020**
Belgium	4225222	35385	9466
Sweden	2515769	37614	8657
France	29901085	168729	50771
Germany	28048190	226764	57796
Italy	18343422	160668	40336
Netherlands	8171396	81193	23595
Norway	1445034	40348	13217
Spain	12734038	227189	57296

DISCUSSION

Table 2 shows Italy and Spain show higher gradients for stages II and III curves meaning that infections are spreading faster in Italy and Spain. Similarly for Table 3 which shows that with or without restrictions Italy and Spain both have a larger number of infections. Germany and France have higher per capita GDP and that a higher standard of living is a likely contributing factor for infection prevention.

After August 17th 2020, the World Health Organization stopped daily reporting infection rates and it was not able to produce analysis of later stages. At the start of the summer some of the restrictions were lifted most likely for economic reasons and during August infection rates of every country began to rise. From October infection rates started to increase fairly rapidly due to a hidden/unknown reservoir or a new strain of the virus appearing.

Diseases were introduced to areas of Central/South America were made by people travelling from Europe in the 15th and 16th centuries (Dobson and Carter, 1996) in the name of exploration, which caused pandemics among the native inhabitants. Air travel which contributes to global warming benefits more the affluent in a capitalist society. The correlation coefficients (Chatfield, 1988) calculated between air passengers and infections are extremely high at 0.88 and 0.86 for 2019 and 2020 respectively. This confirms air travel enhances the spread of the virus and likely impacts more on the part of the population which are less able to afford air travel.

There is more commercial activity in the capital than other cities in a country and major international airports are located at or near the capital and the virus can be spread more quickly than smaller towns. Brussels is an important railway hub and head-quarters of the EU. The population density in Belgium and the Netherlands are higher than are countries of the group and not very surprising that Belgium has a high infection rate.

All the above is evidence that in an industrial and urban society, social inequalities extends to poor health and a higher probability of being infected by Covid-19.

There are fewer people commuting to work in city centres which no doubt affect many businesses which depend on city workers. Secondly, the alteration of the shape of the traditional high street in cities cannot be underestimated. Some businesses won't be able out last the pandemic will be forced to close and this has a bigger impact on small businesses and the lower paid. It is part of the duty of government policy makers to prevent this to happen. The city high streets have to be made very appealing so people have to be attracted them. Out of town shopping centres are most unfriendly to the environment and create more car journeys. Such shopping centres can be dismantled and shops be encouraged to move back into city centre high streets. Shops and businesses can be attracted by lower business rates and lower rents. Cheap bus fares to town centres plus high car parking charges will also discourage people from going to those out of town shopping malls. The high street needs also to be made child friendly such as providing child play areas and/or crèches for young children. Empty office buildings can be converted to apartments. With more people living in city centres more businesses in city centre areas can thrive and has to be done with help of government changing planning rules.

The economic impact of viruses on modern human society is greater than most (if not all) other natural or men made disasters.

CONCLUSION

This work shows that whilst air travel benefits those who can afford it,besides damaging to the environment enhances the spread of Covid-19. This pandemic show some of the inequalities of society increasechances of being infected by the Covid-19 virus. The consequence of increased urbanization is more serious epidemics/pandemics with a bigger impact on the inner city population.

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Conflict of interest

There is no conflict of interest and no competing interest.

Consent or ethical approval

There is no experiment or personal data and all data used in this work are in the public domain and freely available. No consent or ethical approval from anyone is required for this work

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