Case Study Report

The Role of Urban Planning in Containing an Epidemic:

A Proposed Approach to Contain COVID-19 Using Space Syntax

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Abstract

Cities are urban areas where we live, communicate, and navigate. Each area has its own characteristics which greatly affect its users. Urban areas can gather, crowd, or segregate us. Thus, urban planning has an evident role in controlling human's behavior. This relation raises a question; in case of an epidemic, how can urban planning contribute to containing such a crisis?

Recently, the world has been hit by a contagious disease which quickly turned into a pandemic known as COVID-19. This pandemic has been attacking countries with their different aspects; economy, education, tourism, etc.

This paper proposes a methodology to manage epidemic spread using Space Syntax. First, it will review the linkage between urban planning and epidemics. Then, it will propose an urban contagion scale to determine the probability of any urban space to transmit infectious diseases depending on its urban features. This scale will define which factors contribute to transmitting infectious diseases. Thereafter, this scale will be applied to four case study areas. Finally, results and conclusions will be listed.

Keywords

Urban planning – epidemics – Contagion Rate

1. Introduction

"Health is a state of complete mental, social and physical well-being, not merely the absence of disease or infirmity[1]." Maintaining health is not only the responsibility of medical sectors, but also the responsibility of many different sectors. One of the most important of them is urban planning. Urban planners create, improve and manage our surroundings. Their role is to design urban spaces to be healthy spaces for users, especially in cities where urban lifestyle is supposed to have serious negative impacts on human health more than rural areas. Moreover, in case of an epidemic, cities and urban centers contribute to act as catalysts for the rapid epidemic spread due to their large population.

On the other hand, away from pandemics which rarely happens, according to estimations announced by the United States Centers for Disease Control and Prevention (US-CDC) nearly up to 650,000 deaths annually are associated with respiratory diseases from seasonal influenza.

Thus, Urban planners need to create spaces that are less likely to transmit diseases in order to effectively achieve the concept of "healthy urban environment". The concept of healthy urban environment depends mainly either on environmental hazards or man-made things. In addition to some indices related to

1 World Health Organization, 1948

economic and urban poverty. Yet, The concept does not include an environmental assessment of the extent of transmission or containment of infectious diseases (Contagion rate) in public spaces. This paper aims to add another dimension to the concept of healthy urban environment depending on the ability of any urban environment either to contain or spread infectious diseases according to its features.

2. The History of Epidemics

History witnessed that epidemics were responsible for much more mortalities than those killed in wars. Starting from The Plague which had numerous outbreaks, yet the most notable was that happened in the fourteenth century in Europe known as the "Black Death". It was responsible for the death of about one-third to one-half of all Europeans during this era.

Another known pandemic was Cholera. Cholera is an acute diarrheal infection caused by ingestion of food or water contaminated with the bacterium Vibrio Cholerae. During this pandemic urban planning acted a new role, rather than the protection role represented in isolating infected areas, it was a key solution to understand the causes of Cholera epidemic and though contribute to manage it. In 1854 and during the third pandemic outbreak of Cholera Dr. John[2] Snow tracked infected people in London and mapped their location data. This map showed more concentrated infections around a street pump which subsequently led him to discover the source of the outbreak. Although he did not identify the contaminant, he proved that contaminated water was the main agent behind spreading cholera.

Later more, in the eighteenth century in 1918 Spanish Flu pandemic broke-out. It is also called the deadliest flu owing to its number of deaths. This pandemic was characterized by a unique feature, unlike other pandemics, the mortality rate was higher among healthy young adults than elder categories.

Recently, the world has been hit by numerous epidemics such as SARS in 2002, H1N1 pandemic in 2009, and finally the current pandemic COVID-19.

3. The Role of Urban planning in containing infectious diseases

Prevention is better than cure, especially when there is no cure. In case of a pandemic, worldwide efforts are limited to prevention methods represented in isolation, quarantine, and additional urban solutions related to public gatherings. Infectious diseases transmit through individuals and the surrounding environment. Thus, managing the urban environment and the individuals' public behavior is an effective way to control epidemic spread. In another word, as drivers of infectious disease transmission exist in the urban built environment, thus, urban planning could act as an effective tool to control epidemic spread.

2 A British physician and a member of the Royal College of Surgeons in 1838.

4. Methodology of The Paper

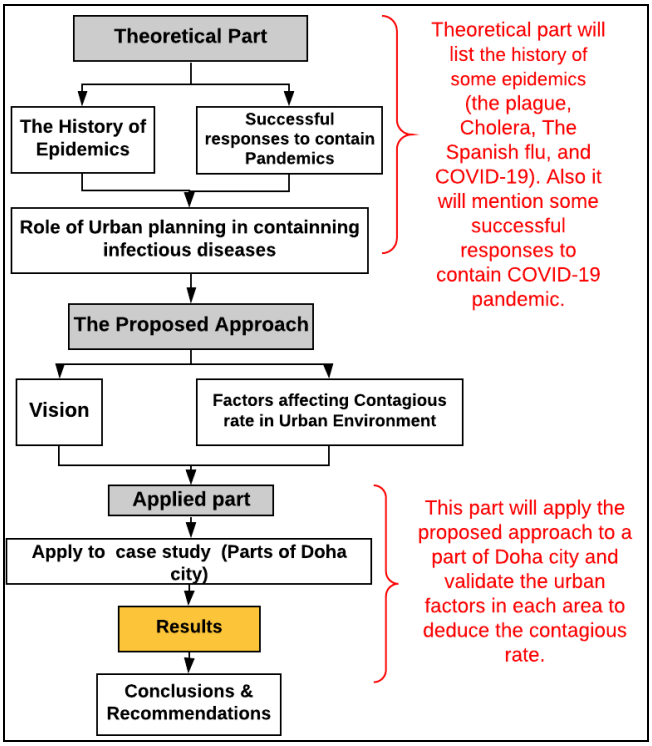

Figure 1: Paper Methodology
Source: By Author

5. Limitation

This approach is limited to epidemics of viral respiratory infections which can transfer from one person to another through droplets or close contact with an infected person.

6. The Proposed Approach (Invulnerable urban space[3])

The proposed approach focuses on adding a new dimension to the concept of healthy urban environments depending on the probability of any urban environment either to contain or spread infectious diseases. This approach aims to create urban spaces that are invulnerable to infectious diseases. Invulnerable urban space is a healthy urban space which is less likely to transmit infectious diseases through effective functionalizing of its urban factors.

This approach will list factors that affect the spread of infectious diseases and will argue the effect of each, the more controlled factors, the safer space from epidemic spread.

7. Factors Affecting Contagious Rate in Urban Environment

This part will argue the effect of some factors in transmitting infectious diseases whether it has a catalytic or an obstructive effect. These factors are classified into two groups; the first group represents factors related to urban environment which are accessibility, crowd, land use, housing type, density, and landscape. While the second group represents factors related to individual's behaviour (moral factors) which are awareness and sense of responsibility.

3 Nomenclature proposed by author

7.1. Crowd

Infectious diseases are almost related to crowd. Any epidemic spread is caused by human mobility. During COVID-19 pandemic, a recent study analysed highly-resolved spatial variables for cities in China versus confirmed cases. The results of this study showed that the epidemic intensity of COVID-19 is strongly shaped by crowding[4]. During pandemics, crowds are not allowed and many countries adopted total lockdown. Yet, this paper seeks to understand, and manage crowds not only for pandemic cases but also for the normal cases to minimize the spread of any infectious diseases. The next factor which is accessibility would help to do so.

7.2. Accessibility

Accessibility describes the spatial structure of urban spaces and how easily users can navigate through them. The importance of accessibility in controlling infectious diseases lies mainly in determining the most integrated areas (most accessible) which are supposed to receive many users, as accessibility is quite related to crowd " areas with high syntactical accessibility have a higher number of pedestrians and car users"[5]. Thus, the more accessible (integrated) space, the higher probability to transmit infectious diseases. This paper will use Space Syntax to analyse accessibility through running integration analysis in the applied part using Depthmap platform.

7.3. Land use

Land use is another vital factor that is quite connected to the number of users. This paper argues four main types of land use which are; residential, commercial, mixed land use, and craft. Residential areas are supposed to have a lower contagious rate than the other three land uses, as residential areas are characterised by definite functions with limited users. On the other hand, commercial and craft spaces are characterised by hustle all day and attract more users. Mixed-use areas are multi-purpose spaces which attract a large number of users.

7.4. Housing Type

Housing type is a notable factor that greatly affects the surrounding urban space. This paper argues three common types of housing which are; private houses (villas), apartment buildings, and shared accommodation buildings. The transmission rate of infectious diseases varies widely among these three housing types according to three main criteria; first the number of families and dwellers in each unit, second, the possibility of home quarantine in case of one family member is infected. And third, the efficiency of home quarantine which depends on the possibility of allocating separate rooms and separate bathrooms for the infected person if possible[6] (table 1).

Evaluation Criteria of Contagious rate in different housing types					
Evaluation Criteria		No. of families	possibility of home quarantine	Efficiency of home quarantine	Contagious rate
Housing Type	private houses (villas)	One family mostly	Exist	Effective	Low
	apartment buildings	One family in each apartment. Yet numerous families share the same elevators, stairs and entry	May be / depends on the number of rooms and baths	Variable from one apartment unit to anotehr	Medium
	Shared accommodation buildings	Non relatives sharing same unit	Do not exist	ineffective	High

Table 1: Evaluation Criteria of Contagious rate in different housing types
Source: By Author

4 Northeastern Universuty, Network Science Institute (April 2020)

5 Penn, et al (1998). Hillier et al (1993)

6 "Guidelines for home quarantine" WHO

7.5. Density

Population density is an index to measure the average number of people in an area. Unlike crowd, there are contradictory arguments about the effect of density in spreading an epidemic. Many recent studies argued the role of density in spreading COVID-19 pandemic, yet there is no evidence that population density is linked with COVID-19 cases and deaths. Although New York City emerged as a hotspot for COVID-19 which highlighted the fact that density might be a main cause for the pandemic spread in the city, many other global cities that are as dense as New York City, such as Seoul, South Korea, report exponentially fewer cases and deaths (CHPC, May 2020) The reason is that the term "density" is a catchall term which encompasses other detailed terms[7]such as: Residential Population ,Internal density , Institutional setting density.

Although there is no evidence that population density is linked with epidemic spread, the situation changes when considering time, as denser locations are more likely to have an early outbreak of epidemics. In addition, dense cities are more likely to spread out epidemics through time which would result in larger total incidence.

7.6. Landscape

There is a wide debate about the role of landscape in spreading infectious diseases. This role differs totally according to the kind of infectious disease and the way it transmits. Landscape plays a main role in understanding and managing vector-borne disease transmission. Yet, according to the limitation of this paper which focuses only on infectious diseases of viral respiratory infections which can transfer from one person to another through droplets or close contact with an infected person, landscape areas act as recreation spaces to promote public health and by considering social distancing between users, they are supposed to be the best places in cities as they are characterised by fresh air and vegetation.

7.7. Awareness

Infectious diseases are mainly transmitted from individuals and by individuals. Thus, there is no doubt that public awareness is a vital factor to control infection. Awareness represents the mindful behavior to deal with others in public spaces and disposing of waste (like napkin) properly.

7.8. Sense of Responsipility

Another vital non-physical factor is sense of responsibility. It is a moral factor which reflects to what extent do people care about their community, to what extent do users follow declared instructions (in general not only in case of a pandemic).

7 Felipe Carozzi, Sandro Provenzano, Sefi Roth (July 2020) "Urban Density and COVID-19"

8. Urban Contagion Scale

The effect of the previously mentioned factors (exclude moral factors) in spreading infectious diseases are summarised in the following table:

Different cases for factors affecting the spread of infectious diseases			
Factors	Different cases for each factor	Catalyst/ Obstruct	Notes
Crowd	Large crowd means more likely infectious diseases could spread. Crowd is defined as catalyst or obstructive according to accessibility.		areas with high syntactical accessibility have a higher number of pedestrians and car users" Penn, et al (1998). Hillier et al (1993)
Accessibility	$I\mu_{AR} \geq I\mu_{CT}$	C	$I\mu_{AR}$: Average integration value of any area $I\mu_{CT}$: Average integration value of the area with suitable buffer or Average integration value of the city in which the area is located
	$I\mu_{AR} \leq I\mu_{CT}$	O	
Land-use	Residential	O	The effect of land-use varies due to the variation of the functions of urban space which attract users.
	Commercial	C	
	Mixed-use	C	
	Craft	C	
Housing Type	private houses (villas)	O	The effect of housing type varies due to the possibility of home quarantine
	apartment buildings	C	
	Shared accommodation buildings	C	
Residential-pop-density	Very High	C	The effect of residential density varies according to the average number of people in each area
	High	C	
	Medium	O	
	Low	O	
Landscape	Exist	O	In case of viral respiratory infections which can transfer from one person to another through droplets or close contact with an infected person
	Do not Exist	C	

Table 2: Different cases for factors affecting the spread of infectious diseases
Source: By Author

This table is applicable to urban environments in order to assess the contagious rate of infectious diseases whether it is high or low. This paper proposes an "Urban Contagion Scale" which describes the severity degree of urban space in spreading infectious diseases depending on its urban features and defines five levels of severity depending on the number of urban factors that stimulate an epidemic spread.

Number of Factors stimulating infectious diseases' spread	Zero	1-2	3	4-5	6
Contagious Rate	Very low	Low	Moderate	High	Very High
Contagion Scale	Invulnerable Urban space	Convenient	Tolerable	Depressing	Communicable

Figure 2: Urban Contaion Scale
Source: By Author

9. Case Study (Parts of Doha city)

This paper will apply the proposed approach to four areas in Doha city to deduce the contagion rate in each area. The four case study areas are; Umm Ghuwailina, Al Thumama, Al Waab, and the Industrial area.

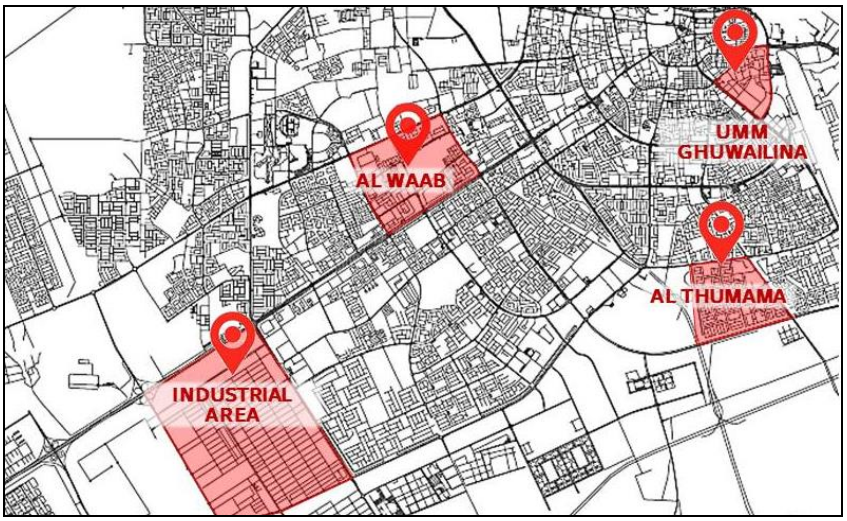

Figure 3: The four case study areas in Doha City

Source: Doha map (https://www.mapacad.com/), edited by author

First, crowd and accessibility were analysed by running integration analyses to a part of Doha city that includes the four case study areas, it was found that the average integration value of the whole area is 0.623. "Salwa" road recorded the most integrated axial line in the map, therefore any area directly connected to it will show higher integration values. Moreover, areas with linear or grid spatial structures have higher integration values than other patterns as they are more accessible and navigable and attract more users. The integration values of Umm Ghuwailina and Al Thumama were less than the average integration value of the whole area; 0.595 and 0.479 respectively. On the other hand, AlWaab and the Industrial area recorded integration values higher than that of the whole area; 0.649 and 0.732 respectively.

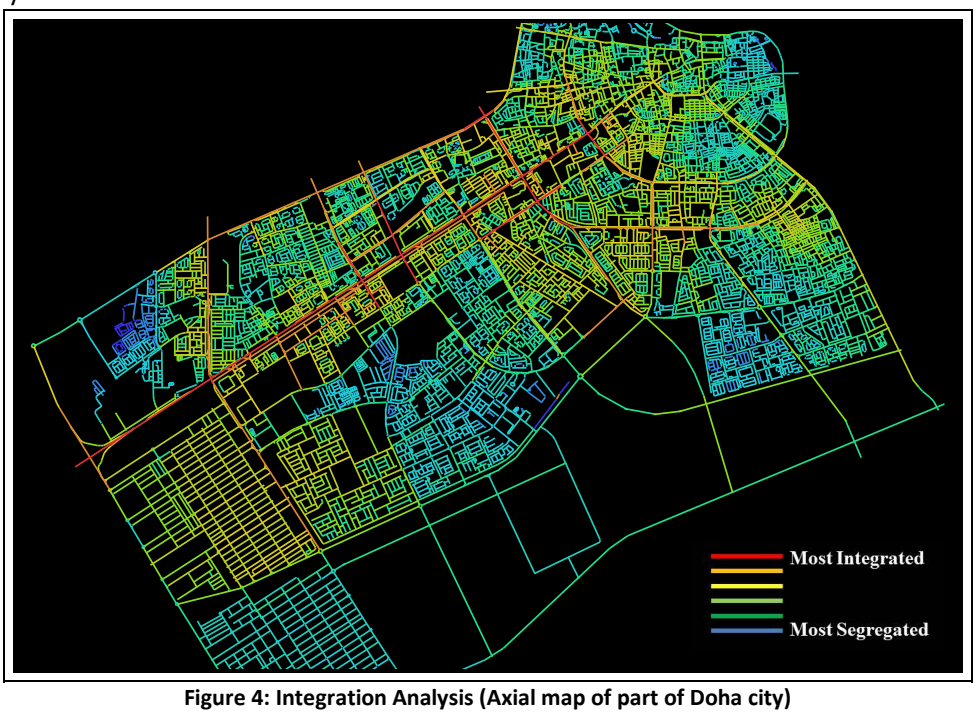

Figure 4: Integration Analysis (Axial map of part of Doha city)

Source: By Author

Second, land-use, landscape, and density of each area are listed on the online map of Land Use & Zoning Regulations published by the Ministry of Municipality and Environment in Qatar. The information of these factors within the study areas are summarised in the following figure.

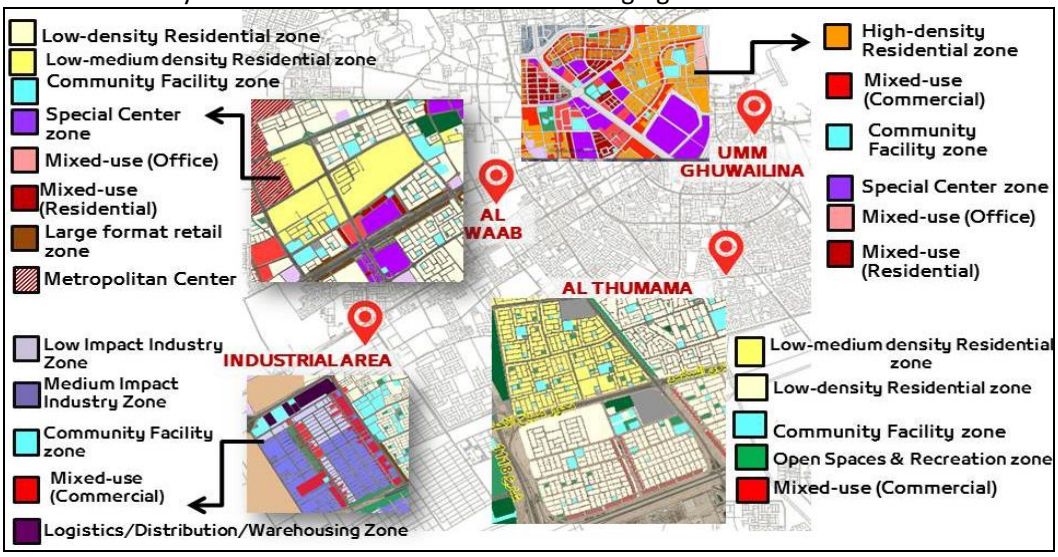

Figure 5: Land-use of the study areas in Doha City

Source: By Author, Land-use information: https://geoportal.gisqatar.org.qa/zoning/

From figure (7) it is shown that the predominant land use in Al Waab area is residential with limited mixed-use (office) located on "Al Sidr" road, and a large format retail zone located on "Salwa" road. The density of the residential areas in Al Waab differs between low density and low-medium density. Al Waab is characterised by many residential compounds such as Beverly Hills, Al Mirqab compound, etc. additional to numerous open spaces and parks.

Moving to Umm Ghuwailina and Al Thumama , the predominant land use in both areas is residential with limited mixed-use in some roads. The residential area in Umm Ghuwailina is characterised by high-density with a lack of landscapes or open areas. While Al Thumama area is characterised by low density in the south part and low-medium density in the north part with numerous open spaces and parks in both parts.

Finally, the Industrial area. It is clear from its name that the predominant land use in this area is industrial with different impact. Additional to Mixed-use (commercial), logistics, and warehousing zone. In this area also, there exists residential use represented in many shared-accommodation buildings for workers. The housing type and the predominant land-use raises the density in the Industrial area. On contrary, Al Thumama and Al Waab areas are characterised by private houses and villas as a predominant housing type with numerous residential compounds in Al Waab. While the predominant housing type in Umm Ghuwailina is building Apartments (Figure 8).

Figure 6: Housing Type of the four study areas in Doha City

Source: By Author, pictures source: (different websites) www.google.com

10. Results

By applying the proposed approach to four areas located in Doha city, it was found that the urban environment in Al Thumama recorded the best results and it approaches to create an invulnerable urban space against epidemic spread, the results in Umm Ghuwailine and Al Waab were moderate . On contrary, the urban environment in the industrial area changed it into a communicable place.
The results are summarised in the following table.

Case Study area		Umm Ghuwailina	Al Thumama	Al Waab	Industrial Area
Variables	Accessibility	obstruct	obstruct	catalyst	catalyst
	Crowd	obstruct	obstruct	catalyst	catalyst
	Residential Density	catalyst	obstruct	obstruct	catalyst
	Housing Type	catalyst	obstruct	obstruct	catalyst
	Land-use	obstruct	obstruct	obstruct	catalyst
	Landscape	catalyst	obstruct	obstruct	catalyst
	Contagious rate	Moderate	Very low	Low	Very High
	Contagion Scale	Tolerable	Invurnelable	Convenient	Communicable
The contagious rate and the contagion scale depend on the mentioned urban features only, and the moral factors (awareness & sense of responsibility) can change the results as any infectious diseases spread through both individuals and surrounding environment.					

Table 3: Results for the Final Assessment of the Four Study Areas
Source: By Author

11. Conclusions

Promoting public health should be always considered in urban planning. The concept of a "healthy urban environment" needs to be widened to encompass new variables. This paper targets adding a new dimension to the concept of (healthy urban environment) inspired by the current crisis (Covid-19 pandemic). It proposed a "contagion scale" to describe the probability of any urban area to spread infectious diseases depending on eight factors. when all of the previously mentioned urban factors exist in the catalytic case in the same urban environment, they change it to a communicable urban space that is more likely to transmit infectious diseases among its users. This case is clear in the applied part of the paper, as the Industrial area in Qatar has been described as a communicable urban space according to the "urban contagion scale". This area acted as an epicenter for the outbreak of Covid-19 in Qatar in March 2020 and was the hub for many confirmed cases.
Finally, it is important to mention that the role of the same urban factor can change to the opposite according to the type of an epidemic. For example, the landscape acts as an obstruct to respiratory infectious diseases, while this role will totally reverse in vector-borne epidemics.

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