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A Historical Perspective on the Impact of the Infectious Disease Outbreaks on Architectural and Urban Changes

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ABSTRACT

There has been illnesses and pandemics all through the history effecting the cities. Some of the most significant architectural and urban changes occured in the cities due to infectious illnesses. The recent emergence of the coronavirus disease (SARS-CoV-2) which was declared as a pandemic in March 2020 with its continuing effects on human life despite all technological and medical advances in the last century and together with the phenomena such as population growth, rapid urbanization, increase in urban and architectural life comfort, has led to an immediate expectation to produce solutions with rapid changes in urban and architectural areas. This paper investigates what happened in the history of cities to develope healthy and hygenic living environments in search of an evaluation whether it is possible to provide humanity architecturally with living spaces in cities free of illnesses or if it is an illusion in terms of reality.

Keywords: Healthy Cities, Healthy Design, History of Architecture, History of Cities, Pandemics.

INTRODUCTION

Infectious diseases, when turned into epidemics as a leading cause of death, have created effects that changes the history. Other natural disasters such as earthquake, famine and fire never matched the destruction caused by epidemic diseases. The outbreaks that caused the deaths of thousands and even millions of people in a few years destroyed empires, ruined armies, and devistated the lives in cities (Ayar, 2007).

All through the history spreading diseases efected towns and cities urging to find solutions for a healthier society. For centuries there were consecutive pandemics, many lasted years resulting in significant number of people to die and they forced architectural solutions in urbanisation to evolve. On the other hand, as the tremendous developments created by humanity in all areas related to science, technology and architecture in the 20th century did not end the spread of illnesses as effectively as it was thought it would, following the sudden emergence of recent COVID-19 virus, an immediate expectation of changes in life styles especially in the crowded urban settlements was arised in order to reduce the pandemic rates. Architectural solutions and alterations were considered to have a crucial impact on future in dealing with viruses in living environments for the benefit of humanity.

This paper is based on the investigation to find out if such an expectation was realistic that whether the architectural decisions were indeed effective in changing conditions of living environments in the past in order to prevent epidemic illnesses and whether it is really possible to make decisions and apply architectural and urban solutions in order to obtain rapid transformations in people's lives urbanvise with respect to epidemic illnesses.

Therefore, the effects of pandemics in history were reviewed. The spread of illnesses in the 19th century and its relation with the human living conditions which resulted drastic changes in urban areas in the 20th century as past of modern architecture were investigated.

The effects of infectious illnesses on cities through history

The earliest infectious illness was recorded in Athens during the Peloponnesian War. According to Thucidydes (1972), in the summer of 430 B.C. which was the beginning years of the Peloponnesian War, almost a third of the Athenian population was killed due the plague took place. Such epidemic that stroke Athens was the deadliest disease in the classical Greek history decimating the

population and contributing to the defeat of Athens by Sparta. The Peloponessian War between Sparta and Athens was a crucial war as the collapse of Athens caused an instability in the region. After the war, Alexander the Great dominated Greece, Anatolia and the Mediterranean, transforming the Greek civilization into something else (Freeman, 1996).

Although Thucidydes did not give any information about why the plague was started, the fact that Aristoteles (1975) proposed to the health inspectors to check the wastes of the city in his book "Politics", indicates that there were serious sanitary problems in the ancient Greek cities. In the ancient Greek cities, it was not possible to find a sanitary facility as in the order that was present in Harappan Civilization three thousand years ago in the Indus Valley. In Greek polies, most of the dwellings did not have a toilet. Observing the Greek polies at a later date, Pausanias expressed that a settlement could not be considered as a city if it did not have a water transportation system with pipes to the administrative buildings, theatres, market place and gymnasion. Also keeping in mind that Strabon did express that the Romans were better at covering the streets, facilitating the use of water resources and sewers, while the Greeks focused on beauty and defense, ports and fertile soil, but building cities with essential infrastructures such as water and sewage systems evidently was not enough (Mumford, 2013).

Always the most important issue was hygiene. Sanitary measures have been taken, which were always crutial to prevent diseases in the cities with crowded populations, since the ancient Roman period. These measures included the use of clean water resources and transporting them to the city, removal of polluted water, sewage and garbage collection (Juuti and Katko, 2007) (Figure 1).

However, the Roman sewage system was not applied everywhere. This system did not exist in most of the Roman cities. As Lanciani (1898) quotes: "*...before the construction of the Cloaca Maxima, every valley between the seven hills was nothing but a boggy quagmire. These hot-beds of malaria were fed by numberless springs, running sometimes above, sometimes under ground, impregnating the whole region with dampness, which is one, and perhaps the most active, of the three coefficients of the plague*".

Although there was the Cloaca Maxima, the oldest Roman engineering monument in Rome, the drainage systems was not going up the first floor and worse yet, not connected to crowded rental homes at all. The mechanical installation to meet that need was minimal where the need was the greatest.

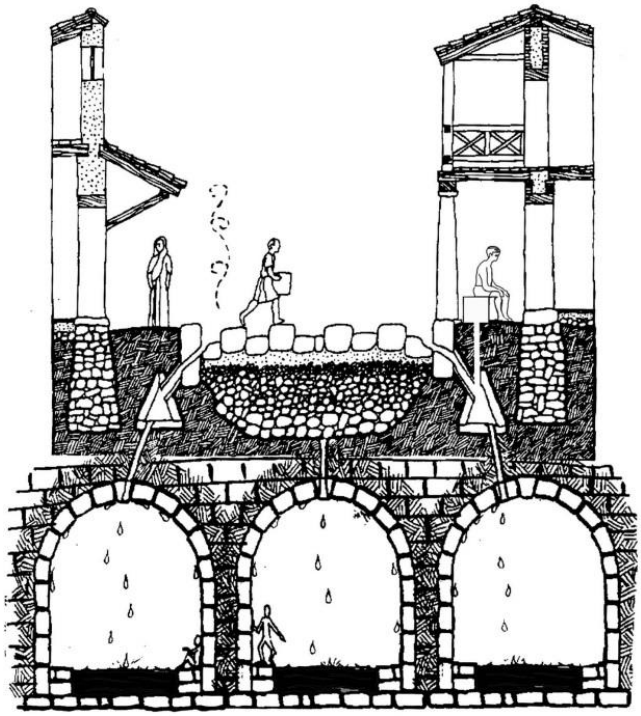

Figure 1. Roman Sewage System (Source Link)

The vast majority of the population was using the public toilet facilities during the day. The toilet waste in the houses was accumulated in cisterns under the basements. The urine collected in special jars was used in fabric making, while the feces transported by horse carriages was served as agricultural fertilizers. But the feces especially from the periferical areas must have been too much for the nearby lands to carry, as records indicate in residential areas that there were open-top sewage pits since they could not be removed (Mumford, 2013).

The examples given illustrate the lack of basic measures to be taken against diseases by removing large quantities of waste and trash accumulated in a large city. Recurrent outbreaks of infectious illnesses caused thousands of deaths in a single day resulting as the infected bodies being dumped causally in large pits called "*carnarium*". Additionally, there was no hospital in Rome until the 3rd century AD to help people with illnesses and medicine was not practiced as science (Lanciani, 1898). Wealthy aristocratic people were running away from the city. They also owed their survival to it.

The Roman population between the brightest periods of the empire and the dark ages was declined at least ten times due to the wars with the contribution of illnesses.

The spreading diseases played a major role in the weakening of the empire and there was a period of continuous wars and deaths until the end of medieval times, epidemics being effective in this process.

In the 14th century, the bubonic plague, causing a two third of the population in Europe to die, for the first time forced the first attempts for health measures to be taken and carantine laws were passed. By the 16th century, sanitary measures and tendencies for better solutions were becoming widespread (Mumford, 2007). However, since they did not know anything about microbes, viruses and bacteria, there was no explanation for the spread of infectious illnesses other than vague theories about miasmas and air pollution (Sigerist, 1945). Miasma theory was depended on the polluted or foul air which was believed to be what was spreading illnesses since the antiquity (Yıldırım, 2010).

Many medieval cities were attempting to cure diseases. In 1388, a law was passed in the English parliament that prohibited throwing trash into pits, rivers and waters. In the 15th century, Leon Battista Alberti was discussing a system that divided the canals into those carrying dirt to the river, the lake and the sea, and those carrying the deep pits descending under the ground. Leonardo da Vinci was suggesting an effectively working canal draining off sewage pipes (Ingersoll, 1996). In the 16th century, the first public sewage system was installed in Silesia, Bunzlau (Mumford, 2007). Although plans were made and measurements were taken, they were all related only with the sanitary systems. Effective solutions that would take care of the problem from the root were not considered until the 19th century. In the urban texture, which has existed for many generations from the Middle Ages to the Renaissance, formal changes were seen as if they were back to the concept of "rebirth" rather than deep-rooted innovations, which would also address hygiene and sanitary problems. Theories and practices remained formal, given the infrastructural problems of urban life. Speaking of order and ratio, Alberti stated that the streets would look more noble if the doors were made in the same model, the houses next to each other follow the same line and were built with the same height. Uniform elements such as lineer streets, round arches, repitative windows and columns, bands running across the facades, roof cornices that continue without interruption were appeared as symbols of the new approach. Until the 18th century the Renaissance and immediately afterwards, openness, clarity, proportion and order, which would express new understandings and approaches, replaced the irregularity that was accepted in the course of life in the past. Again, the symbols of this period, stone and brick road pavements, sculptured square fountains that use water abundantly, did not provide solutions to the city's infrastructural shortcomings and dense residential areas that create an environment for disease spread (Mumford, 2007).

The effects of infectious illnesses on the cities in the 19th century

At the end of the 18th century the industrial revolution took place with the lead of England in Europe and in the 19th century resulted in great changes in cities. There was extensive population growth in the 19th century as the world population quadrupled resulting in more than half of the population of the World starting to live in urban areas by the end of the century. The rapid growing rates of population and migration from rural areas to industrial cities was not responded immediately as to prepare the cities to meet with the requirements of an urban development which would accomodate people in a healthy and safe manner. Apart from the wealthy, residential areas for the poor and the laborers were dense, damp and dirty with little amenities and almost no facilities for provision of clean drinking water and adequate sewage disposal. The streets remaining from the previous centuries were crooked and narrow (Figure 2).

The uncovered sewer systems were run down the streets of many cities in Europe until the last quarter of the 19th century (Figure 3).

There were a number of mechanisms in the 18th and the 19th century which was used to maintain healthy environments in the cities. These were either related with eliminating the threats coming from outside the cities like quarantine stations or certain urban services such as sanitary measures and infrastructural systems. The earliest quarantine stations in Europe were built in the 15th century and usually located on the islands or peninsulas just at the entrance of the cities where people and goods were held for a certain period of time before making sure that there was no illness of any kind existed (Collins, 2020). Quarantine stations were continued to be used as the major procaution against infectious illnesses until the 20th century.

As the inevitable consequence of the industrial revolution, the existing cities were overpopulating, while the unplanned cities were growing rapidly. Since the state was pursuing a "not interfering with the economy" policy, there was no attention paid to the most basic housing and working standards.

Figure 2. Lower Fore Street in Lambeth, London, 1865 (Source Link).

Figure 3. An example of an uncovered sewer system in Paris, 1865 (Source Link).

With the rapidly increasing populations, the existing plans of the cities became out of date. The air circulation through the narrow streets was insufficient. Houses built in adjoining order received little sunlight. It was not uncommon for more than one family to live together among the working class, sanitary facilities were inadequate, and it was difficult to find running water. Since the garbage collection system was not developed, garbage was accumulated on the streets, forming rotten, stinking debris. There were no strict construction standards for the dwellings, as they were built quickly and carelessly using cheap materials. They did not have the standarts of healthy housing where people could live in a warm environment comfortably. The roofs and windows were leaking and damp.

Statutory recognisiton came when the consequences of the desease ridden industrial cities were reached to the degree that could not be ignored anymore. In the middle of the 19th century, London suffered from recurrent cholera outbreaks. In 1853 – 1854, more than 10,000 Londoners died due to the illness. The first new planning efforts was already started with the Public Health Act in 1848. It was not concerned directly with the threathening conditions of the existing cities but rather with the new developments, however, it did lead to a number of acts to improve sanitation and new sewage systems to be progressed (Cherry, 1979). At the time, it was believed that miasma, the foul air was responsible for the spread of illnesses. It was emmited by the rotten disposals, vegetation, dirt in interiors or outside, causing pestilences. The dead bodies which were not buried deep enough under the ground were also a source which was not uncommon considering the circumstances. The germ theory of desease replaced the theory of miasma at the end of the 19th century after the succesive outbreaks of deadly epidemics and that medical scientists proved that the micro-organisms spread the illnesses but not the miasma (Kannadan, 2018).

In 1856, London's metropolitan working board was established. The board was the first organization to unite supervised public work all over the city and Joseph Bazalgette was appointed as the first chief engineer. The whole sewers in London were drained to the River Themes which was also the main clean water source of the city. However, the amount of waste and dirt accumulated in the river was continuously fermenting to contaminate the whole city. In the hot summer of 1858, there was an overwhelming bad smell began to radiate from the surface of the river which was called in the history as 'The Great Stink of London'. Thus, it accelerated the introduction of new laws on sewage and street improvements (OAC).

Bazalgette designed plans for the drainage of London and in 1858 it was began to be implemented (Figure 4). It involved an extensive underground system of sewers collecting together the existent drain pipes of municipality running under the streets of the city. Although it was opened in 1865, the whole work was completed in 1875. The other significant urban change in the city was the London Embankment which was started as part of the rehabilitation process of the sewege system since it was not quite possible without building the stone embankment in1862. London Embankment reclaimed about 22 acres of land from the Thames forming The Chelsea, Victoria and Albert embankments which are still the basis of the sewage system of London today (Collinson, 2019).

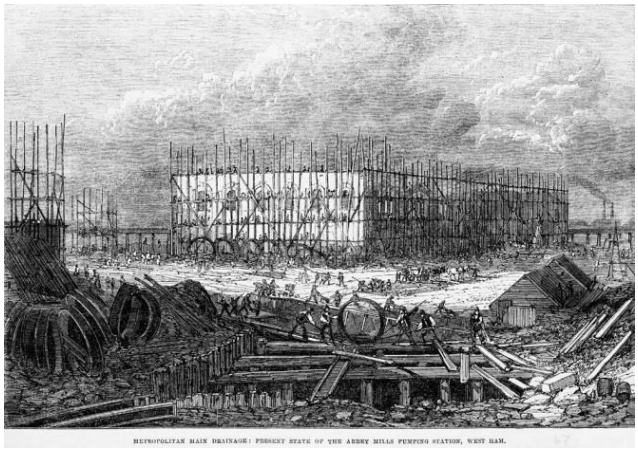

Figure 4. Abbey Mills pumping station, West Ham, 1867 (From the Illustrated London News. ID no. Z499/58)

As a result, British town planning was not developed under the full influence of health and sanitation perspectives, however it did contribute to solve a major problem with regards to the infrastructural requirements which were crutial to prevent epidemics in the cities.

All through the century, broad aims such as achieving lower density in cities with more fresh air, sun light and spatial designs accomplishing a higher standards of residential and working area developments were pursued also in Paris. Although there have been work of architects proposing plans for the shortcomings of Paris such as Latte and Sutcliffe, and the French Revolution in the 18th century transformed everything in the country, it had no effect in urban developments. There was a great population increasment due to the industrilisation, doubling up the number of people living in Paris at the begining of the 19th century with no expansion urbanwise. The city faced the same problems as London because of the lack of planning in the industrial areas developing rapidly at the time. It was already overcrowded, unhealthy and crime and illness ridden with inadequate urban services. It was common for few families to live together in small squaremeters. The streets were narrow, dark and dirty with poor water supply. There was no adequate system to collect waste or sewage (Hall, 1997).

Things started to change when Louis-Napoléon Bonaparte declared himself in 1851 as Emperor Napoleon III of the Second Empire and appointed Georges-Eugène Haussemann to operate one of the largest urban transformation implementations in the 19th century (Aran, 2015).

He was not an architect but the prefect with a vision, he focused on the city transportation axes such as streets, boulevards and public substructural works including sewer system, water and gas lines as the cholera epidemics were striking and there was high rates of unemployment which was causing discontent and revolts at the same time. It has been argued that while changing the city completely by constructing streets, avenues and boulevards 26,294 km long in total; creating thousands of hectares of parks – four at the cardinal points of the city; and building 24 new squares totaling 150,000 square meters, Haussemann's main object was not to clear the city from spread of infectious illnesses in order to provide a healthy urban environment for everybody living in Paris including socially and economically less fortunate (Kunstler, 2003 and Aran, 2015). It was said that as Napoleon conceived the renovations, the great wide and long boulevards were opened in order to prevent the revolters from barricating in the dark and narrow streets by using cobble stones available in every corner and to enable military troops to move around the city without difficulty (Kunstler, 2003). Others argued that Napoleon did have a sincere concern in eliminating poverty and improving living standards of the workers. Haussemann was also criticized for his urban development policy for not providing well designed alternative housing programmes while demolishing slums and relocating the working class from one place to the other (Hall, 1997). However, the transformation of the city with the developments pursued provided a healthier and hygenic urban environment which mitigated the epidemics. Asolphe Alphand was assigned by Haussemann with the task of setting up a landscape scheme as part of renovations of Paris in order to enhance the sanitation of the city (Blanc, 2019).

Waste water discharge was a difficult issue. This problem continued to be a problem in many places except for small cities with sufficient waste water drying pools where they can transfer their waste water. However, towards the end of the 19th century, a private and sanitary toilet for each family became standard. In cities consisting of intertwined buildings, this meant a toilet directly connected to the main sewer pipes. NewYork was the first city to have a large clean water supply. The city's water was supplied from the Croton water reserve and aqueduct system which was opened in 1842. Over time, other major cities followed this example. The practices of urban health reformers eliminated the city's worst physical and structural shortcomings that led to epidemics. The environment in industrialized cities was so far from being healthy that the innovations brought by the outbreaks of epidemic diseases made the biggest contributions to urban planning in the 19th century (Mumford, 2013).

The effects of infectious illnesses on the cities in the 20th century

In the early 20th century, the urban concepts were arised both from social ideals which were exemplified in the architectural utopias in the 19th century that involved proposals of human and nature bonding healthy environments, and urban hygiene (e.g. The Garden City Movement), with the help of the technological progress that was taking place (Blanc, 2019).

Towards the end of the second half of the 19th century, the focus on the provision of clean water and efficient sewer system shifted to the discussions on improving the inadequate physical conditions of working class urban dwellings which was causing increased rates of tuberculosis and respiratory diseases (Campbell, 2005). As in the 19th century rigorious spread of infectious illnesses, such as cholera, caused the renovation of the city layouts, radical improvements in sewer systems and expanding arteries like broad boulevards, in the 20th century, deseases such as tuberculosis, thphoid and the Spanish flu induced a new kind of urban planning that seperated residential and industrial areas, introduced new housing types and was composed of architectural designs with light and airy spaces by using more sterile materials like steel and glass. They all emphisized the hygiene in overall design. Scientists and architects found that improved environmental conditions in new housing developments with better hygiene was reducing the rate of tuberculosis which was on the way to become the widely spreading new illness of the era. Institutions such as asylums and sanatoria were started to be established (Campbell, 2005) which soon inspired the new design approaches of modernism (Figure 5).

Zoning of the areas and urban construction were regulated together according to the principles of urban hygiene. Designing urban spaces to allow sunlight and air penetration and individualizing the land in construction were becoming crucial principles of the architecture in the era. The modernist trend promoted by the CIAM which was founded by Le Corbusier in 1928 was seeking to design urban areas that were organized in order to contribute to the conditions of human existance by improving the built environment and living spaces. In order to realize that, the urban hygenie and comfort issues were approached by modern architecture principles (Blanc, 2019). Thus, at the begining of the 20th century, the way that the buildings were designed and built went through cathastrophic changes.

New architectural elements, such as flat roofs, balconies, whitewashed walls, sun parlours, roof gardens and terraces, were introduced as health improving features of Modernist architecture and they were inspired from the health oriented buildings such as the senatoria (Gross, 2020). Le Corbusier's one of the most famous Villa Savoye (1929–31) combined these elements which manifested his “Five Points of Architecture” that were pilotis, a free plan, a free facade, long horizontal sliding windows and a terrace (Le Corbusier, 1987). Moreover, the sink located right at the entrance hall of Villa Savoye was a very powerful indicator to reflect the essence of the time, athough it has been rarely mentioned with such a role in the architectural writings unless it is directly related to the health issues (Figure 6).

Figure 5. The Purkersdorf Sanatorium near Vienna; white, light, aired and hygienic (Source Link).

Figure 6. The Entrance Hall of Villa Savoye by Le Corbusier (Source Link).

In his writings in 1925, Le Corbusier was visualising a city where houses were all painted in white (the Law of Ripolin) in order to achieve an utter cleanness and hygiene (Le Corbusier, 1987). Intertwining with other principles of Modern Architecture, he designed many flat roofed and whitewashed buildings with great pastoral landscape views as another healing element which brings the outdoors to the interiors of the buildings as a Modernist idea.

As the germ theory was better understood, the isolation of people became a key measure in order to prevent illnesses to spread and live in sunlit spaces with plenty of fresh air. Thus, the overlap between sanatorium designs and modernism resulted in developing a new type of architecture which integrated the health, hygiene and sterility ideas to the designs. Modernist architects such as Le Corbusier, Mies van der Rohe and Alvar Aalto were writing, designing and building to create a healthier living environments as well as addressing social issues such as low-cost housing and improving the life styles of masses. Designing in accordance with the needs of people was interpreted by the Modernist architects as in body comfort without actually taking the social and cultural differencies into the account. As Le Corbusier defined it "… A house is a machine for living in. Bath, sun, hot water, cold water, warmth at will, conservation of food, hygiene, beauty in the sense of good proportion…" (Blanc, 2019).

As the density of the built environment continued to grow, multi-storey buildings were preferred to meet the housing needs of the increasing population, especially in the newly developing urban areas through the 20th century. In multi-storey residences built in recent years, balconies have been removed to gain space, even windows have been started to be built with window opening control devices for safety reasons.

Athough the summer house or garden house has been known since the 17th century for leisure purposes, in 1920s and 1930s they were very commonly used in treatment of tuberculosis as they provided constant flow of fresh air and sun light. In 1983, a letter to the Country House magazine was inquiring what the purpose of a summer house with shutters on both sides of the doors was. Although the purpose of a building with such architectural elements was common knowledge in 1920s, it was completely forgotten since the tuberculosis was eliminated in 1970s (Campbell, 2005).

As the progression made, cures were found for the treatment of the infectious illnesses in the second half of the 20th century. Thus, the contagiousness of the widespread illnesses such as tuberculosis were diminished eventually which resulted in people to forget why and how they began to live in such urban settlements with evolving architectural designs in accordance with the health and hygiene issues in the first place. Additionally, as the current idea of an healthy life has been understood not only as a life with absence of illnesses but as a state of physical, mental and social well-being in modern world, in the following decades it has been more and more expected of the architectural and urban designs to provide the built environment with the necessary indoor and outdoor qualities in order to live an healthy life, since the beginning of the Modern Architecture in the early years of the 20th century (Pinter-Wollman et al., 2018).

At the begining of the 21st century, new types of infectious illnesses emerged such as MERS-CoV and SARS (severe acute respiratory syndrome) having partially impact in a number of countries but not others. Recently the suddent emergence of COVID-19 spreading vigorously with a very high contegion in close contact brought back the concepts of healthy building environment such as isolation, hygiene and well ventilated spaces as key preventions. The ventilation system and plumbing of the buildings accelerates the dispersion of viral fine particals suspended in the air as was the case in 2003 outbreak of SARS in Honkong indicating the importance of the role of physical structures in containment measures for the spreading of infectious illnesses (McKinney et al., 2006). Also the selection of materials and coatings of surfaces enabling easy cleaning and sterilization in order to reduce the contamination of pathogens inside and outside of the buildings including walls, furnatures and frequently touched areas such as door handles, electric switches and push buttons have been proved to be effective (Pinter-Wollman et al., 2018).

As the architectural designs directly affect the inhabitants' interactions in buildings and cities, it becomes crucial to understand usage network of buildings in cities. A recent study consisting of analysis of architectural distances between workstations in relation with the transmission of infectious illnesses presents promising results which shows that "incorporating architectural and organizational data into large-scale epidemic forecasting models may improve the accuracy of epidemic predictions, thus improving our ability to contain and control epidemics" (Potter et al., 2015).

CONCLUSION

The sanitary innovations that are critical for an healthy living environment were started to be implemented in the

ancient Roman period. The importance of water and sewage systems was recognised and procautions such as garbage collection were began to be taken in Roman times. However the medical innovations did not reach until the end of the 19th century and the sanitary measurements alone could not be enough to reduce deaths, at least to the extent that they could be implemented by the city administrations as a prime solution. Also, even if there are spatial, financial and medical equipment opportunities, it is not possible to cure a disease unless there is the medicine. However, the spread of infectious illnesses can be controlled by architectural design desicisions which organize human interactions in built environment in the urban areas.

In the 19th century, the rapid spread of infectious illnesses causing thousands of people to die such as cholera and smallpox accelerated the finding of solutions to the urban problems that caused outbreaks, and helped architectural and urban design innovations such as wide boulevards, city-wide sewage systems, indoor sanitary installations and the establishment of new suburbs. However the 19th century was not the begining of the spreading illnesses. Until then, rather personal decisions were taken where and if possible, for personal isolation. In the 19th century, as the population of the urban areas were increased in numbers, the industrial developments were becoming a core issue which indeed was amongst the most significant changes in towns and cities in forcing the administors to face the problems and find solutions. On the other hand, the town planning efforts pursued were not developed under the full influence of health and sanitation perspectives, although it did contribute to solve the problems eventually with regard to the infrastructural requirements that were crutial to prevent epidemics in the cities.

The transformation, however, was not immediate but slow. It took decades before a groundbreaking transformation occurred in architecture and urban designs in order to contribute to the solutions for stopping the spread of infectious illnesses. In spite of all the infrastructural and urban planning alterations were made in cities such as London and Paris, to recognize that there was a need for a paradigm change architecturally and urbanwise which would arrange the human interactions in cities with respect to providing healthy living environments for every layer of society were yet to come. Between the beginning of the formation of a serious awareness for the acute need to take immediate actions architecturally in order to prevent and contain the spread of deseases and the actual architectural and urban design perspective were changed, the alterations made could be considered only as a beginning. Infectious illnesses were one of the prime reasons what forced a new kind of architecture in the early 20th century: The Modern Architecture. It initiated new concepts of healthy environment such as hygiene, sterility, airy and sunlit spaces to be included in designing cities and buildings, as well as using new building materials along with the new technical and technological developments. As the epidemiological knowledge transformed societies into more healthy conscious entities in the 20th century, more health and hygiene related quality of life expectancies were included in architectural designs.

As urban populations increase and building density keeps growing rapidly, infectious deseases will continue to demand solutions architecturally in different aspects such as designs, materials, construction methods and technology. Also, in order to achieve more systematized results in organizing interactions between people living in urbanized areas to reduce the spreading rates of infectious illnesses, there is a need for more investigations to be carried out to determine the relationship between the daily mobility patterns of people, the spatial use of buildings and the density of both the urban population and the built environment.

DECLARATIONS

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Conflict of interest

The author hereby confirms that there is no conflict of interest whatsoever with any third party.

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