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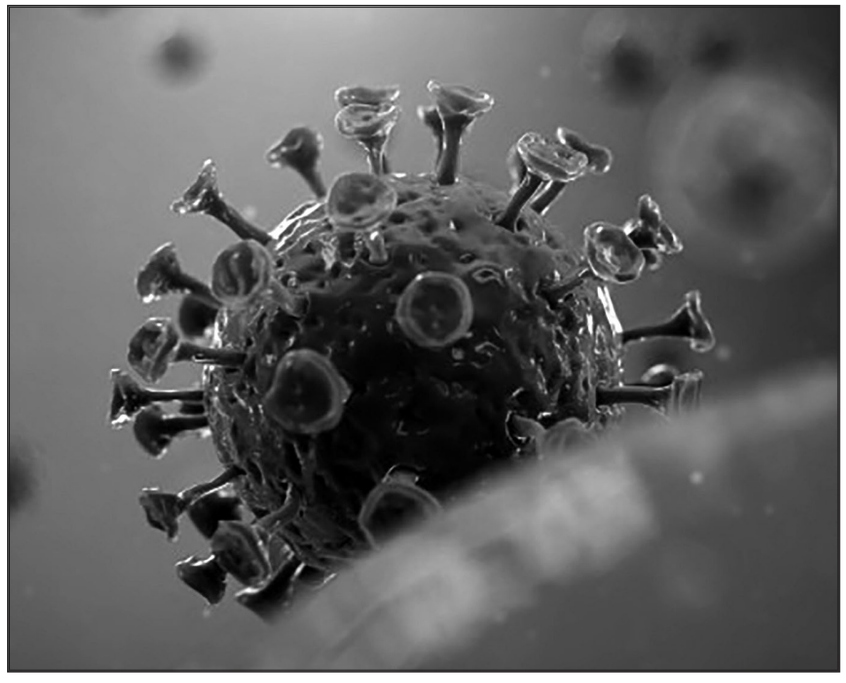
que la "todopoderosa ciencia" no logra someter por ahora. Se burla de los más preclaros investigadores, epidemiólogos, cientistas sociales, econometristas médicos. Veremos cuánto tiempo más va a correr sin ser atrapado.

Norma Isabel Sánchez
Directora del Instituto Historia de la Ciencia
SCA



THE CHOLERA MAP BY JOHN SNOW (LONDON, 1854): A HEALTH SOLUTION AS A CONCEPTUAL SUMMARY OF APPLIED GEOGRAPHY

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ABSTRACT

Although Geography was defined as a human science in the late nineteenth century with the book Antropogeogaphie. Grundzüge der Anwendung der Erdkunde auf die Geschichte (1882) by Friedrich Ratzel (1844-1904), the study that relates it to Medicine and population's health is systematized the previous century in the book Versuch iener allgemeinen medicinisch- praktischen Geographie (1792) by Leonhard Ludwing Finke (1747-1837). It is in this initial contribution that the term Medical Geography is proposed as a field that studies the spatial distribution and transmission of diseases. The map created by Doctor John Snow (1813-1858), in which he represented the deaths caused by the cholera epidemic in London in 1854 along with the spatial distribution of water pumps, is an important example in this line of studies. It was used illustratively in his book On the Mode of Communication of Cholera (1855) to support the hypothesis of contagion by water (bacteriological perspective) and, from a spatial perspective, it presents many important concepts as a conceptual summary of Applied Geography. This paper analyzes the map as a tool for decision-making focused on the conceptual aspects that prevail at present.

Keywords: Geography of Health, Medical Geography, Spatial Analysis, John Snow's Map, Cholera Maps

RESUMEN

EL MAPA DEL CÓLERA DE JOHN SNOW (LONDRES, 1854), UNA RESOLUCIÓN EN SALUD COMO SÍNTESIS CONCEPTUAL DE LA GEOGRAFÍA APLICADA

A pesar de que la Geografía se define como ciencia humana a finales de siglo XIX con el libro Antropogeogaphie. Grundzüge der Anwendung der Erdkunde auf die Geschichte (1882) de Friedrich Ratzel (1844-1904), el estudio que la relaciona con la medicina y la salud de la población se sistematiza un siglo antes, en el libro Versuch iener allgemeinen medicinisch-praktischen Geographie (1792) de Leonhard Ludwing Finke (1747-1837). Es en este inicial aporte en el cual se propone el término Geografía Médica como campo que analiza la distribución espacial y difusión de las enfermedades. El mapa realizado por el médico John Snow (1813-1858) en el cual representó las muertes producidas por la epidemia de cólera en Londres en 1854 junto a la distribución espacial de las bombas de agua constituye un importante ejemplo en esta línea de estudios. Fue utilizado de manera ilustrativa en su libro On the Mode of Communication of Cholera (1855) para apoyar la hipótesis del contagio por el agua (perspectiva bacteriológica) y, desde un punto de vista espacial presenta de manera clara muchos conceptos de importancia como síntesis conceptual de la Geografía Aplicada. Este artículo analiza el mapa como herramienta para la toma de decisiones centrada en los aspectos conceptuales que se mantienen vigentes hasta la actualidad.

Palabras claves: Geografía de la Salud, Geografía Médica, Análisis Espacial, mapa de John Snow, mapas del cólera

INTRODUCTION

The map that presents the spatial distribution of deaths caused by the cholera epidemic in London in 1854 by Doctor John Snow (1813-1858) arouses great interest in the history of science as it is considered a central document for the birth of modern epidemiology[1] [2] [3] [4], an original cartographic piece[5] [6] [7] and a milestone for social sciences[8] [9] [10].

The cartographic document served its author as support in checking the hypothesis that cholera was transmitted through water, since from a spatial perspective it showed a large concentration of deaths near the Broad Street pump.

Geography, as a science, made contributions to the spatial study of diseases and it related to Medicine in interdisciplinary studies long before it was defined as human science in the late nineteenth century. Thus, it can be demonstrated that he showed great interest in the study of population health from a spatial perspective.

However, while the spatial representation of diseases on a map was initially made descriptively, the contribution made by John Snow is the result of a cartographic

modeling work as a rationalist procedure in the search for a solution. It constitutes an approach in applied science.

The aim of this article is to analyze the map by John Snow from both a Human Geography and an Applied Geography perspective for planning purposes since many conceptual elements that were essential a century later for the definition of these fields of study can be found in this document.

For this purpose, the field will first be delimited considering its evolution from the pioneer contribution of Finke[11] to the Geography of Health in its current thematic conformation, conceptually delineated as from 1976. Features of the cholera epidemic of 1854 will be presented based on the hypothesis provided by John Snow and his spatial perspective through the maps made at the time by various authors. The basis of Human Geography will be presented to show the way in which this cartography is linked to its foundations and finally the methodological procedures applied and the concepts of the spatial analysis that can be observed on the cholera map of John Snow.

From a geographical perspective, the map acquires a seldom explored dimension and broadens its recognition towards currently relevant spatial analysis issues, constituting a very important antecedent as a basis for current advances in Digital Cartography, development of spatial analysis methods[12] in connection with Geographical Information Systems[13] [14].

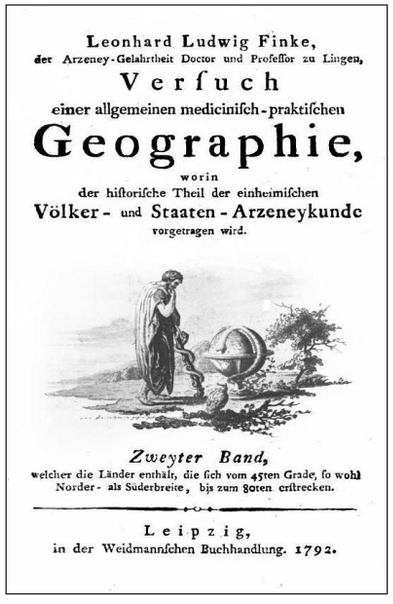
FROM MEDICAL GEOGRAPHY TO GEOGRAPHY OF HEALTH

The spread of diseases is one of the biggest problems in the history of humanity. The balance achieved by the partially closed systems in which some populations and their environment were was deeply affected ever since voyages of discovery and migration[15] and, consequently, millions of deaths occurred. The territories that were exposed to the population movement experienced great impacts.

It is estimated that from Christopher Columbus' first landing in the Americas in 1492 and up to the year 1620 approximately, 100 million indigenous people died from different epidemics. An Aztec codex represents the population affected by the smallpox epidemic of 1538 and, with it, a tragic dimension of the conquest. On the other side of the world, in Central Europe, the Holy Trinity Square in Budapest serves as an example of the epidemics' impact on the continent's urban populations until the eighteenth century as well as a commemoration of its end. The square gets its name from a baroque column built in 1713 in memory of the victims of the plague epidemics of 1691 and 1709.

Finke's book is considered the first work which refers to the new multidisciplinary field of study based on the relationship between Medicine and Geography under positivist philosophy and with a special focus on the descriptive study of diseases in each country. This is the context in which the term Medical Geography appears.

Figure 1. Finke´s book cover


Leonhard Ludwig Finke,
der Arzeney-Gelahrtheit Doctor und Profeſſor zu Lingen,
Verſuch
einer allgemeinen mediciniſch-praktiſchen
Geographie,
worin
der hiſtoriſche Theil der einheimiſchen
Völker- und Staaten-Arzeneykunde
vorgetragen wird.
Zweyter Band,
welcher die Länder enthält, die ſich vom 45ten Grade, ſo wohl
Norder- als Süderbreite, bis zum 80ten erſtrecken.
Leipzig,
in der Weidmannſchen Buchhandlung. 1792.

An important milestone in the study of diseases centered on the spatial dimension is the work of John Snow addressing the cholera epidemic which took place in 1854 near Golden Square, London. His study was based on the hypothesis that cholera was transmitted by water and, from there, he made a map that is regarded as the beginning of modern Epidemiology and would be taken as an initial example of spatial analysis[16]. Linking the location of cholera deaths (spatial distribution and number of cases) to that of water pumps showed an epicenter in the Broad Street pump. His observations based on distance would lead to consider the pump as a vector agent and render it useless by removing the handle, thus continuing the epidemic's decline until its disappearance. The map was used as a tool to show the spatial dimension of health problems.

The adverse effects of the Industrial Revolution (1760-1840) gave way to the prevalence of a hygienist approach to health with a special focus on workers' conditions, their homes and occupational diseases. The accelerated impact of urbanization, inadequate living conditions in the city and the strengthening of the labor movement arose interest in the study of poverty in cities. The social conditions related to health and mortality gave rise to what is called Social Epidemiology, of which Louis René Villermé (France), Edwin Chadwick and Friedrich Engels (England) and Rudolf Virchow (Germany) are considered founders.

From this perspective, the spatial distribution of all diseases was also linked to poverty, which generated a line of work that would produce its first results as of the publication of Charles Booth's (1840-1916) work, *Descriptive Maps of London Poverty*

(1903), in which the spatial distribution of social conditions of London's population is presented as an indicator of areas with different levels of general vulnerability. Any type of subsequent relational analysis was performed visually.

In the first half of the twentieth century, from a geographical perspective, the contributions which stand out are those made by Max Sorre (1880-1962) and Jean Brunhes (1869-1930), who engaged in Medical Geography to study what is called *pathogenic complexes*, which corresponds to the fabric of essential and lasting relationships between living beings, the population and the environment[17]. Regarding this subject, the zoologist and geographer Yevgeny Pavlowski (1884-1965) proposed the existence of a *natural nidality* of human diseases considering that the specific outbreaks are determined by the ecosystem's macro-scale.

The Congress of the International Geographical Union (IGU) held in Lisbon (1949) recognizes the specialty called Medical Geography, which was supported by the definition of health provided a few years earlier by the World Health Organization[18] as a state of complete physical, mental and social well-being, and not the mere absence of conditions or diseases.

The concept of pathogenic complex was broadened by Jaques May (1896-1975) [19] who incorporated socio-demographic and economic aspects. The objective was still to determine the areas of disease and to map their location. This way, Medical Geography consisted in the systemic study of the diseases of the earth and the diseases of the population.

The rise of Medical Geography occurred in the second half of the twentieth century with the increase in research and the theoretical-methodological support provided by the *quantitative revolution* that expanded its content[20]. During that period, in 1966, the first journal of the specialty was published, *Hungarica Medical Geographia*, (*Magyar Földrajzi Társaság. Sectio Medico-Geogrpahica*) by the Hungarian Geographical Society.

The methodologies are based on rational procedures in the search for regularities and the formulation of spatial models in which diseases can be studied from a spatial perspective.

In 1976, a new congress of the IGU held in Moscow (former Union of Soviet Socialist Republics, USSR) approved a change of denomination of the specialty and expanded its content. Medical Geography was replaced by *Geography of Health*, which included two well-defined lines of application: the Geography of diseases that included traditional Medical Geography and the Geography of health services as an orientation of Geography of Services[21].

It was in this way that its complete conceptual content was defined, which prevails until today, where its great disciplinary and interdisciplinary possibilities stand out[22] and its resolutions frame it in applied science.

CHOLERA EPIDEMIC IN LONDON (1848)

HYPOTHESIS

Cholera was a disease that caused early attention in terms of its distribution and spatial diffusion[23]. In the mid-eighteenth century, the explanation for cholera disease was in a medical context of confrontation between the "contagionists" and the "anti-contagionists". The former considered that the disease was transmitted by contact with the sick, either directly or indirectly through their belongings, finding the solution in isolation and burning of what had been in contact with those infected. The latter considered that the disease was caused by fetid emanations (miasmas) that were transported by air, and they ruled out the previous solutions.

John Snow had had his first contact with cholera victims in 1832, and for years he studied the disease in detail to get to develop his main hypothesis during the next epidemic produced in London in 1848-49, when he proved a first spatial differentiation of the distribution of cases in absolute values, as the area north of the Thames had much higher values than that of the south.

From a clinical perspective, cholera is a disease that is located in the intestines and, from there, body fluids are rapidly eliminated. Logical reasoning led him to think that the disease entered through the mouth and was eliminated with fecal matter. The analysis of the spatial distribution of the second epidemic cases suggested that people in London who lived from the Thames to the West did not receive water with the amount of sewage that those who lived to the East did, due to the direction of the flow towards the mouth of the river.

The hypothesis of water contagion was published in a book that analyzed this experience[24] without it being accepted, neither by the academic community nor by government managers.

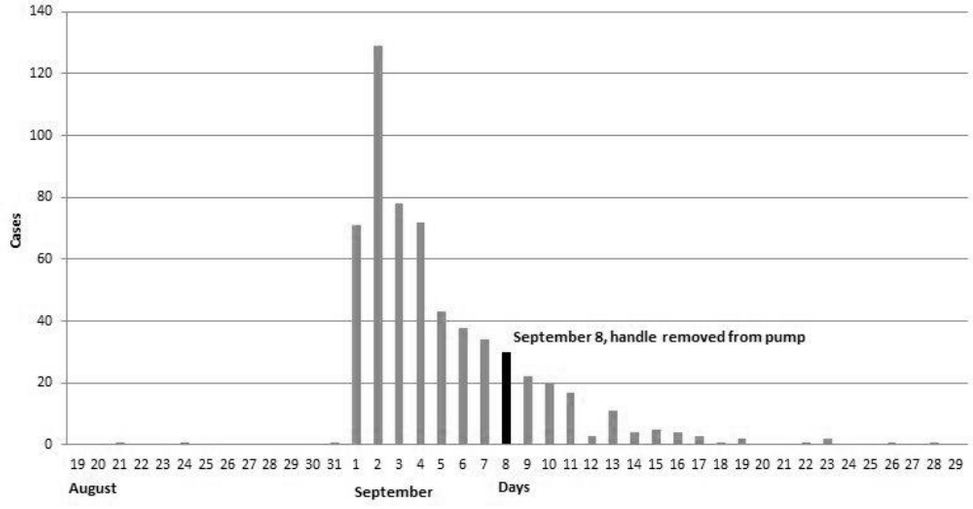
The next cholera epidemic (the third one witnessed by John Snow) occured in 1854 and, from it, he could collect data to try to test his hypothesis and be able to face it empirically.

In the early Second Industrial Revolution, London was the largest city in the world. It had approximately 2.5 million inhabitants, and its production was based on the use of energy such as gas, oil and electricity. The urban lifestyle had reached remarkable levels of unhealthiness. The countryside-city migration had given way to low wages, which would lead to one third of the population being poor and living in overcrowded conditions.

In this context, records show that Frances Lewis, a 5-month-old girl domiciled at 40 Broad Street, died on September 2nd. She was one of the first fatal victims of cholera. According to the information provided by her mother, the girl had contracted the disease on August 24th. That day, the dirty water from the washing of her clothes was poured into the cesspool in front of her house, it seeped into the cistern of the Broad Street pump through a crack and caused the cholera outbreak[25]. John Snow considered this to be the *index case*.

Figure 2 shows the evolution of deaths from cholera near the Broad Street pump during the days of the epidemic. September 8th is of particular importance, when the pump was rendered useless by removing its handle.

Figure 2. Cholera deaths during the epidemic (Soho, London, 1854)



Source: Author, based on Koch and Denike (1997)

Some studies show that this ended the epidemic drastically, but the evolution of data is not so clear, which is why having overcome the cholera epidemic of 1854 did not represent the definitive confirmation that the hypothesis proposed by John Snow was correct.

A few years later, Louis Pasteur (1822-1895) confirmed the germ theory of disease (1866), after which the bacteriological paradigm began to prevail. The cause for cholera was a microscopic living being (*Vibrio cholerae* bacteria) that settled in the intestine and created chemical processes of decomposition and fermentation, causing the death of the sick.

SPATIAL PERSPECTIVE

In 1854, during the cholera epidemic, three maps showing the spatial distribution of those killed by the disease were simultaneously created. Along with the aforementioned map created by John Snow (53.80 ha. and 596 deaths), there are also those made by engineer Edmund Cooper from the Metropolitan Commission of Sewers (49.45 ha. and 351 deaths) and by Reverend Henry Whitehead from the parish investigation committee (44.29 ha. and 684 deaths).

Bearing in mind that the first map of the spatial distribution of cholera was made in September 1854 by Edmund Cooper raised questions about whether the map made

by John Snow was essential for the formulation of the hypothesis, whether it was an illustrative tool or whether it was mainly a propaganda element[26].
Basically, the map made by Cooper (Figure 3) attempted to show that the sewers as a place of ventilation were not the reason behind the epidemic and Whitehead's map (Figure 4) was intended as a census.

Figure 3. Edward Cooper´s map

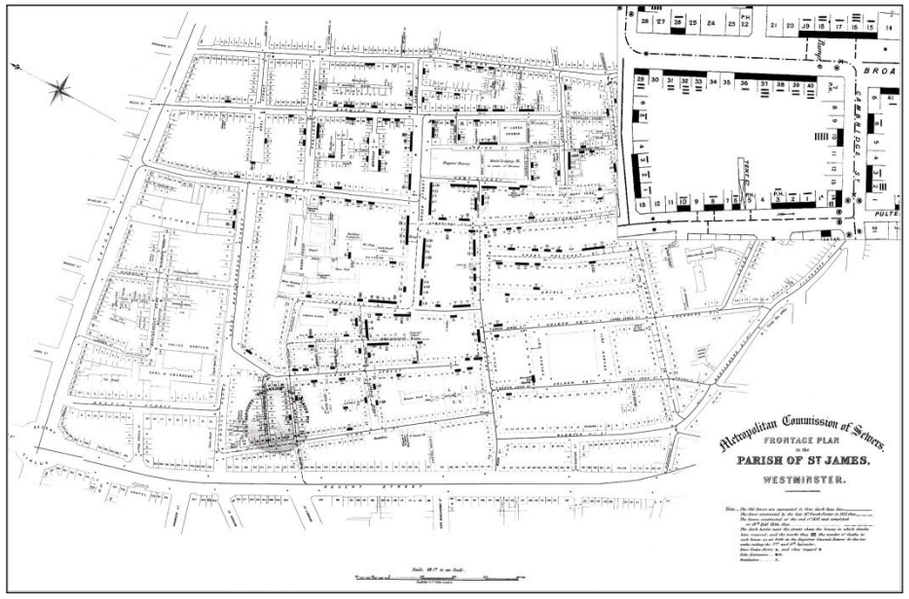
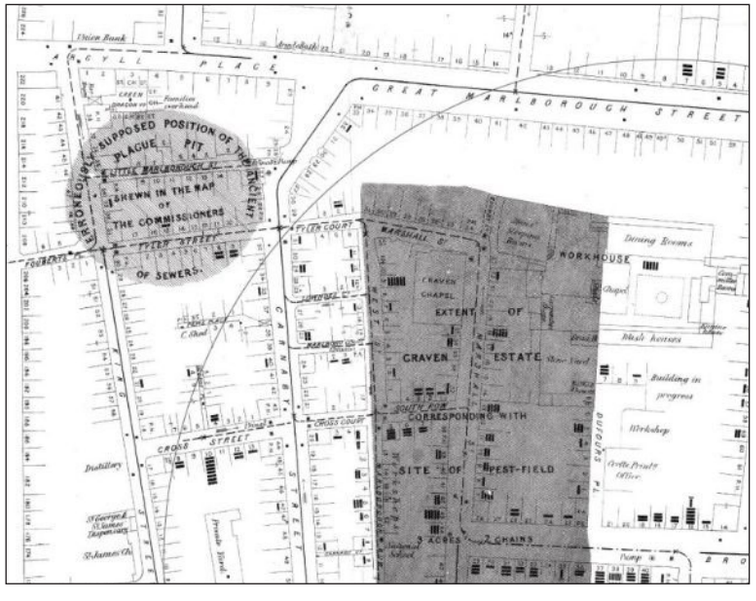
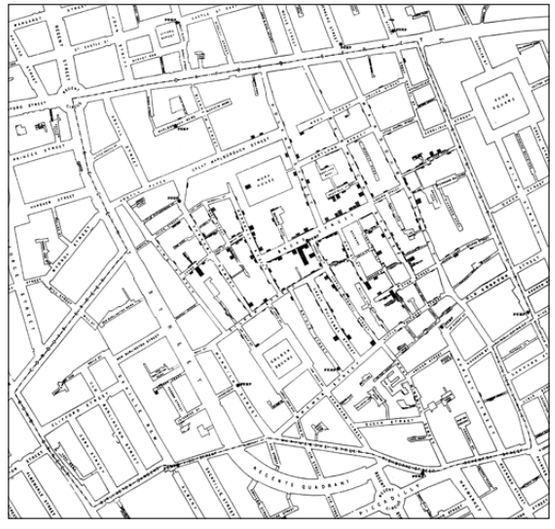


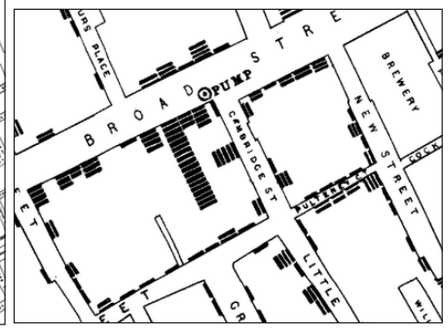
Figure 4. Henry Whitehead´s map



The map made by John Snow after recording the spatial distribution of cholera deaths in the Soho neighborhood is the most popular and famous document of his research. However, this cartographic representation was not revealed until December 4th, 1854, when he presented it to the Epidemiological Society of London as support for his hypothesis[27].
The investigation did not follow an inductive method in which deaths would be recorded and the mapping would be the basis of the formulation of the hypothesis. Rather, the hypothesis was formulated in a deductive manner, and the map represented an important tool to support its confirmation from a visual perspective. The cartographic confirmation was not used in the first edition of his book[28], though it was included in the second[29].

Figure 5. John Snow´s map





Broad Street Detail

Whitehead's map showed the distribution of cholera deaths and Cooper's map linked them to the distance from the sewers. However, none of them could explain the concentration observed around the Broad Street pump (Figure 5). Only John Snow could have an explanation for this situation, which came from a previous hypothesis, and the spatial dimension operationalized from the map illustrated it clearly. This combination of factors makes Snow's map the one with the greatest general recognition, as it could serve as support to a bacteriological hypothesis that was proved to be correct.

Figure 6. Replica of Broad Street water pump (London)
Monument in memory of John Snow and the cholera deaths in 1854
(Fotography taken by G Buzai in Broad (now Broadwick) Street)

CHOLERA MAPS IN THE PARADIGMATIC BASIS OF HUMAN GEOGRAPHY

GEOGRAPHY AS HUMAN SCIENCE

In the late nineteenth century, the first book that systematizes Geography as a human science was published. Written by Friedrich Ratzel (1844-1904), the book was based on the guidelines developed by Karl Ritter (1799-1859) and Ferdinand von Richthofen (1833-1905) as it included human activities on the planet. Without underestimating the traditional physical-natural components, it included the population and its activities, defining the human science that evolved to this day.

Throughout the twentieth century, three operational definitions of the discipline that correspond to the sequence of different paradigms of Human Geography were developed. They corresponded to the study of (1) the relationship between society and nature, (2) areal differentiation, and (3) the laws of spatial distributions. The first one arose from Regional Geography (prevalence: 1900-1930), which focused on the study of the region as a unique objective reality. The second one arose from Rationalist Geography (prevalence: 1930-1950) for the study of areas which are built upon cartographic overlay as a central rational procedure of Geography. The third

one arose from Quantitative Geography (prevalence: 1950-1970) through the study of spatial units that present regularities for model formulation.

The prevalence of a paradigm did not cause the disappearance of the previous one. Currently, all contribute to the evolution of geographical thinking and, this way, the spatial distribution of diseases[30] is studied through human and physical-natural variables, their spatial differences and the formulation of models.

For just over a century, the three aforementioned definitions have been identifying the field of study, which is focused on the spatial dimension and on the applications made within the framework of Applied Geography from a socio-spatial perspective.

CONCEPTS OF SPATIAL ANALYSIS ON THE CHOLERA MAP BY JOHN SNOW

The search for the geographical principles that provide the basis of spatial analysis was an important theoretical task of Geography. The initial considerations of Emmanuel de Martonne (1873-1955) were adjusted by different authors[31] [32] [33] [34]. The central concepts of current spatial analysis are location, spatial distribution, spatial association, spatial interaction and spatial evolution, which, together, reach the principle of *territorial globality*[35].

The map made by John Snow is a clear example that includes all the previously mentioned concepts.

Location: It considers that all entities have a specific location in geographical space. It can be seen in two complementary ways: if *absolute space* is considered, it is a specific and fixed site of placement; and if *relative space* is considered, it is a specific and changing position in relation to other sites with which links appear from the distance.

In his map, Snow takes into account the location (site) at the spot of each water pump, and the location (position) at each cholera death bar. While in the first one each spot is located at the real coordinate; in the second one, each bar shows a relative intensity as a cartodiagram.

Spatial distribution: It considers that the set of entities of the same type are distributed in a certain way over the geographical space. This concept can be seen in a single cartographic representation and always taking into account a single theme, although several appear on the map.

Snow's map shows the spatial distribution of cholera deaths through bars indicating intensity. It also shows the way in which water pumps are distributed. In the first case, it shows the specific spatial concentration. In the second, it displays an equitable distribution as an element of service to the population.

Spatial association: It considers the study of similarities found when comparing different spatial distributions. The clearest and most direct way is the visual analysis that can be performed after cartographically overlaying them.

Snow's map presents this concept as central to his work and uses it to support his hypothesis by providing the spatial dimension when comparing the spatial

distribution of deaths by cholera and that of water pumps, thus discovering the large spatial concentration around The Broad Street pump.

Spatial interaction: It considers the structuring of a relational space in which locations (sites), distances (ideal or real) and their horizontal links (movement flows) turn out to be essential to the definition of functional spaces.

Snow's map does not indicate it directly but it is implied, since the relationship between cholera deaths and water pumps shows a distance from which the water was delivered to the users' house in a differential distance. Hence, a decrease in cases is clearly seen as the distance increases (*distance decay*) from the Broad Street pump.

Spatial Evolution: It considers the addition of the temporal dimension through the transition from one state to another or through the sum of elements by historical accumulation. Geographical studies mainly approach the present. However, the time is often taken into account to achieve a cumulative analysis.

The map by Snow shows bars corresponding to cholera deaths in the 42-day period of the epidemic. The addition of the temporal dimension made it possible to create the representation in the form of a cartodiagram based on the accumulated data bars.

CONCLUSIONS

The map made by John Snow clearly shows the importance of the spatial dimension as an approach to the study of the cholera epidemic of 1854 in London and, at the same time, it showed that cartography is an important complement to medical research[36] by visually supporting his central hypothesis about the way the disease is transmitted and disseminated.

The analysis of the map from the perspective of Applied Geography allows us to observe the way in which he combines a series of key elements based on central concepts of the spatial analysis based on the rationalist and quantitative paradigms of the twentieth century that converge on current Applied Geography.

Considering the fundamental works of Finke[37] and Ratzel[38] it can be observed that approximately a century went by between the emergence of Medical Geography and Geography as human science. The map made by John Snow emerged in this context; and through his technical capabilities, he summarized the spatial theoretical-methodological developments of that moment.

The purpose was not geographical but medical. His intention was to support the solution to a public health problem. However, representing spatial aspects led him to develop a magnificent summary that is greatly appreciated today as an example of an effective resolution in the field of spatial analysis.

The application made by John Snow is not only presented as an example of scientific work in the field of Epidemiology and Medicine, but his cartographic support also places him in an important position within Applied Geography by clearly showing how a resolution in cartographic modeling can support the search for solutions to improve the quality of life of the population. The resolution method is based on

rationalism and, more than a century later, it remains a clear example of the way in which people think and act spatially.

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