A critical perspective on pandemics and epidemics: building a bridge between public health and science education

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Abstract

This academic position paper focuses on building a bridge between public health and science education in order to recognize the relationships between science and society—politics, economics, and ideology—in a pandemic context. To do this, we first present the contemporary dispute between the ways of understanding and explaining public health problems in light of a historical-territorial critical perspective; then, we show the configuration process of the formal and hegemonic concept of pandemic that has taken place over the period of the pandemics of the 1918 flu and the 2019 coronavirus disease; later, we give way to a historical-territorial understanding of the genesis of the 2002 and 2012 epidemics in relation to the coronavirus in the twenty-first century; and lastly, we indicate the key points from the historical-territorial critical perspective of public health that science education can use in order to contribute to a critical and reflective understanding of epidemics and pandemics. In this framework, "configuration process" is a category we propose and use in order to explain that specific events such as epidemics and pandemics are interwoven in a social, historical-territorial, trajectory of world power relations.

Keywords Pandemic · COVID-19 · Science education · Public health · Configuration process

Resumen

Este documento de posición académica, titulado «Una perspectiva crítica de las pandemias y las epidemias: construyendo un puente entre la salud pública y la educación científica», se enfoca en la construcción de un puente entre la salud pública y la educación científica que tiene por objeto reconocer las relaciones que existen entre la ciencia y la sociedad—esto es, entre la ciencia y la política, la ciencia y la economía, y la ciencia y la ideología—en un contexto de pandemia. Para ello, después de ofrecer una necesaria introducción, se presenta en la primera parte, y a la luz de una perspectiva crítica histórico-territorial, la disputa contem-

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poránea entre las formas de entender y explicar los problemas de salud pública. Esta disputa se presenta en dos subtítulos, uno denominado «De la teoría del germen a la biomedicina», y otro denominado «De la perspectiva sociohistórica a la perspectiva histórico-territorial». En la segunda parte se expone el proceso de configuración del concepto de «pandemia» que, formal y hegemónico, ha tenido lugar entre la pandemia de gripe de 1918, declarada por el Ministerio de Salud de Inglaterra y Gales en 1920, y la pandemia de la enfermedad por coronavirus de 2019, declarada por la Organización Mundial de la Salud en 2020 el mismo año. En la tercera parte, la denominada «Crónica de una pandemia anunciada en tiempos del capitalismo neoliberal», se presenta una comprensión, de perspectiva histórico-territorial, sobre la génesis de las epidemias que estuvieron relacionadas con coronavirus en los años 2002 y 2012. Con el ánimo de mostrar la similitud encontrada entre las génesis de las epidemias de 2002 y 2012, el apartado dedicado a la epidemia de 2002 se subtitula «Un mercado de animales salvajes en la génesis de la epidemia del Síndrome Respiratorio Agudo Severo (SARS)», y el dedicado a la epidemia de 2012, «Un mercado de animales domesticados en la génesis de la epidemia del Síndrome Respiratorio de Oriente Medio (MERS)». Finalmente, en la última parte, se señalan asuntos clave de la perspectiva crítica histórico-territorial de la salud pública que la educación científica puede utilizar para contribuir a una comprensión crítica y reflexiva de las epidemias y pandemias. En este marco, «proceso de configuración» es una categoría que se propone y utiliza para explicar que acontecimientos concretos, como las epidemias y las pandemias, están entretejidos en una trayectoria social de relaciones mundiales de poder, que es histórico-territorial.

Palabras clave Pandemia · COVID-19 · educación científica · salud pública · proceso de configuración

We have written this article from Latin America. Here, as in other parts of the world, the 2019 coronavirus disease pandemic has revealed the advanced state of fragility which our species and, differentially, our society have been in after the passage of fifty years of neoliberal capitalism. In the shadow of the invisible hand of Adam Smith and the spontaneous order of Pierre-Joseph Proudhon and Friedrich Hayek (Rothbard, 1990), the processes of the commodification, the flexibilization, and the industrialization of health, work, and food have led to impoverishment, abuse, disease, and the death of billions of human beings and billions of other animals (Harvey, 2007); and in the midst of these individual profitability relations at the expense of collective life, a coronavirus has resulted to be highly pathogenic in humans, and a pandemic has been configured.

These capitalist relationships, so typical of our time, have appeared in the speeches and actions of the States and their institutions regarding the pandemic but only in a veiled way, however. According to a biomedical conception—fundamentally germist the coronavirus and the disease would constitute one and the same entity, and humans would be waging a kind of war against germs. In this framework, the pandemic has been presented as the result of a coronavirus pathogen in itself, actions have been centered on the conception and implementation of microbiological barriers that prevent the convergence between the coronavirus and humans, and the idea of a saving vaccine has appeared and reappeared.

The configuration process of the pandemic, far more than a virus moving around the world, shows the trajectory of world power relations in which the pandemic is interwoven. The category, which we proposed inspired by Norbert Elias's "human figurations" (Elias, 1994; Henao-Kaffure & Hernández-Álvarez, 2020; Hernández-Álvarez et al., 2021),

exceeds the germist biomedical ideas that a nanoscopic corporeal entity has been the cause of the disease and its becoming a pandemic. In this kind of war that humans would be waging against the coronavirus, the humans would only be able to act on the possibilities found in the ambit of the individual; and reluctant to the understandings and procedural explanations, States and their institutions have continued to rely on germist biomedical ideas to act solely on what is considered to be the cause. In this framework, a vaccine has been presented as the only true weapon capable of ending the only true cause of the pandemic, and of finally returning us to the desired normality, which, moreover, now feigns to ever having been pleasant, fair, free, supportive, and collective.

The configuration of a pandemic has put public health thinking on the ropes, and in the *longue durée*, other epidemics have also. Since the 1980s, several epidemics and pandemics have been configured with increasing frequency which has put a strain on public health explanations. The study of these epidemics from a historical-territorial critical perspective of public health has revealed, as we mentioned earlier, that the history of neoliberal capitalism, and not simply the biology of certain microbiological entities, underlies the configuration process of the contemporary epidemics and pandemics, and it will be necessary to think of something more than microbiological barriers to prevent the configuration of these processes from continuing.

Science education faces challenges related to the construction of a broad and critical perspective of the social context—political, economic, and ideological—in which the pandemics and epidemics of recent times have been configured. Since the historical-territorial critical perspective of public health has advanced precisely in this sense, we have written this academic position paper with the aim of building a bridge between both terrains of thought and action, and to encourage the debate for the recognition of the relationships between science and society: politics, economics, and ideology.

This paper is organized into four parts. Initially, we present the contemporary dispute between ways of understanding and explaining public health problems, and ways of acting accordingly, and the emergence of the historical-territorial critical perspective in that framework. Next, within the framework of the dispute, we present the configuration process of the formal and hegemonic concept of pandemic which has taken place over the period of the pandemics of the 1918 flu and the 2019 coronavirus disease. The theoretical and conceptual disputes are located in the third part where we present a historical-territorial understanding of the genesis of the 2002 and 2012 epidemics which were also related to coronavirus, and thereby show that this is not the first time that a coronavirus has been pathogenic in humans nor is it the first time that an epidemic has been configured around it in the twenty-first century. Finally, after having presented the key issues from the historical-territorial critical perspective of public health that could contribute to science education in its understanding of epidemics and pandemics, we build the envisioned bridge between the terrains of thought and action, and we encourage the debate for the recognition of its social character.

Disputed contemporary perspectives on public health

The 2019 coronavirus disease pandemic, declared and named COVID-19 by the World Health Organization (WHO) (OMS, [2020c](#)), has been shown to be related to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), thus named by the International Committee on Taxonomy of Viruses (ICTV) (Gorbalenya et al., [2020](#)). The name given to

the disease by the WHO implies the name of the virus related to it since hegemonic thinking in health considers that the relation between pathogenic microorganisms and epidemic diseases is causal and that, ultimately, the microorganism and the disease constitute one and the same entity.

This reduction of the disease to one of its biological aspects has resulted in the reduction of its treatment to warlike actions against microorganisms. In view of the fact that the disease is assumed to be a corporeal entity, although on a nanoscopic scale as in the 2019 coronavirus disease pandemic, germist thinking suggests that the disease is external and human beings can put themselves in a position of attack in order to annihilate it. To keep in line with war metaphors, the pathogenic microorganisms that cause the disease, and are in fact the disease, constitute the enemy to be defeated in the war against disease.

In contrast to this hegemonic thinking of health, critical thinking recognizes the social domains, the spatial scales, and the durations of historical time, and proposes that the microorganisms that are related to the disease, and are by definition its *sine qua non*, are pathogens only in the perspective of humans and do not explain the pandemic configuration process on their own. More than an attack and colonization of the cells of many people at the same time by some type of pathogenic microorganism, epidemic diseases are configured as historical-territorial processes that materialize in our human corporeity, as subjects and as a society, amidst the pain, illness, and the deaths of many, generally in a differential way between social classes, genders, and ethnic groups. Looking at the pandemic with this clarity would allow us to undertake efforts with a more transformative sense and direction.

The ways of understanding and explaining the disease and of acting accordingly are aligned with these two distinct theoretical corpora of understanding and explaining public health: the hegemonic way, which emerges from fundamentally germist biomedicine, and the counter-hegemonic way, which emerges from a historical-territorial perspective.

In the *longue durée*, five centuries before the common era, Western thought in health emerged from Hippocratic-Galenic medicine (the medicine of Hippocrates of Kos and Galen of Pergamum); between the fifteenth and nineteenth centuries, it moved through the miasmatic-telluric theories and the animate contagion theory (the theories of Thomas Sydenham and Girolamo Fracastoro, respectively); it passed through a sociohistorical perspective and through the germ theory from the second half of the nineteenth century (Laín-Entralgo, 1982; López Piñero, 2017); and in the twentieth and twenty-first centuries, it has become the historical-territorial and biomedical perspectives of the contemporary dispute. Let's look to the nineteenth century to find out the roots of the contemporary dispute.

From the germ theory to biomedicine

The roots of the germ theory are woven in the thinking of Louis Pasteur, Robert Koch, and Edwin Klebs. These thinkers provided scientific consistency to the idea of the animate contagion, which had practically died out in the mid-nineteenth century, and gave rise to the germist idea that microorganisms are not simply necessary to cause disease, but sufficient to cause it on their own. As an augury for the magic bullets project, Koch's argument, contrary to sociohistorical argumentation, was based on the assumption that considering the disease as an expression of social misery, particularly in the case of tuberculosis, made the fight against it, an indeterminate fight, while the identification of tangible parasites offered, in this sense, a more definite future (Koch, 1882, p. 444).

Between the second half of the twentieth century and the turn of the twenty-first century, the germ theory evolved into more of a biomedical perspective of public health to which thinkers such as Thomas Aidan Cockburn contributed with the “ecological triad” concept, H.L. Laframboise and Marc Lalonde with the “health field” concept, and Henrik L. Blum with the “force fields” concept (Gómez-Arias, 2018). In the times of Pasteur, Koch, and Klebs, the germ theory intended to account for infectious, acute, and bacterial diseases and causes, and in ours, it also intends to account for chronic and viral diseases and causes, which were not considered infectious before. From a biomedical perspective, germs continued to be the cause of diseases, but the transit between germs and disease, that is, between cause and effect, began to require a spatiotemporal confluence of many and varied factors. In this sense, it is said that the biomedical perspective of public health is accompanied by a multifactorial way of understanding and practicing epidemiology, instead of the unilinear way of the germ theory.

The idea of a sort of individual biological balance, which could be restored with biomedical technology, has resided in the aspirations of public health thought and action from a germist biomedical perspective since its origins. The magic bullets project of the last years of the nineteenth century and the first years of the twentieth century, and the medical-industrial complex into which it became after the neoliberal rise of the 1970s (Iriart & Merhy, 2017), are nothing more than the incarnation of such aspirations, and vaccines and antiviral drugs make up the germist biomedical ideal of magic bullets for epidemics and pandemics and the *leitmotiv* of one of the greatest powers of the neoliberal capitalist world (Law, 2006).

From the sociohistorical perspective to the historical-territorial perspective

The roots of the sociohistorical perspective are woven in the thinking of Friedrich Engels and Rudolf Virchow; two thinkers who, more miasmatic-telluric than contagionist, transcended the dispute of medical thought of their time and revealed the sociohistorical background that underlies the configuration of the disease. In his iconic report on the condition of the working class in England of 1845, Engels concluded that, in all aspects—way of life, clothing, and food—the conditions of the workers were miserable, and that in this, as with alcoholism and the inability of obtaining adequate medical attention, lay the cause of their diseases and premature deaths (Engels, 1974, pp. 99–128). And Virchow concluded in his study of the 1848 epidemics that “atmospheric conditions” produce epidemics “only due to the social situation generated by the abnormal conditions people have long lived in”; and in his study of unitary efforts in scientific medicine, that “disease is the expression of individual life under unfavorable conditions” and epidemics are consequently “indicative of mass disturbances of mass life” (Rosen, 1985, pp. 82–83).

Virchow’s quote, “Medicine is a social science and politics is nothing else but medicine on a large scale” emerged from his study of the typhus epidemic of 1847 and 1848, in Upper Silesia, for which he was commissioned by the Prussian government (Michel, 2003). A few months after presenting the report in which he attributed “the outbreak to a set of social and economic factors” and proposed “radical social reforms” instead of medical treatments, Virchow began to edit a weekly magazine with Rudolf Leubuscher which they titled *Die Medizinische Reform* (Medical Reform) (Rosen, 1985, pp. 78–79). The reformist spirit of Virchow would contrast, however, with the revolutionary spirit of Engels, of which we would continue to know in the course of the nineteenth century, and would lead Virchow to affirm that, amid the turbulence of this revolutionary 1848, medicine could not

remain unscathed and continue to postpone unpostponable radical reforms (Rosen, 1985, p. 79).

From this sociohistorical perspective of the second half of the nineteenth century, the health of the population is a problem of the whole society, and it is up to the State to protect it; health is related to social conditions and that relationship must be subjected to medical and social scientific research; and medical and social measures must be taken to promote health and combat disease (Rosen, 1985, pp. 81–84).

The British-oriented liberal era in which the elaborations of Engels and Virchow took place was followed by a period of wars, crises, and world revolutions during the first half of the twentieth century (Hobsbawm, 1996), and the very brief period of European-oriented social democratic welfare, in which this particular correlation of forces became, was followed, starting in the 1970s, by the liberal resurgence of US orientation that we know today (Harvey, 2007).

And in direct response to this new liberalism and to the public health problems that it brings with it, the sociohistorical perspective reemerged, contemporary, in the thought of Latin American social medicine and collective health, and already alien to any miasmatic-telluric idea. In this thinking, the health/disease processes are socially configured in three domains: a singular domain, which accounts for the subjects, their families, ways of life, and genotypic characteristics, a particular domain, which accounts for the modes of life of social classes, and a general domain, which accounts for the socio-natural issue of the mode of production (Breilh, 2010, 2015). More recently, in this twenty-first century, the social domains of Latin American social medicine and collective health have shown, just as we do in this article, that they are underlain by a history of simultaneous durations—short-term, medium-term, and long-term—and a territory of territorialities and territorializations of various scales—micro, meso, and macro—and this historical-territorial perspective embodies, precisely, this moment of the debate (Henao-Kaffure & Hernández-Álvarez, 2017, 2020; Henao-Kaffure et al., 2020; Hernández-Álvarez et al., 2021).

The hegemonic contemporary concept of pandemic

As has been expressed, since the end of the nineteenth century and until today, Western thought in health has been debated between the germ theory that became biomedicine, and the sociohistorical perspective that became the historical-territorial perspective. Without a doubt, fundamentally germist biomedicine has positioned itself as a guide for health thinking, and in its theoretical corpus, the contemporary concept of “pandemic” has been defined. The concept comes from a century-long configuration process that elapses between the 1918 flu and the 2019 coronavirus disease. These two occurrences, and also that of the 2009 flu, were officially declared pandemics, and in all three cases, the germ theory provided the basis for the declarations. The 1918 flu was declared “pandemic” by the Ministry of Health for England and Wales in 1920 (Ministry of Health for England and Wales, 1920), and the 2009 flu and 2019 coronavirus disease were declared “pandemic” by the WHO (OMS, 2009a, 2020a, b).

In the Ministry’s declaration of pandemic for the 1918 flu, the concept of “pandemic” appears to be tied to epidemiological features. Pandemics, according to the Ministry, appear in waves, appear suddenly and evolve rapidly, generate high mortality, show little relation to social conditions, and occur simultaneously with other diseases (1920, pp. XII–XVII). To give credence to the mention of the warlike metaphors of public health, let us state that, according to the Ministry, the “influenza pandemic” was the result of a war

between the influenza germ and humans, which had been fought for centuries and from which, ultimately, the germ would have been victorious (p. XVIII). In the metaphor, the influenza germ, a still unidentified microorganism, is claimed to be the cause of the pandemic; and an amalgam between the germ and the disease begins to meld, as if it were one and the same entity. In the same sense, influenza refers, simultaneously, to the causative microorganism and the infectious disease, both being specific. This is the germ theory of the early twentieth century, pure and simple.

Before declaring the 2009 flu “influenza pandemic,” the WHO had issued three preparedness and response plans for possible influenza pandemics, which included their concept of pandemic: one in 1999, one in 2005, and one in 2009—the same year the pandemic was declared (OMS, 1999, 2005, 2009b). In the first plan, the WHO defined a pandemic as a human infection with a new strain that is efficiently transmitted between people in one country and spreads to others, with disease patterns that indicate that morbidity and mortality can be severe. In the second plan, the WHO defined a pandemic as a human infection, confirmed in the laboratory, with a new virus subtype that is transmitted between animals and humans and from person to person. And in the last plan, a few days after the first cases of the flu that would later be declared “pandemic” appeared, the WHO defined a pandemic as a human infection with a new virus that is transmitted efficiently from person to person and affects the inhabitants of at least two of their six regions.

Between 1999 and 2009, the concept of “influenza pandemic” referred to a human infection with a germ, just as it did in the Ministry’s declaration, but in contrast to the 1920 germ, the 2009 germ was precisely identified and characterized as an influenza A (H1N1) virus. The 2005 definition eliminated the severity criterion that had been considered in the 1999 definition, an administrative criterion appeared in the 2009 definition for the first time, and in the three definitions, influenza refers, as it does in the Ministry’s declaration, to a causative microorganism and an infectious disease simultaneously. Thus, like the Ministry, the WHO explains pandemics from the biological nature of the germ. “The virus writes the rules,” said Margaret Chan, the WHO’s director-general at the time, in her declaration of “influenza pandemic” in 2009, “and” she continued, “this one, like all influenza viruses, can change the rules, without rhyme or reason, at any time” (OMS, 2009a). Fundamentally, this is germist biomedicine from the beginning of the twenty-first century, pure and simple.

Finally, the WHO’s declaration of the 2019 coronavirus disease pandemic—COVID-19 in their terms—, published one day and ratified the next, highlighted a new movement in the concept: “alarming levels of spread and severity,” and “alarming levels of inaction” were the words used by the WHO’s current director-general to bring the criterion of severity back to the forefront and give a new tone to the administrative criterion. In the same sense of the 1920 and 2009 declarations, a germ, more and more precisely identified and characterized, is held responsible for causing the pandemic, and more and more precisely, the germ becomes the target of all our attacks.

Chronicle of a pandemic announced in a time of neoliberal capitalism

In the historical-territorial perspective that we propose, the genesis of the configuration process of the 2019 coronavirus disease pandemic takes place in one of the wildlife markets that began to emerge in the 1980s, following the liberalization of the formerly socialist Chinese economy. The commercialization of these animals made its way into politics,

by the hand of Deng Xiaoping, with a fighting flag against the famines that the socialist economy, by the hand of Mao Tse Tung, would have brought to the farmers (Carrasco, 2020). However, after forty years, this political flag has been incinerated and a luxury food industry for the world's wealthy consumers has emerged, which has not resolved the problem of hunger, of course.

We have written elsewhere about the genesis of this particular configuration process in the “Huanan Seafood Wholesale Market,” in the city of Wuhan, capital of the Hubei province (Henao-Kaffure et al., 2020; Hernández-Álvarez et al., 2021). For this article, we focus more on showing that, given what has happened in only twenty years of this century, the configuration process of the 2019–20 pandemic was predictable.

In 2002, an epidemic of a severe acute respiratory syndrome related to a coronavirus, similar to the one related to this pandemic, broke out in a niche of these same markets from the same industry, not in the Hubei province, but in the Guangdong province. And more recently, in 2010, another epidemic of severe acute respiratory syndrome, also related to a coronavirus, broke out in a niche of another market for live domesticated animals, the market for dromedaries, or Arabian camels (*Camelus dromedarius*), in which the Greater Horn of Africa has been promoted as an exporting region of these animals to the Middle East, also since the 1980s.

The retrospective of the genesis of these epidemic configuration processes related to coronavirus in the twenty-first century shows the predictability of the pandemic to which we have referred, and probably, if we do not take the situation seriously, the predictability of other pandemics. For science education, just as for public health, taking the situation seriously means training critical thinkers, building transdisciplinary bridges, and understanding the relationships between science and society: politics, economics, and ideology. At this point, the survival of many human beings, of the species itself, and of other species is in question. If not now, then when? At this stage, it is necessary to change the conditions that make foreseeable new pandemics. We need to change the conditions of health commodification, nature exploitation, global warming, and the lopsidedness of the world—the concentration of advanced productive forces and technology in rich countries and the poverty and shantytownization of the poor countries.

A wildlife market at the genesis of the Severe Acute Respiratory Syndrome (SARS) epidemic

While the 2019 coronavirus disease pandemic has been presented as a new and unpredictable event, it is possible to follow its trail, at least, at the beginning of the present century. The first coronavirus-related severe acute respiratory syndrome epidemic in the twenty-first century broke out in mid-November 2002, when the first cases of the disease began to appear in small and sporadic independent groups in at least seven municipalities in southern China's Guangdong province (OMS, 2003b, pp. 79, 81). During the first week of February in 2003, the number of cases increased in relation to “the care provided in the hospitals,” and a large part of the health workers in the hospitals of the province were affected. In mid-February, cases began to appear in Hong Kong (Guan et al., 2003, p. 276), and by the end of February, outside of China. Given the situation, the WHO issued a first global alert on March 12th, and on March 15th, presented the first case definitions and some recommendations for international travelers with symptoms, and named the disease severe acute respiratory syndrome, SARS (OMS, 2003b, pp. 79–81).

In order to identify the pathogenic microorganism related to the syndrome, the WHO established a global network of laboratories that, quickly, fulfilling Koch's postulates, found a coronavirus (WHO, 2003). On April 16, the microorganism had been found "in all cases of the disease," it had been "isolated from the host and grown in pure culture," the "original disease" had been reproduced by introducing the microorganism "into a susceptible host," and, finally, the microorganism had been "found in the experimental host so infected" (OMS, 2003c). Between May 2nd and 4th, the coronavirus was recognized "as a species," classified in the genus *Coronavirus* and named "severe acute respiratory syndrome coronavirus," SARS-CoV, by the ICTV (ICTV, 2003). Over time, the taxonomy of the microorganism would become somewhat more complex, but it would lead to the betacoronavirus that we know today (ICTV, 2020).

According to epidemiological studies on SARS, the earliest cases, in the Guangdong province, occurred among restaurant workers who traded "seafood" and "live caged animals [...] as exotic game food" (Zhong et al., 2003, p. 1355). Consequently, it was necessary to deal with the relationships with wild and domesticated animals traded in the province's markets which could have led the virus to cross the species barrier.

In Shenzhen—one of the two sub-provincial cities of the province of Guangdong and with live animal markets of its own—a comprehensive study on the epidemiology of the syndrome was undertaken by Chinese researchers from Guangdong and Hong Kong, and it revealed that live animal markets "provide a venue for the [...] viruses to amplify and to be transmitted to new hosts, including humans" (Guan et al., 2003, p. 278). According to the results of the study of nasal, fecal, and blood samples, taken from the market workers and the live wild animals traded in it—beavers (*Castor fiber*), Chinese ferret-badgers (*Melogale moschata*), Chinese hares (*Lepus sinensis*), Chinese muntjacs (*Muntiacus reevesi*), domestic cats (*Felis catus*), hog-badgers (*Arctonyx collaris*), Himalayan palm civets (*Paguma larvata*), and raccoon dogs (*Nyctereutes procyonoides*)—using reverse transcription polymerase chain reaction (RT-PCR), inoculation in Fetal rhesus monkey kidney cells (FRhK-4), electron microscopy, and Western blot techniques, the researchers claimed that amidst culinary market practices, Himalayan palm civets, raccoon dogs, and Chinese ferret-badgers may have been infected with the coronavirus from the source animal which would constitute its natural reservoir, and these animals would become the intermediate hosts in the perspective of humans, who saw increased opportunities for an infection. Over time, horseshoe bats (*Rhinolophus*) were identified as the natural reservoir of the SARS coronavirus, and the possibility that this coronavirus and others could pass directly from bats to humans without intermediate hosts started to become visible (Ge et al., 2013, p. 535).

By July 5, 2003, when the WHO announced that "the human-to-human chain of transmission of this [...] disease" had been broken around the globe, the SARS epidemic had affected more than 8,000 people in 30 countries and territories, "20% [...] [among] health workers," and caused the death of about 10% of them (OMS, 2003a). According to the WHO, "the economic impact of the [...] outbreak ha[d] been considerable" and showed "the importance [...] [of] a severe new disease [...] in a closely interdependent and highly mobile world" (OMS, 2003b, p. 84).

A domesticated animal market at the genesis of the Middle East Respiratory Syndrome (MERS) epidemic

The second coronavirus-related epidemic of severe acute respiratory syndrome in the twenty-first century broke out in April 2012, Zarqa (Jordan). There, five members of the

intensive care unit staff became seriously ill and two died. The samples from these two health workers were stored and later analyzed and confirmed for what would be a new coronavirus (Bleibtreu et al., 2020; WHO, 2012).

This new coronavirus was isolated for the first time in June 2012, in Jeddah (Saudi Arabia) (Zaki et al., 2012). In September 2012, the coronavirus was isolated again, from samples of a man received at a London hospital with an unexplained serious respiratory illness, coming from Qatar and with a history of having traveled to Saudi Arabia (Bermingham et al., 2012). The virus from Jeddah was called “human coronavirus Erasmus Medical Center (EMC),” and the London virus, “human coronavirus England 1” (de Groot et al., 2013, p. 7790).

Already by July 2013, cases of the disease had been reported in Jordan, Saudi Arabia, Qatar, and the United Arab Emirates, and cases in the United Kingdom and France were shown to be related to some of the cases from these Middle Eastern countries, and the new coronavirus was called “Middle East Respiratory Syndrome Coronavirus (MERS-CoV)” by the ICTV in consensus with pioneering researchers from the WHO and the Saudi Arabian Ministry of Health (de Groot et al., 2013, p. 7791). Based on phylogenetic and epidemiological findings, ICTV researchers affirmed the primarily zoonotic nature of the infection and its limited person-to-person transmission and refrained from labeling MERS-CoV a human coronavirus (pp. 7790–7791).

The experience with SARS had led to the identification of the role of bats in the genetic diversity and the propagation of coronaviruses, and this new epidemic sharpened the findings. African bats appeared as the natural hosts of the virus, and, although “epidemiological relationships between human infections of MERS-CoV and bats could not be established” (Goldstein & Weiss, 2017, p. 3), and the jump between the species seemed more likely via intermediate hosts (as it did with SARS-CoV), bats could still become the “immediate source” of the virus for humans (de Groot et al., 2013, p. 7790).

The confirmation of the natural host and the search for the intermediate host of the virus continued to guide the investigations. Quickly, genotypic relationships were established between MERS-CoV and the betacoronavirus identified in African and European bats (Corman et al., 2014; Goldstein & Weiss, 2017) of the genus *Tytonycteris* (Hu et al., 2015), and epidemiological relationships were established between human cases of MERS and dromedaries (Haagmans et al., 2014; Memish et al., 2014; Reusken et al., 2013). At this point, the epidemiological, genetic, and phenotypic relationships between human infections of MERS-CoV and dromedaries seemed conclusive (Goldstein & Weiss, 2017, p. 3).

Dromedaries from Egypt, Tunisia, Nigeria, Sudan, South Sudan, Ethiopia, and Kenya, from Africa, and Saudi Arabia, Oman, Qatar, Jordan, and Kuwait, from the United Arab Emirates, in the Middle East, “ha[d] shown high rates of MERS-CoV seropositivity in serum samples collected” since the 1990s—Spain had also joined the list (Corman et al., 2014) and Burkina Faso and Morocco would do so in 2017 (Miguel et al., 2017). On this basis, a group of European and African researchers decided to delve into the spatial and temporal distribution of such animals and test serum samples of dromedaries from Somalia, Sudan, and Egypt that had been collected and archived since the 1980s (Müller et al., 2014). Of the 189 samples, 81% tested positive for MERS-CoV neutralizing antibodies and, on this basis, the researchers confirmed, supported by previous studies, that a “long-term virus circulation in these animals” was taking place (p. 2093).

In addition to ratifying the seropositivity of dromedaries from the Greater Horn of Africa to MERS-CoV, adding Somalia to the list, and extending the time of said seropositivity by a decade, this group of researchers opened the door to two fundamental interrelated issues to be questioned. The first, directed toward the establishment of a relationship

between the epidemic and the dromedary livestock industry, by pointing out, on the one hand, that “[m]ost dromedar[ies] traded in the Middle East are bred in the Greater Horn of Africa, primarily in Ethiopia, Sudan, Somalia, and Kenya” (Müller et al., 2014, p. 2093), and, on the other hand, that the maintenance of the virus in these animals may be related to the high densities of camel populations, in combination with nomadic husbandry, the presence of susceptible young animals, and the frequent contact between herds (Corman et al., 2014, p. 1321; Müller et al., 2014, p. 2094).

The second issue, to which this group of researchers opens the door, is the unveiling of the possibility that in poor African countries “that have been exposed to civil unrest, such as Somalia and Sudan”—two of the main dromedary exporters—there have been previously undiagnosed human MERS infections (Müller et al., 2014, p. 2094). Thus, in addition to determining whether or not infections have occurred in the past, the husbandry and the marketing conditions of dromedaries that could be related to the genesis of the MERS epidemic, whether it broke out in the Middle East or in Africa, should be explored.

The exploration of these issues reveals that, in the last forty years, justified by “economic development narratives, which have placed commercialization and export trade as [...] a driving force for poverty reduction,” “substantial investments [...] in livestock marketing” have been carried out in the Greater Horn of Africa (Aklilu & Catley, 2010, p. 4). This situation has led to the fact that these countries have become the main dromedary exporters to Egypt and the Middle East, with Ethiopia as one of the most important points of convergence between animals, traders, and exporters (Mahmoud, 2010; Müller et al., 2014).

However, contrary to promises to reduce poverty, the dromedary exporter status these countries have acquired has meant more poverty for poor traditional herders. The normative institutional arrangements of the export systems have contributed “to a gradual redistribution of livestock assets from poorer to richer herders” and, in the process in which they have lost their animals, the poorest herders have been doomed to become hired herders, to engage in non-livestock activities, and even fall into destitution (Aklilu & Catley, 2010, pp. 4–5). Furthermore, the flow of dromedaries from the Greater Horn of Africa to Egypt and the Middle East has meant a marked decrease in the supply of the local markets and a loss of traditional sources of food for local populations (Mahmoud, 2010).

Having said that, the situation for the animals is not more encouraging. The dromedary exporter status that the countries of the Greater Horn of Africa have acquired has meant an increase in the levels of animal abuse to which tourism had already subjected them (Petalatino, 2019). In addition to this tourism, right now in the Birqash market, the main market in Egypt, dromedaries from Sudan, Ethiopia, and other countries of the Greater Horn of Africa, are gathered in groups of more than 3,000 for their commercialization. The animals arrive at the market after having been shipped in trucks some 35 km to the southeast from Cairo, the capital of Egypt. But to get to Cairo, coming from Sudan, they have had to undertake a painful trek of up to 40 days, and the difficulties for the dromedaries coming from more distant countries are undoubtedly greater. In Cairo, and in the Birqash market, animals are beaten in order to get them to move and onto the vehicles that transport them. Dromedaries always have one leg bent at the knee and tied up which requires them to balance on only three legs so that they cannot escape (ElComercio.com, 2019; SPARE, 2010).

As for the progression of the MERS epidemic, 2,494 people had fallen ill, and 858 had died by November of 2019, according to the WHO. The fatality rate had reached 34.4% (WHO, 2019). In 2013, according to the ICTV Coronavirus Study Group, this rate was close to 60% and, although there was no evidence of sustained transmission, the concern

was that the virus could take a next step and adapt to efficient person-to-person transmission (de Groot et al., 2013, pp. 7790–7791).

The cases presented previously (SARS and MERS) show political, economic, and ideological aspects playing a role in the configuration process of the epidemics, and this poses the requirement of having a historical-territorial critical perspective which allows us to understand illness as a social process. This is an important starting point for science education because it fosters a pandemic understanding that overcomes the narrow view of illness as a solely biological issue.

Just as in public health, science education needs a change: linking science and society

The configuration of the 2019 coronavirus disease pandemic has completely altered the dynamics of the social organization and its relationships, and as part of this, has caused the schools' in-person activity to stop, and its operations have had to make an abrupt move to the remote dimension. In the framework of these unforeseen transformations, the links between education and society have come to light, and it has become more than apparent that the need to reflect and to formulate proposals for understanding and explanation of these links should always be foregrounded (Pietrocola et al., 2020; Plá, 2020).

According to what has been exposed in this paper, public health is a terrain of thought and action in dispute, dominated, since the end of the nineteenth century, by a germist perspective which has become the basis for the biomedical model since the second half of the twentieth century. Since its emergence, the biomedical perspective has been opposed by sociomedical and sociohistorical perspectives that have highlighted a determined social character in the processes related to health/disease, and in the dispute, a critical perspective has emerged from sociohistory and has highlighted the historical-territorial character of such processes, and the network of political, economic, and ideological relationships that, typical of their time and territory, underlie them. From this perspective, the concept of pandemic, the 2019 coronavirus disease pandemic, and the previous similar epidemics of 2002 and 2012 are the result of complex configuration processes in which biological and social issues—political, economic, and ideological—are combined, both being historical, and it is precisely in this sense that problems must be understood, actions must be considered, and transformations must be oriented.

From a historical-territorial critical perspective, the genesis of the configuration processes of the pandemic and previous similar epidemics is found in the anthropocentric and progressive nature-society relationship, which we have established in tune with the capitalist mode of organization and relationships, and which has seriously accelerated in this latest neoliberal phase. The genesis of these configuration processes is especially found in the relationship we have established with animals. The historical-territorial consciousness of the nature-society relationship urges us to foreground the need to reflect on the large-scale rearing of domestic animals, the consumption of wild animals, the abuse of animals, and on the health, work, and food systems that, among others, have been subjected to neoliberal capitalism which is harmful to collective life and conducive to individual profitability.

For science education, the debates presented by the historical-territorial critical perspective of public health show that scientific discussions occur in social relations with history and territory, and that revealing these relations refutes any neutrality intended for science. According to this perspective, the pandemic and previous similar epidemics are far

from being simple, biological, and individual issues in the coil of science intervention—a saving, aseptic, and neutral science—and are, rather, complex, social, and historical-territorial, susceptible to transformation, which can be traced by delving into the mode of organization and relationships that human beings have established among one another and, consequently, between ourselves and other species and forms of life. Science education needs a change like that of public health: linking science and society (Alsop & Hoeg, 2020; Bencze, 2020); and to tend to this challenge it faces in obtaining a critical and broad perspective of the context in which these processes are configured, the critical historical-territorial perspective of public health allows a pillar to be seen in order to build the bridge, and to encourage the debate for the recognition of the social character of both terrains of thought and action.

This bridge allows public health to update science education in terms of a more contemporary debate for understanding and explaining its problems and how to act accordingly, and it allows the teaching of science to shift from neutral to political as it should be. From a critical historical-territorial perspective, the coronavirus-related epidemics and pandemics of the twenty-first century transcend the biopathological facts, fundamentally germ-related, from the dominant perspective, with the aim of explaining, not just facts, but the configuration processes that account for a contemporary evolution in the way in which humans have organized ourselves as a society and how we relate to nature. And, by following the objective of training critical thinkers (Ali, 2020; Bencze, 2020; Blandford & Thorne, 2020), science education can bring pandemics and epidemics from the critical perspective of public health into the classroom and study them there as socio-scientific issues: as issues that are configured in the fabric of nature-society and that demand natural and social sciences for their understanding and transformation (Stevens, 2020).

Studying the ideas of the configuration processes from the historical-territorial critical perspective of public health, and the socio-scientific issues of science education, will allow public health professionals, educators, and students to reflect on explanatory issues of the pandemic and previous similar epidemics of the twenty-first century, and most likely on other human suffering also. In commemoration of the fiftieth anniversary of neoliberal capitalism, perhaps one of the most central issues is the fragility in which a good part of human beings find themselves. In the words of Boaventura de Sousa Santos, “pandemics do not kill as indiscriminately as is believed” (2020, p. 65), and in this sense, it is fundamental to understand and explain how they do and why. The case of immigrants in the USA is paradigmatic, even from sociomedical perspectives (Clark et al., 2020).

Public health professionals, science educators, and other thinkers of human order issues from Latin America and the rest of the world, we must ask ourselves from a critical perspective, like Sousa Santos, what potential knowledge comes from the 2019 coronavirus disease pandemic? (2020, p. 19). The critical perspective pursues this dialog here: the pandemic is part of a crisis that has been configuring for five decades and has been accentuated more and more intensely for the last two years, and it is related to the processes of commodification, flexibilization, and industrialization to which neoliberal capitalism has subjected everything, even life.

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References

- Aklilu, Y., & Catley, A. (2010). *Livestock Exports from the Horn of Africa. An Analysis of Benefits by Pastoralist Wealth Group and Policy Implications*. Feinstein International Center, Tufts University. <https://bit.ly/3nFOHgr>
- Ali, S. (2020). Combatting against Covid-19 & misinformation: A systematic review. *Human Arenas*. <https://doi.org/10.1007/s42087-020-00139-1>
- Alsop, S., & Hoeg, D. (2020). Collegial conversations at a time of COVID-19. *Journal for Activist Science and Technology Education*. <https://doi.org/10.33137/jaste.v11i2.34536>
- Bencze, L. (2020). Post-pandemic Science & Technology Education: An opportune and necessary ideological battle. *Journal for Activist Science and Technology Education*. <https://doi.org/10.33137/jaste.v11i2.34534>
- Bermingham, A., Chand, M. A., Brown, C. S., Aarons, E., Tong, C., Langrish, C., & Zambon, M. (2012). Severe respiratory illness caused by a novel coronavirus, in a patient transferred to the United Kingdom from the Middle East, September 2012. *Eurosurveillance*, 17(40), 20290. <https://doi.org/10.2807/ese.17.40.20290-en>
- Blandford, R. D., & Thorne, K. S. (2020). Post-pandemic science and education. *American Journal of Physics*, 88(7), 518–520. <https://doi.org/10.1119/10.0001390>
- Bleibtreu, A., Bertine, M., Bertin, C., Houhou-Fidouh, N., & Visseaux, B. (2020). Focus on middle east respiratory syndrome coronavirus (MERS-CoV). *Médecine et Maladies Infectieuses*, 50(3), 243–251. <https://doi.org/10.1016/j.medmal.2019.10.004>
- Breilh, J. (2010). La epidemiología crítica: una nueva forma de mirar la salud en el espacio urbano. *Salud Colectiva*, 6(1), 83–101. <https://www.redalyc.org/articulo.oa?id=73115246007>
- Breilh, J. (2015). Epidemiología crítica latinoamericana: raíces, desarrollos recientes y ruptura metodológica (La determinación social de la salud como herramienta de ruptura hacia la nueva salud pública – salud colectiva). In C. Morales & J. C. Eslava, (Eds.), *Tras las huellas de la determinación: memorias del Seminario Interuniversitario de Determinación Social de la Salud* (pp. 19–75). Universidad Nacional de Colombia.
- Carrasco, J. (2020, 25 de marzo de 2020). Serpientes, cocodrilos y roedores: por qué China permite la venta de animales salvajes que transmiten virus. *Telemundo*. <https://www.telemundo.com/noticias/2020/03/25/serpientes-cocodrilos-y-roedores-por-que-china-permite-la-venta-de-animales-salvajes-que-tmna3727845>
- Clark, E., Fredricks, K., Woc-Colburn, L., Bottazzi, M. E., & Weatherhead, J. (2020). Disproportionate impact of the COVID-19 pandemic on immigrant communities in the United States. *PLOS Neglected Tropical Diseases*, 14(7), e0008484. <https://doi.org/10.1371/journal.pntd.0008484>
- Corman, V. M., Jores, J., Meyer, B., Younan, M., Liljander, A., Said, M. Y., & Müller, M. A. (2014). Antibodies against MERS coronavirus in dromedary camels, Kenya, 1992–2013. *Emerging infectious diseases*, 20(8), 1319–1322. <https://doi.org/10.3201/eid2008.140596>
- de Groot, R. J., Baker, S. C., Baric, R. S., Brown, C. S., Drosten, C., Enjuanes, L., & Ziebuhr, J. (2013). Middle East respiratory syndrome coronavirus (MERS-CoV): Announcement of the Coronavirus Study Group. *Journal of virology*, 87(14), 7790–7792. <https://doi.org/10.1128/JVI.01244-13>
- ElComercio.com. (2019, 26 de julio de 2019). No hay derechos para los camellos del principal mercado de Egipto. *ElComercio.com*. <https://bit.ly/3iMHBmR>
- Elias, N. (1994). *El proceso de la civilización: Investigaciones sociogenéticas y psicogenéticas*. Fondo de Cultura Económica. (1939).
- Engels, F. (1974). *La situación de la clase obrera en Inglaterra*. Morgan y Drake. (1845).
- Ge, X.-Y., Li, J.-L., Yang, X.-L., Chmura, A. A., Zhu, G., Epstein, J. H., & Shi, Z.-L. (2013). Isolation and characterization of a bat SARS-like coronavirus that uses the ACE2 receptor. *Nature*, 503(7477), 535–538. <https://doi.org/10.1038/nature12711>
- Goldstein, S. A., & Weiss, S. R. (2017). Origins and pathogenesis of Middle East respiratory syndrome-associated coronavirus: recent advances. *F1000Research*, 6, 1628–1628. <https://doi.org/10.12688/f1000research.11827.1>
- Gómez-Arias, R. D. (2018). ¿Qué se ha entendido por salud y enfermedad? *Revista Facultad Nacional de Salud Pública*, 36, 64–102. <https://revistas.udea.edu.co/index.php/fnsp/article/view/335873>
- Gorbalenya, A. E., Baker, S. C., Baric, R. S., de Groot, R. J., Drosten, C., Gulyaeva, A. A., & Ziebuhr, J. (2020). The species Severe acute respiratory syndrome-related coronavirus: Classifying 2019-nCoV and naming it SARS-CoV-2. *Nature Microbiology*, 5(4), 536–544. <https://doi.org/10.1038/s41564-020-0695-z>

- Guan, Y., Zheng, B. J., He, Y. Q., Liu, X. L., Zhuang, Z. X., Cheung, C. L., & Poon, L. L. (2003). Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. *Science*, 302(5643), 276–278. <https://doi.org/10.1126/science.1087139>
- Haagmans, B. L., Al Dhahiry, S. H. S., Reusken, C. B. E. M., Raj, V. S., Galiano, M., Myers, R., & Koopmans, M. P. G. (2014). Middle East respiratory syndrome coronavirus in dromedary camels: An outbreak investigation. *The Lancet Infectious Diseases*, 14(2), 140–145. [https://doi.org/10.1016/S1473-3099\(13\)70690-X](https://doi.org/10.1016/S1473-3099(13)70690-X)
- Harvey, D. (2007). *Breve historia del neoliberalismo (Primera (reimpresión))*. Madrid: Akal.
- Henao-Kaffure, L., & Hernández-Álvarez, M. (2017). La pandemia de gripe de 1918: un caso de sub-sunción de lo biológico en lo social. *Americania, Revista de Estudios Latinoamericanos*(6), 8–52. <https://www.upo.es/revistas/index.php/americania/article/view/2742>
- Henao-Kaffure, L., & Hernández-Álvarez, M. (2020). Flu pandemic, world power, and contemporary capitalism: Building a historical-critical perspective. *International Journal of Public Health*. <https://doi.org/10.1007/s00038-020-01441-z>
- Henao-Kaffure, L., Miranda-Canal, N., & Hernández-Álvarez, M. (2020). La encrucijada de la pandemia para la salud mundial. In A. Carvajal-Rueda (Ed.), *Nadie se salva solo. Significados de la pandemia que cambió la humanidad*. (pp. 19–47). Paidós.
- Hernández-Álvarez, M., Henao-Kaffure, L., Eslava-Castañeda, J. C., Vega-Vargas, M., Arrubla-Sánchez, D., Rodríguez-Ruiz, J., & Vega-Vargas, M. (2021). La pandemia de la enfermedad por coronavirus (COVID-19) desde una perspectiva crítica histórico-territorial. In C. Tetelboin Henrion, D. Iturrieta Henríquez, & C. Schor-Landman (Eds.), *América Latina. Sociedad, política y salud en tiempos de pandemias*. (pp. 71–114). CLACSO. https://www.clacso.org.ar/libreria-latinoamericana/libro_detalle.php?orden=id_libro=2315&pageNum_rs_libros=0&totalRows_rs_libros=1480
- Hobsbawm, E. (1996). *Historia del siglo XX*. Barcelona: Grijalbo-Mondadori.
- Hu, B., Ge, X., Wang, L.-F., & Shi, Z. (2015). Bat origin of human coronaviruses. *Virology Journal*, 12, 221–221. <https://doi.org/10.1186/s12985-015-0422-1>
- ICTV. (2003). *FT 2003.150V*. I. C. o. T. o. Viruses. <https://bit.ly/3nCwH6G>
- ICTV. (2020). CTV Taxonomy history: Severe acute respiratory syndrome-related coronavirus. Retrieved 27 September 2020 from <https://bit.ly/2SO1Rdb>
- Iriart, C., & Merhy, E. E. (2017). Disputas intercapitalistas, biomedicalización y modelo médico hegemónico. *Interface - Comunicação, Saúde, Educação*, 21, 1005–1016. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1414-32832017000401005&nrm=iso
- Koch, R. (1882). Über die Ätiologie der Tuberkulose. In: Robert Koch-Institut. <https://edoc.rki.de/handle/176904/5164>
- Laín-Entralgo, P. (1982). *Historia de la Medicina*. Salvat. (1978).
- Law, J. (2006). *Big pharma: Exposing the global healthcare agenda*. Carroll & Graf.
- López Piñero, J. M. (2017). *Breve historia de la medicina* (Segunda ed.). Herederos de José María López Piñero; Alianza Editorial, S.A.
- Mahmoud, H. A. (2010). *Camel marketing in the Northern Kenya/Southern Ethiopia Borderlands, Research Update*. Future Agricultures Consortium, University of Sussex. Retrieved 6 October 2020 from <https://bit.ly/21c1xnI>
- Memish, Z. A., Cotten, M., Meyer, B., Watson, S. J., Alsahafi, A. J., Al Rabeeah, A. A., & Drosten, C. (2014). Human infection with MERS coronavirus after exposure to infected camels, Saudi Arabia, 2013. *Emerging infectious diseases*, 20(6), 1012–1015. <https://doi.org/10.3201/eid2006.140402>
- Michel, K. (2003, marzo 31). Politik ist weiter nichts als Medizin im Großen. Retrieved 2 August 2020 from <http://www.faz.net/aktuell/feuilleton/buecher/rezensionen/sachbuch/politik-ist-weiter-nichts-als-medizin-im-grossen-193736.html>
- Miguel, E., Chevalier, V., Ayelet, G., BenBencheikh, M. N., Boussini, H., Chu, D. K., Peiris, & M. . (2017). Risk factors for MERS coronavirus infection in dromedary camels in Burkina Faso, Ethiopia, and Morocco, 2015. *Euro Surveillance*, 22(13), 30498. <https://doi.org/10.2807/1560-7917.ES.2017.22.13.30498>
- Ministry of Health for England and Wales. (1920). *Report on the Pandemic of Influenza, 1918–19*. Majesty's Stationery Office.
- Müller, M. A., Corman, V. M., Jores, J., Meyer, B., Younan, M., Liljander, A., & Drosten, C. (2014). MERS coronavirus neutralizing antibodies in camels, Eastern Africa, 1983–1997. *Emerging Infectious Diseases*, 20(12), 2093–2095. <https://doi.org/10.3201/eid2012.141026>
- OMS. (1999). *Plan de preparación para la pandemia de influenza*. <https://www.who.int/csr/resources/publications/influenza/whoplanspanish.pdf>
- OMS. (2003a). *El brote de SRAS ha sido contenido en todo el mundo*. Retrieved 7 October 2020 from <https://bit.ly/2SNJogG>.

- OMS. (2003b). *Informe sobre la salud en el mundo 2003 Forjemos el futuro*. O. M. d. I. Salud. <https://www.who.int/whr/2003/es/>.
- OMS. (2003c, 16 de abril de 2003). Un coronavirus jamás detectado anteriormente en los seres humanos es la causa del SRAS. Retrieved 27 September 2020 from <https://bit.ly/3iUAhoZ>.
- OMS. (2005). *Plan mundial de la OMS de preparación para una pandemia de influenza*. Organización Mundial de la Salud. https://www.who.int/csr/resources/publications/influenza/WHO_CDS_CSR_GIP_2005_5/es/
- OMS. (2009a, 11 de junio). El nivel de alerta de pandemia de gripe se eleva de la fase 5 a la fase 6. Retrieved 6 August 2020 from http://www.who.int/mediacentre/news/statements/2009/h1n1_pandemic_phase6_20090611/es/index.html.
- OMS. (2009b). *Preparación y respuesta ante una pandemia de influenza*. Organización Mundial de la Salud. http://www.who.int/csr/swine_flu/Preparacion_Pand_ESP.pdf?ua=1
- OMS. (2020a). *Alocución de apertura del Director General de la OMS en la rueda de prensa para las misiones diplomáticas sobre la COVID-19 celebrada el 12 de marzo de 2020*. OMS. Retrieved 18 November 2020 from <https://www.who.int/es/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-mission-briefing-on-covid-19---12-march-2020>.
- OMS. (2020b). *Alocución de apertura del Director General de la OMS en la rueda de prensa sobre la COVID-19 celebrada el 11 de marzo de 2020*. OMS. Retrieved 18 November 2020 from <https://www.who.int/es/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020>.
- OMS. (2020c). *Intervención del Director General de la OMS en la conferencia de prensa sobre el 2019-nCoV del 11 de febrero de 2020*. OMS. Retrieved 10 October 2020 from <https://bit.ly/2H0MIIV>.
- Petalatino. (2019, 1 de julio). Caballos Azotados y Camellos Golpeados Por Paseos Para Turistas. Retrieved 7 October 2020 from <https://bit.ly/3jv8Mx2>
- Pietrocola, M., Rodrigues, E., Bercot, F., & Schnorr, S. (2020). Science education in pandemic times: What can we learn from COVID-19 on science technology and risk society. *EdArXiv*. <https://doi.org/10.35542/osf.io/chtgv>
- Plá, S. (2020). La pandemia en la escuela: entre la opresión y la esperanza. In H. C. Cardiel (Ed.), *Educación y pandemia: una visión académica* (pp. 30-38). Universidad Nacional Autónoma de México, Instituto de Investigaciones sobre la Universidad y la Educación.
- Reusken, C. B. E. M., Haagmans, B. L., Müller, M. A., Gutierrez, C., Godeke, G.-J., Meyer, B., & Koopmans, M. P. G. (2013). Middle East respiratory syndrome coronavirus neutralising serum antibodies in dromedary camels: A comparative serological study. *The Lancet Infectious Diseases*, 13(10), 859–866. [https://doi.org/10.1016/S1473-3099\(13\)70164-6](https://doi.org/10.1016/S1473-3099(13)70164-6)
- Rosen, G. (1985). ¿Qué es la medicina social? Un análisis genético del concepto. In *De la policía médica a la medicina social. Ensayos sobre la historia de la atención a la salud* (pp. 77–137). Siglo XXI. (1974)
- Rothbard, M. N. (1990). Concepts of the role of intellectuals in social change toward laissez faire. *Journal of Libertarian Studies*, 9(2), 43–67. <https://mises.org/library/concepts-role-intellectuals-social-change-toward-laissez-faire-0>
- Santos, B. (2020). *La cruel pedagogía del virus*: CLACSO.
- SPARE. (2010). *Burkash Market*. Society for the Protection of Animal Rights in Egypt. Retrieved 8 October 2020 from http://www.sparelives.org/index.pl/the_camel_market
- Stevens, A. (2020). Governments cannot just ‘follow the science’ on COVID-19. *Nature Human Behaviour*, 4(6), 560–560. <https://doi.org/10.1038/s41562-020-0894-x>
- WHO. (2003, 27 March 2003). *Severe Acute Respiratory Syndrome (SARS) - multi-country outbreak - Update 12*. World Health Organization. Retrieved 27 September 2020 from https://www.who.int/csr/don/2003_03_27b/en/.
- WHO. (2012). *Background and summary of novel coronavirus infection – as of 21 December 2012*. WHO. Retrieved 3 October 2020 https://www.who.int/csr/disease/coronavirus_infections/update_20121221/en/.
- WHO. (2019). *MERS Monthly Summary, November 2019*. WHO. Retrieved 11 October 2020 from <https://www.who.int/emergencies/mers-cov/en/>.
- Zaki, A. M., van Boheemen, S., Bestebroer, T. M., Osterhaus, A. D. M. E., & Fouchier, R. A. M. (2012). Isolation of a Novel Coronavirus from a Man with Pneumonia in Saudi Arabia. *New England Journal of Medicine*, 367(19), 1814–1820. <https://doi.org/10.1056/NEJMoa1211721>
- Zhong, N. S., Zheng, B. J., Li, Y. M., Poon, L. L. M., Xie, Z. H., Chan, K. H., & Guan, Y. (2003). Epidemiology and cause of severe acute respiratory syndrome (SARS) in Guangdong, People's Republic of China, in February, 2003. *The Lancet*, 362(9393), 1353–1358. [https://doi.org/10.1016/S0140-6736\(03\)14630-2](https://doi.org/10.1016/S0140-6736(03)14630-2)

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