SARS: The Disease We Withheld Against

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Introduction(Judy Chen, Isaac Jiang)

A pandemic starts with public service announcements, general paranoia, and caution before spiraling out of control into societal outbursts of confusion and uncertainty. However, through all the devastation and havoc, new insights into virological research can be formed. The SARS, or severe acute respiratory syndrome pandemic, due to its relevance to the current SARS-CoV-2 virus within the family of coronaviruses, continues to fascinate researchers with biological mechanisms that still aren't understood or known. From its potentially zoonotic origins to the side effects of proposed treatment methods, SARS has induced researchers to continue making discoveries, all while finding more inconclusive dead ends.

Origin(April Li)

SARS was first discovered in Foshan, which is located in Guangdong Province, China in November 2002 (Xu, pg. 1). Early on, scientists predicted that SARS originated from an animal, which then passed the disease down to humans. After a few tests of animal produce found at the Shenzhen market, they found a few cases of coronavirus infection with similarities to SARS. These animals included raccoon dogs (*Nyctereutes procyonoides*) and masked palm civets (*Paguma larvata*). Interestingly, Chinese ferret-badgers (*Melogale moschata*) contained antibodies against SARS (Bel, pg. 1). At the time, the main suspects were civets. A 2003 study held by the CDC even showed that almost 72.7% of the masked palm civets that were being traded within the Guangzhou municipality contained SARS antibodies (Xu, pg. 1). However, this study only entailed animal markets. Civets tested from Guangzhou farms during June 2003 had a much lower prevalence of these SARS antibodies than those in Guangzhou animal markets (Tu,

pg. 1). This weakens the hypothesis that civets were the sole origin of SARS, and implies that they may have merely been infected by another animal during transport to the markets. In fact, civets can be more susceptible to catching infections such as SARS when they are stressed, so they could've just caught SARS from the natural reservoir host (Tu, pg. 1). The population of civets being traded around 2002-2003 showed no signs of SARS infection. Additionally, there were few recorded interactions of SARS patients with civets during 2003-2004 (Wang, pg. 1). Consequently, though there are some cases where humans contracted the virus through civets, it is more likely that civets just acted as intermediates after being infected by the original host. Without substantial evidence pointing to civets being the original host, scientists turned to other suspicious animals.

The next theory implicated bats, specifically Chinese Horseshoe Bats, as the hosts of SARS. Multiple scientists throughout the mainland of China held a study in 2004, which showed that 4 species of horseshoe bats had SARS-like infections, while 84% of these bats had the antibody to a recombinant N protein of SARS. Data also showed that the strain of coronavirus found in horseshoe bats was 88%-92% identical to the genomic sequence of the SARS strain infecting humans. The genetic sequence of the human SARS coronavirus had a 29-nt deletion in the open reading frame 10/8 region, which was found in many bat genomes as well. This indicates that the coronaviruses found in SARS and horseshoe bats originated from a common ancestor (Wang, pg. 1). These bats reside in caves very close to each other, meaning genetic recombination may have occurred between viral strains, hence giving birth to new viruses and pathogens such as novel SARS strains (Cyranoski, pg. 1). Later, a 2017 study discovered 11 new SARS strands from horseshoe bats dwelling in a cave found in Yunnan Province. Based on

genome analysis, the bat strains contained essential genetic building blocks for SARS. Sections of a gene called the S gene found within the new SARS bat strands were very similar to the S genes in SARS coronavirus genomes. The scientists conducted some experiments which showed that some of the bat strains were able to enter human cells through the same cellular receptor as the SARS coronavirus, which suggests a mechanism where bats could directly infect humans (Hu, pg. 1). A 5-year long study of Shitou Cave, starting in 2004, showed that several bat coronavirus strains could infect human lung cells, as well as cause SARS-like diseases in mice. Furthermore, it was discovered that horseshoe bats' coronavirus strains were 97% identical to those of civets from Guangdong (Qiu, pg. 1). In addition, the genes that let a virus infect cells were different between the human and bat coronaviruses (Cyranoski, pg. 1). These facts support the hypothesis that civets acted as an intermediate host for the bats, meaning bats didn't directly infect humans.

From the very beginning, there was a clear relationship between SARS and animal markets. Many of the earlier cases of human infection within Guangdong were food handlers or those who dealt with animal markets (Tu, pg. 1), and 13% of animals from traders contained antibodies against SARS in Guangzhou compared to 1.2% in other areas (Xu, pg. 1). It was later discovered by a Chinese government team that 66/508 of the wildlife handlers within Guangdong had antibodies for SARS (Bel, pg. 1). Cross-infections may have occurred due to overcrowded cages as animals were being traded. Animals that would normally never interact in their respective natural environments would meet, which may have caused a new disease such as SARS to appear (Bel, pg. 2). However, the animal trade may just be a way of transmitting the disease. Animals infected by SARS were contagious through their bodily fluids such as urine,

blood, and feces, left in their transport or residential areas (Wang, pg. 1). Other animals would come in contact with these bodily fluids and then become infected, further spreading the virus. Civets and bats were possible carrier hosts, but some believed the list also included cats, muntjac, wild boars, rabbits, snakes, and pheasants (Chen, pg. 1).

However, most of these animals don't contain the necessary biological components to actually infect a human cell, so scientists are confused as to how the disease could've been transmitted (Wang, pg. 1). Despite no clear way of transmission, most scientists believe that horseshoe bats are the original hosts of SARS.

Evolution of Medical Understanding(Andrew Chan, Zoe Zhang)

After the emergence of SARS and its initial slow spread, an expert team from the provincial government and the Ministry of Health went to investigate one of the outbreak spots, City of Zhongshan, concluding it to be atypical pneumonia caused by a viral agent on January 21, 2003. They then issued recommended measures for the prevention and treatment of this infection and suggested reporting measures to monitor the disease. This information was relayed to every hospital in the province, yet didn't draw attention from health officials who were on leave due to the Chinese New Year holiday. Thus, the virus was significantly overlooked as it began to spread drastically due to the uproar of travel in celebration of the holiday. Along with this misstep in prevention, the medical community's understanding of the true etiology of SARS was delayed significantly by a February announcement from a senior scientist at the Chinese CDC, who suspected that the infectious agent was a mere carrier of Chlamydia, a commonly understood bacterial agent that did not warrant public concern. By January 31, 2003, the first

super-spreading SARS patient was identified in the city of Guangzhou, where the patient was transferred among 3 hospitals, infecting an estimated 200 people, most of whom were hospital workers. By then, the international public health community began to receive news of the outbreak among emails, chat rooms, local media outlets, and local electronic reporting systems such as GPHIN or Pro-MED mail. The WHO queried the Chinese government on February 10 and received a response describing the outbreak and the SARS syndrome, with 205 confirmed cases and 5 dead among the Guangdong Province. Similarly, Hong Kong Health authorities set out a quarantine order to halt the spread of SARS on March 31 after 300 new cases were reported due to the virus' aerosolization through fecal matter in apartments. This led to some residents of housing complexes to remain in their apartment until midnight of April 9, further expanding precautionary measures. But on February 21, 2003, 12 people staying at the Metropole Hotel in Hong Kong contracted infections from a symptomatic physician from Zhongshan University; these superspreaders then brought the disease to Singapore, Vietnam, Canada, Ireland, and the U.S., accounting for around 8000 new cases worldwide. Vietnam only managed to eradicate SARS through their lacking infrastructure of sophisticated medical devices and facilities, since those areas exposed more of the population to the virus as shown in Singapore and China. By March 12, after the dissipation of the virus, the WHO issued a global alert of the respiratory disease in Hong Kong and Vietnam and instituted Worldwide Surveillance. This crackdown with news media emphasizing the suspicious symptoms of SARS and recommended restrictions led to a decline of cases in both nations due to greater medical understanding. But after two unfortunate deaths in Canada, of a patient coming from Hong Kong on February 23 and her son, officials recognized that these patients need to be isolated, as the shared rooms identified as a major

spreading environment. This would risk people who were in close contact with the patients, including family members, hospital workers, and nearby patients in those shared rooms. To counter and limit this spread, a protocol was issued to every hospital in Toronto to control the outbreak, which was similarly adapted by a Taiwan hospital in mid-April. This protocol insisted on increased surveillance, redoubling infection control measures, and mass education campaigns in order to reduce the time between symptom onset and patient isolation. The index case of the Metropole Hotel in Singapore on April 4 learned from these earlier measures. Authorities' preventive measures proved effective when 80 percent of Singapore's SARS patients didn't infect anyone else, as knowledge and practices of prevention had become more common. These practices became the sole reason for the end of the SARS outbreak in 2003.

SARS enabled early isolation before transmission because the virus loads peaked at 6-11 days after the onset of illness. Due to the quick response and isolation of the infected patient, secondary cases were drastically reduced. All suspected patients were isolated until SARS was ruled out. Ideally, patients isolated by themselves instead of quarantining together to reduce further transmission. During the mandatory quarantine, health-care workers checked in the patients daily through telephone and record of the temperatures. If the symptoms of SARS were developed, no one was permitted to have any close contact with the patient. On a public health magnitude, police made spot checks in Hong Kong and video cameras were installed at the home of each contact in Singapore. While it was impossible to identify every single person that had contracted SARS, a nation-wide quarantine for every citizen was implemented especially in the so-called "epidemic zone" in China. As time progressed, due to increasingly widespread knowledge through the media and an increasing degree of fear, citizens were willing to take

comprehensive measures of precautions against the infection. In mainland China and Hong Kong, there was an extreme willingness for quarantine if deemed necessary. The strong political commitment, along with a centrally coordinated response, played an essential factor in the control of SARS. Hospital-based precautions included an isolated room with strict enforcement of personal protective equipment of the staff and restriction of visitors and the movement of staff. In Singapore, workers were required to use gloves, gowns, eye protection, and N95 respirators for all contact with all patients. In fact, all visitors for the infected patients were banned unless on compassionate grounds. Both healthcare workers and visitors who had been exposed to facilities where SARS transmission had occurred were not allowed to enter non-SARS regions.

Misinformation(Judy Chen)

During the grand outbreak of the SARS pandemic, misinformation and stigmatization erupted from fear and uncertainty. Similar to the Black Death, those who were misguided from public shame and accusations believed that the disease was “the disease of the poor”, due to the assumption that those who were less wealthy were unable to afford proper treatment and quarantine methods, therefore increasing transmission rates. However, this was soon debunked through a deeper study on the urbanization of developed countries. The rapid development rate of these countries causes an increase in exposure to natural hosts of zoonotic viruses. In addition to this, a greater trading and travel frequency encourages transmission between world powers that rely on each other for economic growth. According to the World Health Organization, “most experts believed that the exotic pathogens that cause so much misery in Africa and densely-populated parts of South-East Asia would never become a problem in wealthy

countries". Contrary to this myth, before the SARS virus reached Guangdong, it was present in Toronto and Beijing, depicting the risk of global trading sectors in the spread of a pandemic. After the virus had infected civilians of many countries, Zhong Nanshan, a doctor based in Guangzhou, developed steroid therapy to treat patients infected with SARS. Despite the initial fallacy that there were no adverse effects of the treatment, its aggressive nature impacted the internal homeostatic environment of many patients, leaving survivors with chronic illnesses. As stated in a post from China Daily, "roughly 30 percent of SARS survivors in China who received the therapy have developed severe bone degeneration." More specifically, 88 percent of SARS survivors were left with osteonecrosis, the slow death of bone cells and tissue due to the lack of a proper blood supply. Typically, this abnormality is caused by a severe sports injury or car accident, as well as corticosteroid medications, which contains the class of glucocorticoids, used in the SARS treatment previously mentioned. In this case, the side effects were due to the high dosage of the steroid. Similar to the stigmatization of East Asian Americans during the current SARS-CoV-2 pandemic, there was a notion that Asian Americans had a higher risk of infection and transmission for SARS. There was no evidence behind this conspiracy. Despite epidemiological evidence that points to the origin of SARS in China, there was no correlation between those with heritage from East Asian countries and their rates of infection or transmission. As written in the US National Library of Medicine National Institutes of Health, "The teammonitored stigmatizing ideas and behaviors in the general population and the media, particularly toward Asian Americans, who were disproportionately reporting fear, stigmatization, and discrimination compared to the general public." The disinformation caused by widespread fear often causes a large spur of confusion and harmful effects.

Information(Phoebe He)

During the 2003 SARS outbreak the spread of information was extremely slow and limited. On November 16, 2002, the first case of the SARS virus was spotted in Guangdong province. However, at this time it was simply recorded as “atypical pneumonia”. These cases of “atypical pneumonia” were not reported to the WHO until 4 months after its discovery. The Chinese government has a tendency to cover up or underplay diseases as seen in the 2003 SARS outbreak as well as the current COVID-19 pandemic.

The silence of the government between November 2002 and March 2003 led to the virus being more widespread than it should have been. In early March, medical staff in Beijing's military hospitals were giving a rundown about the dangers of this disease, but were told to keep it quiet. Additionally, the communication between China and the WHO was extremely sparse. When WHO doctors went to China, they were not allowed access to Guangdong until April 2nd, and access to the military hospitals in Beijing was not given until April 9th. There was no comprehensive rundown about the basics of the SARS virus until April 17, when an anti SARS team was established. In addition to the lack of communication, the Chinese government also maintained a front of independence. The Chinese government refused help from the ministry of health and since the ministry of health did not have access to China's hospitals, there wasn't much they could do. Further statistics about the spread of SARS were kept hidden until mid-April. Many doctors tried to find a sample of the SARS virus to study, but all their attempts failed until the chinese CDC obtained samples from a local disease control center. With these samples they were able to conclude that chlamydia was the etiological agent of SARS. By the

end of April, despite the disingenuous efforts of the Chinese government, basic information about the SARS virus was released to the public. This crucial information informed many citizens to self isolate and quarantine if they showed symptoms, and to avoid densely populated areas.

Public Measure(Isaac Jiang, Edison Chang)

Public health measures are key when it comes to containing a disease outbreak. Their effectiveness can easily determine how severe the outbreak will be. In the hardest-hit areas during the 2003 SARS outbreak, the most common public health measures were: isolating case-patients, quarantining suspected patients, thermal scanning of travelers... (Bell, pg2). Back then, quarantine almost directly targeted low socioeconomic groups and ethnic minorities, locking them up with minimal health care. This was not the case during the 2003 SARS. Modern quarantine focuses more on the medical and mental state of the patients.

With China and Singapore as epicenters where SARS was spreading, the governments naturally had to take public measures. In both countries, public safety measures that were taken were relatively similar to what we experience today. Both the federal government of China and Singapore took actions including shutting down government offices, schools, universities, and areas where people could gather were all shut down. Quarantines were imposed to prevent further spread of the disease.

Social and Economic Consequence(Andy Lin, Andy Jiang)

There were detrimental socioeconomic factors intrinsic to the SARS epidemic, such as damages to the function and public trust in medical systems, damages to tourism-based industries, and weakened controls on population density and mobility. These inherent risks of population loss led to various socioeconomic impacts on both government structure and policy, as well as various population groups. These effects were most notable and prominent in Asian countries, and namely China — which can be attributed to their relatively large number of cases.

For the economic situation of the SARS 2003 outbreak, an estimated amount of 12-18 billion USD in Asia was lost due to the SARS epidemic decreasing travel, tourism, and retail sales. The demand for food, clothes, and travel decreased. The global macroeconomic impact of SARS was 3-10 million USD per case leading to a total of 30-100 billion USD. There was an estimated decrease of 1% in GDP in China and .5% decrease in Southeast Asia, resulting in less income and spending.

The SARS outbreak in 2003 had a very different social impact then most outbreaks preceding it. Information and misinformation was spread quickly due to the developments of mobile devices. SMS and social media caused the spread of many rumors that had caused social panic and unrest. For example, rumors of Banlangen and vinegar as a cure for SARS had spread. With this announcement, people began panicking and buying Banlangen, clearing the shelves in a brief matter of time. The lack of information about SARS in general caused a lot of dissatisfaction with the public. Experts wrote to the government, criticizing them for hiding the epidemic situation as well as questioning the government as to whether it was under control.

The SARS outbreak, in both healthcare workers and in the general populations, held significant negative psychological impacts on individuals. Health care workers experienced greater psychological distress, with some symptoms matching those of PTSD. Additionally, persons quarantined also exhibited negative physiological symptoms, especially with those perceiving difficulty with following quarantine procedures. These difficulties, among other (varying, often case-by case) factors demonstrated wide-reaching effects associated with quarantine, a procedure commonplace in modern outbreak responses. Reported losses of household income were commonplace, despite financial support from provincial and national governments to eligible persons in quarantine.

Conclusion(Andy Jiang)

The SARS outbreak exemplified common characteristics in the response to a global pandemic, which is especially relevant in the current wake of the extreme outbreak of SARS-CoV-2. Both narratives were marked by notable acceleration and magnitude. However, despite the evident parallels between past and present outbreaks, the SARS outbreak had a relatively fast resolution in spite of common factors for outbreak spread and size: such as the population density of Asian countries, and misinformation and stigmatization. The SARS outbreak remains especially relevant in today's virology-based discussions for its cementing of notable public health measures and practices with a preventive objective — quarantining procedures and closing of public facilities and functions. When analyzing how to battle the SARS-CoV-2 outbreak, the SARS outbreak provides key insights into the treatment, prevention, and socioeconomic effects of such events. Future research, with continued conclusions and

explorations into the less understood facets of the outbreak, is needed to to learn how to battle this virus in these unprecedented times.

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