

Emergence of Severe Acute Respiratory Syndrome (SARS) in the People's Republic of China, 2002–2003: A Case Study to Define Requirements for Detection and Assessment of International Biological Threats^{*,**}

Marat G. Polyak, M.A.,^{***} Jane Blake, M.S.,^{***} Jeff Collmann, Ph.D.,^{***} James M. Wilson, M.D.^{***}

Abstract

In November 2002, a novel pathogen, later dubbed severe acute respiratory syndrome-associated coronavirus (SARS-CoV), emerged as an “atypical pneumonia” in Guangdong Province, People’s Republic of China (PRC). This outbreak progressed to an epidemic in the southern PRC and was first reported in major Chinese media and other public sources in February 2003. By the time the World Health Organization (WHO) issued its Global Alert in March 2003, the disease had infected hundreds of people, disrupted everyday social life in China, and spread to eight other countries. A total of 8,098 people from five continents were infected; of these, 774 died. In this paper, we present a retrospective analysis of the local, regional, national, and international open-source media that reported on the social disruption in China in the months before WHO issued its Global Alert on SARS. This analysis revealed multiple indications and warnings of an unusual disease outbreak in southern China in 2002 and 2003. The goal of our analysis was to further the development of a taxonomy of indications and warnings that could be used as the basis for a global infectious disease monitoring system. Such indications and warnings may allow for earlier detection of developing biological events that pose a translocation threat to the United States, and thus may enable more proactive and efficient mitigation.

INTRODUCTION

In November 2002, a novel pathogen, later dubbed severe acute respiratory syndrome-associated coronavirus (SARS-CoV), emerged as an “atypical pneumonia” in Guangdong Province, People’s Republic of China (PRC). This outbreak progressed to an epidemic in southern China and was first reported in national Chinese media and other public sources in February 2003. By the time the World Health Organization (WHO) issued its Global Alert in March 2003, the disease had infected hundreds of people, disrupted everyday social life in China, and spread to eight other countries. A total of 8,098 people from five continents were infected; of these, 774 died. [1-3]

* **Reprint Requests:** Jane W. Blake, Georgetown University Medical Center, Imaging Science and Information Systems Center, PO Box 571479, Washington, DC 20057, blake@isis.imac.georgetown.edu, 202-687-0438.

** **Corresponding Author:** James M. Wilson, MD, Georgetown University Medical Center, Imaging Science and Information Systems Center, PO Box 571479, Washington, DC 20057, Wilson@isis.imac.georgetown.edu, 202-360-7147, Fax: 202-784-3479

*** Division of Integrated Biodefense, Imaging Science and Information System Center, Georgetown University Medical Center, Washington, DC, USA.

The SARS epidemic in the PRC merits attention not only because of the associated morbidity and mortality, but also because of the level of consequent socioeconomic disruption. The economic cost of the epidemic in 2002 and 2003 has been conservatively estimated at \$15 to 30 billion in Asia alone. [4] The epidemic affected multiple business sectors, notably the airline and tourist industries worldwide. The psychological cost of the epidemic is unknown, although studies suggest that in the short term, SARS caused severe depression, feelings of helplessness, and suicidal thoughts. [5] The long-term effects of the epidemic were more profound: SARS challenged the political status quo in China and stigmatized its victims.

Although epidemiological studies have not been able to pinpoint precisely where the epidemic began, initial local media reports of SARS cases in the population suggest that it started in Heyuan and Zhongshan, Guangdong Province. One study has suggested that the worldwide outbreak of the disease was associated with exposures to a single health care worker in the province. [6] Reports from September, October, and early November 2002 revealed an abnormally sharp increase in “influenza” cases compared with 2001, as well as multiple hospitalizations in several cities of Guangdong Province. The first diagnosis of “atypical pneumonia” was reported on November 14, 2002. By December 2002, the virus had traveled with sick residents of rural Guangdong Province to Guangzhou city, the capital of Guangdong. By January, seekers of medical treatment, migrant workers, animal traders, and business travelers from Guangdong had spread the virus to other Chinese provinces and cities, including Beijing and Shanghai. By March 2003, the disease had been reported in eight countries, and it continued to spread unabated until June 2003. Initially, Guangdong authorities dismissed the epidemic as a rumor, but with increasing morbidity, mortality, public anxiety, and social disruption, they could no longer conceal its extent, nor could they control the reporting of its spread.

In this paper, we present a retrospective analysis of the local, regional, national, and international open-source media that reported on social disruption in China in the months before WHO issued its Global Alert on SARS. This analysis revealed multiple indications and warnings of an unusual disease outbreak in the southern PRC in 2002 and 2003. One goal of our analysis was to further the development of a taxonomy of indications and warnings that could be used as the basis for a global infectious disease monitoring system. Such indications and warnings may enable earlier detection of developing biological events that pose a translocation threat to the United States.

BACKGROUND

SARS is a viral respiratory illness that affects humans and some animals, including Himalayan palm civets, raccoon dogs, and cynomolgous macaques. [6-7] The virus that causes it, SARS-CoV, was first identified by researchers in Hong Kong, the United States, and Germany in March 2003. [8-9] Results of recent research suggest that bats may be the natural reservoir of the coronaviruses from which SARS has emerged. [10-11]

Coronaviruses are large, enveloped, single-stranded ribonucleic acid (RNA) viruses – the largest of the RNA viruses. Replicating in the cytoplasm of animal host cells, they generally are transmitted from person to person by droplets, hand

contamination, fomites, and small-particle aerosols. [12-13] Previously identified human coronaviruses have been proven to live on environmental surfaces for up to three hours. [14] In the past, human coronaviruses (HCoV) have caused only mild disease. [15]

SARS is believed to spread primarily through close person-to-person contact through respiratory droplets and by touching of contaminated surfaces. Infection begins with influenza-like symptoms, including fever, followed by headache and muscle aches, cough, and shortness of breath. Most of those infected subsequently develop pneumonia. [16] In December of 2004, a clinical trial began for a SARS vaccine. [17] To date, no specific treatment for the disease has been identified; supportive medical care is the primary therapy employed.

As of this writing, no known SARS transmission is occurring anywhere in the world. The most recent human cases of SARS-CoV infection were reported in China in April 2004; these cases were associated with an outbreak resulting from laboratory-acquired infections. [18-19]

Guangdong Province represents an excellent test case for media-based surveillance of indications and warnings. The province has experienced an economic boom since 2000 and is a major trade and industrial center, accounting for 33.3 percent (\$283.64 billion) of China's foreign trade volume. [20] Additionally, Guangdong's provincial government actively encourages and participates in foreign ventures. Currently, the province has 100,000 foreign-invested enterprises. [21] The spending of Guangdong's urban residents further documents its economic boom. In 2003, Guangzhou, the provincial capital, had the highest per capita urban consumer expenditures in China, amounting to 1,065.37 yuan (US\$128.4) per year. [22] Also, Guangdong Province is ranked fourth in the PRC in Internet use. The 2004 report of the China Network Information Center, the PRC's official Internet watchdog in 2004, stated that 9.5 million residents of Guangdong (12.1 percent of the province's population) used the Internet. [23] Therefore, Guangdong's economic and internet connectivity with the West, its proximity to Hong Kong, and its abundance of media sources provide an environment conducive to reporting events like SARS that threaten infrastructure.

Three general conditions favor the use of the indication and warning approach to monitoring open-source media for signs of infectious disease outbreaks that pose a global health threat: (1) inadequate support for local disease reporting, (2) suppression of information about health crises, and (3) emergence of a previously unrecognized pathogen. The SARS outbreak in Guangdong Province, PRC, fit all three conditions. The outbreak also serves as an excellent test case for the indication and warning approach because it emerged within an extremely active society with access to local and international media outlets.

METHODS

We retrospectively examined open-source news media for articles related both to the SARS epidemic itself and to associated social disruption in China from September 2002 to April 2003, the months leading up to the WHO Global Alert. For this purpose, we used isisMiTAP, an online news service and information retrieval system that captures and categorizes information according to user-defined, searchable newsgroups

(see “isisMiTAP: A Tool for Using Open-Source News to Detect and Analyze Infectious Disease Outbreaks” in this issue). [24-27] The multiple keyword combinations used for our search yielded approximately 4,000 articles published in English and Chinese by local, regional, national, and international open news sources (59 Chinese local, regional, and national sources, and 27 international sources). Table 1 lists all the newspapers that we reviewed. In addition, we reviewed the archives of ProMED (www.promedmail.org), WHO (www.who.int), and CDC (www.cdc.gov) to understand the chronology of the international public health community’s awareness of the epidemic.

Table 1. Newspapers Examined for This Study

Newspaper	Region Covered	Data Type	Reference
<i>Asia Times</i>	Hong Kong, PRC	International	isisMiTAP
<i>China Daily</i>	China	National	isisMiTAP
<i>Eastday</i>	Shanghai, PRC	Regional	isisMiTAP
<i>People’s Daily</i>	China	National	isisMiTAP
<i>Xinhua</i>	China	National	isisMiTAP
<i>China Post</i>	Taiwan, HK, PRC	National	isisMiTAP
<i>Taipei Times</i>	Taiwan, HK, PRC	Regional	isisMiTAP
<i>PLA Daily</i>	China	National	isisMiTAP
<i>China Livestock Newspaper</i>	Beijing, China	National	isisMiTAP
<i>Farmer Daily Newspaper</i>	Beijing, PRC	National	isisMiTAP
<i>Guangdong Government Security News</i>	Guangdong	Regional	isisMiTAP
<i>Health SOHU</i>	Beijing, PRC	National	isisMiTAP
<i>JCRB/Examiner Daily</i>	Beijing, PRC	National	isisMiTAP
<i>People Security Newspaper</i>	Beijing	National	isisMiTAP
<i>South China</i>	Guangzhou, Guangdong, South China	Regional	isisMiTAP
<i>SunStone Pharmacy Guangdong</i>	TangShan, Beijing	Local	isisMiTAP
<i>Telecommunications News</i>	Guangdong	Regional	isisMiTAP
<i>Worker Daily News</i>	Beijing, PRC	National	isisMiTAP
<i>Hong Kong Health Journal</i>	Hong Kong	Regional	isisMiTAP
<i>Central News Agency</i>	Taiwan	Regional	isisMiTAP
<i>ET Today</i>	Shenzhen, Guangdong	Local	isisMiTAP
<i>Beijing Daily News</i>	Beijing, PRC	Regional	isisMiTAP
<i>ChaoZhou</i>	ChaoZhou, Guangdong	Local	isisMiTAP
<i>Fujian South East Express</i>	Fujian, Guangdong	Local	isisMiTAP
<i>Feng Kai</i>	Feng Kai, Guangdong	Local	isisMiTAP
<i>Fujian Daily</i>	Fujian, Guangdong	Local	isisMiTAP
<i>Foshan Daily</i>	Foshan, Guangdong	Local	isisMiTAP
<i>Fujian Window</i>	Fujian, Guangdong	Local	isisMiTAP
<i>Fuqing Evening News</i>	Fuqing, Guangdong	Local	isisMiTAP
<i>Fuzhou Evening News</i>	Fuzhou, Guangdong	Local	isisMiTAP
<i>Guangzhou Daily</i>	Guangzhou, Guangdong	Regional/Local	isisMiTAP
<i>Hong Kong Commercial News</i>	Hong Kong, PRC	Regional	isisMiTAP
<i>Information Times</i>	Guangzhou, Guangdong	Regional	isisMiTAP
<i>MeiZhou</i>	Meizhou, Guangdong	Local	isisMiTAP
<i>Maoming Daily</i>	Maoming, Guangdong	Local	isisMiTAP

<i>Xian Kuai Bao</i>	Guangdong	Regional/Local	isisMiTAP
<i>Nanfang Daily News</i>	Guangzhou, Guangdong	Regional/Local	isisMiTAP
<i>NanXiong</i>	NanXiong, Guangdong	Regional	isisMiTAP
<i>Qianyuan Daily</i>	Guangzhou, Guangdong	Local	isisMiTAP
<i>Shantou</i>	Shantou, Guangdong	Local	isisMiTAP
<i>SiHui</i>	SiHui, Guangdong	Local	isisMiTAP
<i>Shantou City News</i>	Shantou, Guangdong	Local	isisMiTAP
<i>Strait Times</i>	Fujian, Guangdong	Local/Regional	isisMiTAP
<i>Shantou Special Zone Evening News</i>	Shantou, Guangdong	Local/Regional	isisMiTAP
<i>Shenzhen Daily</i>	Shenzhen, Guangdong	Local/Regional	isisMiTAP
<i>Xianmen Daily</i>	Xianmen, Guangdong	Local	isisMiTAP
<i>Yancheng Evening News</i>	Guangdong	Regional	isisMiTAP
<i>YunFu</i>	YunFu, Guangdong	Local	isisMiTAP
<i>Zhuhai</i>	Zhuhai, Guangdong	Local	isisMiTAP
<i>Zhuhai Daily</i>	Zhuhai, Guangdong	Local	isisMiTAP
<i>Zhuhai Eveing Post</i>	Zhuhai, Guangdong	Local	isisMiTAP
<i>Takung Daily News</i>	Hong Kong	Regional/Local	isisMiTAP
<i>Hongkong Wen Wei Po</i>	Hong Kong	Regional	isisMiTAP

RESULTS AND ANALYSIS

As we performed the search described above, we documented both direct and indirect indications and warnings of the SARS epidemic in China (see Box 1). In contrast with other infectious diseases, such as Venezuelan equine encephalitis and Rift Valley fever (see the related papers in this issue), enviroclimatic indications and warnings of SARS were unknown and thus were not examined. Thus, the direct indications and warnings of SARS fell into the category of *reports of human disease*. These reports contained evidence of high or unusual mortality or morbidity in the human population or in a particular job sector, such as health care. Additionally, they provided information on the spread of disease within multiple medical facilities or geographical locations. Indirect indications and warnings of SARS fell into six categories of social disruption:

- *Official action* undertaken by authorities, including investigations, activation of biosurveillance or screening, implementation of countermeasures, prosecution of individuals, and “social stability” enforcement (forcing medical personnel to abstain from quitting), as well as extensive campaigns to suppress information.
- *Official acknowledgment* of a biological event. Whereas Chinese officials at various political and regional levels accepted or denied the presence of the SARS epidemic, media accounts varied from asserting that information on SARS cases was classified to declaring that regional Communist Party Secretaries were directly accountable for accurate reporting of SARS cases.
- Increased *demand for medical services*. Articles reported an increased demand for medical care and supplies across multiple areas and hospitals, as well as mobilization of resources to assist in the relief effort (such as pharmaceuticals, vaccines, supplies, and manpower).

- An increase over time in the *local perception of threat*. Articles provided accounts of public concern or anxiety; self-preservation behavior, such as rioting to prevent construction of SARS-designated hospitals in a community; and public outcry regarding the handling of the epidemic.
- *Compromised infrastructure*. Initial shortages of beds at SARS-designated hospitals suggested compromised infrastructure. In later stages of the epidemic, the media reported rumors of hospital closures, hospitals refusing to admit additional patients, desertions by health care staff, and police cordoning off both SARS-designated and other hospitals with overflowing patient loads – all suggesting a profound infrastructure collapse.
- *Change in business practices*. Increased perception of threat and subsequent hoarding of drugs and staples influenced the decision among grocery stores and pharmacies to increase prices ten to twelve fold just days after wide-spread rumors of “lung virus” and “mystery virus” began in December 2002 and January 2003.

Box 1. Indications and Warnings of the SARS Epidemic in China, 2002–2003

Direct indications and warnings

Reports of human disease

Indirect indications and warnings

- Official acknowledgment
- Official action
- Demand for medical services
- Local perception of threat
- Comprised infrastructure
- Change in business practices

In sum, our examination of the previously mentioned sources revealed indications and warnings of increasing complexity and diversification, suggesting a biological event that progressed from moderate infrastructural impact to a situation of total loss of containment (see Figure 1). These indications and warnings are detailed below.

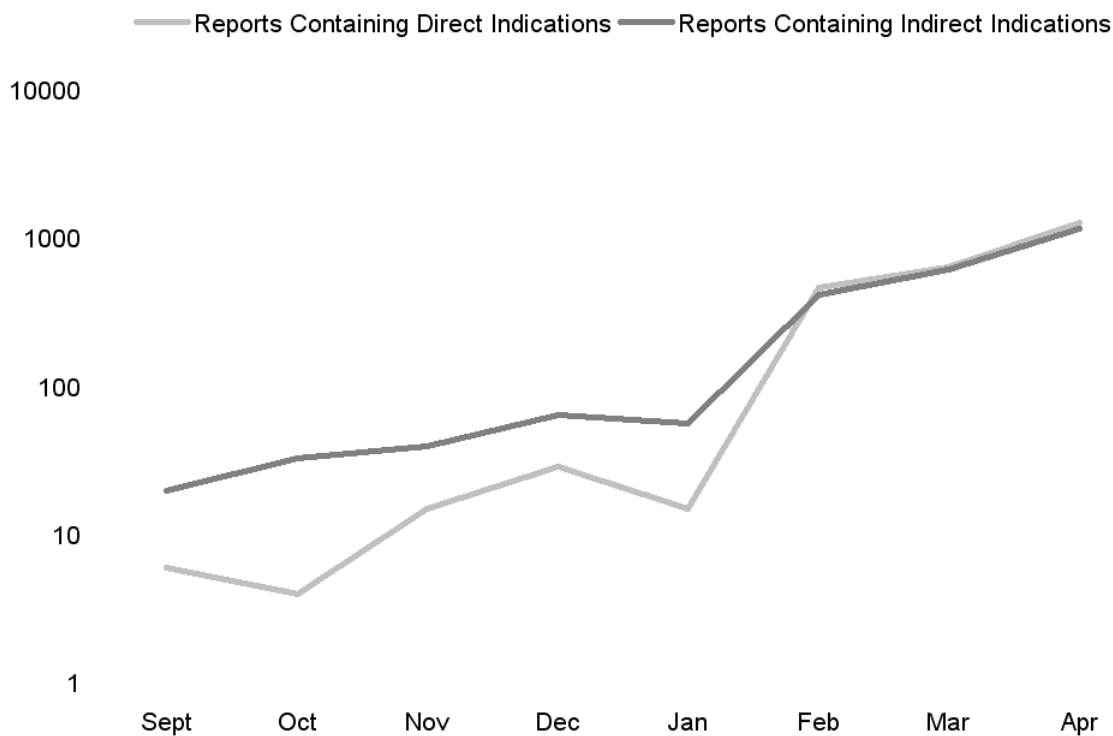


Figure 1. Logarithmic progression of numbers of reports, by month, of direct and indirect indications and warnings of the 2002 and 2003 SARS epidemic in China, including local, regional, and national media reports, ProMED postings, and WHO and CDC announcements.

September 2002

On September 17, 2002, *Guangzhou Daily* and *Information Times*, regional newspapers in Guangdong Province, provided *direct reports* of an abrupt, unseasonal appearance of influenza-like illness in humans in the province. [28-29] One newspaper stated that during the first two weeks of September, Guangzhou Traditional Medicine University Hospital received 7,000 patients with “acute respiratory viral illness,” 30 percent of whom were confirmed to have influenza – a 20 percent increase compared with the 2001 influenza season. [30] Similarly, experts interviewed in September by *Zhuhai Daily*, another regional newspaper in Guangdong Province, advised the elderly, schoolchildren, and health care professionals to be vaccinated against influenza. [31] In addition, several newspapers reported on an unusual outbreak of influenza among clothing factory workers; out of 121, 105 became ill.[32-33] The reports on this incident, describing Guangdong health officials taking precautionary measures during an unexpected influenza outbreak, revealed *official action*.

October 2002

In October, multiple Guangdong newspapers reported on several influenza outbreaks in the province, as well as in northern regions of China. For example, the *Zhujiang Evening Post* stated that Women and Children's Hospital in Zhuhai City, Guangdong, was seeing 300 influenza patients daily. [34] Reports in the local and regional press revealed *official acknowledgment* of influenza and acute respiratory viral infections in Guangdong. Similarly, the *Information Times* of Guangzhou City noted public anxiety and asked residents to remain calm regarding influenza outbreaks in parts of northern China. [35-36] These reports stated that Guangdong was not in "peak flu season" at the time.

November 2002

November saw an increase in dissemination of information on influenza in Guangdong Province. Articles in both local and regional media contained direct and indirect indications and warnings, including *reports of human disease* in the form of case numbers and descriptions, and diversification and amplification of *official acknowledgment* of the disease among children in Beijing and in several Guangdong cities. While regional media detailed this official acknowledgment, local media revealed limited information suppression and official ambiguity.

According to articles in local media, particularly in *Xin Kuai Bao*, health officials in Guangdong reported multiple outbreaks of influenza from September through November 15, 2002. [37-39] According to various local and regional reports, the Guangdong Department of Health (DOH) acknowledged 30 outbreaks of influenza in Guangdong Province, 22 in Guangzhou, and eight in Jiangmen cities. [40-43] DOH officials provided additional indications and warnings of disease by stating that they considered these outbreaks to be abnormal, since the influenza season in Guangdong usually occurs between April and July. [44-45] Furthermore, as noted in *Shentou Special Zone Evening News*, officials stated that 68 percent of all cases were in children. [46] Newspapers noted concurrent diarrhea and colds in pediatric populations as well. [47-48]

Regional media, such as the *Information Times* of Guangzhou, reported *official action* in the form of regional countermeasures, including vaccination advisories and disinfection of public infrastructure. [44] As early as November 28, local media noted *local perception of threat*, stating that Guangzhou city leaders feared disease-associated panic. In addition, local media compared the "flu outbreak" in Guangzhou to a disaster. [49-51]

December 2002

In December, the media contained *reports of human disease* and revealed *official acknowledgment*, *official action*, *local perception of threat*, and *demand for medical services*. Newspapers such as *Shenzhen Daily* and *Guangzhou Daily* reported on unusual disease within their respective regions. [52-59] These articles detailed *reports of human disease* in a quickly expanding, multifocal area. Additionally, accounts of individual

doctors acknowledging pediatric “influenza” outbreaks in Guangdong cities provided anecdotal evidence of official acknowledgment of the disease. [60-66] Officials and newspapers warned about the presence of “flu” in Guangdong Province and discussed the sudden influx of patients at infectious wards of Guangdong hospitals. [58, 60, 62-63, 67-73] Early December brought discussion of *demand for medical services* and *official action* that included several countermeasures, such as issuing influenza warning circulars, asking people to be vaccinated against influenza, increasing medical supplies in emergency rooms, and asking people to avoid places of mass congregation. [52, 54, 67, 73-86]

January 2003

In January, indications and warnings of SARS amplified and diversified, suggesting that the event had intensified. For the first time, multiple newspapers were replete with “rumors of the mysterious virus” and denials that a virus was killing residents of Guangdong Province. [87-91] Newspapers contained *reports of human disease*, citing statistics on “abnormal flu” incidence and spread of the disease among discrete populations, including health care workers and youths, in the affected areas. [92-96] The media coined the phrase “atypical pneumonia” and supplied detailed descriptions of amplified and diversified *local perception of threat*. *Information Times* reported on January 4 that rumors of disease were causing local residents to panic-buy antiviral and antibiotic drugs, which in turn led to local supply depletions. [88, 97-100] Reports of increased numbers of patients in local emergency rooms proliferated as well. [94, 101] Several articles were designed to allay the public’s fears by providing preventative information or detailing *official action* on the part of regional authorities, including containment techniques and other countermeasures. [92, 94, 102-109] National and regional sources reported *demand for medical services*, including transportation of new supplies of antiviral drugs from surrounding regions to affected areas. The regional and local press expanded on this topic, criticizing *changes in business practices*, such as widespread profiteering from sales of antibiotics and antiviral medications. [88-90, 97, 99-100]

February 2003

During this month, China was celebrating the Lunar New Year, a holiday during which many Chinese visit family and friends both nationally and internationally. [110] Migrant workers in China used this time to visit families in their home provinces, and Guangdong Province, as a major industrial center, experienced no exception to this trend. This situation represented a major change in the potential for the spread of disease through the transportation grid.

Following a short break in reporting due to the holiday, articles in regional and local newspapers in Guangdong contained several direct indications and warnings of disease, reporting on rumors of epidemic pneumonia, as well as on increased disease prevalence and resulting high mortality. [111-153] Initially, there was confusion over the

nature of the disease, with medical experts struggling to identify the pathogen involved. [146, 149, 152, 154-162, 179-180] Officials used newspapers, such as the *Zhuhai Daily*, *Information Times*, *Zhujiang Evening Post*, *Yangcheng Evening News*, *Shantou News*, and *Guangzhou Daily*, as a means of *official acknowledgment*, initially in the form of denial. [111-113, 115-116, 163-165, 169] These newspapers also provided up-to-date reporting on *official action*, such as countermeasures. Discussion of prophylactic treatments, as well as circulars describing the disease and ways to prevent it, dominated Guangdong newspapers. [111-112, 135, 139, 140-142, 144, 166-184] The countermeasures included disinfecting facilities and means of transportation, sending out circulars to the population at large, establishing disease hotlines, conducting public awareness campaigns, and creating special infectious wards for SARS patients or transferring them to military hospitals to avoid accountability. [111, 135, 137-140, 166, 168-170, 174, 184-207] Newspapers served as the government's conduit for denying rumors. Nonetheless, consistent claims of a "nonexistent" virus increased public anxiety, which in turn led to abandonment of traditional means of public transportation, such as subways; a decrease in public congregations; and voluntary avoidance of hospitals and public parks. [189, 192, 208-216] *Official acknowledgment* took a form that revealed information suppression and a lack of communication among Chinese governmental and party organizations. [217-218]

The continuing disease-related news items in Chinese newspapers drew the attention of international media and international health organizations. [219-221] WHO was alerted to the real possibility of a new, rapidly transmitted respiratory viral pathogen on February 10 and 11 via an email and a media report issued by the Guangzhou Bureau of Health. Increased dialogue with Chinese officials ensued in an attempt to verify the outbreak. The WHO pandemic influenza plan was activated on February 20 when Hong Kong reported two human cases of avian influenza (H5N1).

The proliferation of indirect indications and warnings in early February illustrates the exploding impact of SARS. The media reported on *local perception of threat* in the form of self-preservation behaviors such as province-wide panic buying and self-medication. [124, 136, 143, 200, 222-241, 243-246] In addition, the media sensed the weakness of regional party leaders and exposed their ineptitude in editorials. [217, 242] Critical discussion of sharp increases in the prices of vinegar and drugs and other staples, as well as an emerging black market and increased demand for traditional medicines, evidenced *changes in business practices*. [112, 222-223, 229, 231, 235, 237, 239, 243-263]

The *official action* taken by the government diversified. In addition to disease countermeasures, reports noted that the government was engaged in criminal prosecution of rumor mongering, selling of fake drugs, and profiteering. [119, 131, 210, 224, 227, 233, 247, 252, 264-273]

The Chinese government attempted to use the media as a means to counter rumors of a quickly spreading epidemic of SARS, urging people not to believe the rumors and denying the epidemic's spread. [119-120] These reports denied deaths among hospital workers, cautioned against rumor mongering about the "abnormal fever," and claimed control of the epidemic. [116, 121, 205-206, 213, 271, 274-299] By the end of February, the city government had reversed the official stance on SARS with a statement from the

Guangzhou Vice Mayor acknowledging that the epidemic was not yet under control. [300]

February marked the first reports of *compromised infrastructure*. Articles noted rumors and denials of hospital closures, as well as civilian infrastructure quarantines. [301-303]

March 2003

March saw a significant increase in discussion of SARS both in China and internationally. *Reports of human disease* increased, *local perception of threat* amplified and diversified, *official action* continued, and *changes in business practices* diversified. In previous months, newspapers had navigated around the topic, towing the government line and carefully inserting “rumors,” hearsay, and other such terms into the discussion of the presence and transmission of disease. By contrast, in March, they actively discussed the events, asked readers how they felt about the issue, and presented their own views, even if they ran contrary to those of the local or regional government. [304-328]

Reports of human disease and deaths among the public and health care workers were present both in official government pronouncements and in the newspapers. [329] For the first time, regional and national governments were acknowledging a significant rise in SARS mortality and morbidity statistics. [317-319, 330-331] Multiple reports described the incidence of the disease in health care workers. [317, 319, 321, 332-333]

Indirect indications and warnings presented a picture of a Chinese society struggling to understand the true nature of the threat, to prevent its spread at all costs, and to remain stable. *Official acknowledgment* of the threat was no longer a novel occurrence; rather, it occupied the front pages of Chinese newspapers. The government reversed its strategy of partial denial and, through various spokespersons, reported SARS events as they progressed. [328, 334-347] However, this information was designed for domestic consumption. As late as March 18, 2003, the Chinese Minister of Health refused to comment internationally on the rumors that SARS had spread to areas of China other than Guangdong Province. [348-350]

Official action focused on taking disease prevention countermeasures, arresting rumormongers and profiteers, and pacifying the population at large. [327, 344, 347, 351-355] The government issued SARS warning circulars; sent thousands of expedition teams to find diseased patients; forced suspected SARS patients to self-quarantine; and imposed closures of businesses, libraries, schools, and other areas of mass congregation. [337, 345-346, 356-362]

The media also described *demand for medical services*, with reports of Beijing hotels, resorts, and sanatoriums being overtaken by the Beijing municipal government. An order issued by the city authorities did not specify how the facilities would be used, but *South China Morning Post* analysts believed that the government was eager to find new sites in the suburbs to accommodate medical staff and patients who were recovering. These reports also focused on heightened *local perception of threat*, noting multifocal barricading from the outside world, massive panic buying, and hoarding of staples and herbal medications believed to fight off SARS. [340, 363-365] Residents continued to avoid businesses, means of public transportation, and other areas of mass congregation.

[366-367] Wearing of surgical masks became ubiquitous in such venues as horse races, college entrance exams, and workplaces. People gave offerings at Buddhist temples, praying for the disease outbreak to stop. [332, 368-375] According to newspaper reports, even Triad gangsters were involved in selling cheap surgical masks in Hong Kong's Tsim Sha Tshui district. Furthermore, as the disease spread to Hong Kong, public expression of displeasure with the government intensified. [335, 376-377] Multiple polls taken by Hong Kong radio and television stations revealed that 65 percent of respondents were critical of the government for mishandling the event; 76 percent believed SARS was going to spread further; and 53 percent feared becoming infected themselves. [378]

Finally, evidence of *compromised infrastructure* appeared when the media reported that SARS-designated hospitals had opened, an entire school system in Hong Kong had closed, various mass events had been cancelled, road traffic in Hong Kong had been suspended, schools had been quarantined, workers were absent from their jobs, and businesses had closed either temporarily or permanently. [379-384]

April 2003

The greatest number of articles including direct and indirect indications and warnings of social disruption appeared in April 2003. However, the sophistication and quality of the articles varied because of an official ban on SARS reporting in Guangzhou.

Reports of human disease among health care workers and the public continued throughout April in national and regional newspapers. [385-395] The government provided up-to-date reporting, punished deceitful officials, and made provincial party personnel responsible for accurate case counting. [396-398]

Indirect indications and warnings continued to diversify and amplify as the disease challenged the fabric of daily life in China. In April, *official acknowledgment* no longer involved denying the disease; rather, the presence of the disease was confirmed in areas previously rumored to be infected. [399-400] *Official action* included maximal enforcement of countermeasures, as well as criminal prosecution for hoarding, speculation, and illegal manufacturing of medical supplies, antiviral medications, and general staples. [393, 394, 401-414] In addition, *official action* was taken by providing sustained medical relief for SARS patients. [415-416] The government prosecuted health care workers and medical facilities for refusing to treat SARS patients and posted guards at hospital entrances and exits to prevent medical staff from leaving hospitals. [417-420] Also, the government attempted to decrease the burden on medical workers by mobilizing military doctors and providing additional benefits to keep them working. [391, 421-427] In some cases, the police arrested runaway SARS patients and ordered mandatory home confinement of all members of households with confirmed SARS patients. [428-429]

Demand for medical services appeared when the media reported that army medics were being mobilized to fight SARS in Beijing, and that medical supplies were being airlifted to stockpile-depleted areas. These reports also revealed heightened *local perception of threat*, noting multifocal rioting and voluntary evacuation, worker protests, discrimination against workers with SARS and SARS victims, and various efforts at self-preservation. [416, 424, 430-443]

Finally, *compromised infrastructure* was reported in the form of hospital closures in SARS-affected areas; designation of special SARS hospitals; temporary closures and work suspensions among national cultural, financial, and historical institutions; and suspension of major tests used to determine the future of young graduates from law and engineering universities. [391, 419, 444-464] Additionally, temporary suspension of marriage licenses in Beijing and 24-hour cremation of SARS victims demonstrated that the very fabric of social life in China had been damaged. [465-466]

CONCLUSIONS

As shown in Figure 1, reporting on SARS by indigenous and international media increased over time. The epidemic began in the context of an abrupt, reportedly “unseasonal” appearance of influenza. As with Venezuelan equine encephalitis and Rift Valley fever, this biological event was not simply an epidemic involving a single novel pathogen, but most likely a multi-pathogen event. It could be argued that influenza had placed a background strain on the Chinese medical infrastructure at the same time that SARS became an increasingly serious public health threat, and that this situation, coupled with confusion regarding the diagnostic etiology of the disease, facilitated loss of containment.

As the epidemic progressed, local public awareness and anxiety increased, despite the government’s attempts to suppress information. Local pharmaceutical, herbal, and medical supplies were depleted when the medical infrastructure exhibited strain. This situation contributed to escalating public panic, loss of confidence in officials, and eventual rioting. In summary, SARS proceeded from a unifocal biological event, to a multifocal one, and finally to a socially disruptive one that eventually resulted in infrastructure strain and collapse.

SARS represented the first event during which the WHO’s Global Outbreak and Alert Network (GOARN) was alerted to a rapidly spreading transnational threat. The WHO was first notified on February 10 and 11, 2003, via an email and a media report issued by the Guangzhou Bureau of Health. This notification prompted increased dialogue between the WHO and Chinese officials in an attempt to verify the outbreak. Our retrospective indication and warning analysis of open-source news suggests that SARS transmission may have begun as early as September or October 2002; however, epidemiological studies have been able to confirm its start no earlier than November. One of the poignant lessons learned by GOARN was that, “as many times occurs with emerging and reemerging infectious diseases, national surveillance mechanisms failed to identify and respond to the emerging outbreak of SARS early enough to prevent its toll of sickness, death, and international spread.” [467] This point was reinforced by the fact that WHO’s Global Alert was issued after eight countries throughout the world had already been affected by the epidemic. Apparent in hindsight is the significant confusion that was involved in determining the nature of the threat as it began to manifest itself from September 2002 to February 2003.

This case study demonstrates that biological threats may be rapidly detected and characterized using a model that is independent of traditional national surveillance mechanisms. Using multiple categories of indications and warnings to analyze reports of

social disruption related to SARS in the PRC may have prompted more timely scrutiny in anticipation of an uncontained biological event. This model and process could serve as a valuable adjunct to the current threat detection and assessment capabilities of GOARN and its international partners.

The identity and characteristics of particular indications and warnings will vary with the disease involved and the social routines of the affected culture. Determining what constitutes indications and warnings may depend on understanding local disease baselines and social conditions. Reports in local and regional indigenous media provide valuable information because they reflect timely, qualitative knowledge of typical and atypical phenomena. Further research is needed to determine the broader applicability of the indication and warning approach across time periods, societies, and pathogens.

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