Colloque International de Statistique Appliquée pour le Développement en Afrique
International Conference on Applied Statistics for Development in Africa

Sada'07 nn, 1–2 (2007)

SPATIO-TEMPORAL EXPLORATION OF SARS EPIDEMIC

Arnaud Banos

Abstract. The Severe Acute Respiratory Syndrome (SARS) appeared in November 2002 in China. Between March and July 2003, the virus dramatically spread, reaching 30 countries all over the world and obtaining rapidly the status of "first pandemic of the XXIth Century". Six months after its second emergence in Hong-Kong in March, more than 8500 cases had been identified, and 800 people had died from that new coronavirus. We propose a spatio-temporal exploration of national numbers published daily by the World Health Organization during that period, providing original insights on that major epidemic

Keywords: Animated Cartography, Geovisualization, GIS, SARS, Spatio-temporal information

§1. Main lessons from SARS

While the SARS epidemic was retaining great attention from medias, becoming the major world event of the moment with Iraq war, one couldn't help questioning the epidemiologic numbers updated daily by WHO (figure 1) : what could these numbers represent, compared to the score reached by the lethal trio "AIDS-malaria-tuberculosis" (5 to 6 million deaths each year) ?

First, as Bary R. Bloom quoted recently, "*in the absence of effective vaccines or drugs, infectious diseases that are spread by the respiratory route – whether the influenza epidemic of 1918 that killed 20 to 40 millions people worldwide or measles, which spreads rapidly among children – must be taken very seriously*" (Bloom, 2003). Indeed, two epidemiological studies published at the end of the epidemic draw the conclusion that the SARS coronavirus was sufficiently transmissible to infect a majority of people, and from that perspective was able to cause - if uncontrolled - a very large epidemic (Lipsitch and al., 2003 ; Rilez and al., 2003).

Second, the fatality rate of that new virus proved to be higher than expected: it was estimated to 13.2% for patients younger than 60 years and 43.3% for patients aged 60 years or older (Donnely and al., 2003). Two points that highlight how lucky we were the virus spared Africa…

Third, beyond this fortunately limited - but real - human burden, economic consequences proved to be dramatic. Thus, Singapore experienced a significant decrease of its GNP (around 4.3 %) during the epidemic period, due to a spectacular fall of its tourist activity (minus 63 %). The cost for China was evaluated around 20 billions dollars, while for Canada it raised 1.2 billion dollars, medical costs not being taken into account (Zylberman, 2004).

More generally, the SARS episode revealed a great weakness of our global and networked society: the virus spread dramatically in a few days from the Hong-Kong source through intercontinental flights, managing to establish itself in a large city of a well developed country, Toronto.

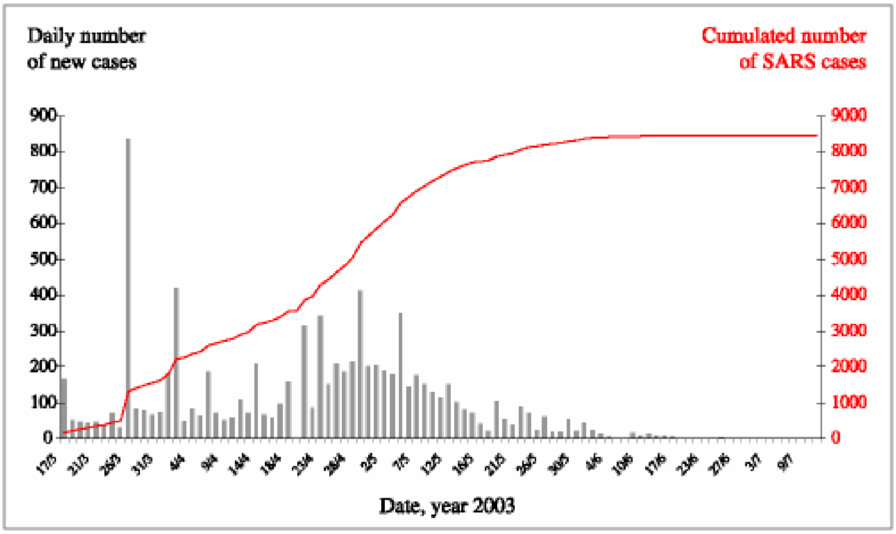

Figure 1: A time-line view of the SARS outbreak
(Source : WHO, http://www.who.int/en/)

Therefore, one of the great lessons from SARS is that we need an efficient global health network to cope with such unanticipated outbreaks as the security of even rich countries, from now on, depends on our capacity to identify potential health threats around the world and to address them locally. From that perspective, the SARS epidemic is very remarkable, as Bary Bloom underlined : "*in the 1980s, it took 2 years to identify HIV as the cause of AIDS. In 2003, WHO created and extraordinary network of 13 laboratories in 10 countries, which identified a virus associated with SARS in 2 weeks and had its entire genome sequenced in two more. Those labs shared their knowledge in an unprecedented fashion, to the benefit of everyone*" (Bloom, 2003).

§2. Geographical spread of the SARS epidemic

Rapidly identified as a major world event, SARS inspired a large number of epidemiologic studies, dealing with various crucial aspects of the phenomenon. But, from our point of view, a basic perspective of the geographical spread of the SARS epidemic was still missing. Yet, appropriate data existed that may help reveal the global dynamic of the virus propagation. Indeed, as soon as the World Health Organization (WHO) declared a global alert - the first of its history, daily statistics on the epidemic became available on its website. Believing, as a geographer, that a map is worth a thousand numbers, we tried to shed new light on that fascinating world phenomenon, from the public database available online [http://www.who.int/en/]. Having such a perspective in mind, we therefore created two "lively" maps and made them available on the Internet [http://www.univ-pau.fr/~banos/sars_epidemic.html], allowing anyone to explore the SARS epidemic from a geographic perspective.

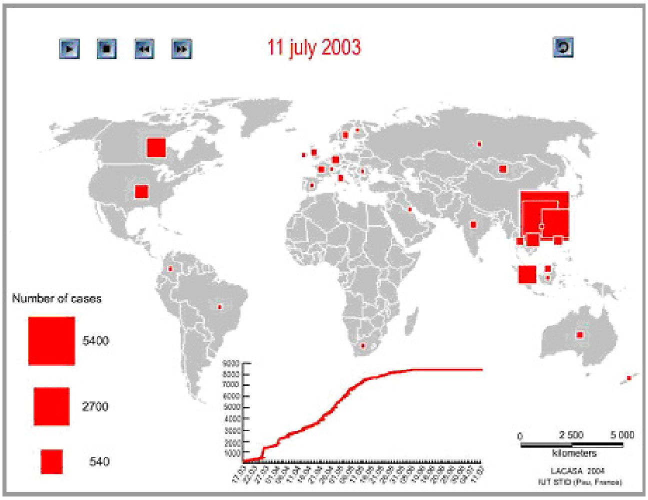

Figure 2: The generic map designed

The first animation [http://www.univ-pau.fr/~banos/maps.html] provides therefore a global view of the world diffusion of SARS (Figure 2). It is based on day-by-day maps of the phenomenon, such as the one below. Note that China'symbol is localised on the Guangdong province, where most of the cases occurred. Symbols' size follows a logarithmic scale, in order to allow countries concerned with only few cases of SARS to be visible. The graph at the bottom shows the global cumulative curve of the SARS cases, from the beginning to the end of the alert. Finally, upper buttons allow interactive and automated navigation through the animation. Figure 3 shows the kind of pattern revealed by such an animation.

Figure 3: Overview of the map animation
[Full animation: http://www.univ-pau.fr/~banos/sars_epidemic.html]

Note that the global cumulative curve of the SARS cases grows gradually, revealing the day-by-day progression of the virus. Note also the dramatic geographic spread of the virus, which had reached most of its "target" countries by 1st of April. Note finally the cumulative self-enforcement of the Asian original source, the rapid growth of the Canadian one (Toronto) and the remarkable quietness of Africa and South-America.

Such a dynamic animation proves useful to reveal the spreading process of the virus at a global scale and to communicate about it. Since it is based on raw data produced by the World Health Organization, it could be generated and updated daily, providing the scientific community and the public a more eloquent view of the phenomenon running. However, it can hardly be considered as a self-sufficient document, based as it is on a single scale, the macro-geographic one.

§3. Back to local

It is our belief that modern science must - and more and more often does - provide multiple views on a single problem (Banos and al., 2003). Therefore, we provide a second animation, allowing for more localised explorations to be led (Figure 4).

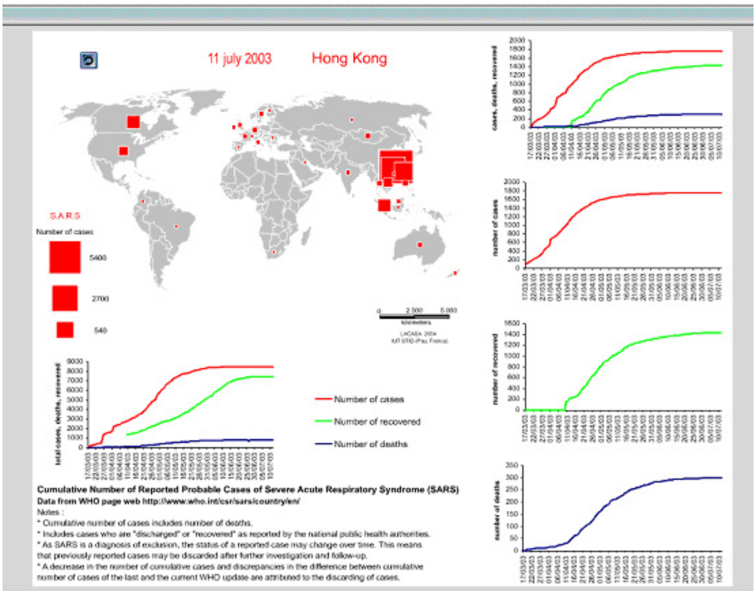

Figure 4: Interactive local exploration of the SARS epidemic
[Full animation: http://www.univ-pau.fr/~banos/series.html]

Dynamic linked graphics are thus as simple as powerful tools to investigate one's data set, particularly in a space-time perspective, by simply linking the spatial and temporal dimensions through appropriate graphs. We exploit here the Flash technology, allowing the user to click on a SARS case symbol on the map, so as to display different cumulative curves drawn from WHO data: cumulative number of cases, recovered and deaths.

For each selected country, the desktop is composed as follows: the world cumulative curves appear below the map, while the different country specific curves appear on the right side, jointly then separately. The sigmoidally (or S-shaped) curved displayed here is quite typical of epidemic outbreaks that tend to occur as well-marked epidemic waves rather than in temporally uniform or random forms (Cliff and al., 1986). Between the starting point (WHO alert here) and the saturation level (upper limit for each curve), the shape of the curve shows the day-to-day rate of growth. The key point here concerns our ability to compare different curves for different countries, identifying at a glance various local dynamics of the epidemic (figure 5).

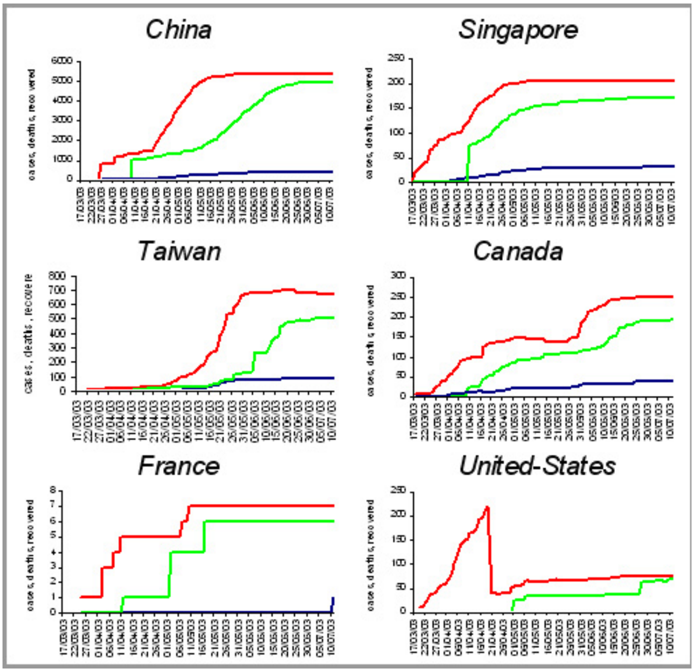

Figure 5: A bouquet of epidemiologic curves

Each curve indeed tells a story: the China one reveals the late acknowledgement of the local SARS disaster, as well as the lasting will of China authorities to minimize its consequences. Singapore and Taiwan reveal two different timings of the epidemic. The Canadian curve warns of the need to maintain vigilance, as a resurgence of cases is always possible. The French curve shows a strictly controlled and contained epidemic, where each new case has been identified and isolated rapidly. Finally, the US curve reveals a systematic over-estimation of cases at the beginning of the epidemic, underlying the problem of accuracy in such sensitive data.

§4. Conclusion

Our objective was to provide original insights on the SARS epidemic and to highlight the exploratory power of animated and interactive maps as spatial surveillance tools. Hence, the two documents proposed and made available on the Internet underline the complexity of the epidemic process and the high variability of local situations a "smooth" global pattern can be composed of. Two crucial parameters -amongst many - we need to control before building any diffusion model.

References

[1] BANOS A., BANOS F., 2003 Towards integrated spatial surveillance tools of urban risks : space-time analysis of road accidents in Lille, in Géographie des risques des transports, BANOS Arnaud and al. Editors, Paradigme, Orléans, pp. 9-22

[2] BLOOM B., 2003 Editorial: Lessons from SARS, Science, vol. 300, p. 701

[3] CLIFF A., HAGGETT P., ORD J., 1986 Spatial aspects of influenza epidemics, Pion Limited, 280 p.

[4] DONNELY C., GHANI A., LEUNG G. and al., 2003 Epidemiological determinants of spread of causal agent of severe acute respiratory syndrome in Hong Kong, The Lancet, Vol. 361, pp. 1761-1766

[5] LIPSITCH M., COHEN T., COOPER B. and al., 2003 Transmission dynamics and control of severe acute respiratory syndrome, Science, Vol. 300, pp. 1966-1970.

[6] RILEY S., FRASER C., DONNELLY C. and al., 2003 Transmission dynamics of the etiological agent of SARS in Hong-Kong : impact of public health interventions, Science, Vol. 300, pp. 1961-1966

[7] ZYLBERMAN P., 2004 Le SRAS, une épidémie postmoderne ?, La Recherche, n° 371, pp. 46-47

Arnaud Banos
SET (UMR 5603 CNRS), Université de Pau, France
Arnaud.banos@univ-pau.fr