SARS: What the Figures Say

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Measuring the Spread of Infection

How best to track the spread and lethality of SARS? First, spread. The country-based epidemic curves that WHO publishes exclude cases where the date of onset is unknown and are consequently vulnerable to mismeasurement. Daily series for each country are highly volatile. However, longer term series that are more likely to be complete and are updated daily may be used to compute a control variable for the spread of the infection. This control variable may be called the infection spread rate.

Define the spread rate *s* as the number of people currently infected by one person who was infected in the past. While $s > 1$ the number of new cases is rising, and while $0 < s < 1$ the infection continues to spread but at a diminishing rate; $s - 1$ is the growth rate in the number of current infections over the previous infection period where the latter is the number of days over which the sufferer is normally infectious.

The WHO publishes daily figures for the cumulative number of cases to date, Y_n, and the totals of cases already concluded by death or recovery from which X_n, the cumulative total of concluded cases, may be computed; *n* is the serial number of the current infection period counting from the first transmission to the country concerned or, globally, to the first human victim.

Given X_n and Y_n we can compute the steady-state value of *s* both globally and in each country, where "steady-state" means we assume a stable rate of spread since the beginning of the infection. Of course in practice the rate of spread is not stable. It varies according to demography, geography, and counter-measures which have proved to be effective in some countries and not others. Still, it will sensitively indicate the degree of the current problem presented by demography and geography and the current progress of the counter-measures. It is computed as the ratio of Y_n to X_n. In the steady state, by definition,

1. $Y_n = 1 + s + s^2 + \ldots + s^n$ and

2. $$X_n = Y_n - s^n$$
$$= 1 + s + s^2 + \ldots + s^{n-1}$$

Where s has a steady value of $\hat{s}$, it follows that

3. $$X_n = \frac{1 - \hat{s}^n}{1 - \hat{s}}$$
$$= \frac{1 - (Y_n - X_n)}{1 - \hat{s}}$$

Therefore

4. $\hat{s} = \frac{Y_n - 1}{X_n} \rightarrow \frac{Y_n}{X_n}$ when X_n is large.

This gives the spread rate but not the period over which it spreads. Define the infection period *p* as the number of days over which a victim is infectious. The value

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of p can be computed from t, the time elapsed in days since first infection, and n, the number of intervals. The number of intervals is given from the fact that $\hat{s}$ is the nth root of $\hat{s}^n = X_n - Y_n$, so that $n = \frac{\log(X_n - Y_n)}{\log \hat{s}}$, and $p = \frac{t}{n}$. This variable is relevant only for countries where there has been onward transmission and the date of first infection is known. Therefore I calculate p only globally. I do the same for the daily spread rate of the infection, $g = \hat{s}^{\frac{1}{p}} - 1$.

Measuring the Lethality of Infection

Second, the crude death rate d associated with the disease in each country and globally may be computed as the cumulative number of deaths divided by the cumulative total of concluded cases, that is X_n, not Y_n, since the latter includes a number of victims who will die but have not died yet; thus $d = \frac{D_n}{X_n}$.

Current Figures on Spread and Mortality

The table overleaf shows the current state of the disease worldwide. According to the figures, SARS has spread over the past six months in such a way that the cumulative total of victims has increased globally at the rate of 4.2% a day. The global figures suggest that, with an infection period of approximately two weeks, each infectious person has on average infected 1.75 others. Globally the disease is now spreading more slowly than a month ago, when the spread rate was closer to 2.0.

I calculate country statistics for the spread rate, growth rate, and death rate for those countries where the cumulative total of cases is currently 50 or more. Taking the global average as a benchmark SARS appears to be continuing to spread more or less unchecked in two countries: China (row 4) and Taiwan (row 7). I discount the case of the United States (row 30) on the grounds that the high stock of current to concluded cases there is not associated with local transmission according the WHO (http://www.who.int/csr/sars/areas/2003_05_19/en/). SARS is being controlled in Canada, Hong Kong, and Singapore, and has been controlled in Vietnam. For Vietnam, for example, the steady-state spread rate $\hat{s}$ is now computed as exactly 1.0 because the cumulative number of concluded cases is the now same as that of all cases; the disease has ceased to spread.

There are wide variations in local mortality; globally the crude death rate is currently 14 per cent.

Since China accounts for the majority of world cases, the diagnosis for the world is that at present, while a number of local outbreaks have been controlled, there is still an uncontrolled focus of infection. The fact that globally (row 31) the incidence of Sars is no longer doubling every two weeks appears to be mainly due to the leakage of cases from China to rich countries such as the United States where, with limited numbers and superior detection and handling, the infection is prevented from spreading further.

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Current Figures

From: 1 Nov 2002 To: 19 May 2003, 18:00 GMT+2

	Country	Cumulative number of case(s)	Number of deaths	Number recovered	Date last probable case reported	Date for which cumulative number of cases is current	Spread rate, *s*	Infection period, *p*	Daily growth rate, *g*	Crude death rate, *d*
		1	2	3	4	5	6 = 1:(2+3)	7. See text	8. See text	9 = 2:(2+3)
1	Australia	6	0	6	12/May/2003	19/May/2003	...	...	...	...
2	Brazil	2	0	2	10/Apr/2003	24/Apr/2003	...	...	...	...
3	Canada	140	23	106	4/May/2003	16/May/2003	1.09	...	...	18%
4	China	5236	289	2148	19/May/2003	19/May/2003	2.15	...	...	12%
5	China, Hong Kong Special Administrative Region[5]	1714	251	1213	19/May/2003	19/May/2003	1.17	...	...	17%
6	China, Macao Special Administrative Region	1	0	0	9/May/2003	15/May/2003	...	...	...	...
7	China, Taiwan	344	40	50	18/May/2003	18/May/2003	3.82	...	...	44%
8	Colombia	1	0	1	5/May/2003	5/May/2003	...	...	...	...
9	Finland	1	0	0	7/May/2003	15/May/2003	...	...	...	...
10	France	7	0	6	9/May/2003	16/May/2003	...	...	...	...
11	Germany	9	0	9	9/May/2003	19/May/2003	...	...	...	...
12	India	3	0	3	13/May/2003	14/May/2003	...	...	...	...
13	Indonesia	2	0	2	23/Apr/2003	19/May/2003	...	...	...	...
14	Italy	9	0	9	29/Apr/2003	19/May/2003	...	...	...	...
15	Kuwait	1	0	1	9/Apr/2003	20/Apr/2003	...	...	...	...
16	Malaysia	7	2	5	9/May/2003	19/May/2003	...	...	...	...
17	Mongolia	9	0	8	6/May/2003	19/May/2003	...	...	...	...
18	New Zealand	1	0	1	30/Apr/2003	19/May/2003	...	...	...	...
19	Philippines	12	2	8	15/May/2003	19/May/2003	...	...	...	...
20	Republic of Ireland	1	0	1	21/Mar/2003	16/May/2003	...	...	...	...
21	Republic of Korea	3	0	1	14/May/2003	19/May/2003	...	...	...	...
22	Romania	1	0	1	27/Mar/2003	22/Apr/2003	...	...	...	...
23	Singapore	206	28	160	18/May/2003	18/May/2003	1.10	...	...	15%
24	South Africa	1	1	0	9/Apr/2003	3/May/2003	...	...	...	...
25	Spain	1	0	1	2/Apr/2003	7/May/2003	...	...	...	...
26	Sweden	3	0	3	18/Apr/2003	13/May/2003	...	...	...	...
27	Switzerland	1	0	1	17/Mar/2003	16/May/2003	...	...	...	...
28	Thailand	8	2	5	13/May/2003	18/May/2003	...	...	...	...
29	United Kingdom	4	0	4	29/Apr/2003	16/May/2003	...	...	...	...
30	United States	67	0	34	17/May/2003	17/May/2003	1.97	...	...	0%
31	Viet Nam	63	5	58	14/Apr/2003	14/May/2003	1.00	...	...	8%
32	**Total**	**7864**	**643**	**3847**			**1.75**	**13.7**	**4.2%**	**14%**

Source, columns 1 to 5: http://www.who.int/csr/sars/country/2003_05_19/en/.