

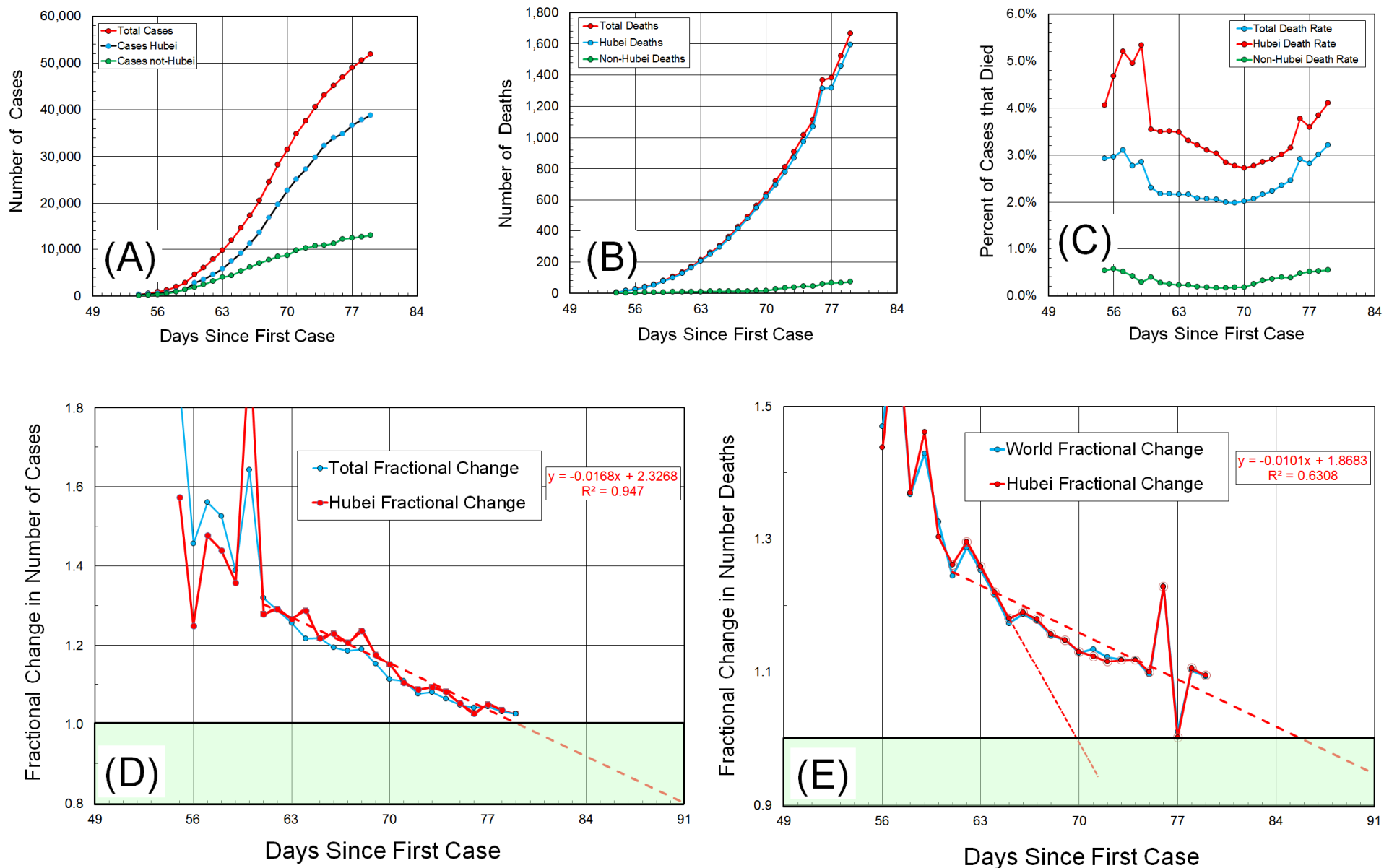
# “17. Analysis of nCov-2019 Data on 2/17/2020” by Michael Levitt, Stanford University, USA

This report is written four days after the previous report (#14), released on 13-Feb (PST). That report attempted to incorporate the additional cases diagnosed by clinical symptoms rather than in the laboratory. We have now chosen to follow the WHO and use the data they release, which does not include these cases. Deaths are not characterized as being from Clinical or Laboratory Diagnosed Cases, although some of the 17,000 additional clinically diagnosed cases may have resulted in death. This uncertainty together with the fluctuations in the number of additional deaths between 13-Feb and 15-Feb make extrapolations less certain.

Date	Day	Number Cases			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases			Fraction Change Number			New/Day Hubei Cases	Deaths
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others		
1/22/2020	54	314	251	63	6	6	0	1.91%	2.39%	0.00%	-								
1/23/2020	55	581	395	186	17	16	1	2.94%	4.06%	0.54%	7.6	1.850	1.573	2.961	2.843	2.676	-	144	10
1/24/2020	56	846	494	352	25	23	2	2.96%	4.68%	0.57%	8.2	1.456	1.249	1.895	1.470	1.437	2.000	99	7
1/25/2020	57	1320	729	591	41	38	3	3.10%	5.21%	0.51%	10.3	1.560	1.477	1.677	1.633	1.645	1.500	235	15
1/26/2020	58	2014	1049	965	56	52	4	2.78%	4.96%	0.41%	11.9	1.526	1.440	1.632	1.367	1.370	1.333	320	14
1/27/2020	59	2798	1425	1373	80	76	4	2.86%	5.33%	0.29%	18.3	1.389	1.358	1.423	1.429	1.462	1.000	376	24
1/28/2020	60	4595	2788	1807	106	99	7	2.31%	3.55%	0.39%	9.2	1.642	1.956	1.316	1.326	1.303	1.750	1363	23
1/29/2020	61	6065	3565	2500	132	125	7	2.18%	3.51%	0.28%	12.5	1.320	1.279	1.384	1.245	1.262	1.000	777	26
1/30/2020	62	7818	4607	3211	170	162	8	2.17%	3.52%	0.25%	14.1	1.289	1.292	1.284	1.288	1.296	1.143	1042	37
1/31/2020	63	9826	5836	3990	213	204	9	2.17%	3.50%	0.23%	15.5	1.257	1.267	1.243	1.253	1.259	1.125	1229	42
2/1/2020	64	11953	7517	4436	259	249	10	2.17%	3.31%	0.23%	14.7	1.216	1.288	1.112	1.216	1.221	1.111	1681	45
2/2/2020	65	14557	9156	5401	304	294	10	2.09%	3.21%	0.19%	17.3	1.218	1.218	1.217	1.174	1.181	1.000	1639	45
2/3/2020	66	17391	11264	6127	361	350	11	2.08%	3.11%	0.18%	17.3	1.195	1.230	1.135	1.188	1.190	1.100	2107	56
2/4/2020	67	20630	13593	7037	425	413	12	2.06%	3.04%	0.17%	17.8	1.186	1.207	1.148	1.177	1.180	1.091	2329	63
2/5/2020	68	24554	16809	7745	491	478	13	2.00%	2.84%	0.17%	16.9	1.190	1.237	1.101	1.155	1.157	1.083	3216	65
2/6/2020	69	28276	19767	8509	564	549	15	1.99%	2.78%	0.18%	15.8	1.152	1.176	1.099	1.149	1.148	1.154	2958	71
2/7/2020	70	31481	22740	8741	637	621	16	2.02%	2.73%	0.18%	14.9	1.113	1.150	1.027	1.129	1.131	1.067	2973	72
2/8/2020	71	34886	25114	9772	723	698	25	2.07%	2.78%	0.26%	10.9	1.108	1.104	1.118	1.135	1.124	1.563	2375	77
2/9/2020	72	37558	27304	10254	812	779	33	2.16%	2.85%	0.32%	8.9	1.077	1.087	1.049	1.123	1.116	1.320	2189	81
2/10/2020	73	40554	29841	10713	909	871	38	2.24%	2.92%	0.35%	8.2	1.080	1.093	1.045	1.119	1.118	1.152	2537	92
2/11/2020	74	43103	32278	10825	1017	974	43	2.36%	3.02%	0.40%	7.6	1.063	1.082	1.010	1.119	1.118	1.132	2437	103
2/12/2020	75	45171	33955	11216	1114	1071	43	2.47%	3.15%	0.38%	8.2	1.048	1.052	1.036	1.095	1.099	1.000	1677	97
2/13/2020	76	46997	34874	12123	1369	1316	58	2.91%	3.77%	0.48%	7.9	1.040	1.027	1.081	1.229	1.229	1.349	919	245
2/14/2020	77	49053	36602	12451	1383	1318	64	2.82%	3.60%	0.51%	7.0	1.044	1.050	1.027	1.010	1.002	1.103	1728	2
2/15/2020	78	50580	37884	12696	1524	1457	67	3.01%	3.85%	0.53%	7.3	1.031	1.035	1.020	1.102	1.105	1.047	1282	139
2/16/2020	79	51857	38839	13018	1666	1595	71	3.21%	4.11%	0.55%	7.5	1.025	1.025	1.025	1.093	1.095	1.060	955	138

**Table 1.** Showing data for New Coronavirus 2019 (COVID-19) from 22 January to 16 February 2020. Total Number of Cases and Deaths is taken from the World Health Organization website <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/>. Before 13-Feb., the WHO did not give Cases and Deaths in Hubei so we also use <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as most deaths are in an area centered on Wuhan in Hubei (**Fig. 2**). The Death Rate is the Number Deaths divided by the Number Cases Confirmed, and Ratio Hubei/Others is the ratio of the Death Rate for Hubei to the Death Rate for non-Hubei. The Fraction Change for all raw data is Value\_Today divided by Value\_Yesterday. We also now give the number of New Cases and New Deaths in Hubei each day (subtract yesterday from today).

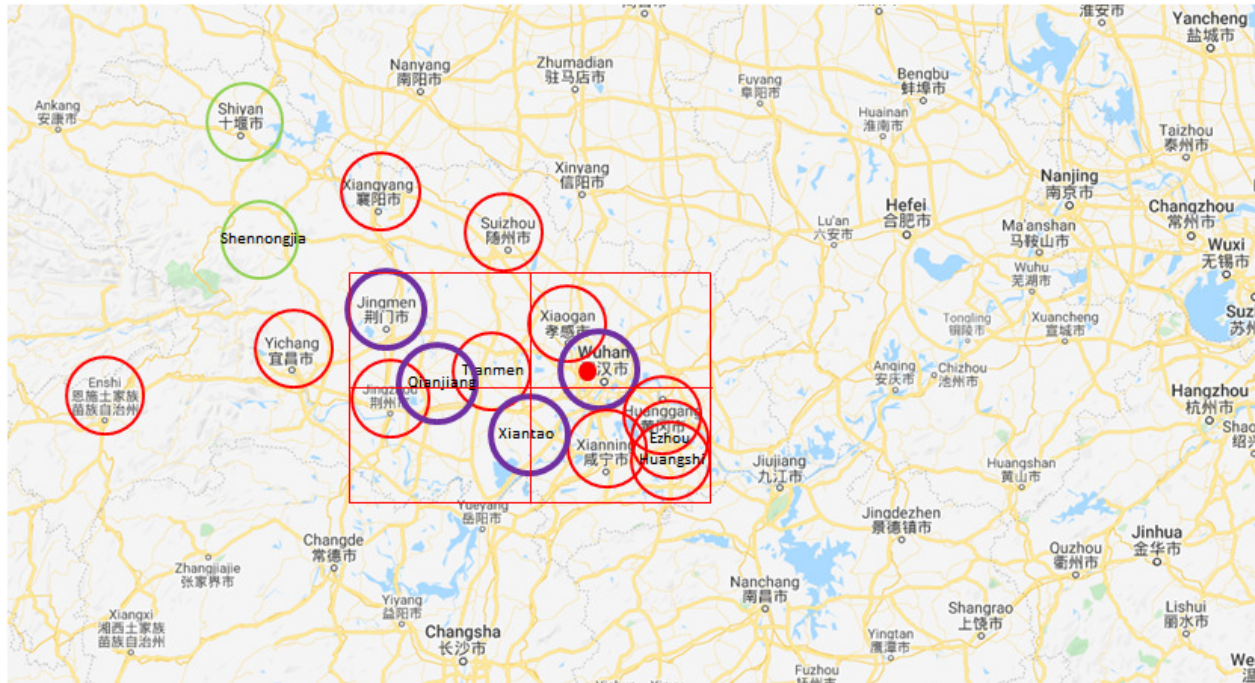
Plots of this data against date are shown in **Fig. 1**. Panel (A) shows a slowing increase in Number of Cases everywhere. Panel (B) confirms that almost all the deaths are in Hubei. Panel (C) shows that the Hubei death rate initially decreased from 3.5% on 27-Jan to 2.7% on 7-Feb. only to rise to 4.12% today (16-Feb.). The non-Hubei death rate is much lower at 0.55%, comparable to that of influenza but worryingly creeping up from 0.2% on 7-Feb. Panel (D) shows that the Fractional Change in Total Cases (Cases\_Today / Cases\_Yesterday) is increasing more and more slowly. More informative is **Fig. 3** showing the number of New Cases and New Deaths in Hubei. While New Cases peaked on 6-Feb., today's data 11 days later still does not show the expected peak in New Deaths. This suggests that death occurs at least 11 days after diagnosis. Until deaths peak we cannot estimate Total Hubei deaths as twice Total Hubei Deaths on the day New Deaths peak (**Fig. 4**). This delay also suggests a 8% Hubei Death Rate.



**Figure 1.** Variation of COVID-19 data against time in days since 29 Nov 2019 (guessed date of the first case). **Table 1** data is plotted from 22 January to 16 February 2020. In Panels (D) & (E) linear trend-lines are added using data from 1/29/2020. The Fraction Change for Cases is an excellent fit to a straight line, whereas that for Deaths is less good due to fluctuations since 13-Feb. We also show in panel (E) a red short-dashed of the straight-line the fit to the four data points for 31-Dec to 02-Feb; this trend was used in the first draft of this analysis dated 2/2/20 and gave rise to the initial expectation that the growth of deaths would slow soon.

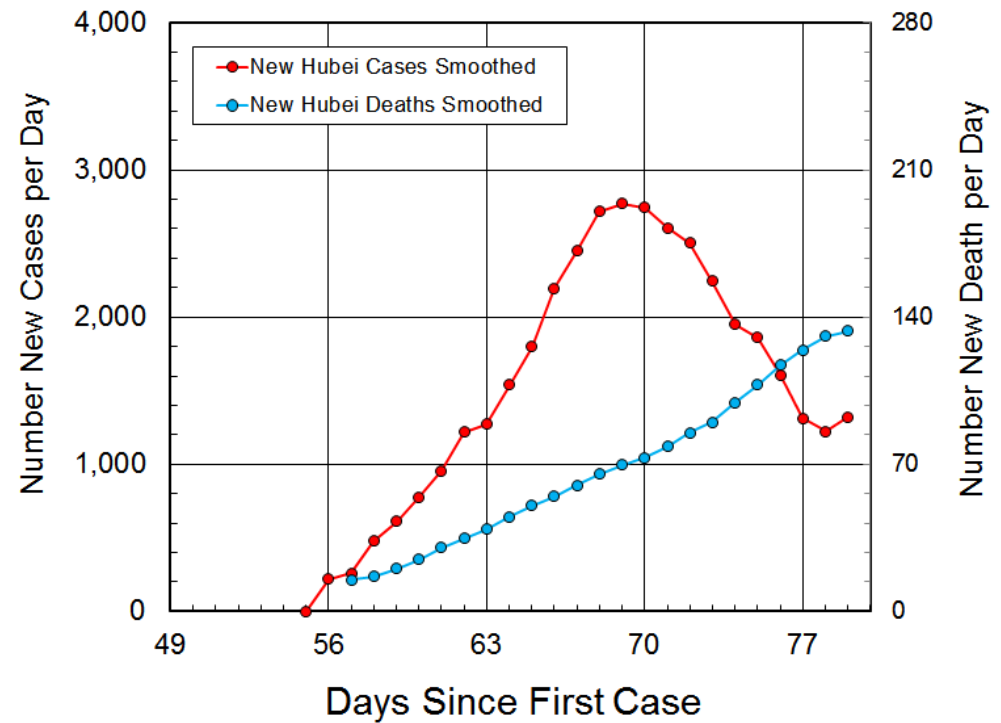
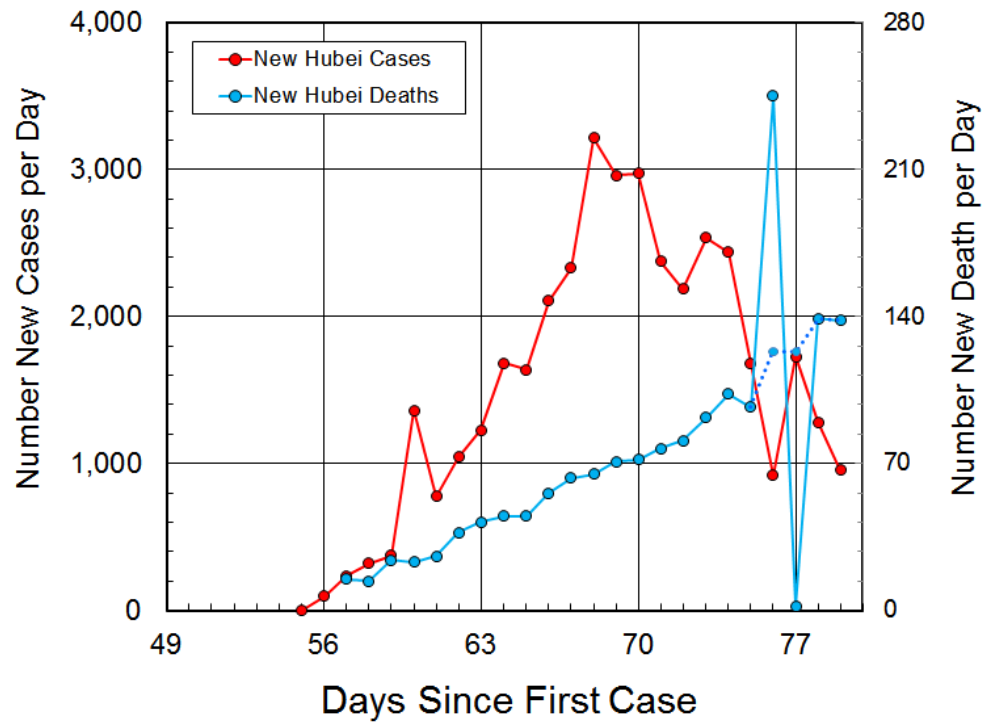
			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate
Hubei	58,500,000	29.0	58,182	1696	2.91%	1.44	34,874	1176	3.37%	1.90	22,112	618	2.79%	1.29	16,678	479	2.87%	1.37	11,177	350	3.13%	1.41	7,153	249	3.48%
Wuhan	11,080,000	118.1	41,152	1309	3.18%	1.45	19,558	902	4.61%	1.89	11,618	478	4.11%	1.32	8,351	362	4.33%	1.37	5,142	265	5.15%	1.38	3,215	192	5.97%
Huanggang	7,403,000	10.5	2,831	78	2.76%	1.34	2,441	58	2.38%	1.81	1,897	32	1.69%	1.28	1,645	25	1.52%	1.47	1,246	17	1.36%	1.21	726	14	1.93%
Xiaogan	4,900,000	14.3	3,279	70	2.13%	1.43	2,839	49	1.73%	1.96	2,141	25	1.17%	1.39	1,462	18	1.23%	1.29	918	14	1.53%	1.17	628	12	1.91%
Jingzhou	3,692,000	10.0	1,501	37	2.47%	1.61	1,114	23	2.06%	2.30	885	10	1.13%	1.11	713	9	1.26%	1.50	499	6	1.20%	1.50	287	4	1.39%
Ezhou	1,050,000	33.3	1,274	35	2.75%	1.17	1,010	30	2.97%	1.67	471	18	3.82%	1.00	382	18	4.71%	1.20	306	15	4.90%	1.67	227	9	3.96%
Jingmen	3,023,000	10.9	915	33	3.61%	1.38	725	24	3.31%	1.41	553	17	3.07%	1.06	422	16	3.79%	1.45	345	11	3.19%	2.20	251	5	1.99%
Suizhou	2,500,000	9.6	1,267	24	1.89%	1.71	1,160	14	1.21%	1.56	915	9	0.98%	1.13	706	8	1.13%	1.60	458	5	1.09%	5.00	304	1	0.33%
Yichang	4,060,000	5.9	895	24	2.68%	2.18	810	11	1.36%	1.57	610	7	1.15%	1.75	496	4	0.81%	4.00	392	1	0.26%	1.00	276	1	0.36%
Xiangyang	900,000	22.2	1,155	20	1.73%	1.54	1,101	13	1.18%	4.33	838	3	0.36%		735	2	0.27%		548	0	0.00%		347	0	0.00%
Xiantao	1,175,000	16.2	531	19	3.58%	1.19	478	16	3.35%	3.20	307	5	1.63%	1.25	225	4	1.78%	1.33	169	3	1.78%	3.00	97	1	1.03%
Huangshi	2,450,000	6.1	983	15	1.53%	1.67	899	9	1.00%	4.50	635	2	0.31%	1.00	509	2	0.39%	1.00	334	2	0.60%	1.00	209	2	0.96%
Tianmen	1,731,000	5.8	485	10	2.06%	1.00	336	10	2.98%	1.00	163	10	6.13%	1.00	128	10	7.81%	1.00	115	10	8.70%	1.43	82	7	8.54%
Xianning	2,800,000	3.6	861	10	1.16%	1.43	528	7	1.33%		443	0	0.00%		384	0	0.00%		296	0	0.00%		206	0	0.00%
Qianjiang	1,000,000	6.0	182	6	3.30%	1.20	94	5	5.32%	5.00	74	1	1.35%	1.00	54	1	1.85%	1.00	35	1	2.86%	1.00	27	1	3.70%
Enshi	750,000	5.3	249	4	1.61%	1.33	210	3	1.43%		157	0	0.00%		138	0	0.00%		111	0	0.00%		87	0	0.00%
Shiyan	3,340,000	0.6	612	2	0.33%	2.00	559	1	0.18%		395	0	0.00%		318	0	0.00%		256	0	0.00%		177	0	0.00%
Shennongjia	76,000	0.0	10	0	0.00%		10	0	0.00%		10	0	0.00%		10	0	0.00%		7	0	0.00%		7	0	0.00%

**Table. 2.** Number of Cases, Number of Deaths, Death Rates and Fractional Changes in Death Numbers (Death Ratio) shown for 17 Hubei cities from 31 Jan to 16 Feb. City data is sorted by decreasing number of deaths. We distinguish Death Rates  $\geq 3\%$  (scarlet),  $\geq 1\%$  (rose) &  $< 1\%$  (green). The deaths per million population is much higher in Wuhan than any other city at almost 120 per million (0.012%). The number of cases (Clinically plus Laboratory diagnosed) is 3.7% of the Wuhan population of 11 million. On 31-Jan. there were 8 of 17 cities with death rates  $< 1\%$ ; by 16-Feb., there were only 2 of 17.



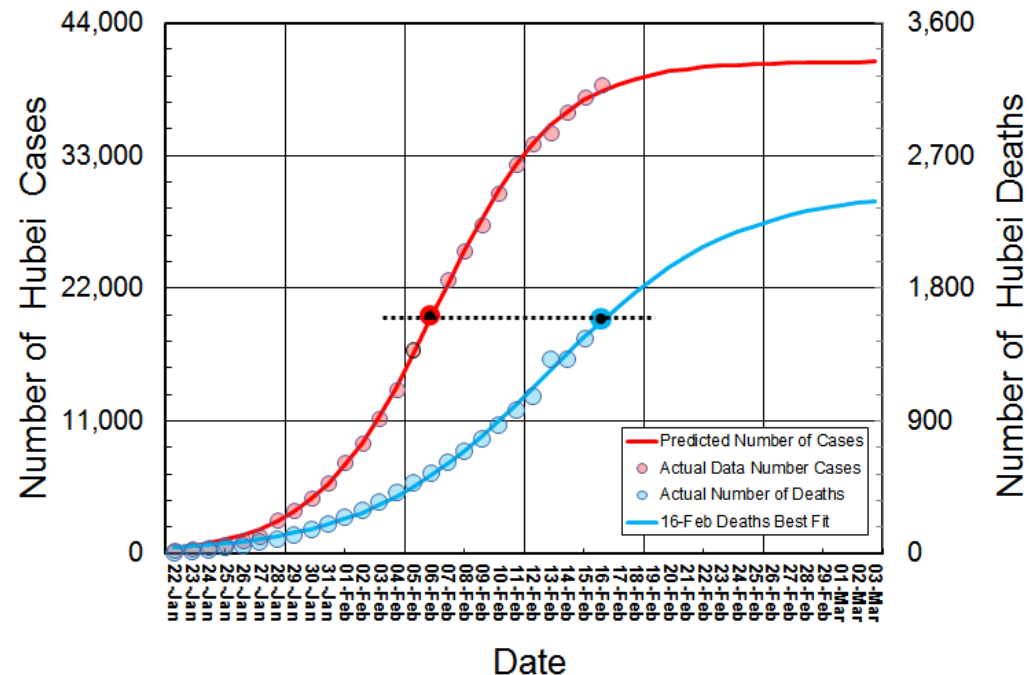
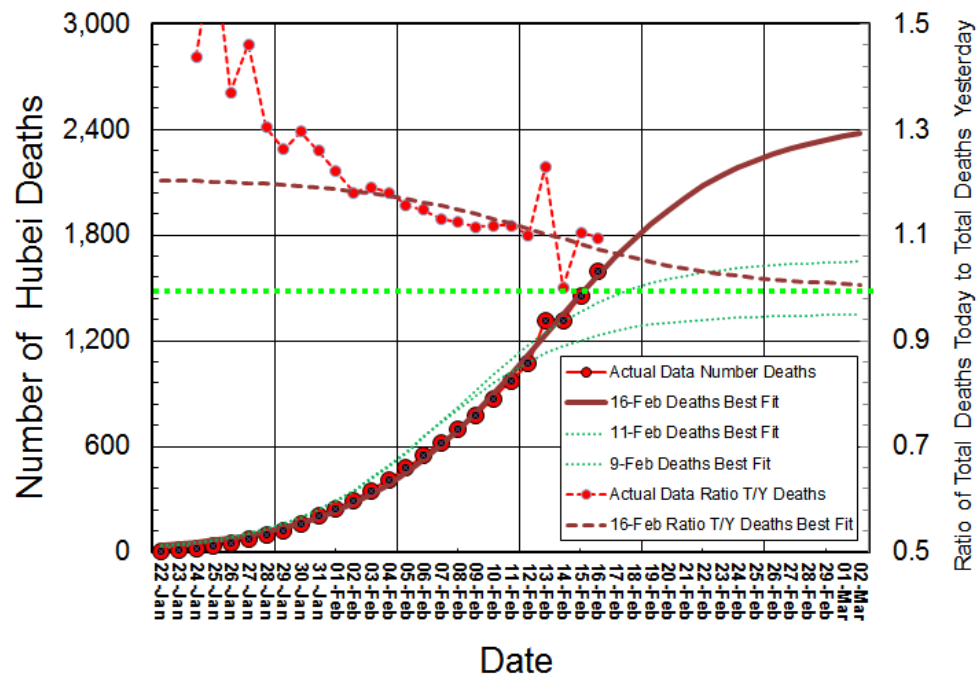
**Figure. 2.** Map of Hubei circling in purple cities with a death rate of  $\geq 3\%$ , in red cities with a death rate of  $\geq 1\%$  and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Jingmen, Qianjiang and Xiantao (See **Table 2**). Two cities, in the same area have low death rates, comparable to those elsewhere in China and the rest of the world data (data from [jobtube.cn](http://jobtube.cn) from 31-Jan. to 16-Feb.). The red dot marks the Wuhan South China Seafood Market thought to be the source of this coronavirus.





**Figure. 3 A.** Showing that the Number of New Hubei Cases per Day peaked on Day 69 (6-Feb), whereas the Number of New Hubei Deaths per Day is still rising linearly and does not seem to have peaked today, 11 days later. For sigmoid growth like that shown in **Fig. 4**, the number of new cases of deaths reaches a maximum midway through the curve. If this holds here, then the total Number of Hubei Cases will reach 41,000 (only laboratory diagnosed cases). Were the Number of New Hubei Deaths to peak today, the number of Total Hubei Deaths will reach 3,200. In the blue dotted line bridging plot, the New Death data values of 245 on 13-Feb. and 2 on 14-Feb. (Table 1) are averaged to give 124 Deaths of each day, correcting what may have been a typo in the value for 13-Feb.

**Figure 3 B.** The same data is smoothed by averaging over a five-day window so that, for example, the value given on day 69 is the average of the values on days 67, 68, 69, 70 & 71.



**Figure. 4 A.** Fit of the sigmoid function  $f(x) = 1/(1-\exp(-x))$  to the actual Total Number of Hubei Deaths from the coronavirus COVID-19 since 22 Jan 2020. The best fit (brown line) is obtained using Excel to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B)/C)$  so that the Number of Deaths values to 12-Feb (red line and circles). Particularly impressive is that the Ratio of Deaths Today to Yesterday (T/Y) from the actual data (red dashed line and circles on secondary axis) is well fit by the calculated Ratio (brown green line on secondary axis), which decreases in the linear fashion assumed in **Fig. 2 (E)**. The fit for the values to 09-Feb or 11-Feb (green dashed lines) are also shown to indicate how sensitive the extrapolation is to new data values. The situation is still very fluid and values released in the next few days will be crucial.

**Figure. 4 B.** Showing the sigmoid fit to the Number of Cases and Number of Deaths in Hubei predicted by the data since 22-Jan 2020. As suggested by **Fig. 3**, the total Number of Cases is close to 41,000. The current estimate for Total Number of Deaths is 2,500 but will grow until the New Deaths in **Fig. 3** peak. The horizontal black dotted line connects Total Hubei Deaths (1,595) today to the Total Hubei Cases 11 Days ago (19,767) suggesting that the real Hubei Death rate may be higher at  $1595/19767 = 8.0\%$ . This suggests that the Total Number of Hubei Deaths could reach 3,300 (8% of 41,000). Note that this analysis is based only on Laboratory Confirmed Cases and does not include the 17,000 Clinically Diagnosed Cases.