“Analysis of nCov-2019 Data on 2/13/2020” by Michael Levitt, Stanford University, USA

Date	Day	Number Cases			Number Deaths			Death Rate (%)			Ratio	Fraction Change Cases			Fraction Change Number		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others	Hubei/	Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	716	605	111	0	0	0	0.00%	0.00%	0.00%	-						
1/23/2020	55	814	605	209	20	19	1	2.46%	3.15%	0.48%	6.6	1.137	1.000	1.883	-	-	-
1/24/2020	56	1140	748	392	29	27	2	2.54%	3.60%	0.51%	7.1	1.401	1.236	1.876	1.441	1.412	2.000
1/25/2020	57	2401	1434	967	62	58	4	2.60%	4.07%	0.41%	9.8	2.105	1.916	2.467	2.155	2.167	2.000
1/26/2020	58	3311	1940	1371	89	85	4	2.70%	4.39%	0.29%	15.1	1.379	1.353	1.418	1.432	1.462	1.000
1/27/2020	59	5458	3699	1759	119	112	7	2.18%	3.03%	0.40%	7.6	1.649	1.907	1.283	1.335	1.316	1.750
1/28/2020	60	7337	4844	2493	147	140	7	2.01%	2.89%	0.28%	10.3	1.344	1.310	1.417	1.235	1.250	1.000
1/29/2020	61	9448	6251	3197	190	182	8	2.01%	2.91%	0.25%	11.6	1.288	1.290	1.282	1.289	1.296	1.143
1/30/2020	62	11884	7914	3970	238	229	9	2.00%	2.89%	0.23%	12.8	1.258	1.266	1.242	1.254	1.259	1.125
1/31/2020	63	13971	9750	4221	289	279	10	2.07%	2.86%	0.24%	12.1	1.176	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	17720	12368	5352	340	330	10	1.92%	2.67%	0.19%	14.3	1.268	1.269	1.268	1.174	1.181	1.000
2/2/2020	65	21315	15235	6080	404	393	11	1.89%	2.58%	0.18%	14.2	1.203	1.232	1.136	1.188	1.190	1.100
2/3/2020	66	25431	18431	7000	476	464	12	1.87%	2.52%	0.17%	14.7	1.193	1.210	1.151	1.180	1.183	1.091
2/4/2020	67	30418	22733	7685	550	537	13	1.81%	2.36%	0.17%	14.0	1.196	1.233	1.098	1.155	1.157	1.083
2/5/2020	68	35270	26805	8465	631	616	15	1.79%	2.30%	0.18%	13.0	1.159	1.179	1.101	1.146	1.146	1.154
2/6/2020	69	38640	30140	8500	709	693	16	1.84%	2.30%	0.19%	12.2	1.096	1.124	1.004	1.124	1.126	1.067
2/7/2020	70	43721	34012	9709	809	784	25	1.85%	2.30%	0.26%	9.0	1.132	1.128	1.142	1.141	1.131	1.563
2/8/2020	71	47117	36939	10178	908	875	33	1.93%	2.37%	0.32%	7.3	1.078	1.086	1.048	1.122	1.116	1.320
2/9/2020	72	51027	40389	10638	1015	977	38	1.99%	2.42%	0.36%	6.8	1.083	1.093	1.045	1.118	1.117	1.152
2/10/2020	73	53888	43247	10641	1135	1092	43	2.11%	2.53%	0.40%	6.3	1.056	1.071	1.000	1.119	1.118	1.132
2/11/2020	74	56502	45480	11022	1241	1198	43	2.20%	2.63%	0.39%	6.8	1.049	1.052	1.036	1.093	1.097	1.000
2/12/2020	75	59901	48206	11695	1368	1310	58	2.28%	2.72%	0.50%	5.5	1.060	1.060	1.061	1.102	1.094	1.349

Table 1. Showing data for New Coronavirus 2019 (nCoV) from 22 January to 12 February 2020. The raw data of Number of Cases and Deaths is taken from https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset/data#, from https://bnonews.com/index.php/2020/02/the-latest-coronavirus-cases/ and https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0. We separate data into Hubei and Others or non-Hubei as most deaths are in a 90 km x 35 km 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. This data uses the revised values released on 13-Feb-20 to allow for revised diagnostic criteria. The values for previous days are scaled by assuming that the change of Hubei Cases and Hubei Deaths between 11 and 12 Feb are 2000 cases and 100 deaths, respectively, and that the added Cases and Deaths due to new diagnostic criteria are evenly spread. This is equivalent to multiplying the previous values for Hubei Cases by factor 1.363 and the values for Hubei Deaths by factor 1.122.

Plots of this data against time are shown in **Fig. 1**. Panel (A) shows expected increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (96%). Panel (C) shows that the Hubei death rate has decreased from 3.5% on 27-Jan to 2.7% today (12-Feb.). The non-Hubei death rate is 6 times lower at 0.5%, which is comparable to that of influenza, but is rather worryingly creeping up from less than 0.2% 10 days ago. Panel (D) shows that the Fractional Change in Total Cases (Cases_Today / Cases_Yesterday) is increasing more and more slowly for Hubei, non-Hubei & Total. Panel (E), shows that on 28-Jan the Fractional Change in Total Deaths (Deaths_Today / Deaths_Yesterday) was 1.3 (30% more deaths per day) but by today this ratio is 1.1 (10% more Total Deaths per day). Specifically, the overall ratio of deaths today to deaths yesterday has decreased steadily since 1/25/2020. This together with the data on Number of Cases in (D) suggests that the rate of increase in the number of deaths and cases will continue to slow down over the next week. An extrapolation based on the sigmoid function (see **Fig. 3**) suggests that the number of Hubei deaths may not exceed 2000 and that it will reach 95% of this limiting value by 20-Feb-2020.

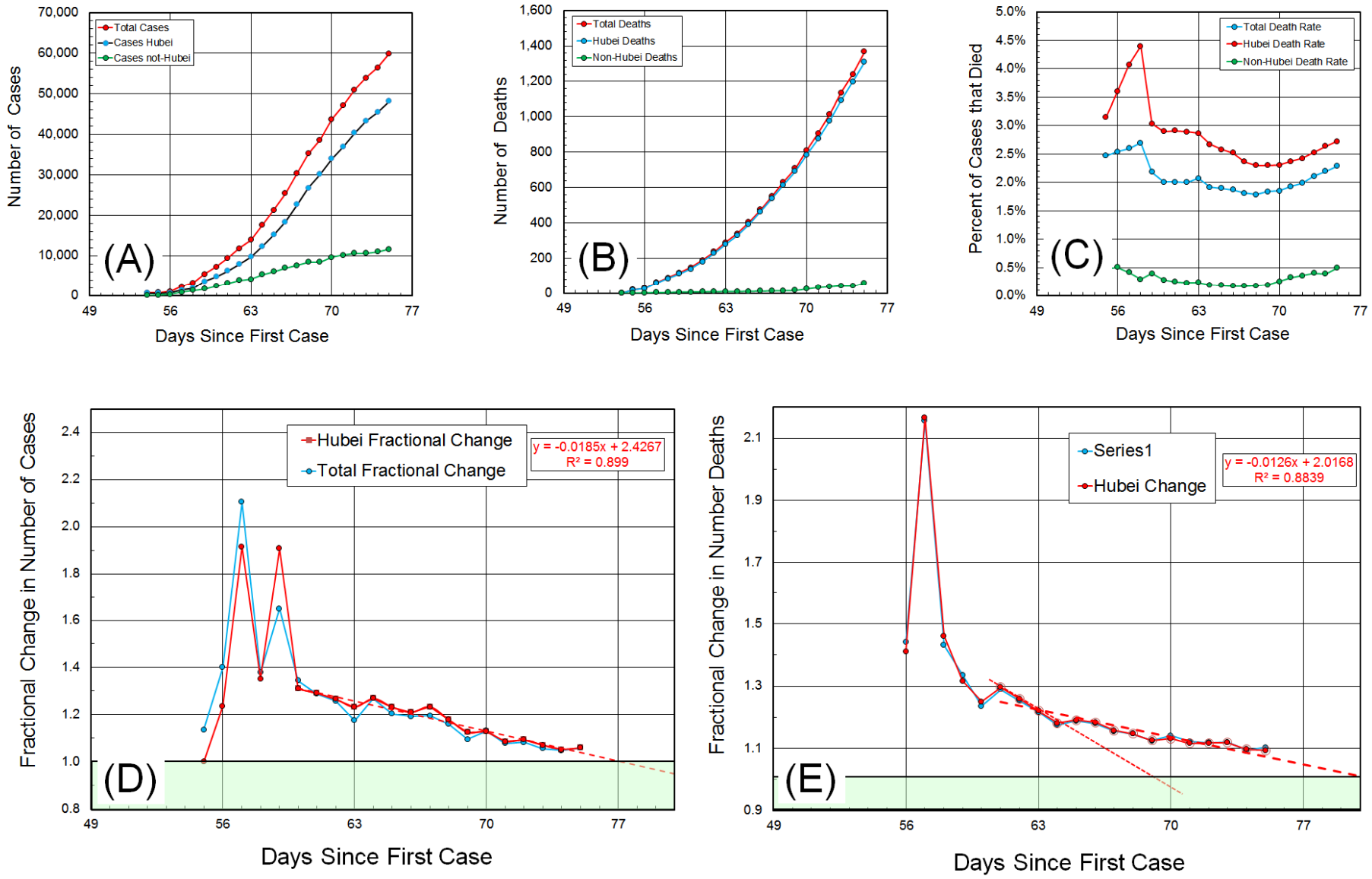

Figure. 1. Variation of nCov-2019 data against time in days since 29 Nov 2019 (guessed date of the first case). Table 1 data is plotted from 22 January to 5 February 2020. In Panels (D) (E) linear trend-lines are added using data for the last 12 days from 1/29/2020. For both Cases and Deaths, the Fraction Change for both Hubei and the world, the fit to a straight line is excellent (correlation coefficient or sqrt(R^2)> 0.94). This linear extrapolation suggests the Fractional Change in Number of Cases and Deaths will decrease to near 1.0 within a week, after which time, numbers of deaths will grow slowly. 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 in initial expectation that the growth of deaths would slow soon.

			6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate
Hubei	58,500,000	10.6	22,112	618	2.79%	1.13	19,665	549	2.79%	1.15	16,678	479	2.87%	1.16	13,522	414	3.06%	1.18	11,177	350	3.13%	1.19	9,074	294	3.24%	1.18	7,153	249	3.48%
Wuhan	11,080,000	43.1	11,618	478	4.11%	1.15	10,117	414	4.09%	1.14	8,351	362	4.33%	1.16	6,384	313	4.90%	1.18	5,142	265	5.15%	1.18	4,109	224	5.45%	1.17	3,215	192	5.97%
Ezhou	1,050,000	17.1	471	18	3.82%	1.00	423	18	4.26%	1.00	382	18	4.71%	1.00	332	18	5.42%	1.20	306	15	4.90%	1.15	278	13	4.68%	1.44	227	9	3.96%
Jingmen	3,023,000	5.6	553	17	3.07%	1.00	508	17	3.35%	1.06	422	16	3.79%	1.14	400	14	3.50%	1.27	345	11	3.19%	1.57	329	7	2.13%	1.40	251	5	1.99%
Tianmen	1,731,000	5.8	163	10	6.13%	1.00	138	10	7.25%	1.00	128	10	7.81%	1.00	117	10	8.55%	1.00	115	10	8.70%	1.43	99	7	7.07%	1.00	82	7	8.54%
Huanggang	7,403,000	4.3	1,897	32	1.69%	1.10	1,807	29	1.60%	1.16	1,645	25	1.52%	1.32	1,422	19	1.34%	1.12	1,246	17	1.36%	1.13	1,002	15	1.50%	1.07	726	14	1.93%
Xiaogan	4,900,000	5.1	2,141	25	1.17%	1.00	1,886	25	1.33%	1.39	1,462	18	1.23%	1.06	1,120	17	1.52%	1.21	918	14	1.53%	1.00	749	14	1.87%	1.17	628	12	1.91%
Jingzhou	3,692,000	2.7	885	10	1.13%	1.00	801	10	1.25%	1.11	713	9	1.26%	1.29	613	7	1.14%	1.17	499	6	1.20%	1.50	333	4	1.20%	1.00	287	4	1.39%
Suizhou	2,500,000	3.6	915	9	0.98%	1.00	834	9	1.08%	1.13	706	8	1.13%	1.33	641	6	0.94%	1.20	458	5	1.09%	1.67	384	3	0.78%	3.00	304	1	0.33%
Xiantao	1,175,000	4.3	307	5	1.63%	1.00	265	5	1.89%	1.25	225	4	1.78%	1.33	188	3	1.60%	1.00	169	3	1.78%	1.00	140	3	2.14%	3.00	97	1	1.03%
Qianjiang	1,000,000	1.0	74	1	1.35%	1.00	64	1	1.56%	1.00	54	1	1.85%	1.00	44	1	2.27%	1.00	35	1	2.86%	1.00	35	1	2.86%	0.00	27	1	3.70%
Yichang	4,060,000	1.7	610	7	1.15%	1.17	563	6	1.07%	1.50	496	4	0.81%	1.33	452	3	0.66%	3.00	392	1	0.26%	1.00	353	1	0.28%	1.00	276	1	0.36%
Huangshi	2,450,000	0.8	635	2	0.31%	1.00	566	2	0.35%	1.00	509	2	0.39%	1.00	405	2	0.49%	1.00	334	2	0.60%	1.00	252	2	0.79%	1.00	209	2	0.96%
Xiangyang	900,000	3.3	838	3	0.36%	1.00	787	2	0.25%	1.00	735	2	0.27%	1.00	632	1	0.16%	1.00	548	0	0.00%	1.00	441	0	0.00%	1.00	347	0	0.00%
Enshi	750,000	0.0	157	0	0.00%	1.00	144	0	0.00%	1.00	138	0	0.00%	1.00	123	0	0.00%	1.00	111	0	0.00%	1.00	105	0	0.00%	1.00	87	0	0.00%
Shennongjia	76,000	0.0	10	0	0.00%	1.00	19	0	0.00%	1.00	10	0	0.00%	1.00	10	0	0.00%	1.00	7	0	0.00%	1.00	7	0	0.00%	1.00	7	0	0.00%
Shiyan	3,340,000	0.0	395	0	0.00%	1.00	353	0	0.00%	1.00	318	0	0.00%	1.00	291	0	0.00%	1.00	256	0	0.00%	1.00	212	0	0.00%	1.00	177	0	0.00%
Xianning	2,800,000	0.4	443	1	0.23%	1.00	399	1	0.25%	1.00	384	0	0.00%	1.00	348	0	0.00%	1.00	296	0	0.00%	1.00	246	0	0.00%	1.00	206	0	0.00%

Table. 2. Number of Cases, Number of Deaths, Death Rates and Fractional Changes in Deaths shown for 17 Hubei cities from 31 Jan to 6 Feb.

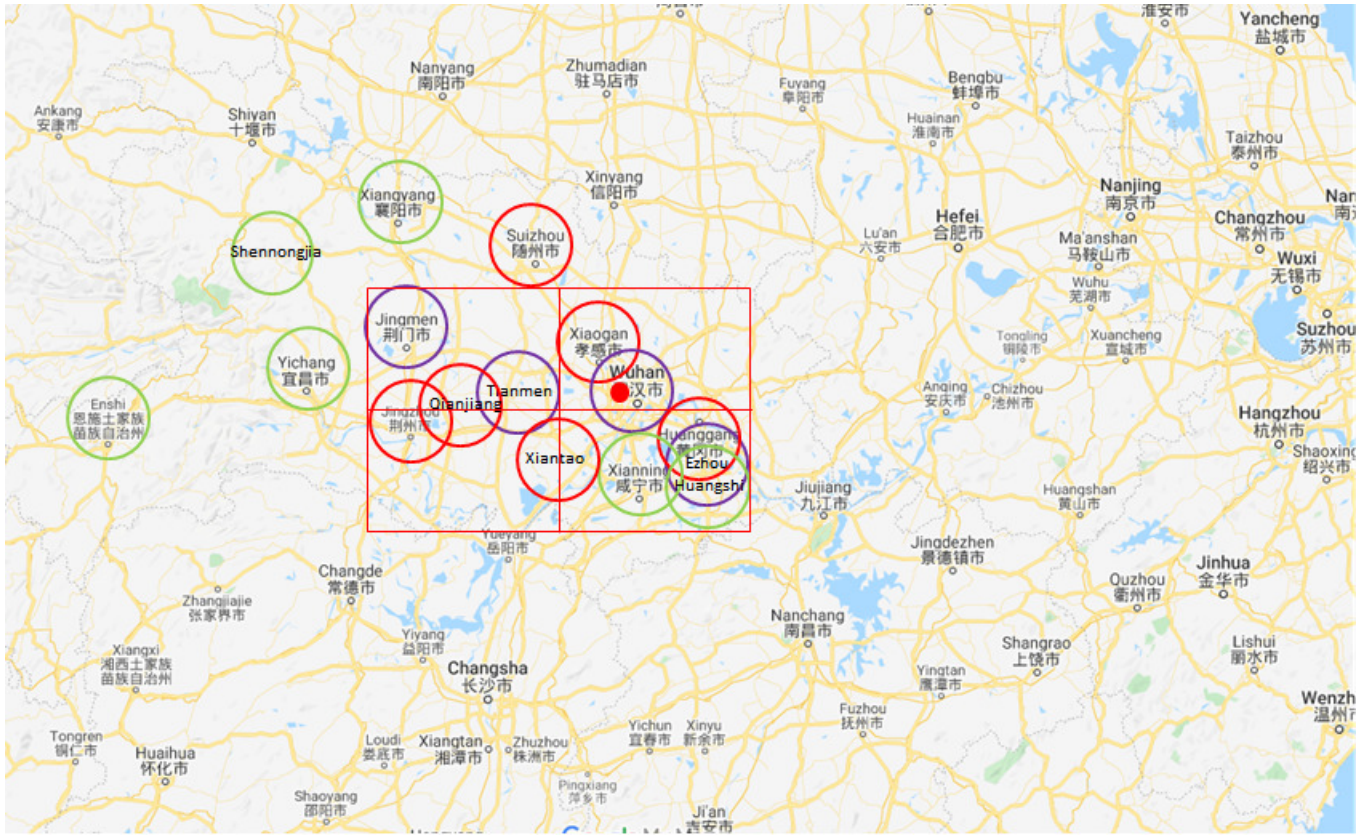

Figure. 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen (Table 2). Other cities in the same area have low death rates, comparable to those elsewhere in China and the rest of the world data (data 1/4/2020 from jobtube.cn). The red dot marks the Wuhan South China Seafood Market thought to be the source of this coronavirus.

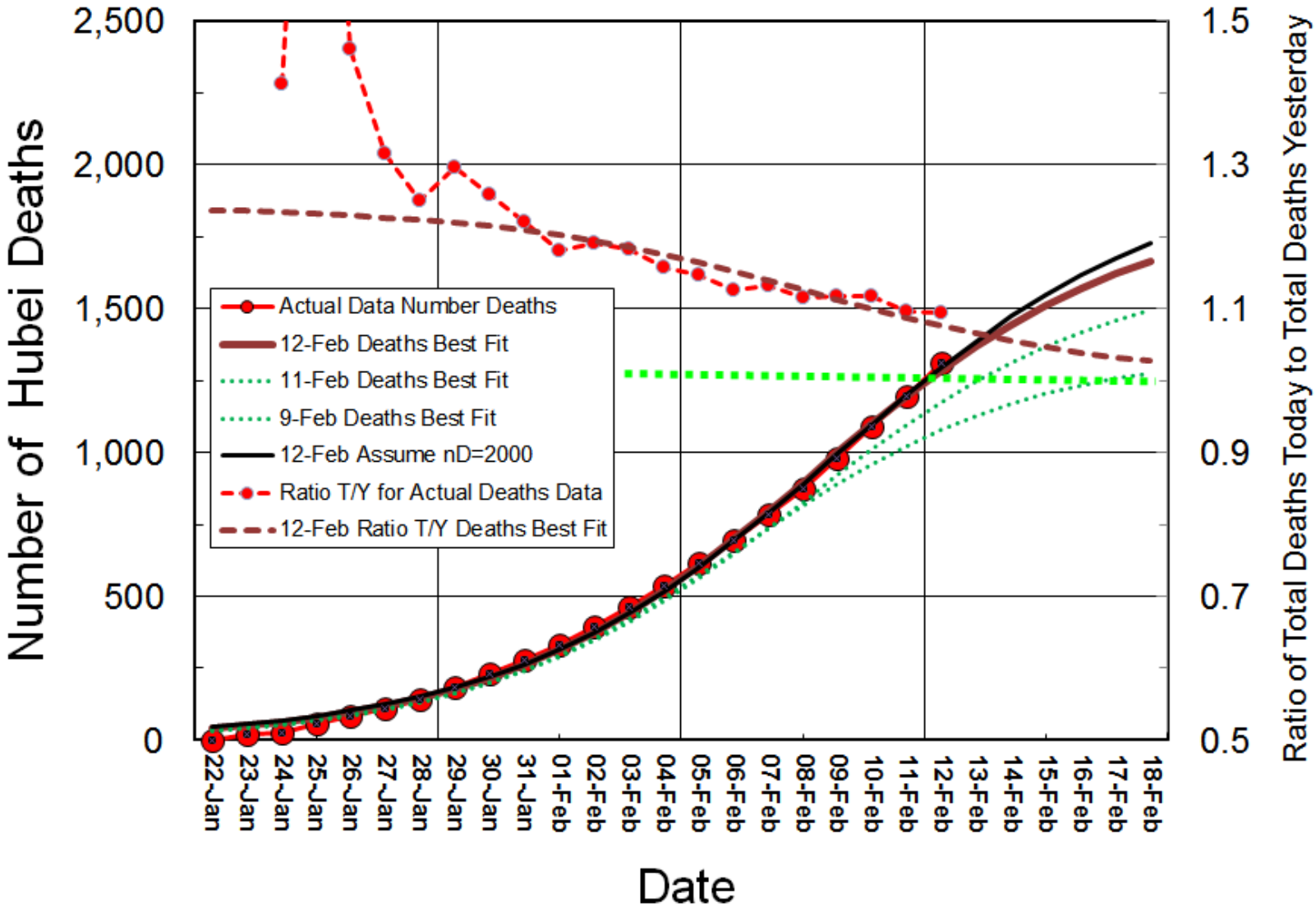

Figure. 3. Fit of the sigmoid function f(x) = 1/(1-exp(-x)) to the actual Total Number of Hubei Deaths from the coronavirus COVID-19 since 22 Jan 2020. The best fit (brown line) is obtained using Excel to optimize the parameters A, B & C in f(x) = A/(1-exp(-x+B)/C) so that the 22 actual Number of Deaths values to 12-Feb (red line and circles) are well fit by the sigmoid function. 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 19 or 21 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 the that are released in the next few days will be crucial. We now expect the total death rate to plateau near the black line that assumes 2000 total Number of Deaths.

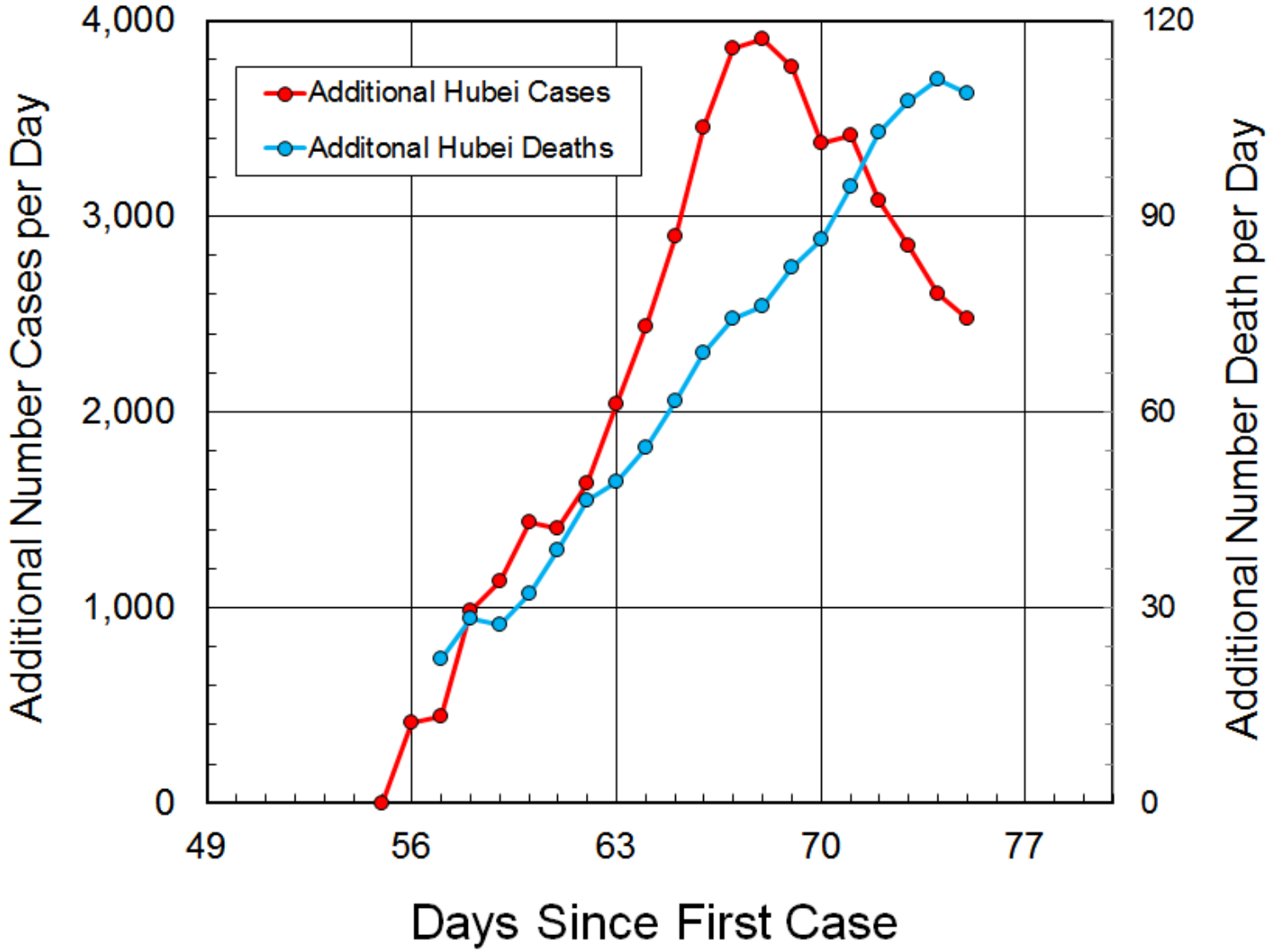

Figure. 4. Showing how the Additional Number of Hubei Cases per Day peaked on Day 67 (4-Feb), whereas the Additional Number of Hubei Deaths per Day may have peaked yesterday (Day 67). For sigmoid growth like that shown in **Fig. 3**, the additional number reaches a maximum midway through the curve. If this holds here, then the total Number of Hubei Cases may reach 50,000 and the Total Number of Hubei Deaths may reach 2500. The curve for Deaths is shifted by 6 days from that of Cases; suggesting that on average death occurs 6 days after being counted as a confirmed case. The data plotted for Additional Cases and Additional Deaths is averaged over a three day window so that, for example, the value given on day 68 is the average of the values on days 67, 68 & 69. This smoothing reduces the noise in the data.

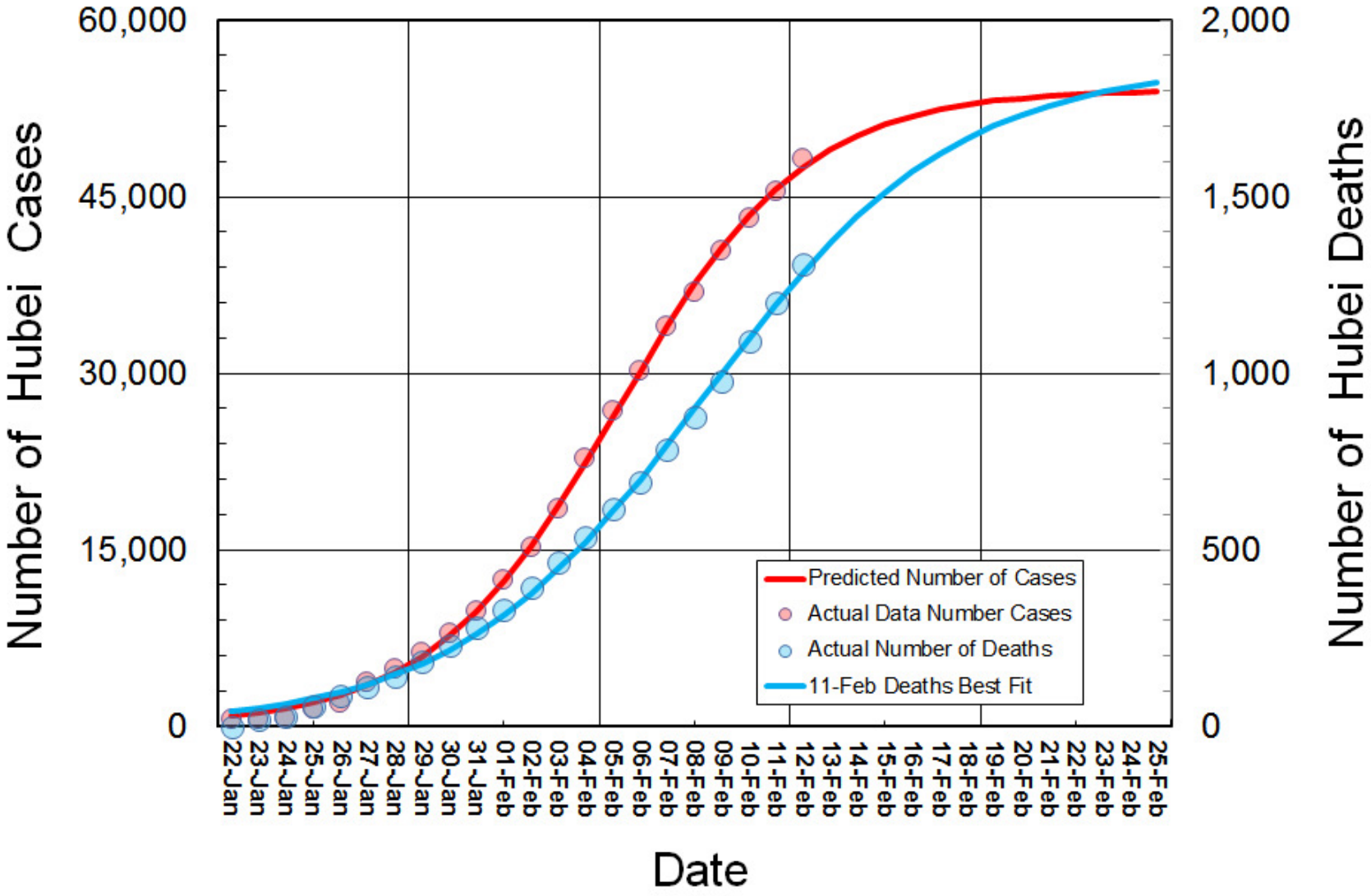

Figure. 5. Showing the extrapolation of Number of Cases and Number of Deaths in Hubei predicted by the data since 22-Jan 2020. As suggested by **Fig. 4**, total Number of Cases is close to 50,000 and the Total Number of Deaths close to 2500.