

# Michael Levitt's Report on Coronavirus 2019 from 2-Feb-20 to 2-Mar-20 as widely distributed in China

The screenshot shows a 'Combine Files' dialog box with the following elements:

- Buttons: 'Add Files...', 'Single PDF' (selected), 'PDF Portfolio'.
- Instruction: 'Drag and drop files to add them, and then arrange them in the order you want.'
- Table of files:

Name	Modified	Size	Page Range
1.Analysis_of_Coronavirus-2019_Data_Michael_Levitt-v1.pdf	2/2/2020 11:38:44 AM	656.89 KB	All Pages
2.Analysis_of_Coronavirus-2019_Data_Michael_Levitt2.pdf	2/2/2020 16:52:22 PM	657.14 KB	All Pages
3.Analysis_of_Coronavirus-2019_Data_Michael_Levitt3.pdf	2/3/2020 9:29:33 AM	674.83 KB	All Pages
4.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/4/2020 14:54:49 PM	649.82 KB	All Pages
5.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/4/2020 15:25:55 PM	1.43 MB	All Pages
6.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/5/2020 13:47:03 PM	1.09 MB	All Pages
7.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/5/2020 20:16:44 PM	1.08 MB	All Pages
8.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/6/2020 18:09:42 PM	1.02 MB	All Pages
9.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/7/2020 21:08:47 PM	1.15 MB	All Pages
9a.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/8/2020 2:24:30 AM	1.09 MB	All Pages
10.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/8/2020 14:43:24 PM	1.07 MB	All Pages
11.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/9/2020 21:16:43 PM	1.17 MB	All Pages
12.Analysis_of_Coronavirus-2019_Data_Michael_Levitt_10Feb20.pdf	2/10/2020 7:20:53 AM	1.29 MB	All Pages
13.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/12/2020 8:29:48 AM	1.36 MB	All Pages
14.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/13/2020 19:53:02 PM	1.20 MB	All Pages
17.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/17/2020 21:30:51 PM	783.93 KB	All Pages
18.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/18/2020 21:14:42 PM	818.93 KB	All Pages
21.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/21/2020 18:27:50 PM	1.01 MB	All Pages
23.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/23/2020 20:13:33 PM	1.07 MB	All Pages
28.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	2/29/2020 11:29:18 AM	1.23 MB	All Pages
30.Analysis_of_Coronavirus-2019_Data_Michael_Levitt.pdf	3/2/2020 17:17:42 PM	1.13 MB	All Pages

Below the table are navigation buttons: 'Move Up', 'Move Down', 'Choose Pages', 'Remove', and a 'File Size' indicator. At the bottom are 'Help', 'Options', 'Combine Files', and 'Cancel' buttons.

# Analysis of nCov-2019 Data by Michael Levitt on 2/2/2020

Date	Day	Cases Confirmed			Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction change Cases Confirmed			Fraction change Cases Confirmed		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.18	1.00	1.88	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.44	1.24	1.88	1.44	1.41	2.00
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.15	1.92	2.47	2.15	2.17	2.00
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.38	1.35	1.42	1.43	1.46	1.00
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.60	1.91	1.28	1.34	1.32	1.75
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.35	1.31	1.42	1.23	1.25	1.00
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.29	1.29	1.28	1.29	1.30	1.14
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.26	1.27	1.24	1.25	1.26	1.13
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.16	1.23	1.06	1.22	1.22	1.11
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.28	1.27	1.30	1.18	1.18	1.10

Table 1. Showing data for New Coronavirus 2019 (nCoV) from 22 January to 1 February 2020. The raw data of Cases Confirmed and of Deaths has been taken from <https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset/data#> and checked against data from <https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We divide data into Hubei and Others on non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan and Tianmen in Hubei (see Fig. 1). The Death Rate is Deaths divided by Cases\_Confirmed, and Ratio\_Hubei/Others is the ratio of the Death Rate for Hubei to Others. The Fraction Change for all raw data is Value\_Today divided by Value\_Yesterday.

Plots of this data against days are shown in Fig. 2. Panel (A) shows expected increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 95%). Panel (C) shows that the Death Rate (Mortality) is high in Hubei but elsewhere it is much lower (16 times) and at 0.2 percent comparable to the mortality of influenza. Panel (D) shows that the number of reported cases changes unpredictably in all three regions (Hubei, non-Hubei & Total). Of all the measures these numbers seem least reliable. Most interesting by far is Panel (E), which shows that the number of cases is growing more and more slowly. Specifically, the ratio of Deaths\_Today divided by Deaths\_Yesterday is decreasing. This decrease is monotonic for Total Deaths and Hubei Death since 1/25/2020 and linear for them both since 1/29/2020. This suggests by linear extrapolation that the number of new deaths will decrease very rapidly over the next week.

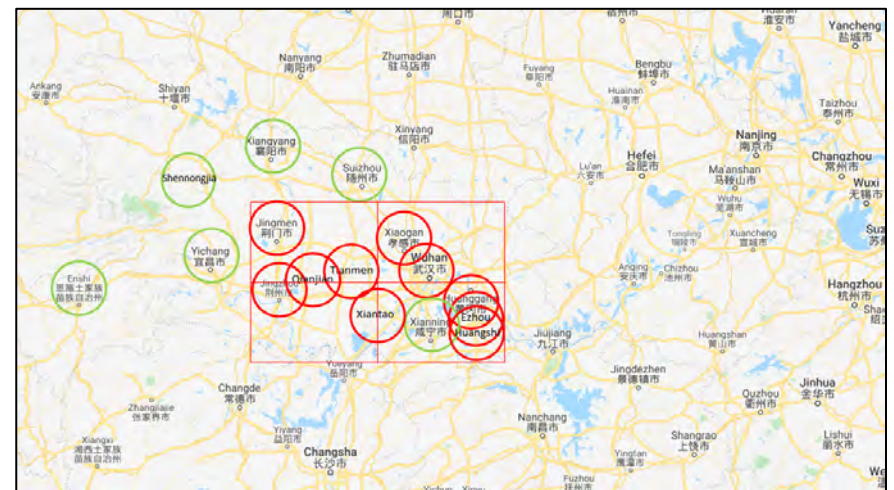


Figure 1. Map of Hubei circling in red cities with a death rate > 1% and in green those with rate < 0.5%. Deaths are localized to a 90km x 35km area centered near Tianmen near (data 12/31/2020 from [jobtube.cn](https://jobtube.cn))



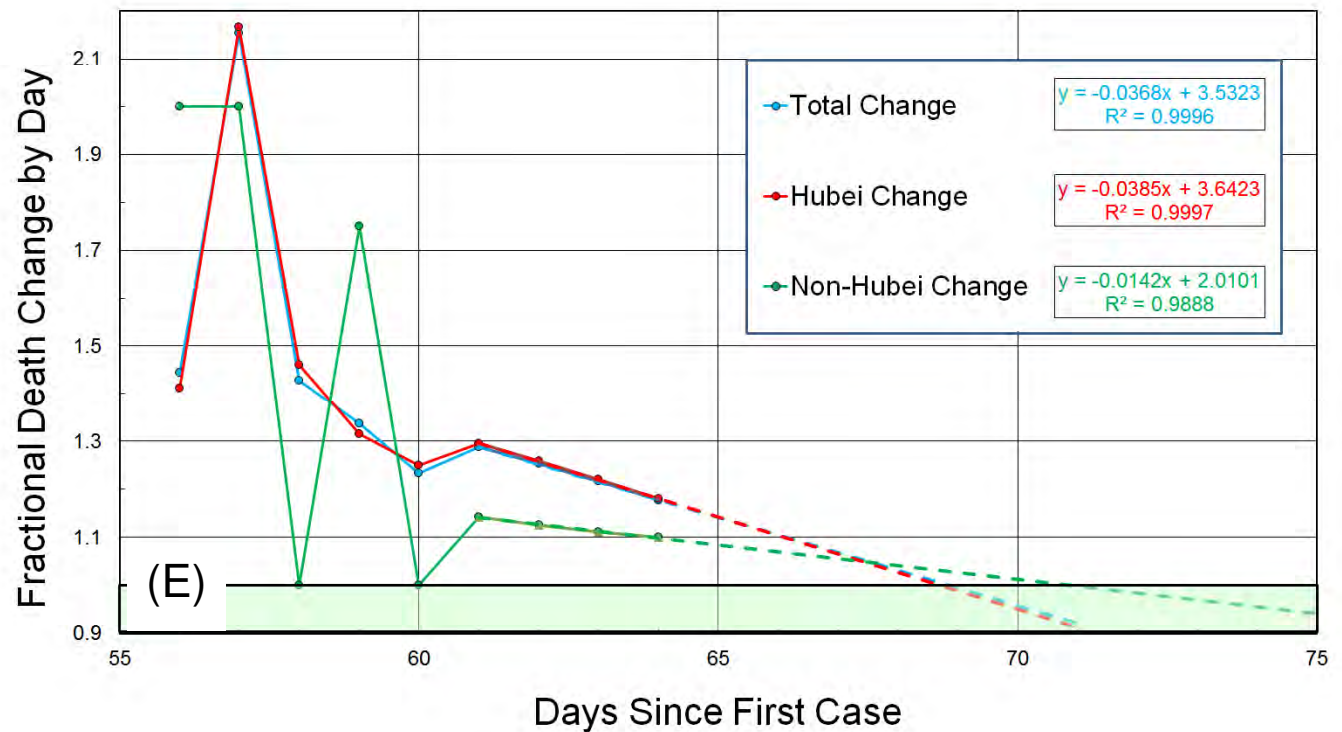
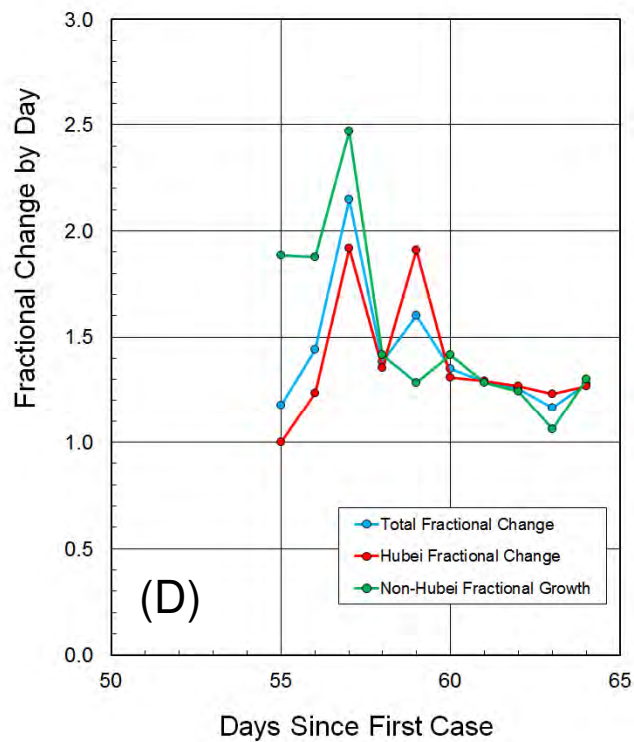
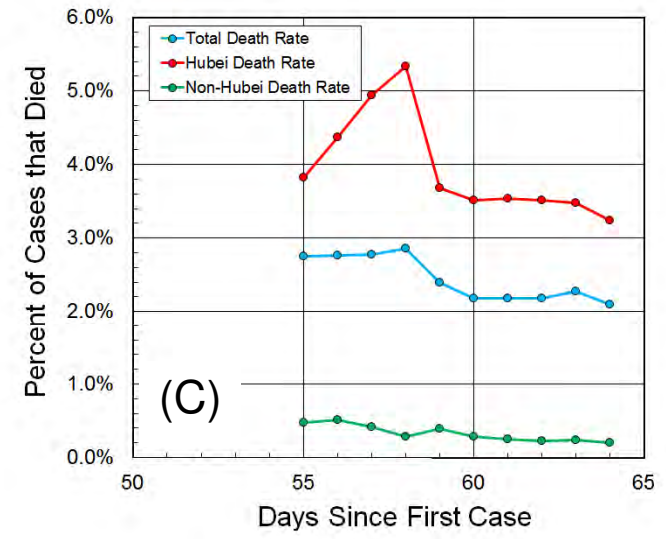
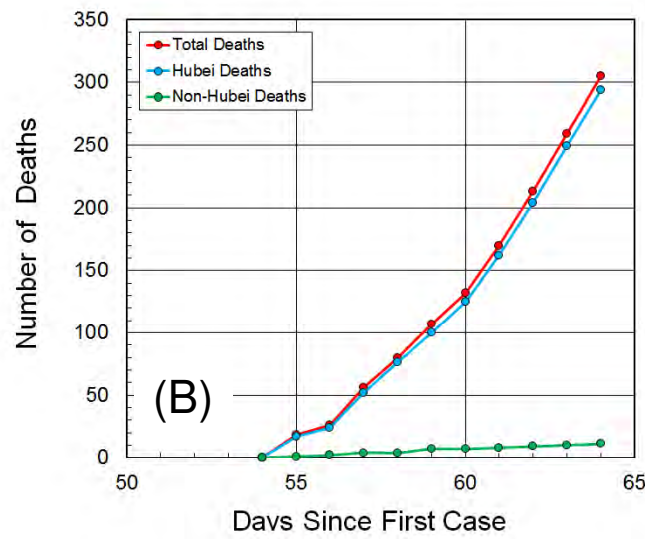
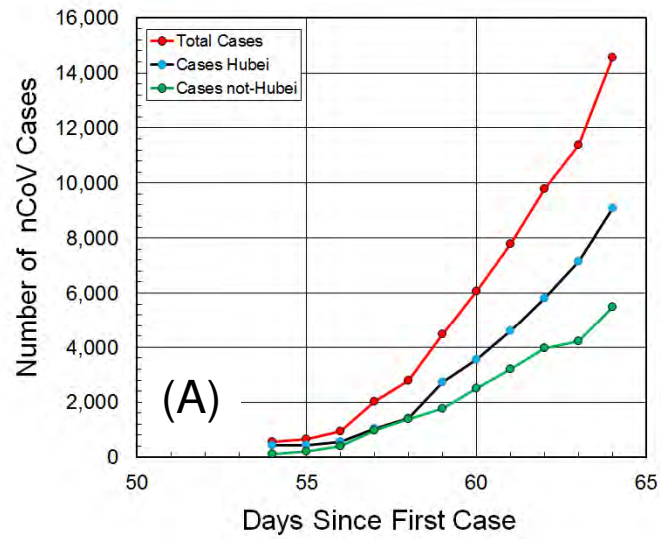


Figure 2. Variation of nCov-2019 data against time in days since 29 Nov 2019 (guessed first case). Table 1 data is plotted from 22 January to 1 February 2020. In Panel (E) linear trend-lines are added using data for last four days from 1/29/2020. For Total Change, Hubei Change and non-Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.99$ ). This suggests that the Fractional Change will decrease to 1.0 within a week, after which time numbers will grow slowly.

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

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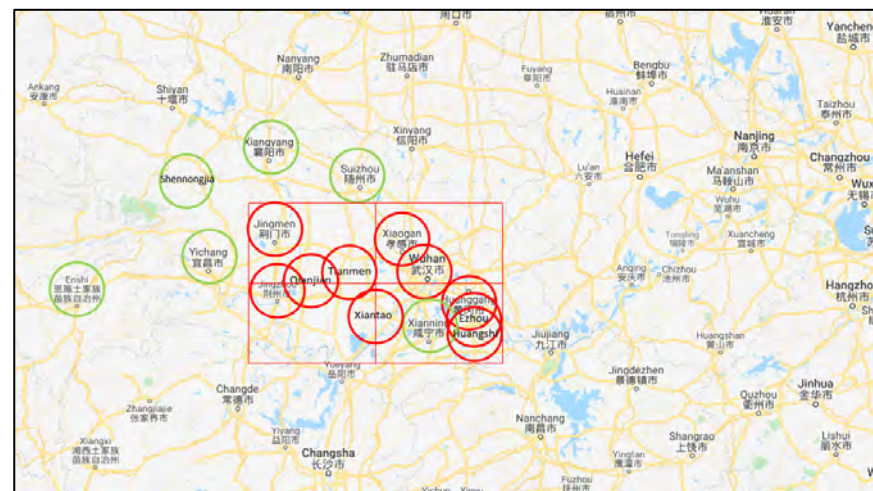


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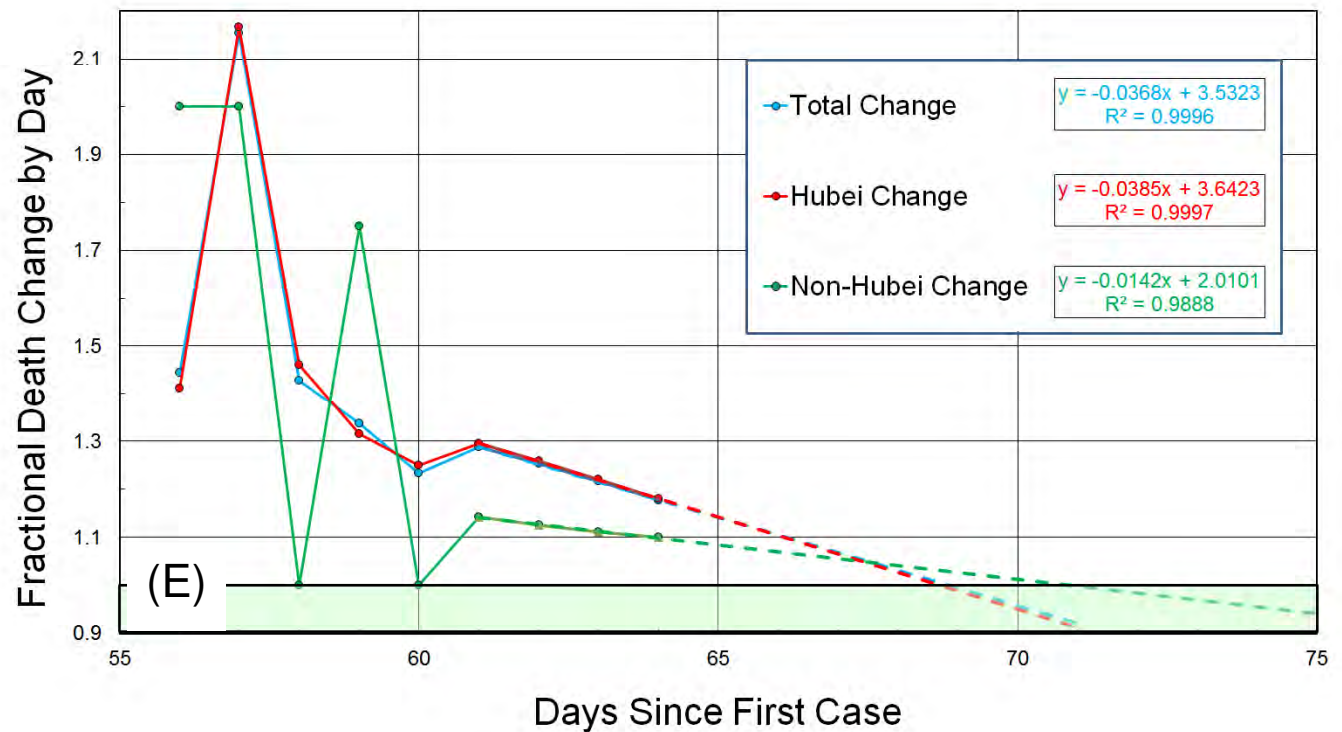
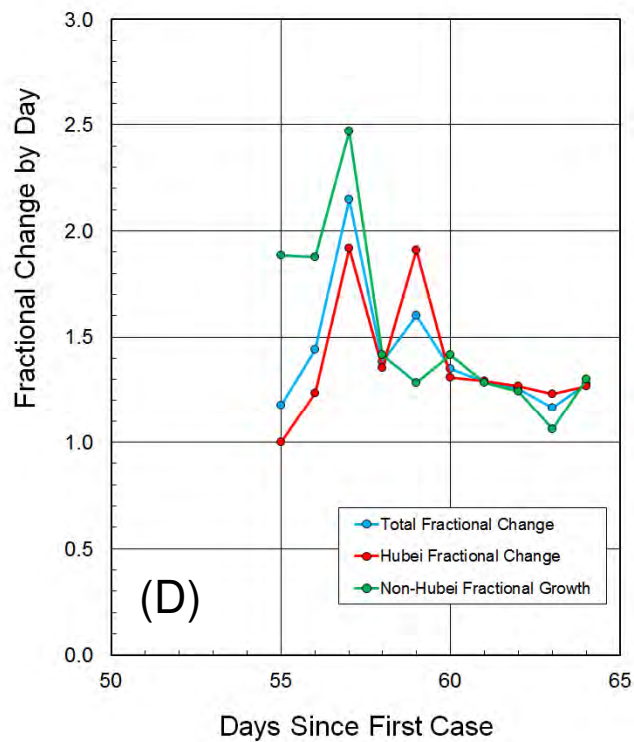
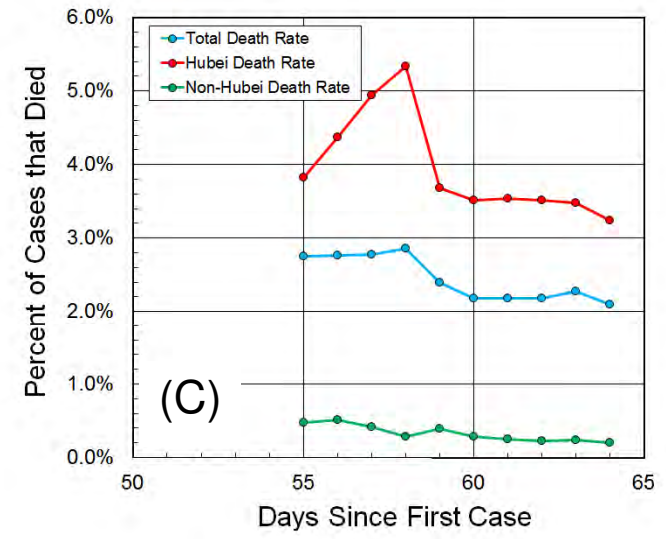
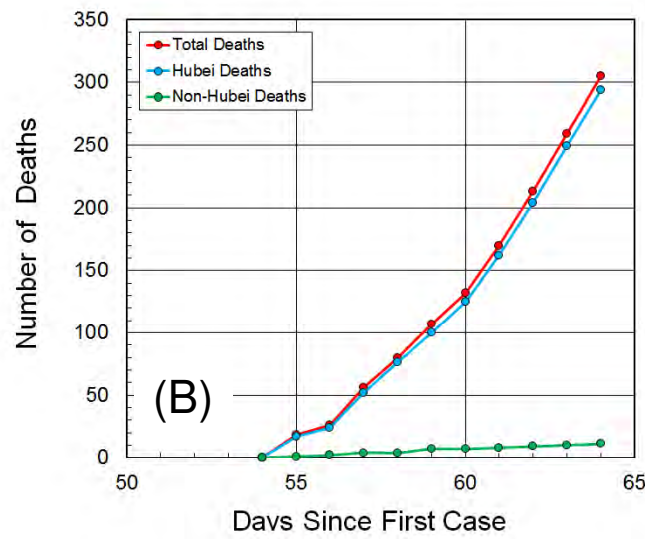
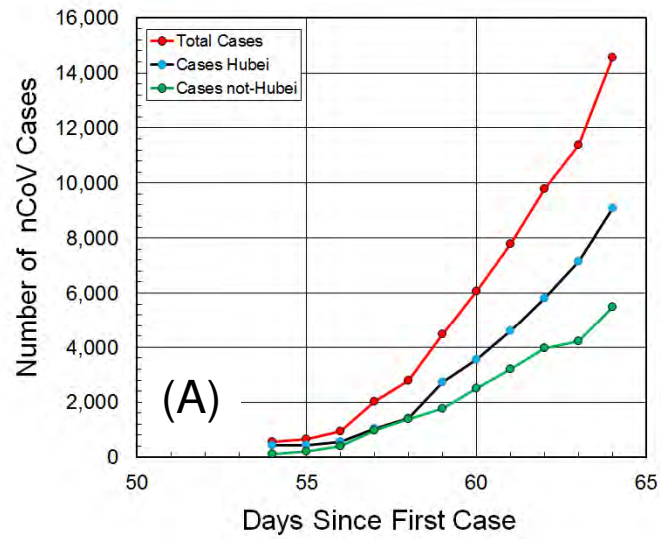


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# “Analysis of nCov-2019 Data on 2/3/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
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1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.60	1.91	1.28	1.34	1.32	1.75
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.35	1.31	1.42	1.23	1.25	1.00
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2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.19	1.23	1.13	1.19	1.19	1.09

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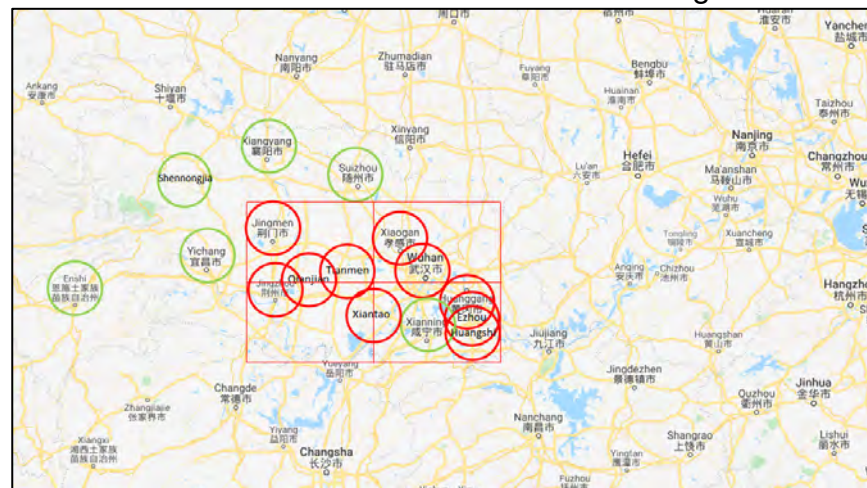


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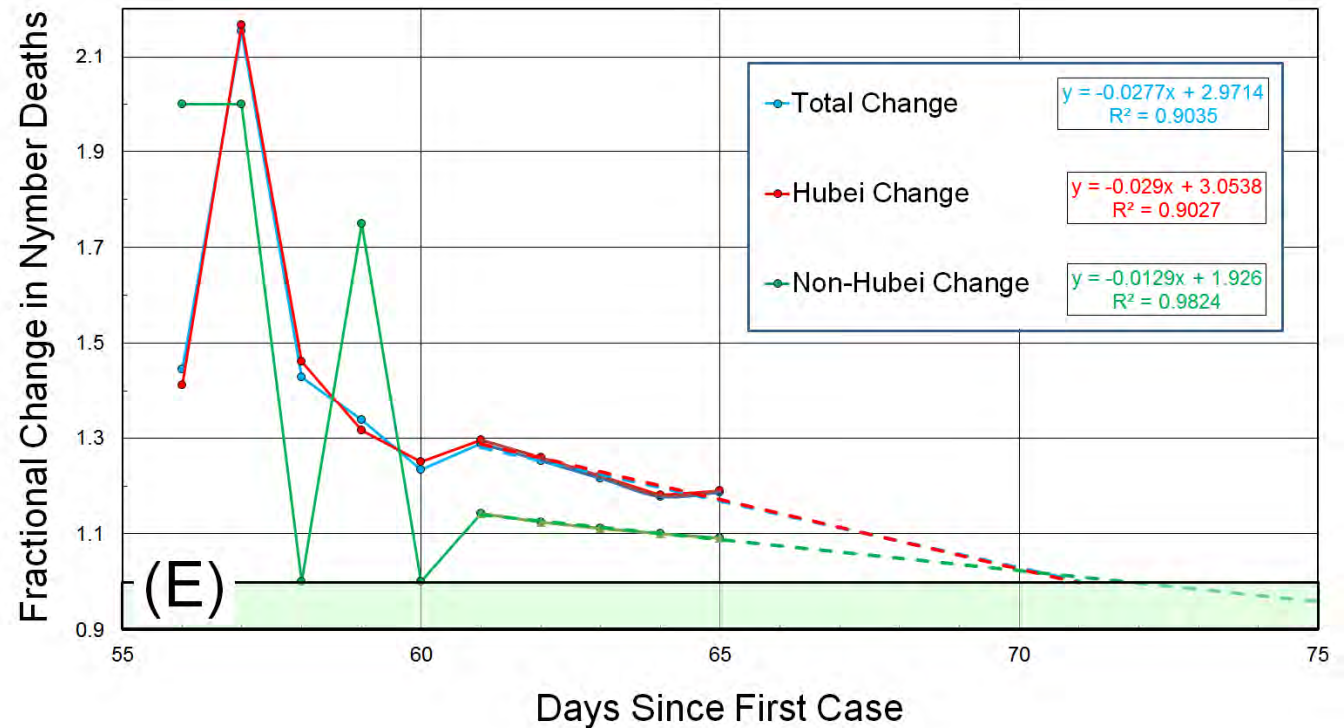
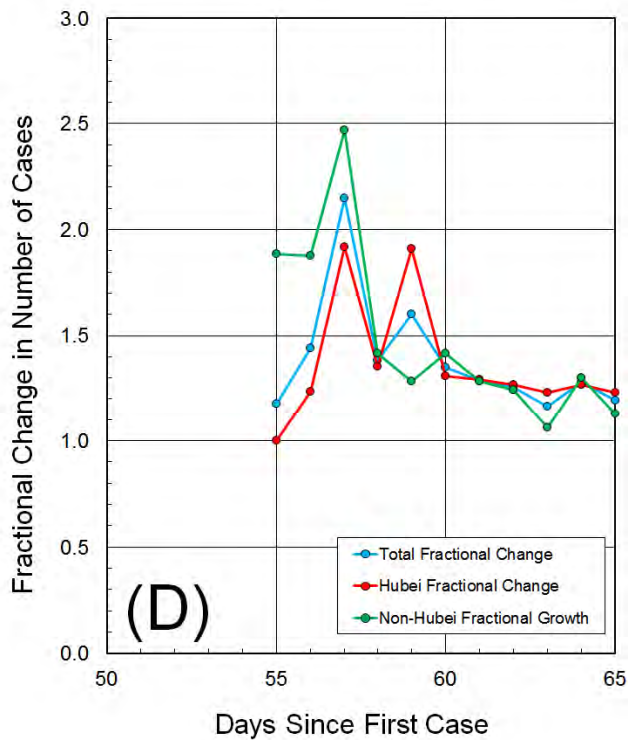
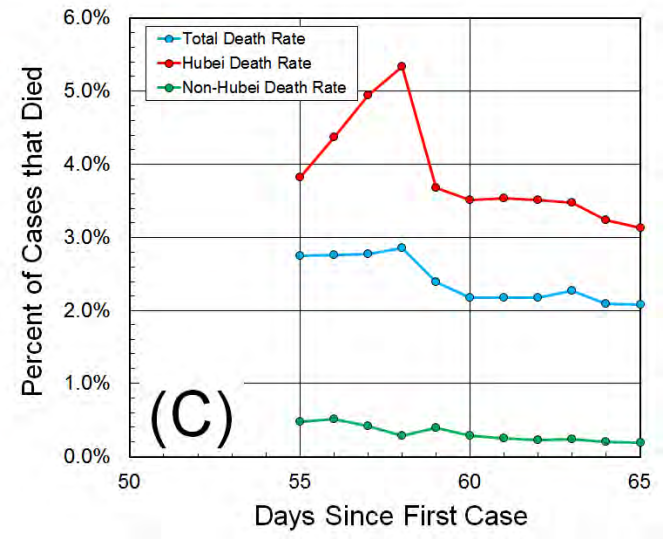
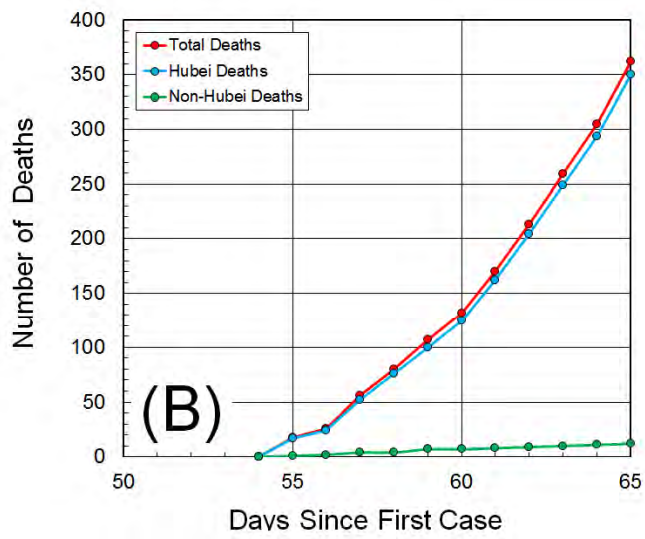
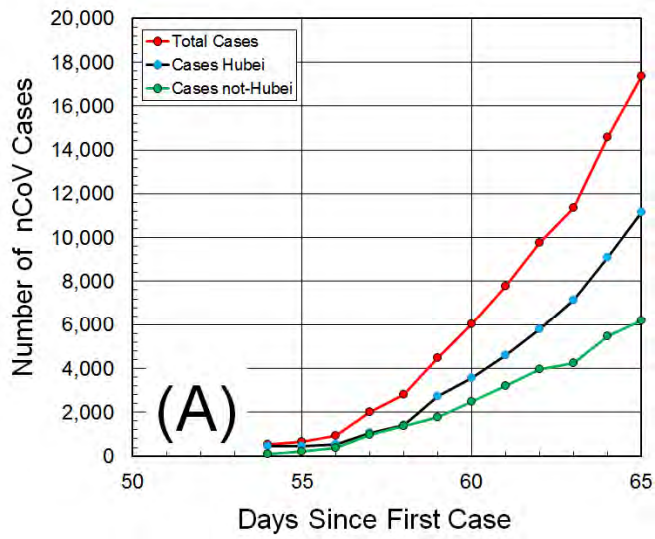


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Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
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2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.19	1.23	1.13	1.19	1.19	1.09
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.19	1.21	1.16	1.18	1.18	1.08

Table 1. Showing data for New Coronavirus 2019 (nCoV) from 22 January to 3 February 2020. The raw data of Cases Confirmed and of Deaths is taken from <https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset/data#> and checked against data from <https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and for regional data from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We divide data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan and Tianmen in Hubei (see Fig. 1). The Death Rate is Number Deaths divided by Number Cases Confirmed, and Ratio Hubei/Others is the ratio of the Death Rate for Hubei to Others. The Fraction Change for all raw data is Value\_Today divided by Value\_Yesterday.

Plots of this data against time are shown in Fig. 2. Panel (A) shows expected increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 95%). Panel (C) shows that the Death Rate (Mortality) is high in Hubei, but elsewhere it is 16 times lower. At 0.2 %, the rate is comparable to the mortality of influenza. Panel (D) shows that the number of reported cases changes unpredictably in all three regions (Hubei, non-Hubei & Total); of all the measures these numbers seem least reliable. Most interesting is Panel (E), which shows that the number of deaths is increasing more and more slowly. Specifically, the ratio of Deaths\_Today to Deaths\_Yesterday is decreasing. This decrease is almost monotonic for Total Deaths and Hubei Death since 1/25/2020 and fairly linear for them both since 1/29/2020. Linear extrapolation that the number of new deaths will decrease very rapidly over the next week.

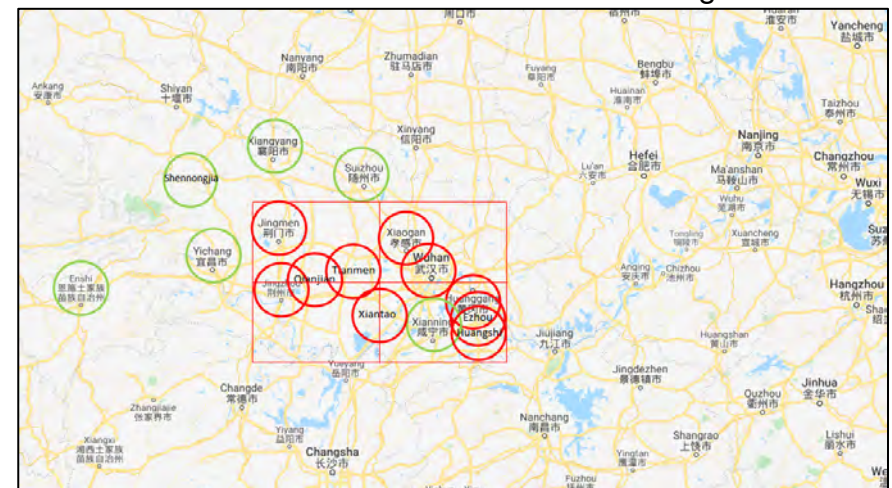


Figure 1. Map of Hubei circling in red cities with a death rate > 0.9% and in green those with rate < 0.4%. Deaths are localized to a 90km x 35km area centered near Tianmen near (data 12/31/2020, [jobtube.cn](https://jobtube.cn))



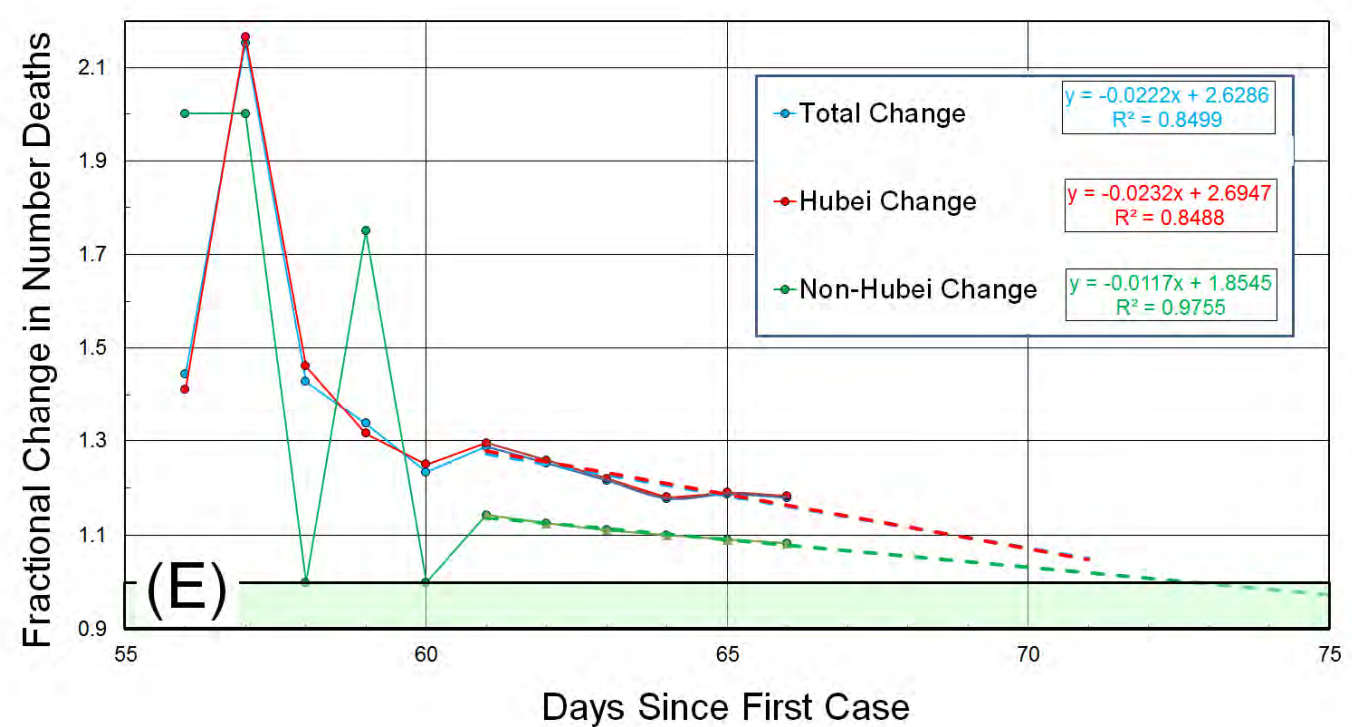
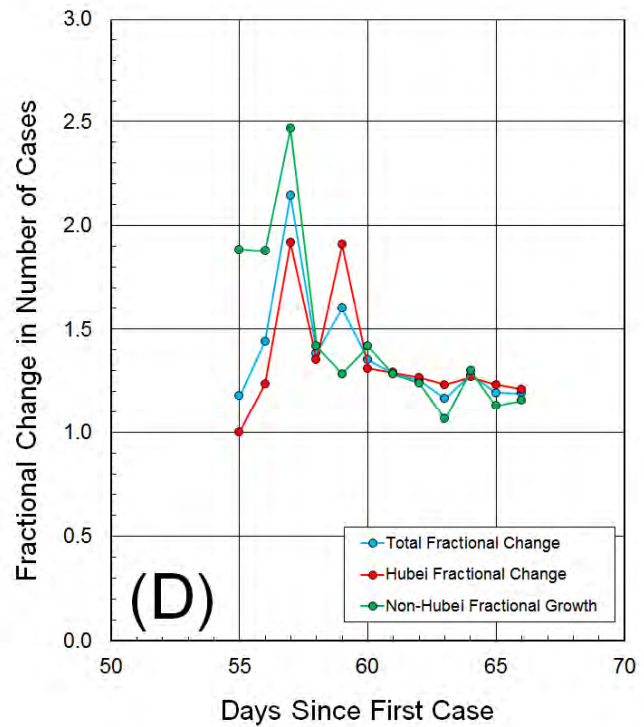
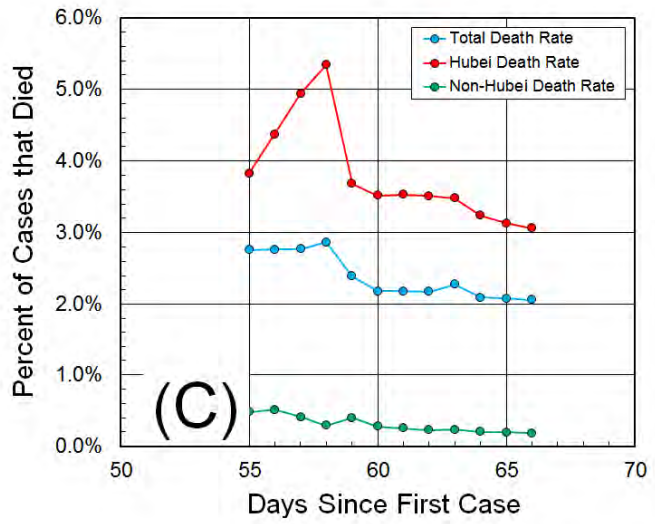
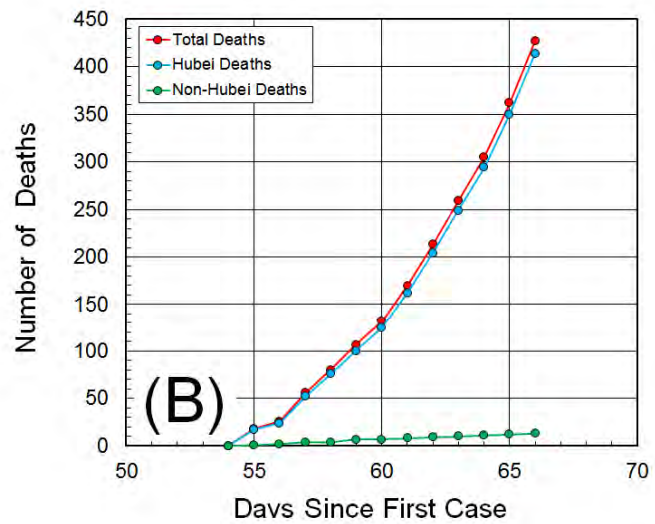
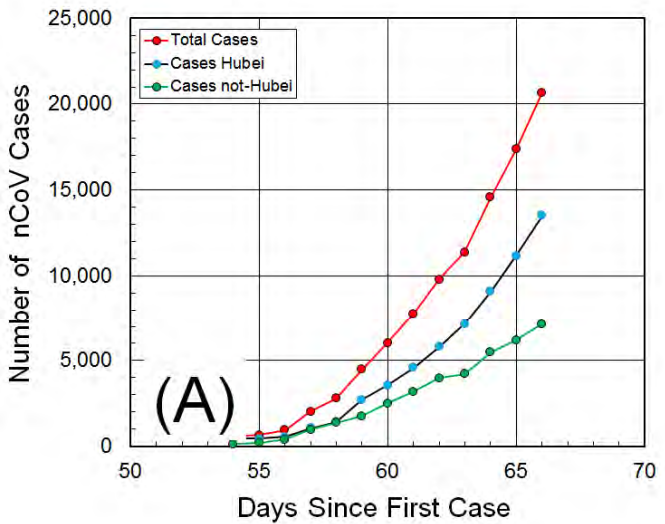


Figure 2. Variation of nCoV-2019 data against time in days since 29 Nov 2019 (guessed first case). Table 1 data is plotted from 22 January to 3 February 2020. In Panel (E) linear trend-lines are added using data for last four days from 1/29/2020. For Total Change, Hubei Change and non-Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.92$ ). This suggests the Fractional Change will decrease to about 1.0 within a week, after which time numbers will grow slowly.

# “Analysis of nCov-2019 Data on 2/4/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.18	1.00	1.88	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.44	1.24	1.88	1.44	1.41	2.00
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.15	1.92	2.47	2.15	2.17	2.00
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.38	1.35	1.42	1.43	1.46	1.00
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.60	1.91	1.28	1.34	1.32	1.75
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.35	1.31	1.42	1.23	1.25	1.00
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.29	1.29	1.28	1.29	1.30	1.14
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.26	1.27	1.24	1.25	1.26	1.13
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.16	1.23	1.06	1.22	1.22	1.11
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.28	1.27	1.30	1.18	1.18	1.10
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.19	1.23	1.13	1.19	1.19	1.09
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.19	1.21	1.16	1.18	1.18	1.08

Table 1. Showing data for New Coronavirus 2019 (nCoV) from 22 January to 3 February 2020. The raw data of Cases Confirmed and of Deaths is taken from <https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset/data#> and checked against data from <https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and for regional data from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We divide data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan and Tianmen in Hubei (see Fig. 1). The Death Rate is Number Deaths divided by Number Cases Confirmed, and Ratio Hubei/Others is the ratio of the Death Rate for Hubei to Others. The Fraction Change for all raw data is Value\_Today divided by Value\_Yesterday.

Plots of this data against time are shown in Fig. 2. Panel (A) shows expected increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 95%). Panel (C) shows that the Death Rate (Mortality) is high in Hubei, but elsewhere it is 16 times lower. At 0.2 %, the rate is comparable to the mortality of influenza. Panel (D) shows that the number of reported cases changes unpredictably in all three regions (Hubei, non-Hubei & Total); of all the measures these numbers seem least reliable. Most interesting is Panel (E), which shows that the number of deaths is increasing more and more slowly. Specifically, the ratio of Deaths\_Today to Deaths\_Yesterday is decreasing. This decrease is almost monotonic for Total Deaths and Hubei Death since 1/25/2020 and fairly linear for them both since 1/29/2020. Linear extrapolation that the number of new deaths will decrease very rapidly over the next week.

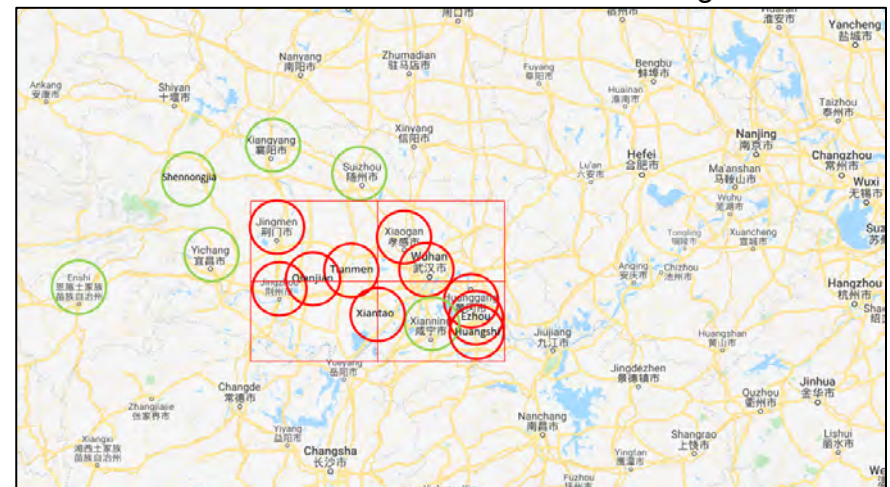


Figure 1. Map of Hubei circling in red cities with a death rate > 0.9% and in green those with rate < 0.4%. Deaths are localized to a 90km x 35km area centered near Tianmen near (data 12/31/2020, [jobtube.cn](https://jobtube.cn))



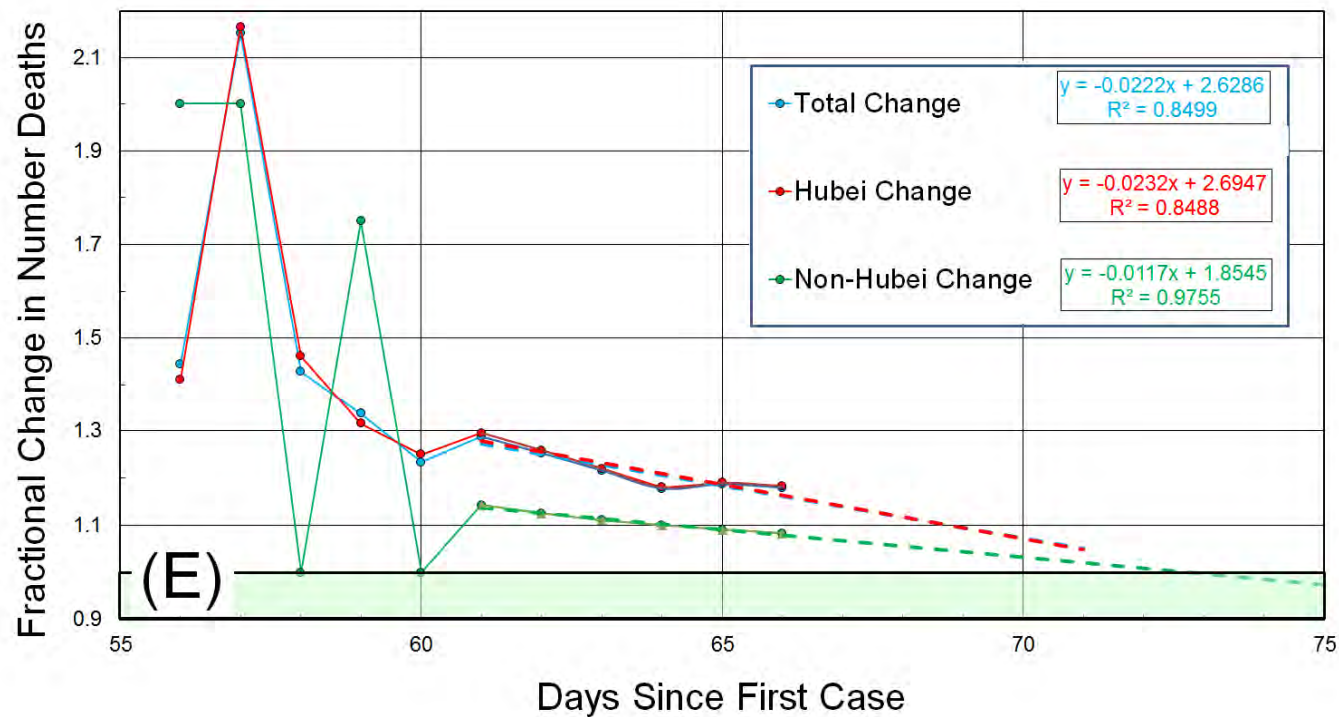
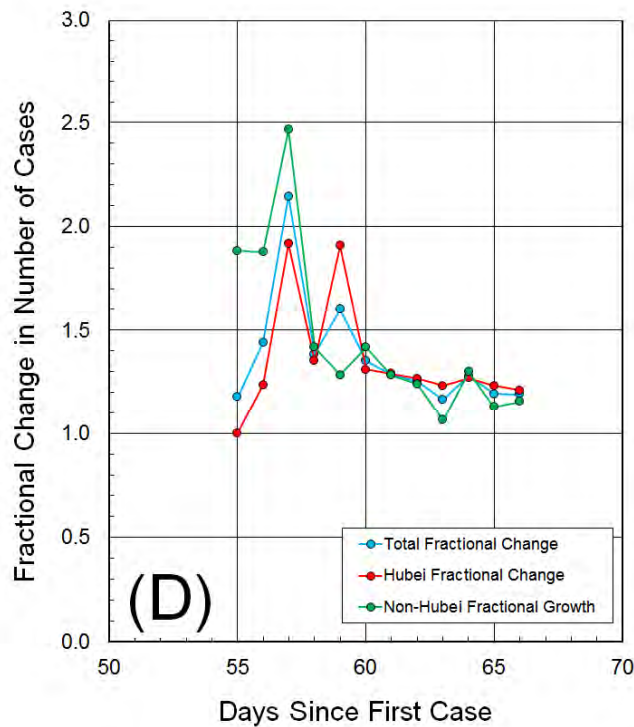
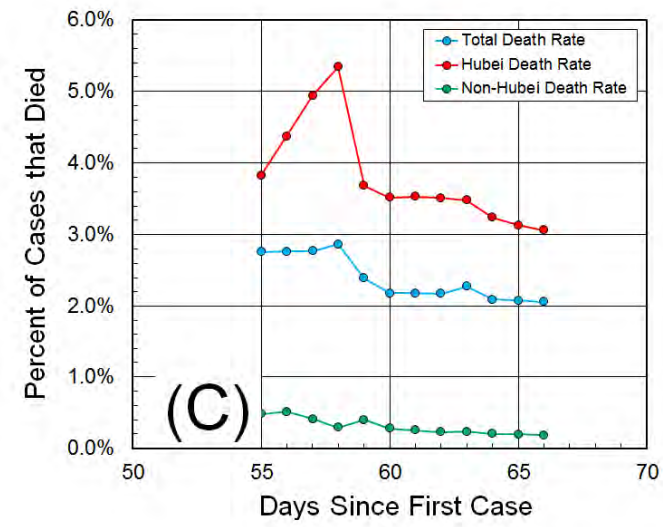
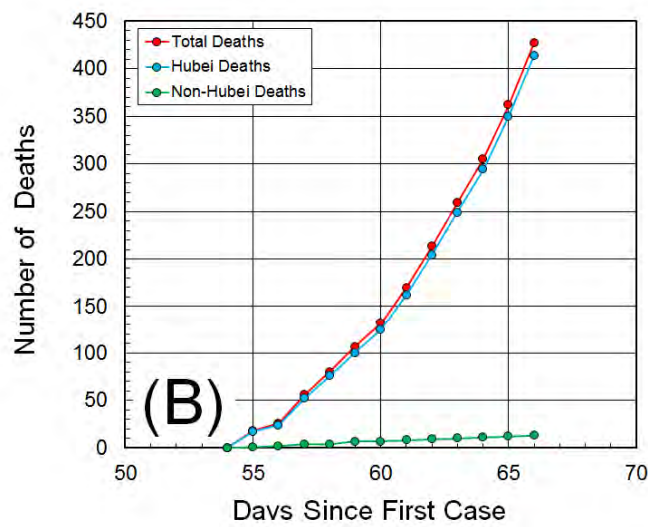
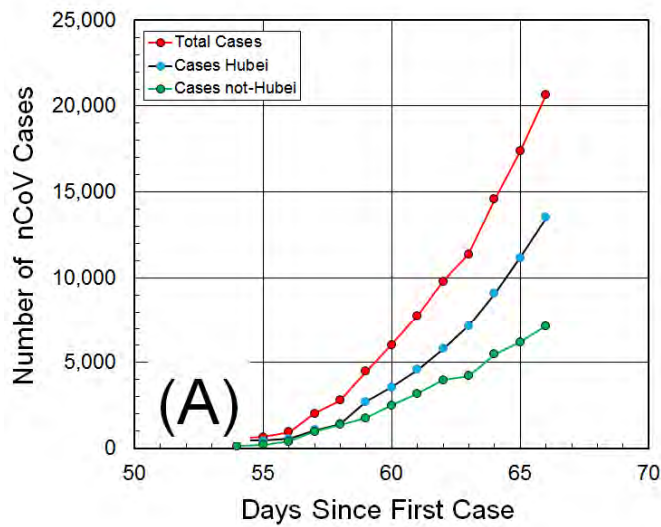
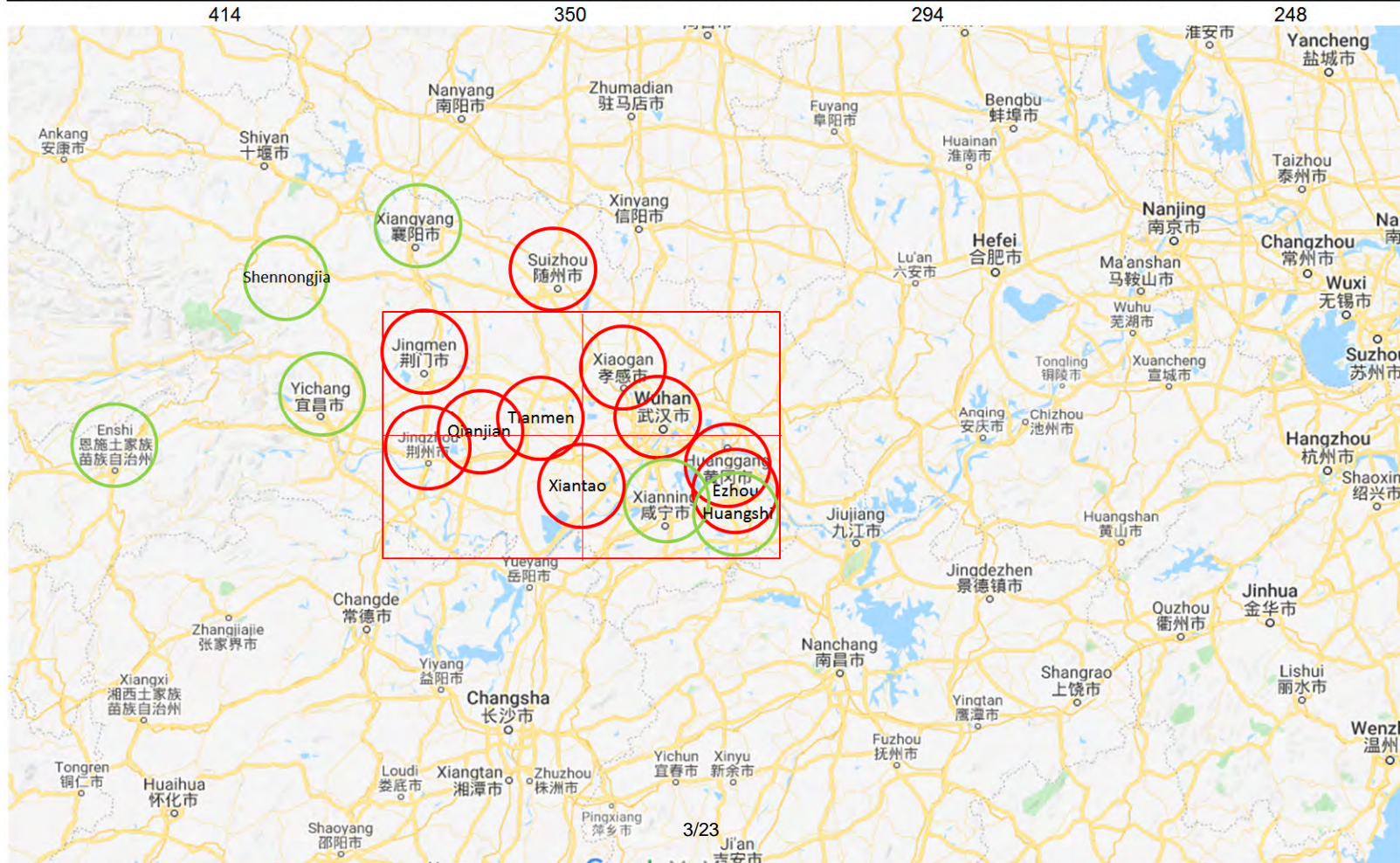


Figure 2. Variation of nCoV-2019 data against time in days since 29 Nov 2019 (guessed first case). Table 1 data is plotted from 22 January to 3 February 2020. In Panel (E) linear trend-lines are added using data for last four days from 1/29/2020. For Total Change, Hubei Change and non-Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.92$ ). This suggests the Fractional Change will decrease to about 1.0 within a week, after which time numbers will grow slowly.



	3-Feb				2-Feb				1-Feb				31-Jan					
Hubei	13522	414	3.06%	1.18	Hubei	11177	350	3.13%	1.19	Hubei	9074	294	3.24%	1.18	Hubei	7153	249	3.48%
Wuhan	6384	313	4.90%	1.18	Wuhan	5142	265	5.15%	1.18	Wuhan	4109	224	5.45%	1.17	Wuhan	3215	192	5.97%
Huanggang	1422	19	1.34%	1.12	Huanggang	1246	17	1.36%	1.13	Huanggang	1002	15	1.50%	1.07	Huanggang	726	14	1.93%
Xiaogan	1120	17	1.52%	1.21	Xiaogan	918	14	1.53%	1.00	Xiaogan	749	14	1.87%	1.17	Xiaogan	628	12	1.91%
Suizhou	641	6	0.94%	1.20	Suizhou	458	5	1.09%	1.67	Suizhou	384	3	0.78%	3.00	Suizhou	304	1	0.33%
Xiangyang	632	1	0.16%	1.00	Xiangyang	548	0	0.00%	1.00	Xiangyang	441	0	0.00%	1.00	Xiangyang	347	0	0.33%
Jingzhou	613	7	1.14%	1.17	Jingzhou	499	6	1.20%	1.50	Jingzhou	333	4	1.20%	1.00	Jingzhou	287	4	1.39%
Yichang	452	3	0.66%	3.00	Yichang	392	1	0.26%	1.00	Yichang	353	1	0.28%	1.00	Yichang	276	1	0.36%
Huangshi	405	2	0.49%	1.00	Huangshi	334	2	0.60%	1.00	Huangshi	252	2	0.79%	1.00	Huangshi	209	2	0.96%
Jingmen	400	14	3.50%	1.27	Jingmen	345	11	3.19%	1.57	Jingmen	329	7	2.13%	1.40	Jingmen	251	5	1.99%
Xianning	348		0.00%	1.00	Xianning	296	0	0.00%	1.00	Xianning	246	0	0.00%	1.00	Xianning	206	0	0.00%
Ezhou	332	18	5.42%	1.20	Ezhou	306	15	4.90%	1.15	Ezhou	278	13	4.68%	1.44	Ezhou	227	9	3.96%
Shiyan	291		0.00%	1.00	Shiyan	256	0	0.00%	1.00	Shiyan	212	0	0.00%	1.00	Shiyan	177	0	0.00%
Xiantao	188	3	1.60%	1.00	Xiantao	169	3	1.78%	1.00	Xiantao	140	3	2.14%	3.00	Xiantao	97	1	1.03%
Enshi	123		0.00%	1.00	Enshi	111	0	0.00%	1.00	Enshi	105	0	0.00%	1.00	Enshi	87	0	0.00%
Tianmen	117	10	8.55%	1.00	Tianmen	115	10	8.70%	1.43	Tianmen	99	7	7.07%	1.00	Tianmen	82	7	8.54%
Qianjiang	44	1	2.27%	NA	Qianjiang	35	1	2.86%	0.00	Qianjiang	35	1	2.86%	0.00	Qianjiang	27	0	0.00%
Shennongjia	10		0.00%	1.00	Shennongjia	7	0	0.00%	1.00	Shennongjia	7	0	0.00%	1.00	Shennongjia	7	0	0.00%





# “Analysis of nCov-2019 Data on 2/5/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths			
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others	
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0							
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-	
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000	
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000	
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000	
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750	
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000	
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143	
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125	
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111	
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100	
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091	
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083	
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000	

Table 1. Showing data for New Coronavirus 2019 (nCoV) from 22 January to 4 February 2020. The raw data of Cases Confirmed and of Number Deaths is taken from <https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset/data#> and checked against data from <https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and for regional data from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan in Hubei (see Fig. 2). The Death Rate is Number Deaths divided by Number Cases Confirmed, and Ratio Hubei/Others is the ratio of the Death Rate for Hubei to Others. The Fraction Change for all raw data is Value\_Today divided by Value\_Yesterday.

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 (over 97%). Panel (C) shows that the Death Rate (Mortality) is high in Hubei, but elsewhere it is 16 times lower. At 0.18 %, the rate is comparable to the mortality of influenza. Panel (D) shows that the number of reported cases changes unpredictably in all three regions (Hubei, non-Hubei & Total); of all the measures these numbers seem least reliable. Most interesting is Panel (E), which shows that the number of deaths is increasing more and more slowly. Specifically, the ratio of Deaths\_Today to Deaths\_Yesterday is decreasing. This decrease is almost monotonic for Total Deaths and Hubei Death since 1/25/2020 and fairly linear for them both since 1/29/2020. Linear extrapolation, which is not necessary applicable, suggests the number of new deaths will stop growing and start to decrease over the next week. The total number of death with then growth more and more slowly.

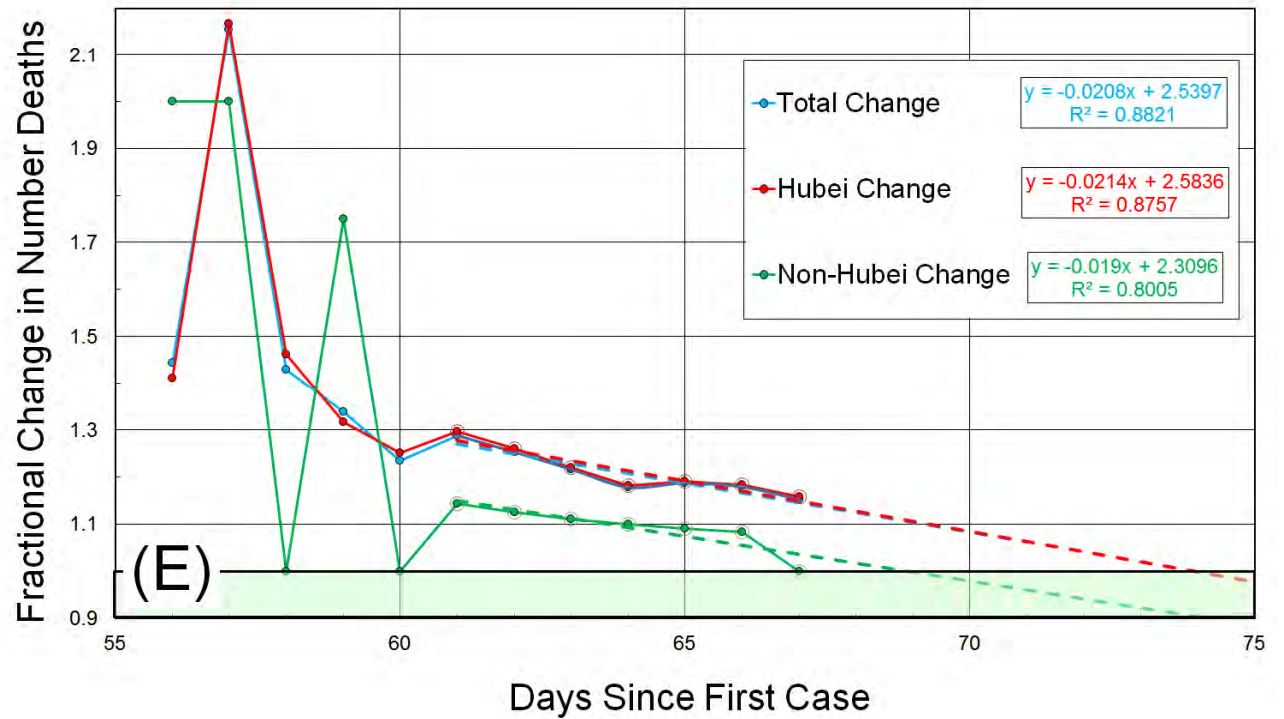
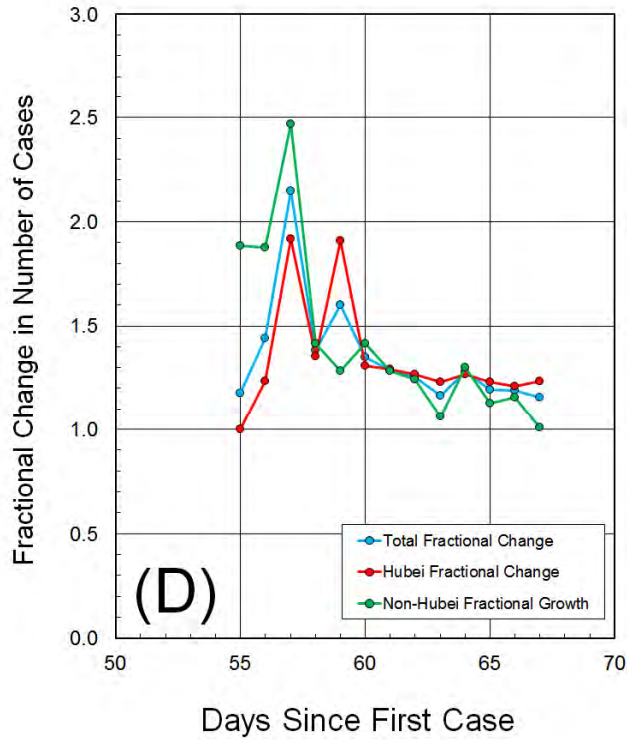
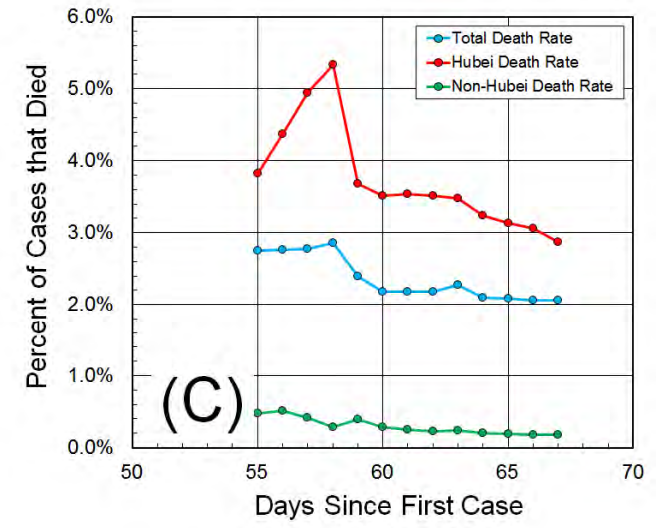
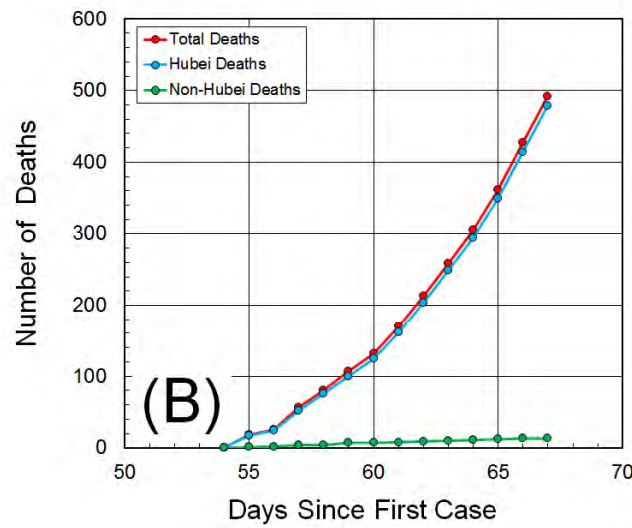
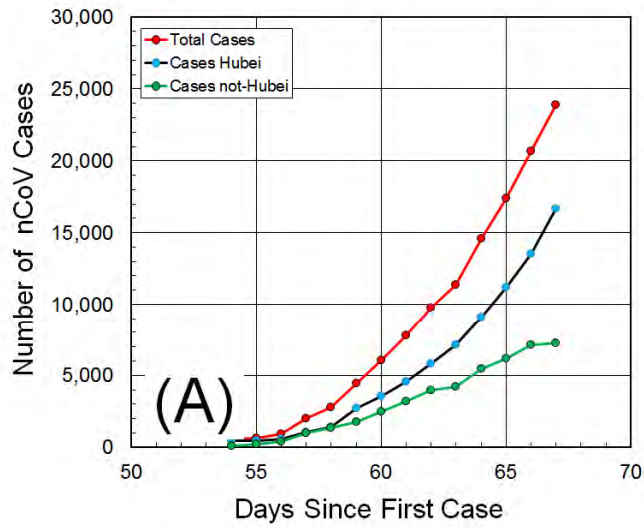
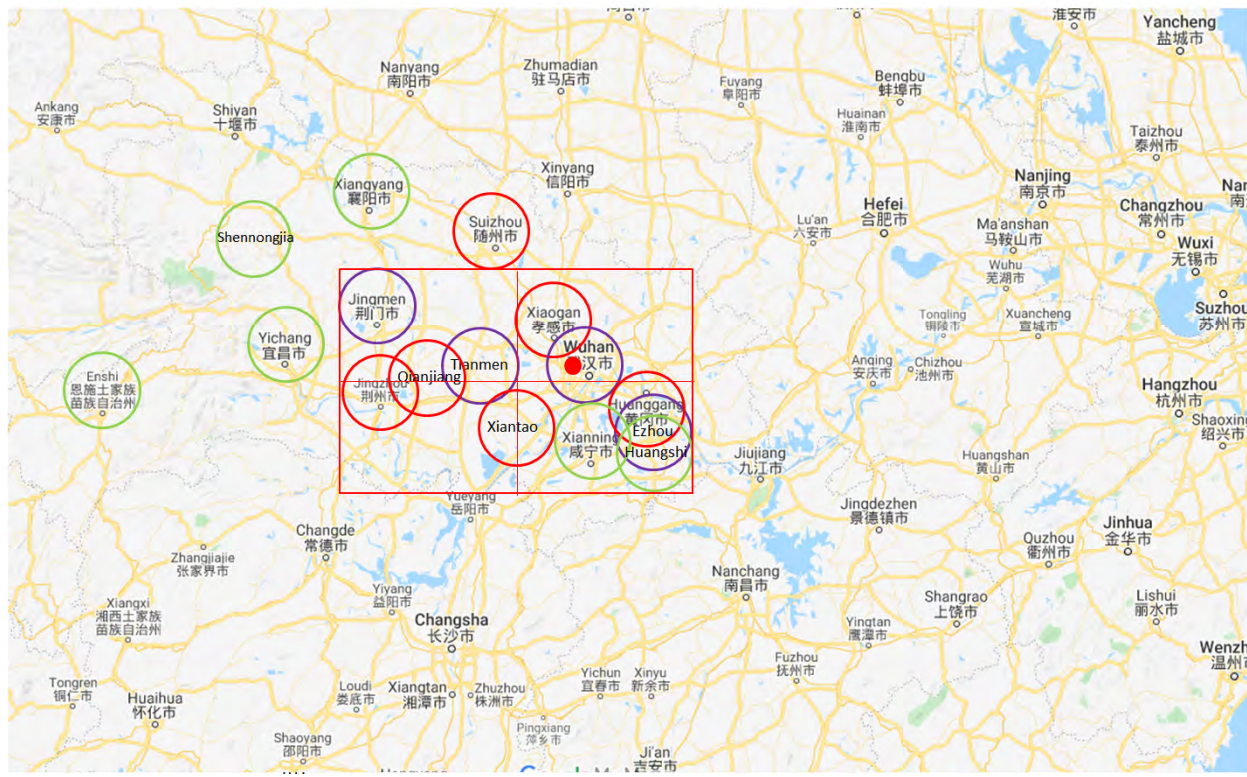


Figure 1. Variation of nCov-2019 data against time in days since 29 Nov 2019 (guessed date of first case). Table 1 data is plotted from 22 January to 4 February 2020. In Panel (E) linear trend-lines are added using data for last four days from 1/29/2020. For Total Change, Hubei Change and non-Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.89$ ). This suggests the Fractional Change in Number of Deaths will decrease to about 1.0 within a week, after which time, numbers will grow slowly.



			4-Feb				3-Feb				2-Feb				1-Feb				31-Jan		
Province	Population	Confirmed/ 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
Hubei	58,500,000	285.1	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%
City in Hubei																					
Wuhan	11,080,000	753.7	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	363.8	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	139.6	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	73.9	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	222.2	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	298.4	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	193.1	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	282.4	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	191.5	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	54.0	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	122.2	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	207.8	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	816.7	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	184.0	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	131.6	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	95.2	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	137.1	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%



**Figure. 2.** Map of Hubei circling in purple cities with a death rate  $\geq 3\%$ , in red cities with a death rate  $> 1\%$  and in green other cities for which there is tabulated data. Deaths are localized to a 90km x 35km area centered near Tianmen near (The table shows that high death rates are concentrated in four cities Wuhan, Ezhou, Jingmen and Tianmen. Other cities in the same area have low death rates comparable to areas elsewhere in China and the rest of the world data (1/4/2020 from [jobtube.cn](http://jobtube.cn)). The red dot marks the Wuhan South China Seafood Market.

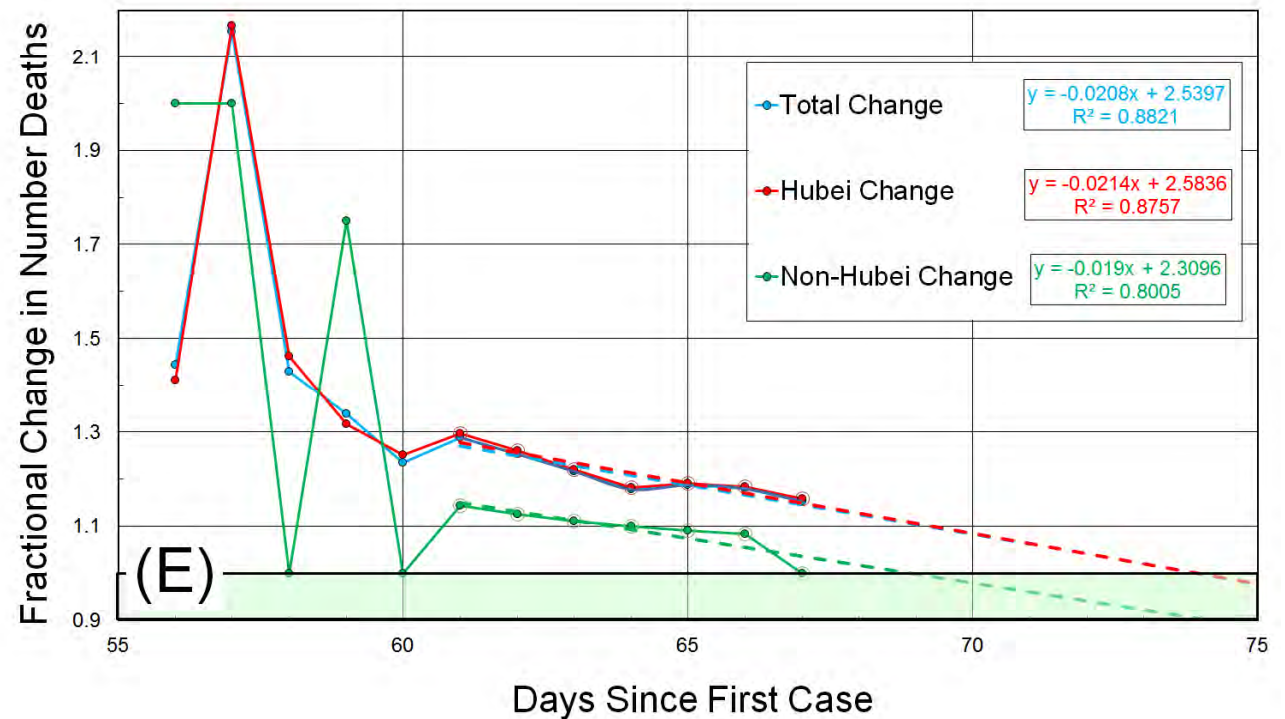
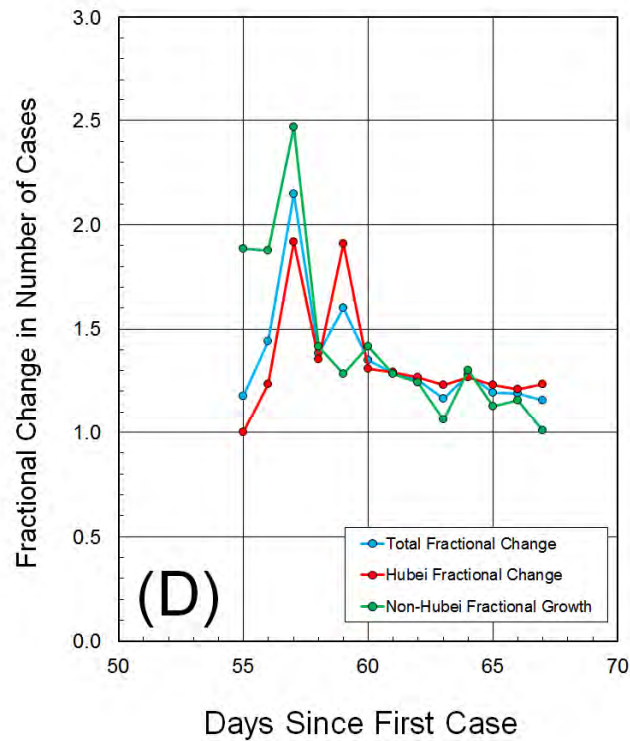
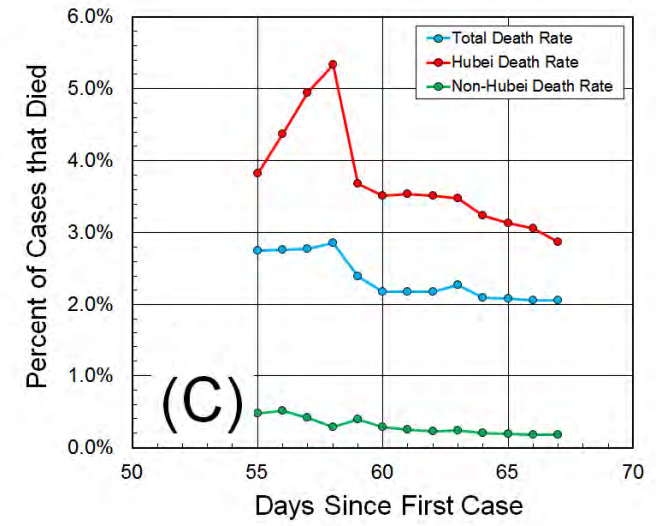
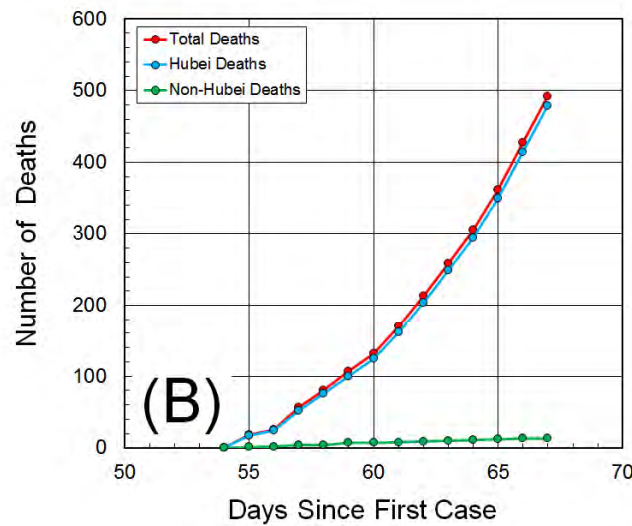
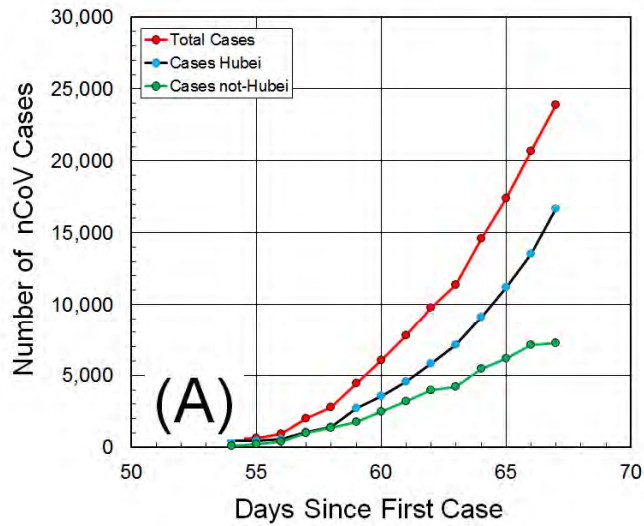
# “Analysis of nCov-2019 Data on 2/5/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 4 February 2020. The raw data of Cases Confirmed and of Number Deaths is taken from <https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset/data#> and checked against data from <https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and for regional data from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan in Hubei (see 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.

Plots of this data against time are shown in Fig. 1. Panel (A) shows expected exponential increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 97%). Panel (C) shows that the Hubei death rate has decreased steadily from 3.5% a week ago to 3% today (5 Feb. 2020). While the Death Rate is high in Hubei at 3%, the non-Hubei rate is 16 times lower. At 0.18 %, the non-Hubei death rate is comparable to that of influenza. Panel (D) shows that the number of cases changes unpredictably for Hubei, non-Hubei & Total, but it is slowly decreasing; of all the measures, these numbers seem least reliable. Panel (E), shows that a week ago the Fractional Change in Total Deaths (Deaths\_Today / Deaths\_Yesterday) was 1.3 (30% more deaths per day) but by today this ratio is just 1.15 (15% more deaths per day). Specifically, the overall ratio of deaths today to deaths yesterday has decreased steadily since 1/25/2020. This suggests that the rate of increase in number of deaths will slow down over the next week.





**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 4 February 2020. In Panel (E) linear trend-lines are added using data for the last seven days from 1/29/2020. For Total Change, Hubei Change and non-Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.89$ ). This linear extrapolation suggests the Fractional Change in Number of Deaths will decrease to near 1.0 within a week, after which time, numbers of deaths will grow slowly.

Province	Population	Confirmed/ million pop	4-Feb				3-Feb				2-Feb				1-Feb				31-Jan		
			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	285.1	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%
City in Hubei																					
Wuhan	11,080,000	753.7	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	363.8	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	139.6	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	73.9	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	222.2	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	298.4	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	193.1	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	282.4	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	191.5	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	54.0	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	122.2	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	207.8	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	816.7	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	184.0	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	131.6	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	95.2	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	137.1	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 4 Feb.

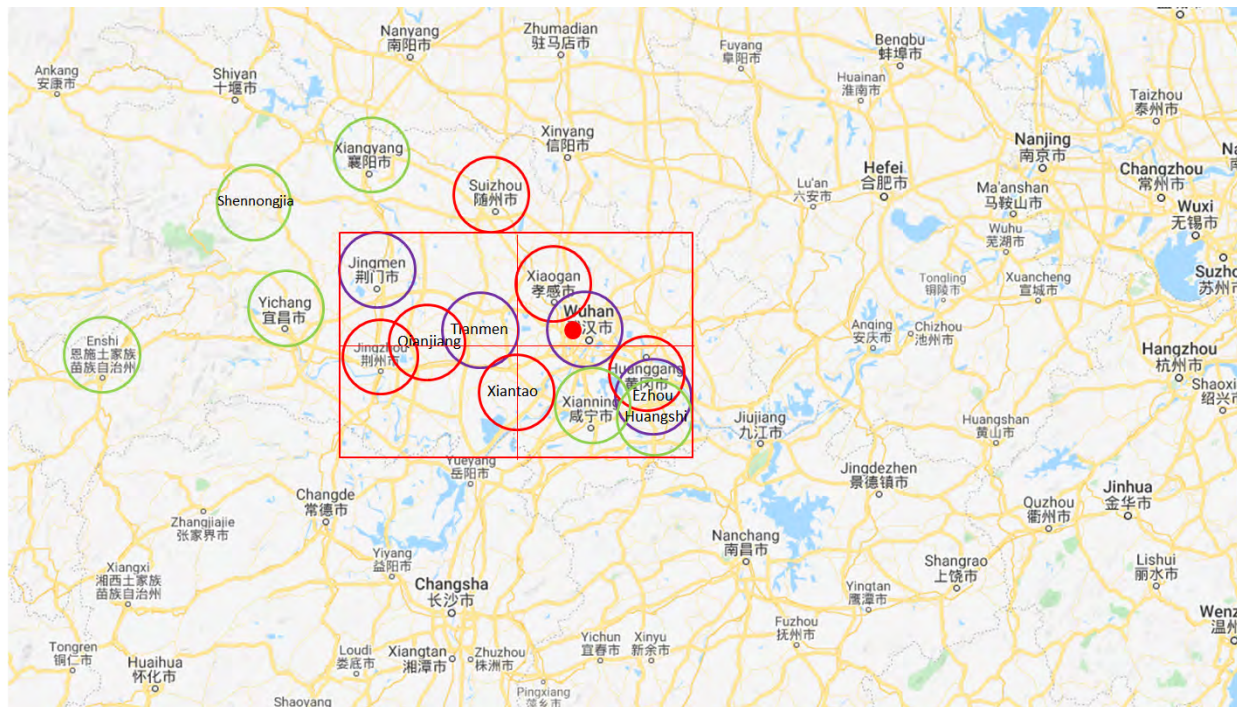


Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen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

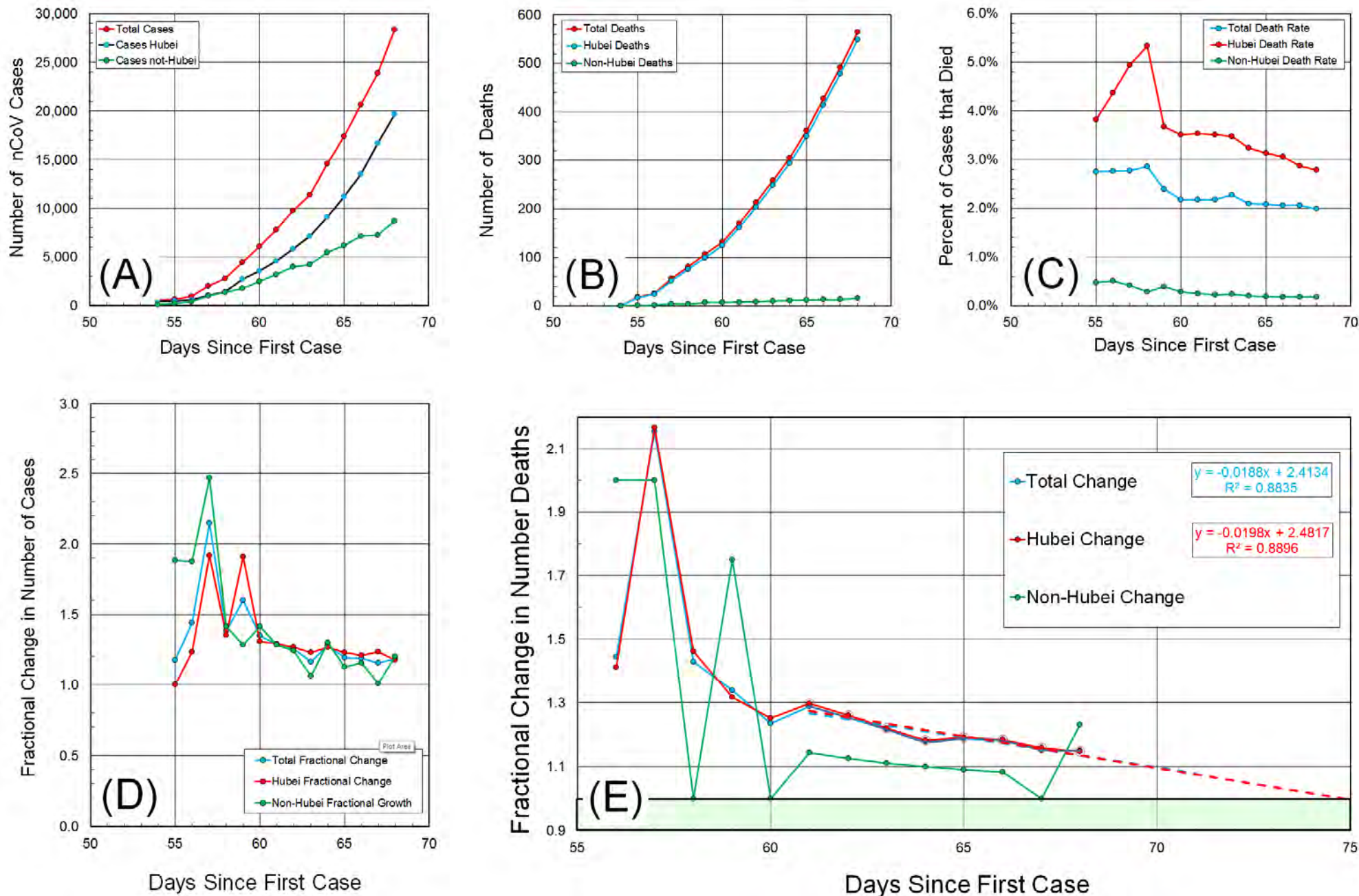


“Analysis of nCov-2019 Data on 2/6/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000
2/5/2020	68	28344	19665	8679	565	549	16	1.99%	2.79%	0.18%	15.1	1.186	1.179	1.201	1.148	1.146	1.231

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 5 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://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan in Hubei (see 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.

Plots of this data against time are shown in Fig. 1. Panel (A) shows expected exponential increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 97%). Panel (C) shows that the Hubei death rate has decreased steadily from 3.5% a week ago to 3% today (5 Feb. 2020). While the Death Rate is high in Hubei at 2.8%, the non-Hubei rate is 15 times lower. At 0.18 %, the non-Hubei death rate is comparable to that of influenza. Panel (D) shows that the number of cases changes unpredictably for Hubei, non-Hubei & Total, but it is slowly decreasing; of all the measures, these numbers seem least reliable. Panel (E), shows that a week ago the Fractional Change in Total Deaths (Deaths\_Today / Deaths\_Yesterday) was 1.3 (30% more deaths per day) but by today this ratio is less than 1.15 (14.8% more deaths per day). Specifically, the overall ratio of deaths today to deaths yesterday has decreased steadily since 1/25/2020. This suggests that the rate of increase in the number of deaths will slow down over the next week. The rate of drop of this ratio for the past 8 days is less than it was for the first 4 days of this analysis (29/1 to 1/2) but it is still dropping.



**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 Panel (E) linear trend-lines are added using data for the last seven days from 1/29/2020. For Total Change and Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.89$ ). This linear extrapolation to Hubei Data suggests the Fractional Change in Number of Deaths will decrease to near 1.0 within a week, after which time, numbers of deaths will grow slowly. The fit to non-Hubei deaths is not shown due to fluctuations of small numbers.



Province or City in Hubei	Population	Deaths / million pop	5-Feb				4-Feb				3-Feb				2-Feb				1-Feb				31-Jan		
			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	9.4	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	37.4	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	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	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	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	3.9	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	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	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	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	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	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	1.5	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	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	2.2	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	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	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	3,530	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	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 5 Feb.

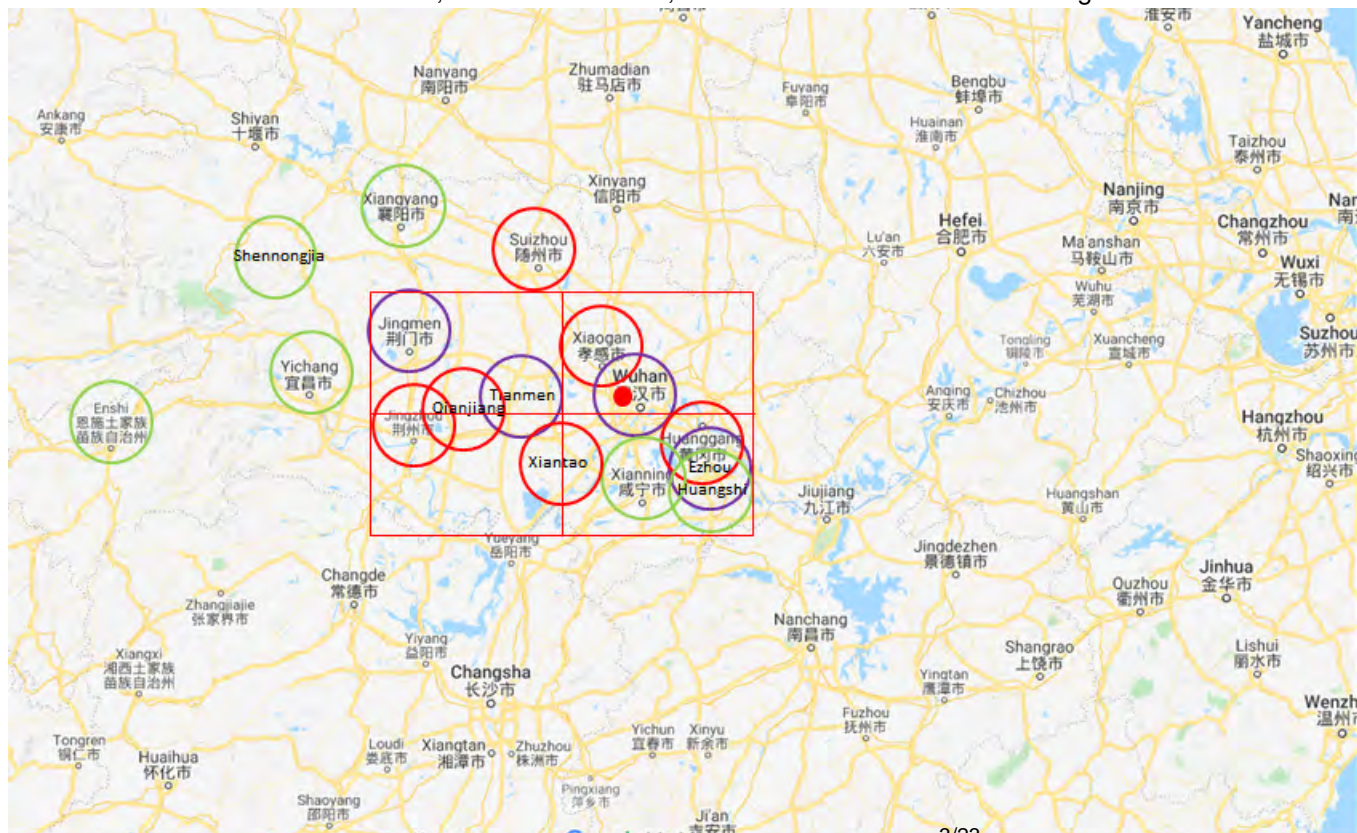


Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen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



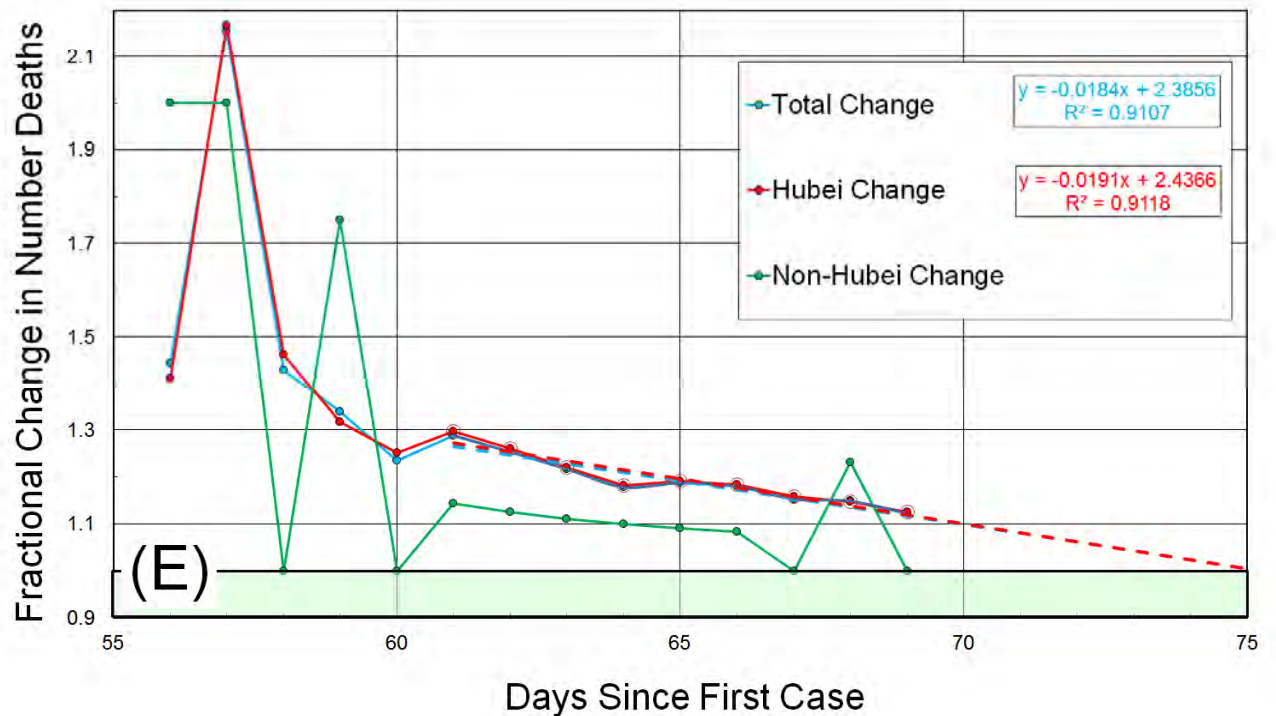
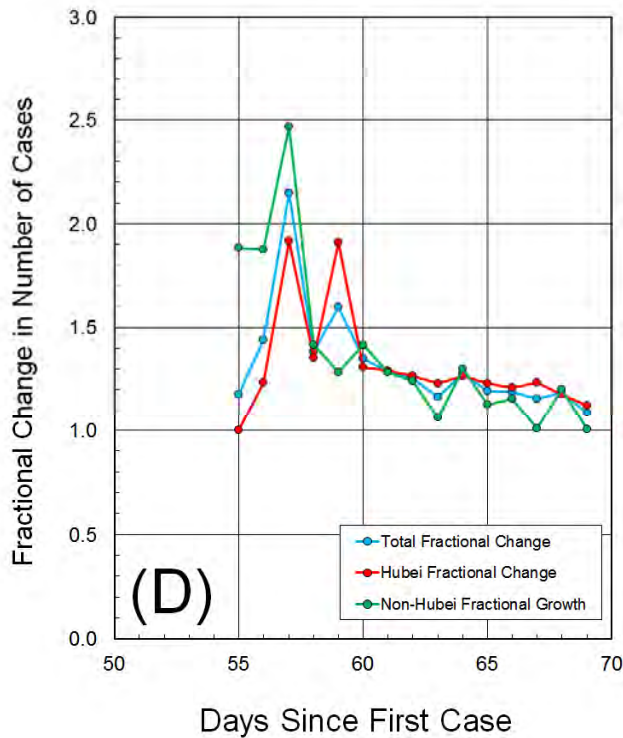
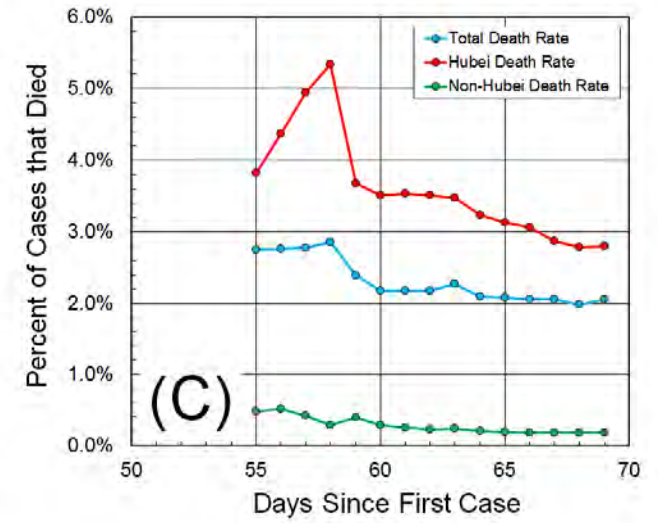
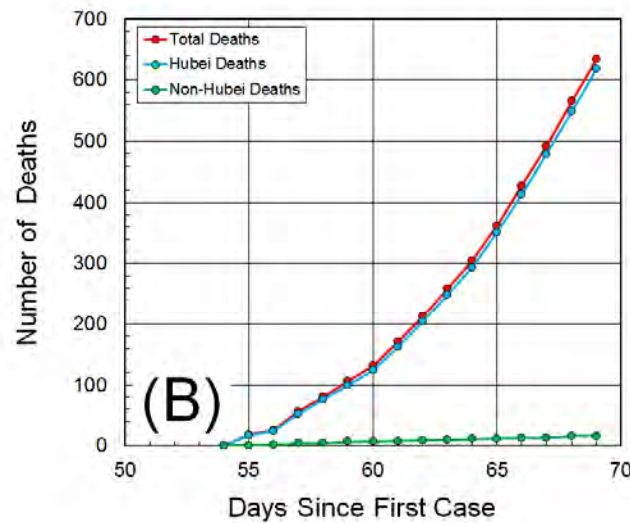
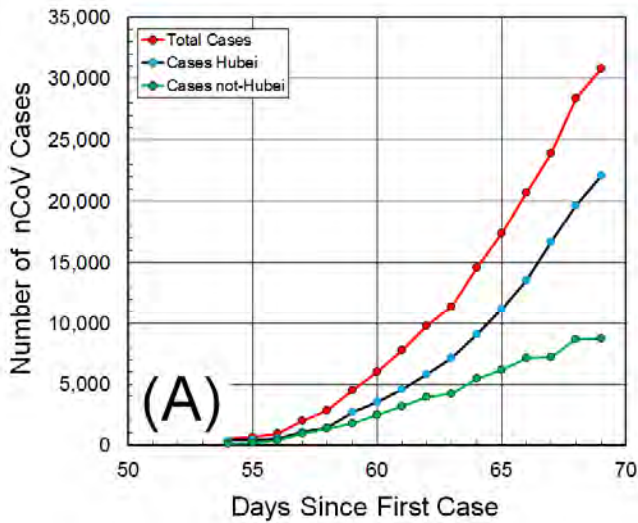
“Analysis of nCov-2019 Data on 2/7/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000
2/5/2020	68	28344	19665	8679	565	549	16	1.99%	2.79%	0.18%	15.1	1.186	1.179	1.201	1.148	1.146	1.231
2/6/2020	69	30818	22112	8706	634	618	16	2.06%	2.79%	0.18%	15.2	1.087	1.124	1.003	1.122	1.126	1.000

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 6 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://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan in Hubei (see **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.

Plots of this data against time are shown in **Fig. 1**. Panel (A) shows expected exponential increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 97%). Panel (C) shows that the Hubei death rate has decreased steadily from 3.5% a week ago to 2.8% today (6 Feb. 2020). While the Death Rate is high in Hubei at 2.8%, the non-Hubei rate is 15 times lower. At 0.18 %, the non-Hubei death rate is comparable to that of influenza. Panel (D) shows that the number of cases changes unpredictably for Hubei, non-Hubei & Total, but it is slowly decreasing; of all the measures, these numbers seem least reliable. Panel (E), shows that a week ago the Fractional Change in Total Deaths (Deaths\_Today / Deaths\_Yesterday) was 1.3 (30% more deaths per day) but by today this ratio is 1.12 (12.2% more deaths per day). Specifically, the overall ratio of deaths today to deaths yesterday has decreased steadily since 1/25/2020. This suggests that the rate of increase in the number of deaths will continue to slow down over the next week. An extrapolation based on the sigmoid function (see **Fig. 3**) suggests that the number of deaths will not exceed 1000 and that it will reach 95% of this limiting value on 14-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 Panel (E) linear trend-lines are added using data for the last seven days from 1/29/2020. For Total Change and Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.95$ ). This linear extrapolation to Hubei Data suggests the Fractional Change in Number of Deaths will decrease to near 1.0 within a week, after which time, numbers of deaths will grow slowly. The fit to non-Hubei deaths is not shown due to fluctuations of small numbers.



Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb				31-Jan		
			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	3,530	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.

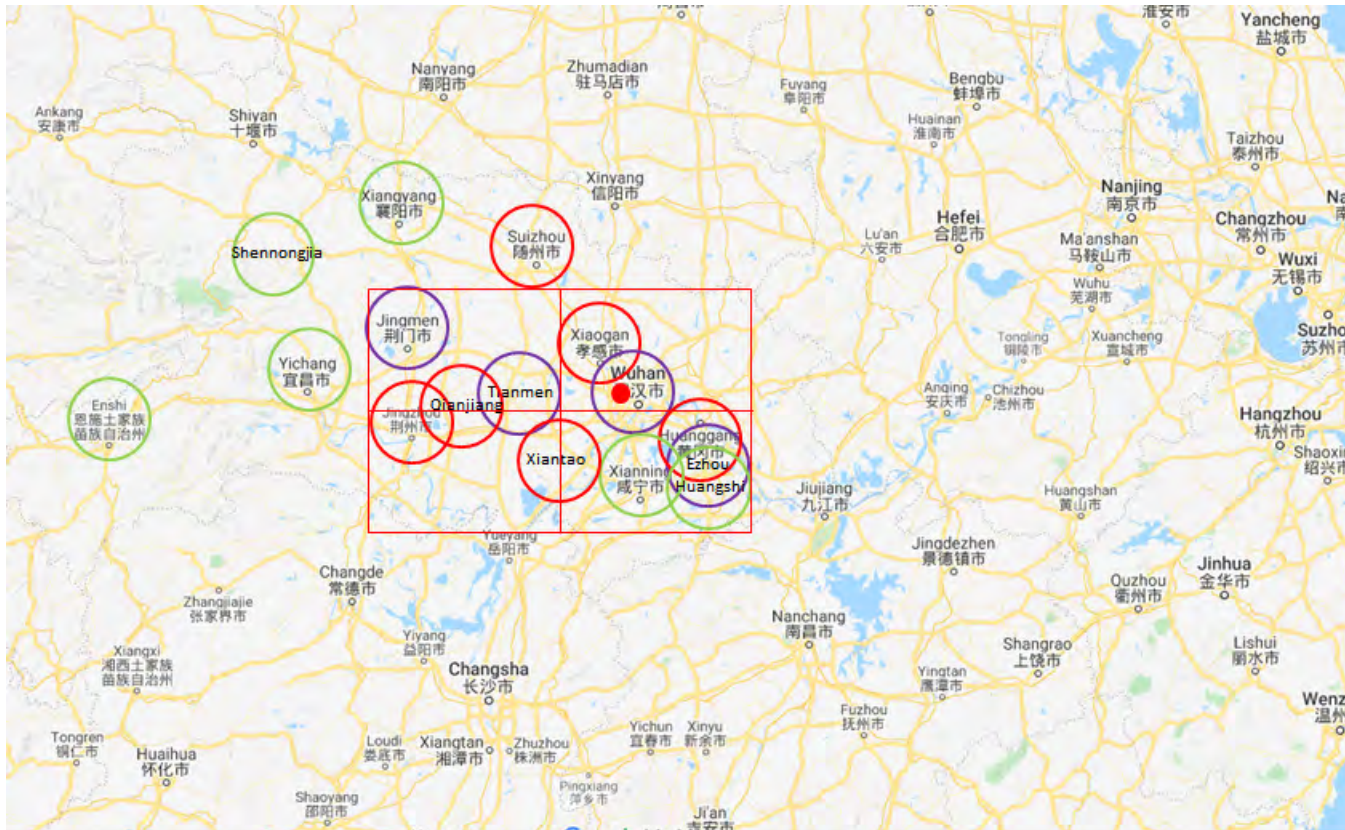
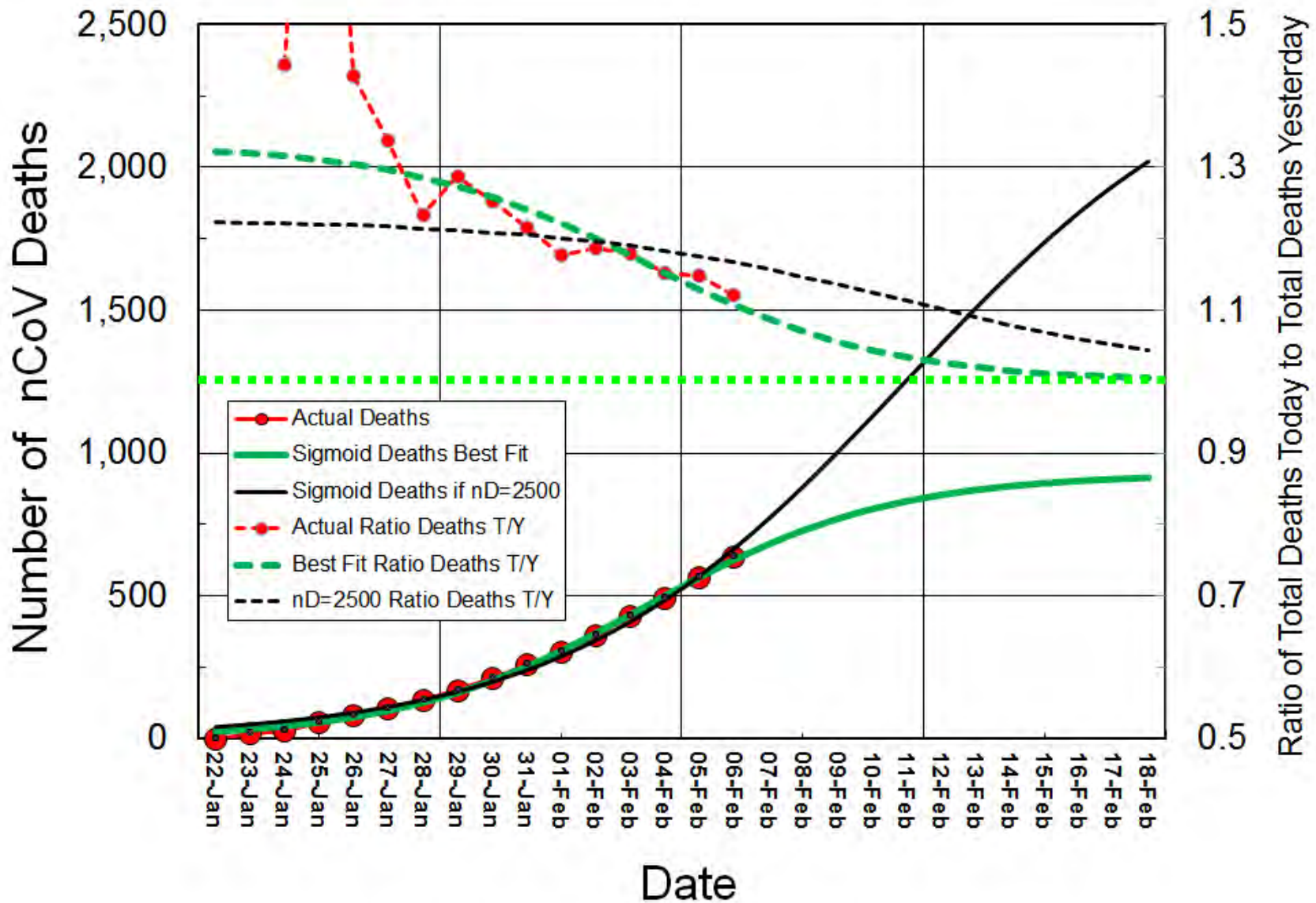


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**Figure 3.** Fit of the sigmoid function  $f(x) = 1/(1-\exp(-x))$  to the Total Number of Deaths from the coronavirus nCoV-2019 since 22 Jan 2020. The best fit (green line) was obtained using Excel to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B)/C)$  so that the 16 Actual Number of Death values (red solid line) best fit the sigmoid function. The optimized parameter values are  $A = 927.8$ ,  $B = 66.5$  and  $C = 3.5$  (RMS error of 10). Particularly impressive is the actual Ratio of Deaths Today to Yesterday (T/Y) from the actual data (red dashed line on secondary axis) is well fit by the calculated Ratio of Deaths Today to Yesterday (dashed green line on secondary axis) as the Ratio drops from 1.3 (30% daily growth on 29-Jan) to 1.12 (12% daily growth on 06-Feb). The black line is the best fit assuming total deaths is 2500, which fits the actual data less well (RMS error of 21). This is hard to see from the Number of Deaths but is much clearer from change of Ratio Deaths T/Y. This extrapolation suggests that we passed the mid-point of the sigmoid function on 04-Feb. and that by 14-Feb. we will have reached 95% of the eventual death count of 928.

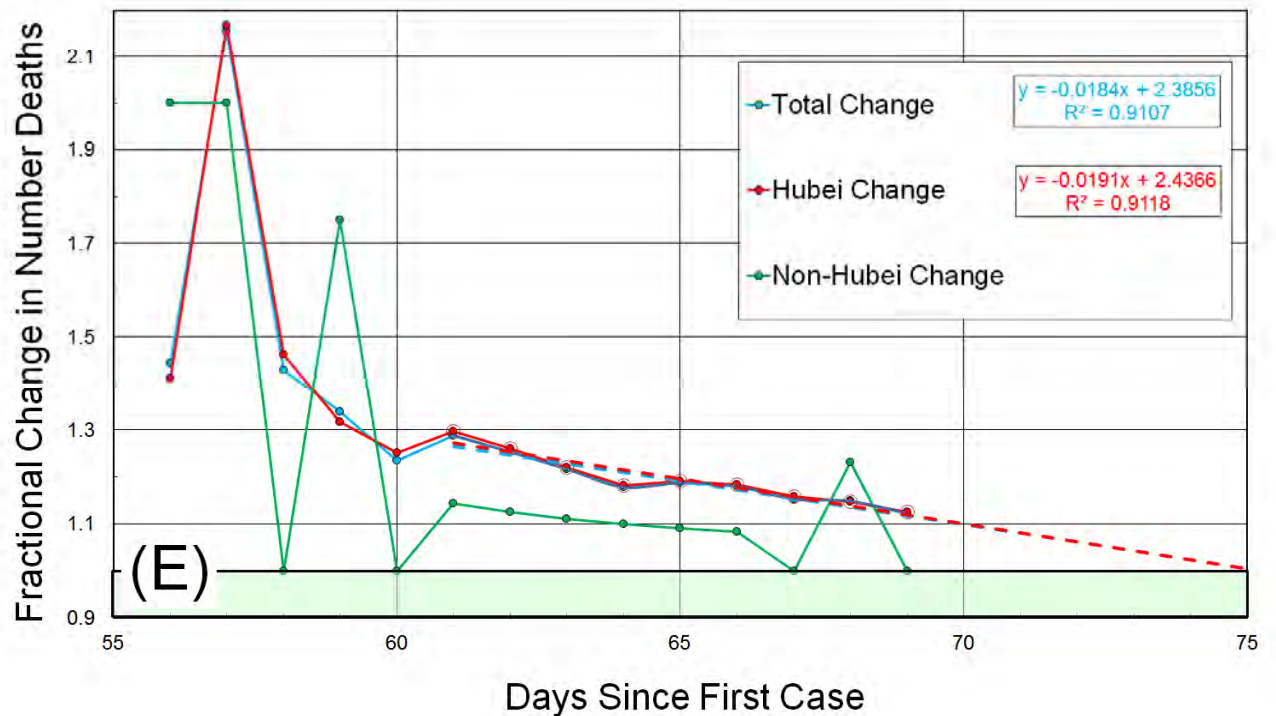
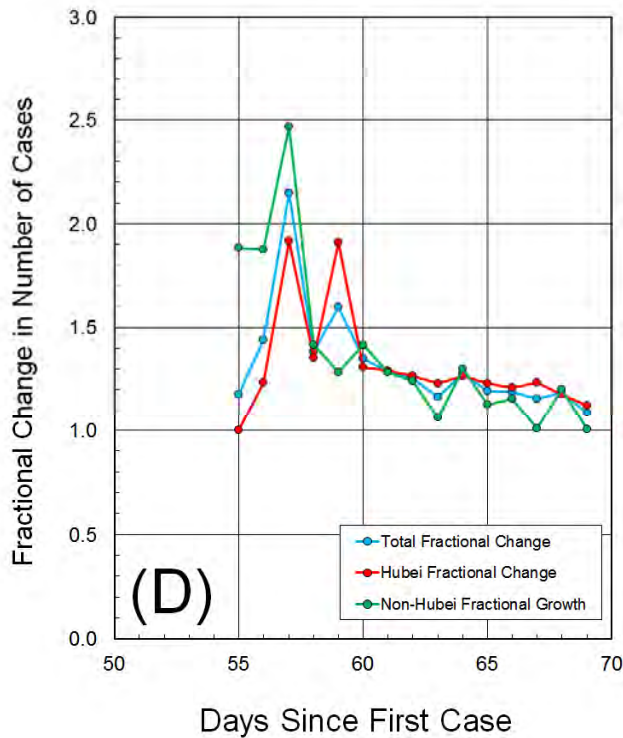
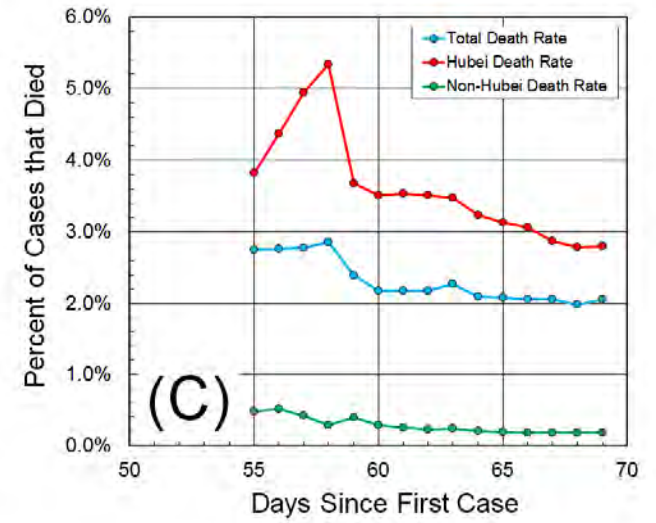
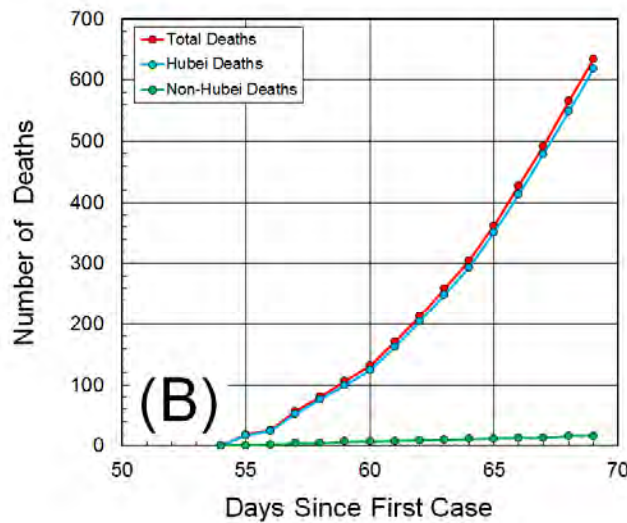
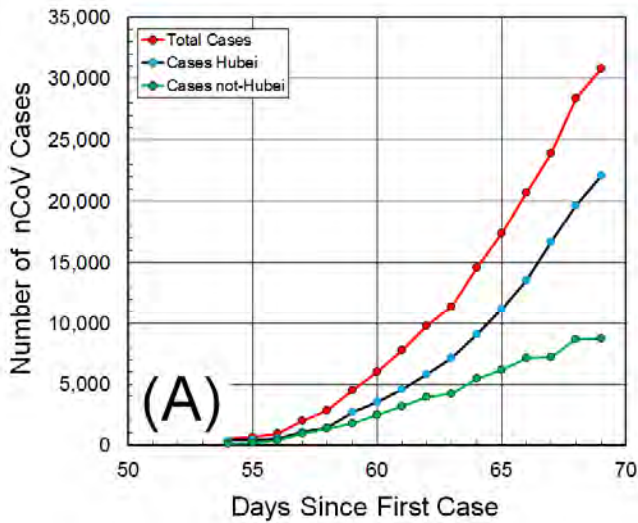
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Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb			31-Jan			
			Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	Death Rate	Death Change	Cases	Deaths	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.

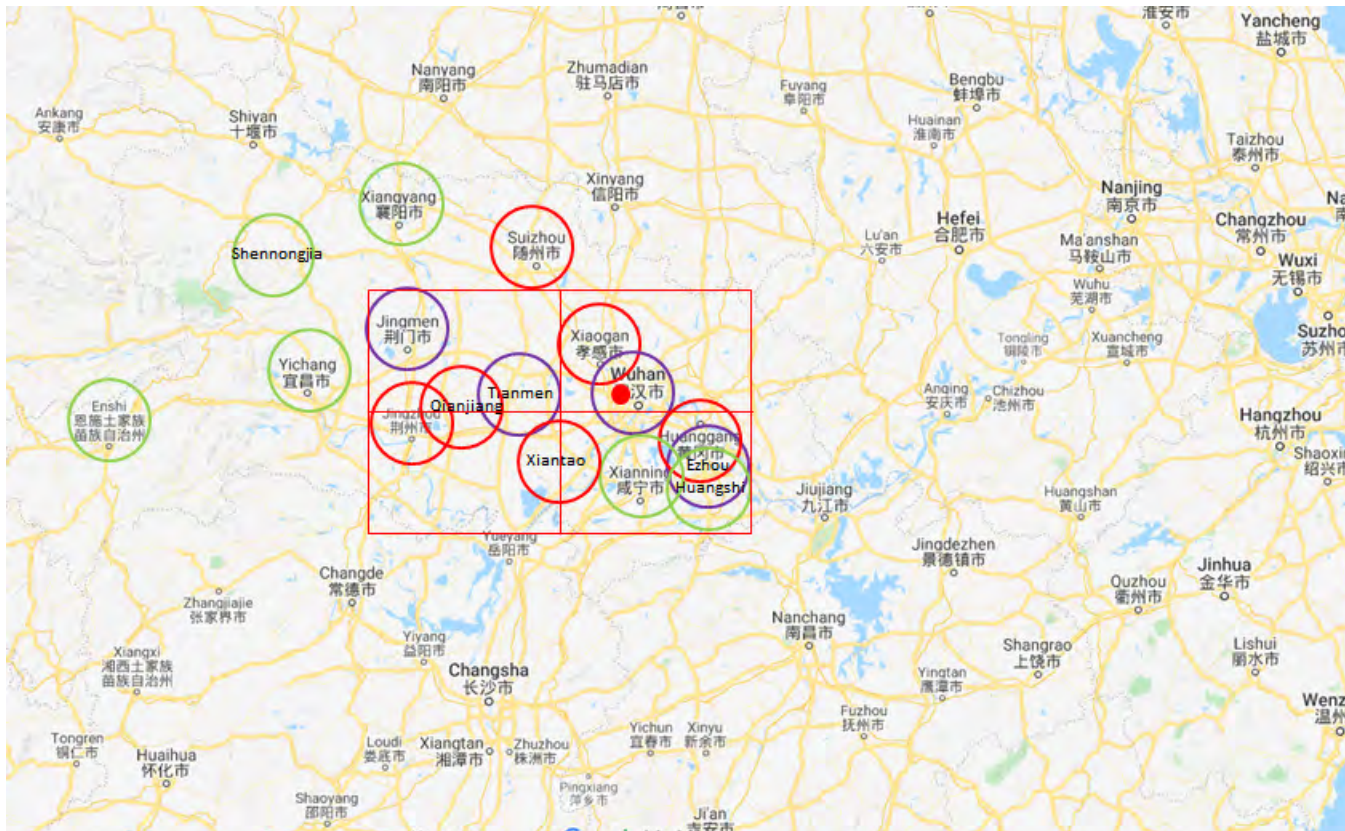
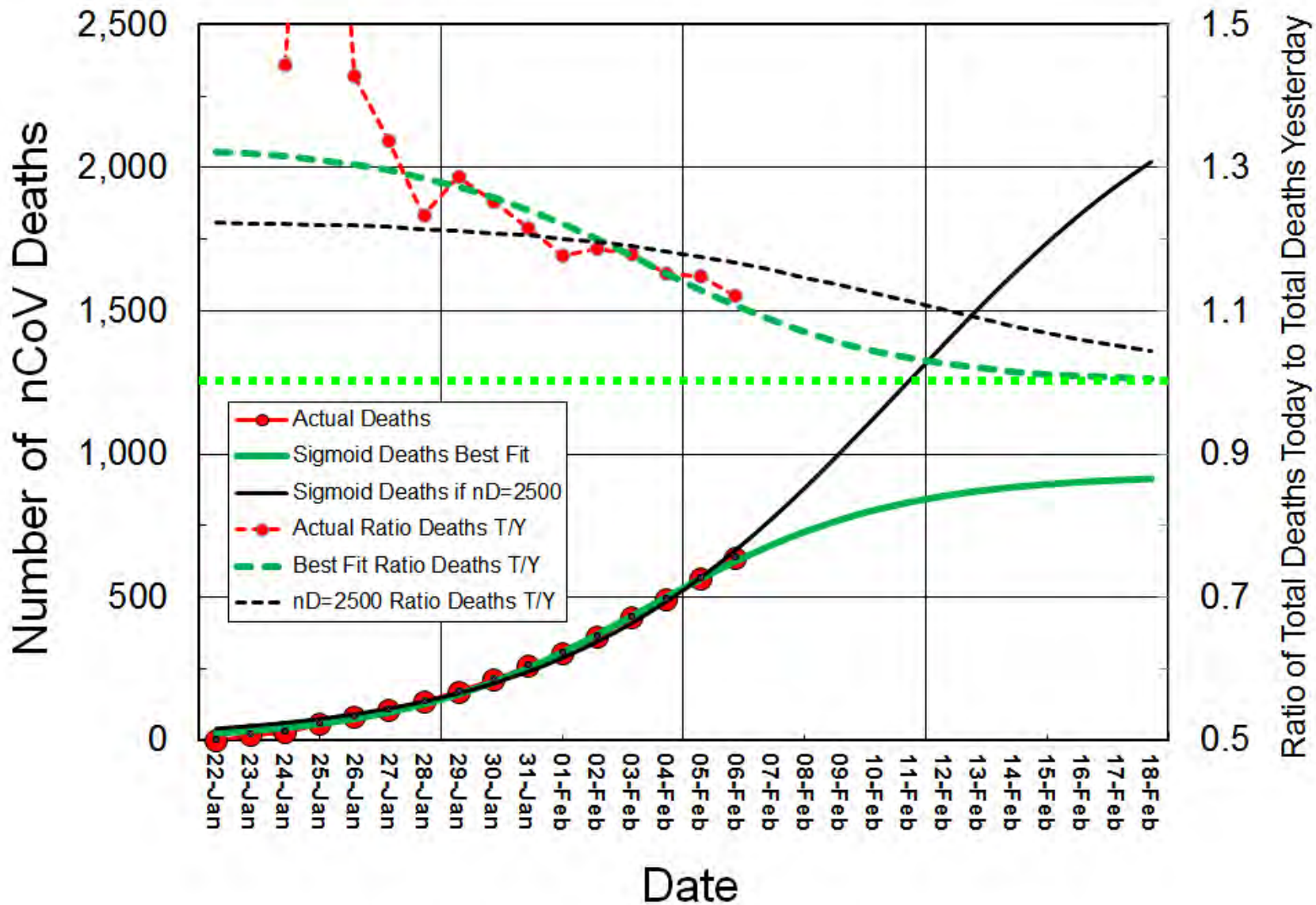


Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen (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](http://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 Total Number of Deaths from the coronavirus nCoV-2019 since 22 Jan 2020. The best fit (green line) was obtained using Excel to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B)/C)$  so that the 16 Actual Number of Death values (red solid line) best fit the sigmoid function. The optimized parameter values are  $A = 927.8$ ,  $B = 66.5$  and  $C = 3.5$  (RMS error of 10). Particularly impressive is the actual Ratio of Deaths Today to Yesterday (T/Y) from the actual data (red dashed line on secondary axis) is well fit by the calculated Ratio of Deaths Today to Yesterday (dashed green line on secondary axis) as the Ratio drops from 1.3 (30% daily growth on 29-Jan) to 1.12 (12% daily growth on 06-Feb). The black line is the best fit assuming total deaths is 2500, which fits the actual data less well (RMS error of 21). This is hard to see from the Number of Deaths but is much clearer from change of Ratio Deaths T/Y. This extrapolation suggests that we passed the mid-point of the sigmoid function on 04-Feb. and that by 14-Feb. we will have reached 95% of the eventual death count of 928.

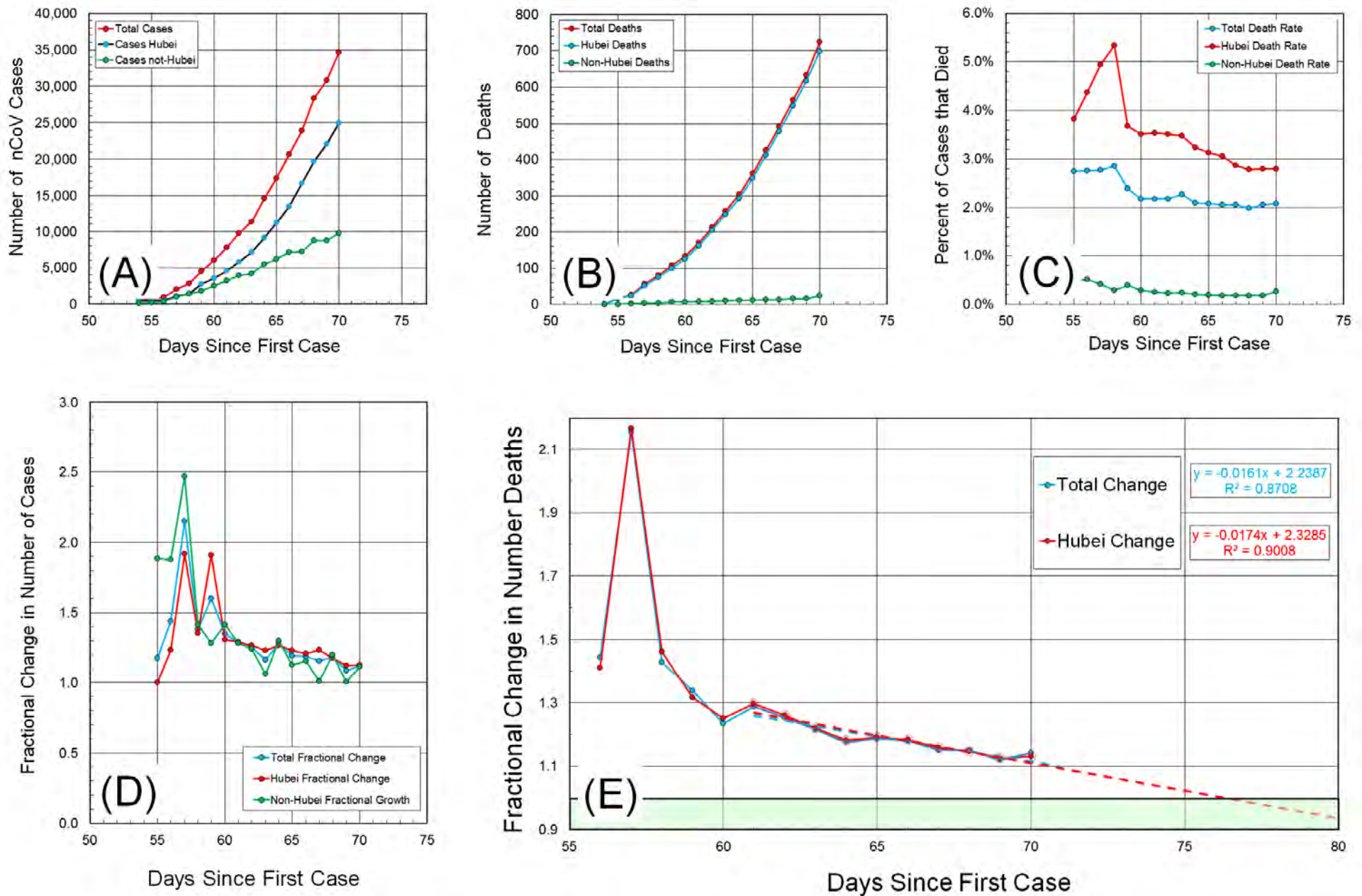
“Analysis of nCov-2019 Data on 2/8/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000
2/5/2020	68	28344	19665	8679	565	549	16	1.99%	2.79%	0.18%	15.1	1.186	1.179	1.201	1.148	1.146	1.231
2/6/2020	69	30818	22112	8706	634	618	16	2.06%	2.79%	0.18%	15.2	1.087	1.124	1.003	1.122	1.126	1.000
2/7/2020	70	34662	24953	9709	724	699	25	2.09%	2.80%	0.26%	10.9	1.125	1.128	1.115	1.142	1.131	1.563

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 7 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://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan in Hubei (see **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.

Plots of this data against time are shown in **Fig. 1**. Panel (A) shows expected exponential increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 97%). Panel (C) shows that the Hubei death rate has decreased steadily from 3.5% a week ago to 2.8% today (6 Feb. 2020). While the Death Rate is high in Hubei at 2.8%, the non-Hubei rate is 11 times lower. At 0.26 %, the non-Hubei death rate is comparable to that of influenza. Panel (D) shows that the number of cases changes unpredictably for Hubei, non-Hubei & Total, but it is slowly decreasing; of all the measures, these numbers seem least reliable. Panel (E), shows that a week ago the Fractional Change in Total Deaths (Deaths\_Today / Deaths\_Yesterday) was 1.3 (30% more deaths per day) but by today this ratio is 1.14 (14.2% more deaths per day). Specifically, the overall ratio of deaths today to deaths yesterday has decreased steadily since 1/25/2020. This suggests that the rate of increase in the number of deaths will continue to slow down over the next week. An extrapolation based on the sigmoid function (see **Fig. 3**) suggests that the number of deaths may not exceed 1000 and that it will reach 95% of this limiting value on 14-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 Panel (E) linear trend-lines are added using data for the last seven days from 1/29/2020. For Total Change and Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.95$ ). This linear extrapolation to Hubei Data suggests the Fractional Change in Number of Deaths will decrease to near 1.0 within a week, after which time, numbers of deaths will grow slowly. The fit to non-Hubei deaths is not shown due to fluctuations of small numbers.



Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb			31-Jan			
			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.

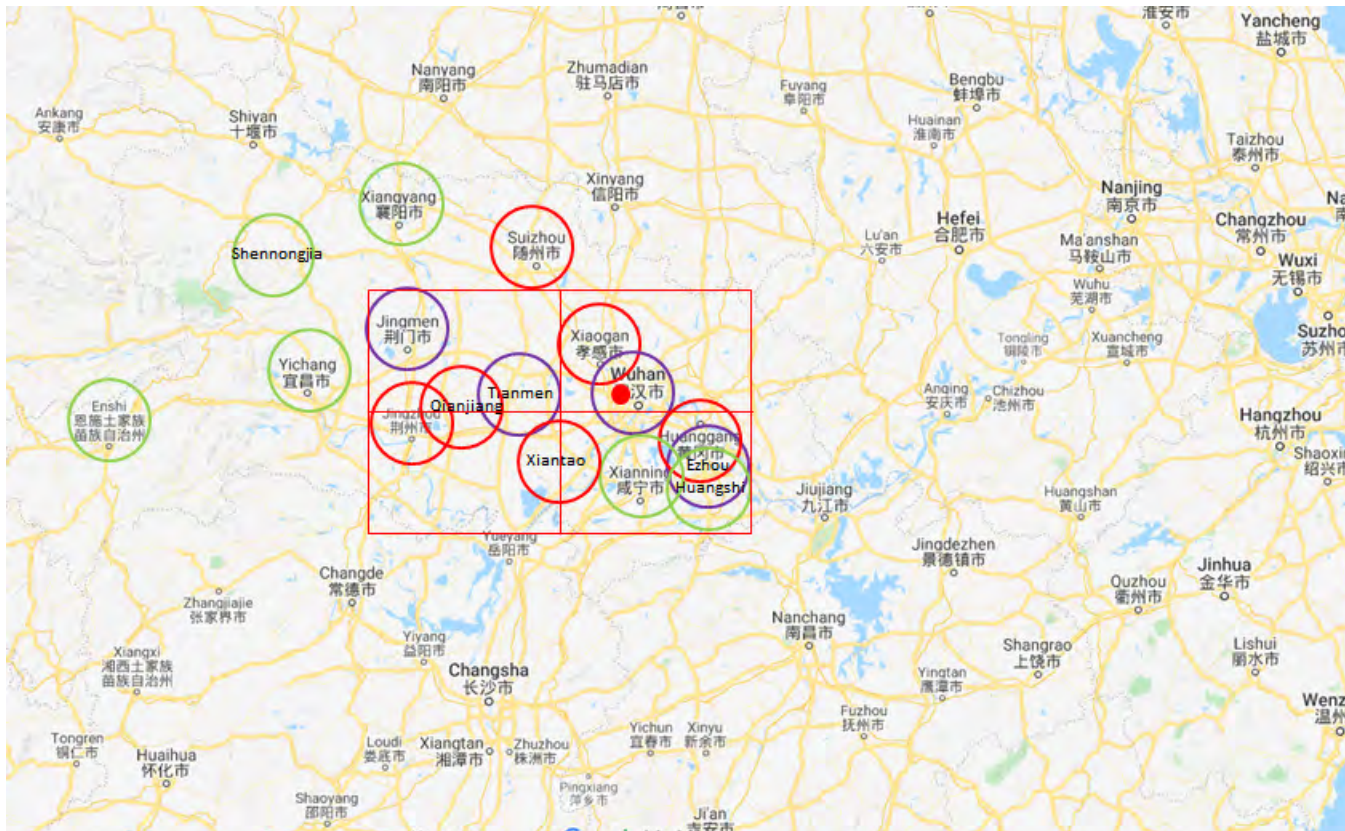
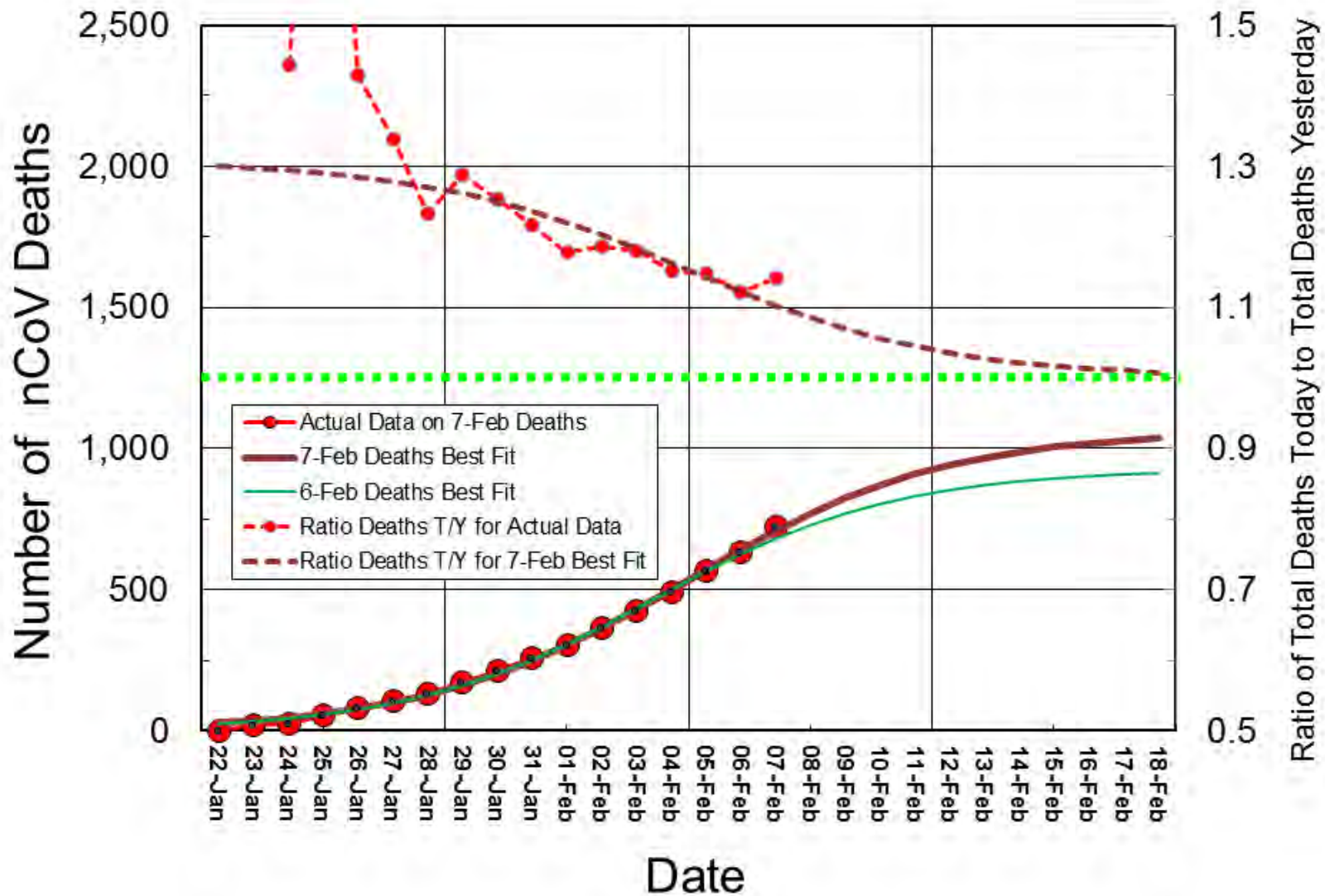


Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen (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](http://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 Deaths from the coronavirus nCoV-2019 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 17 actual Number of Deaths values to 7-Feb (red solid line) 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 on secondary axis) is well fit by the calculated Ratio (brown green line on secondary axis), which decreases in a linear fashion as assumed in **Fig. 2 (E)**. The fit for the 16 values to 6-Feb (green solid line) is 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.

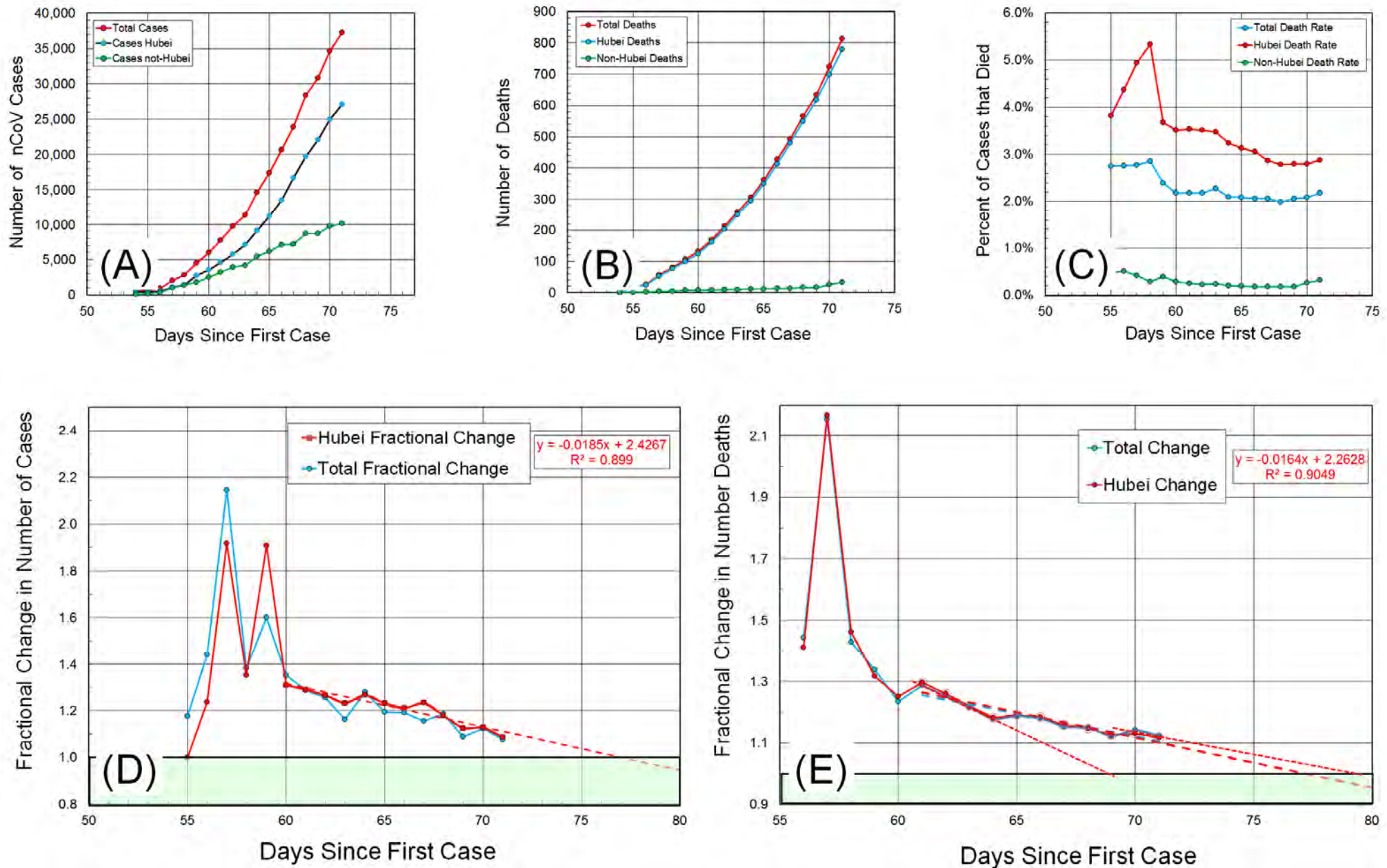
“Analysis of nCov-2019 Data on 2/9/2020” by Michael Levitt, Stanford University, CA

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000
2/5/2020	68	28344	19665	8679	565	549	16	1.99%	2.79%	0.18%	15.1	1.186	1.179	1.201	1.148	1.146	1.231
2/6/2020	69	30818	22112	8706	634	618	16	2.06%	2.79%	0.18%	15.2	1.087	1.124	1.003	1.122	1.126	1.000
2/7/2020	70	34662	24953	9709	724	699	25	2.09%	2.80%	0.26%	10.9	1.125	1.128	1.115	1.142	1.131	1.563
2/8/2020	71	37278	27100	10178	813	780	33	2.18%	2.88%	0.32%	8.9	1.075	1.086	1.048	1.123	1.116	1.320

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 8 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://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6> and from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. We separate data into Hubei and Others or non-Hubei as almost all deaths are in a 90 km x 35 km area centered on Wuhan in Hubei (see **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.

Plots of this data against time are shown in **Fig. 1**. Panel (A) shows expected exponential increase in Number of Cases. Panel (B) confirms that almost all the deaths are in Hubei (over 97%). Panel (C) shows that the Hubei death rate has decreased steadily from 3.5% a week ago to 2.8% today (6 Feb. 2020). While the Death Rate is high in Hubei at 2.8%, the non-Hubei rate is 11 times lower. At 0.26 %, the non-Hubei death rate is comparable to that of influenza. 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 a week ago the Fractional Change in Total Deaths ( $Deaths\_Today / Deaths\_Yesterday$ ) was 1.3 (30% more deaths per day) but by today this ratio is 1.12 (12% more 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 caes will continue to slow down over the next week. An extrapolation based on the sigmoid function (see **Fig. 3**) suggests that the number of deaths may not exceed 2000 and that it will reach 95% of this limiting value by 16-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 Panel (E) linear trend-lines are added using data for the last seven days from 1/29/2020. For Total Change and Hubei Change, the fit is excellent (correlation coefficient or  $\sqrt{R^2} > 0.95$ ). This linear extrapolation to Hubei Data suggests the Fractional Change in Number of Deaths will decrease to near 1.0 within a week, after which time, numbers of deaths will grow slowly. The fit to non-Hubei deaths is not shown due to fluctuations of small numbers.



Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb			31-Jan			
			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.

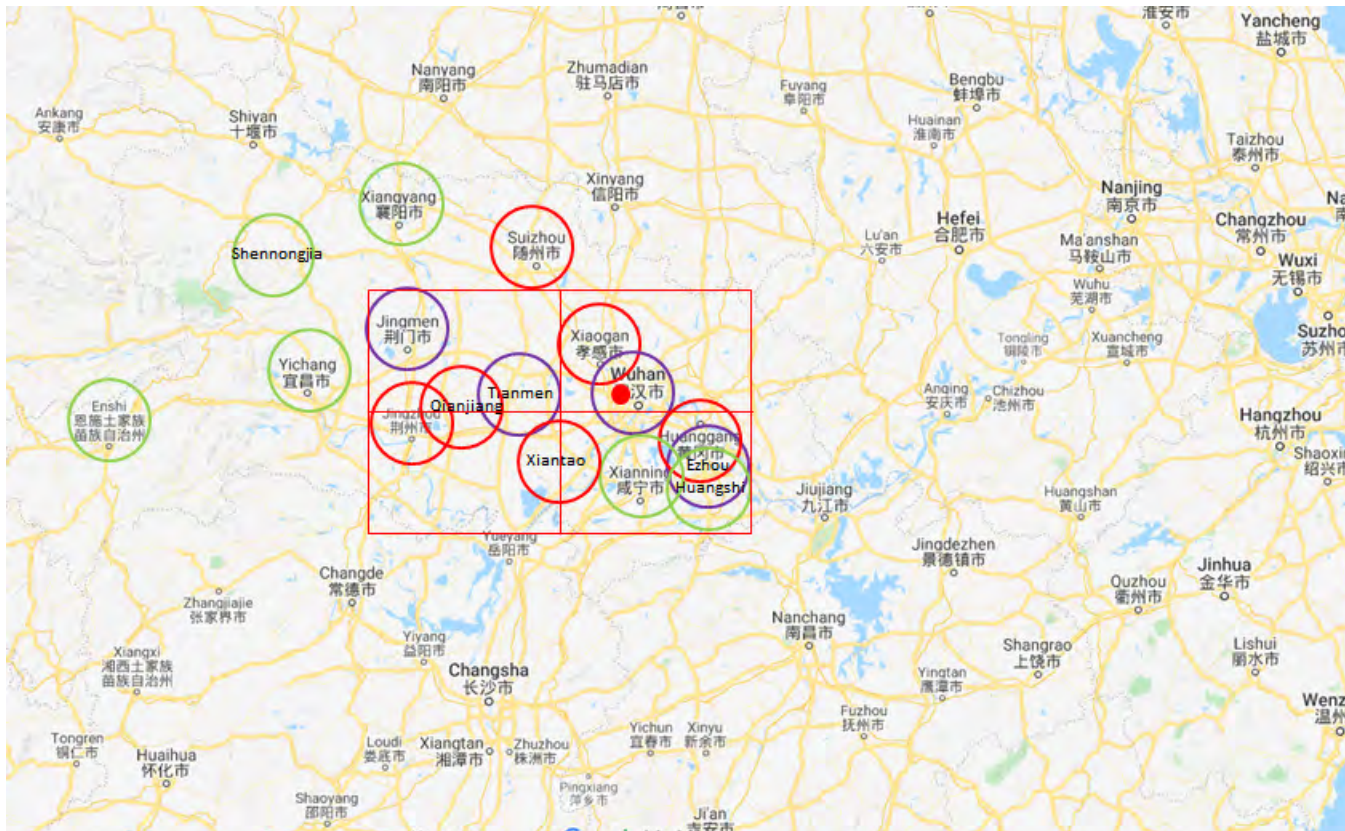
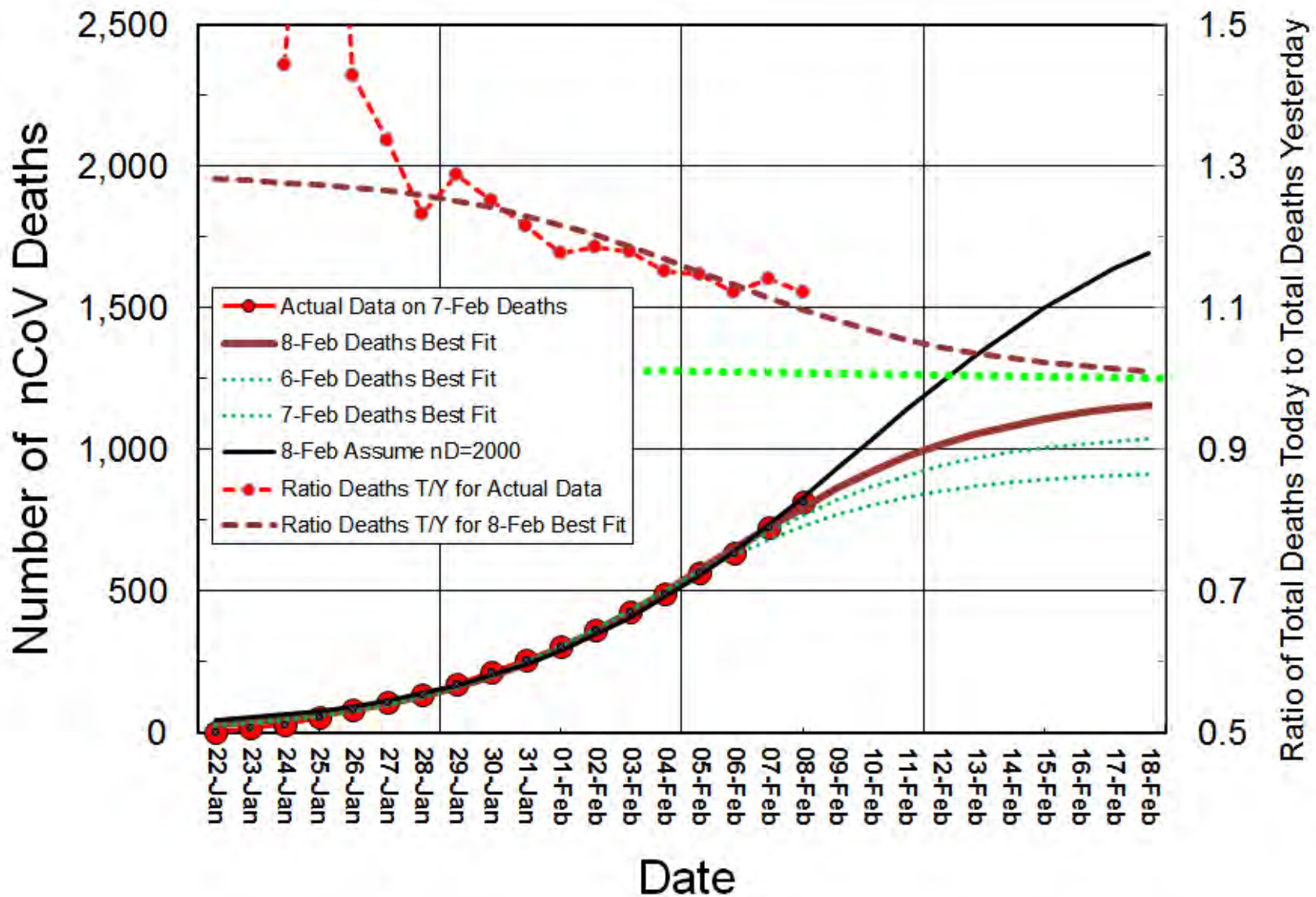


Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen (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](http://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 Deaths from the coronavirus nCoV-2019 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 17 actual Number of Deaths values to 7-Feb (red solid line) 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 on secondary axis) is well fit by the calculated Ratio (brown green line on secondary axis), which decreases in a linear fashion as assumed in **Fig. 2 (E)**. The fit for the 16 & 17 values to 6-Feb & Feb-7 (green dashed line) are also shown to indicate how sensitive the extrapolation is to new data values. The situation is still very fluid and values that are released in the next few days will be crucial. We now expect the total death rate to plateau below the black line that assumes 2000 total Number of Deaths.

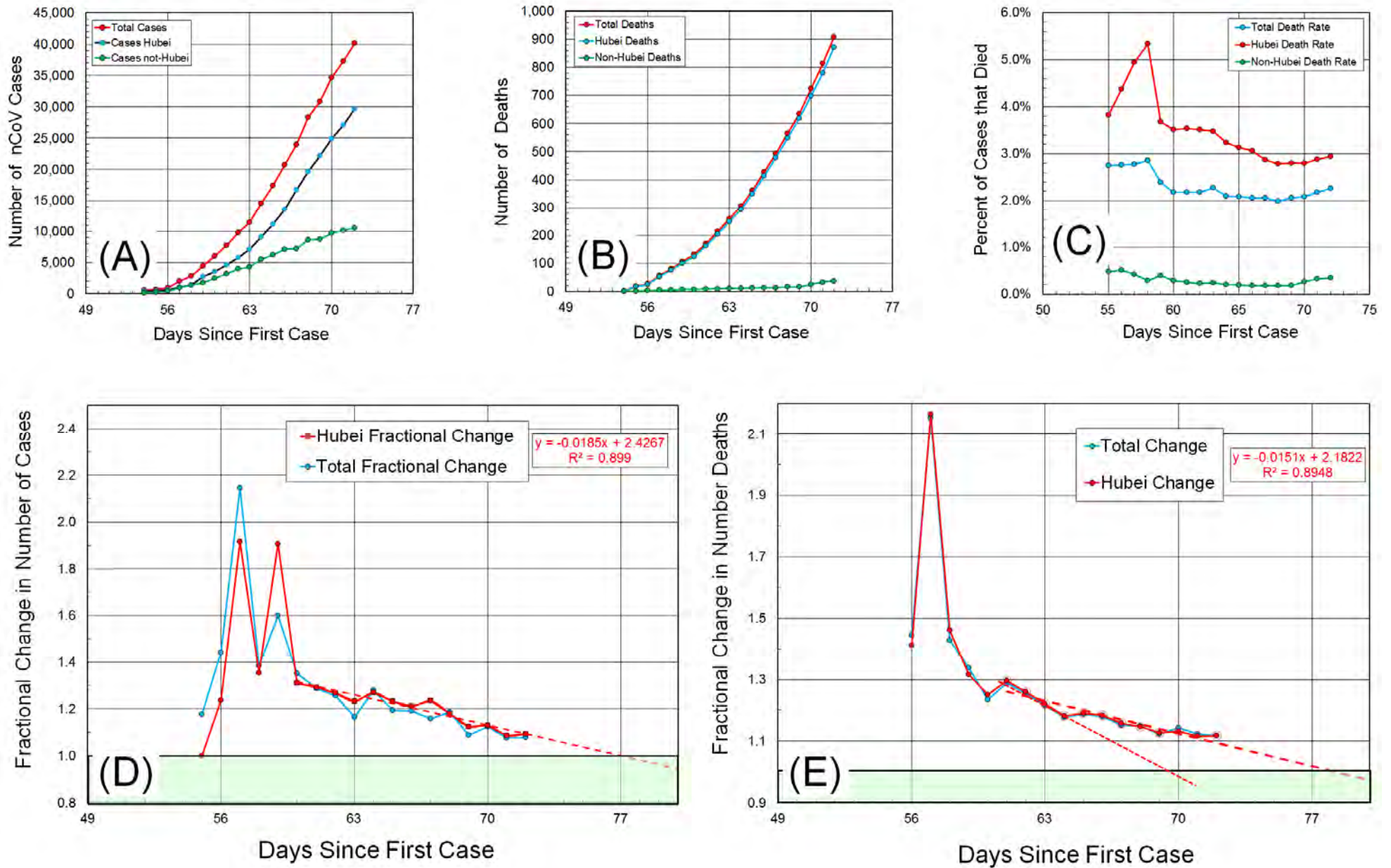
“Analysis of nCov-2019 Data on 2/10/2020” by Michael Levitt, Stanford University,

Date	Day	Cases Confirmed			Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases Confirmed			Fraction Change Number Deaths		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11374	7153	4221	259	249	10	2.28%	3.48%	0.24%	14.7	1.163	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14562	9074	5488	305	294	11	2.09%	3.24%	0.20%	16.2	1.280	1.269	1.300	1.178	1.181	1.100
2/2/2020	65	17373	11177	6196	362	350	12	2.08%	3.13%	0.19%	16.2	1.193	1.232	1.129	1.187	1.190	1.091
2/3/2020	66	20679	13522	7157	427	414	13	2.06%	3.06%	0.18%	16.9	1.190	1.210	1.155	1.180	1.183	1.083
2/4/2020	67	23906	16678	7228	492	479	13	2.06%	2.87%	0.18%	16.0	1.156	1.233	1.010	1.152	1.157	1.000
2/5/2020	68	28344	19665	8679	565	549	16	1.99%	2.79%	0.18%	15.1	1.186	1.179	1.201	1.148	1.146	1.231
2/6/2020	69	30818	22112	8706	634	618	16	2.06%	2.79%	0.18%	15.2	1.087	1.124	1.003	1.122	1.126	1.000
2/7/2020	70	34662	24953	9709	724	699	25	2.09%	2.80%	0.26%	10.9	1.125	1.128	1.115	1.142	1.131	1.563
2/8/2020	71	37278	27100	10178	813	780	33	2.18%	2.88%	0.32%	8.9	1.075	1.086	1.048	1.123	1.116	1.320
2/9/2020	72	40171	29631	10540	908	871	37	2.26%	2.94%	0.35%	8.4	1.078	1.093	1.036	1.117	1.117	1.121

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 10 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://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6>, <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.

Plots of this data against time are shown in **Fig. 1**. Panel (A) shows expected exponential 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 1-Jan to 2.9% today (9-Feb.). While the Death Rate is high in Hubei at 2.9%, the non-Hubei rate is 9 times lower at 0.35 %, which is comparable to that of influenza. 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 1.09 (9% more 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 deaths should not exceed 2000 and that it will reach 95% of this limiting value by 16-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 2/3/20 and gave rise to the expectation that the growth of deaths would slow soon.



Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb			31-Jan			
			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.

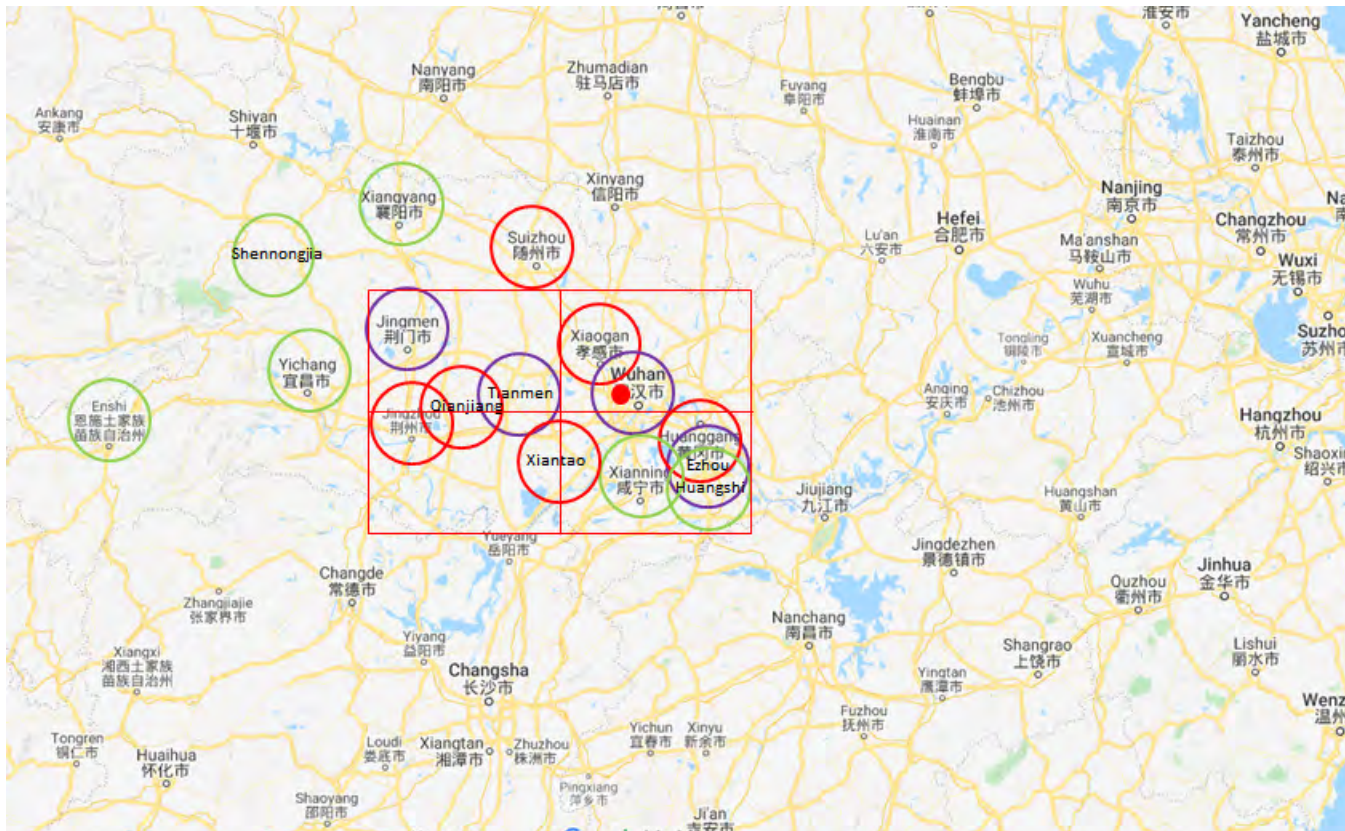
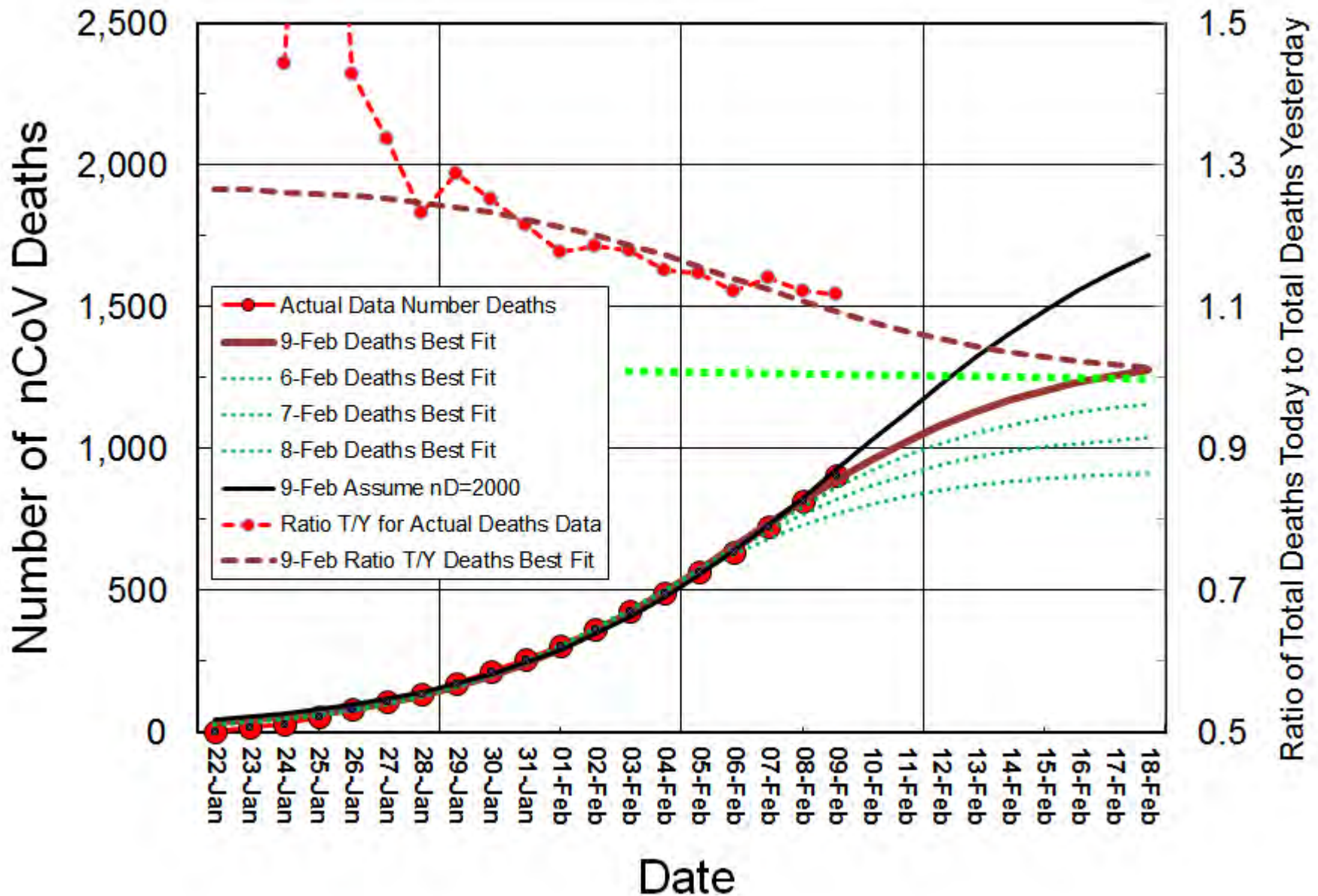
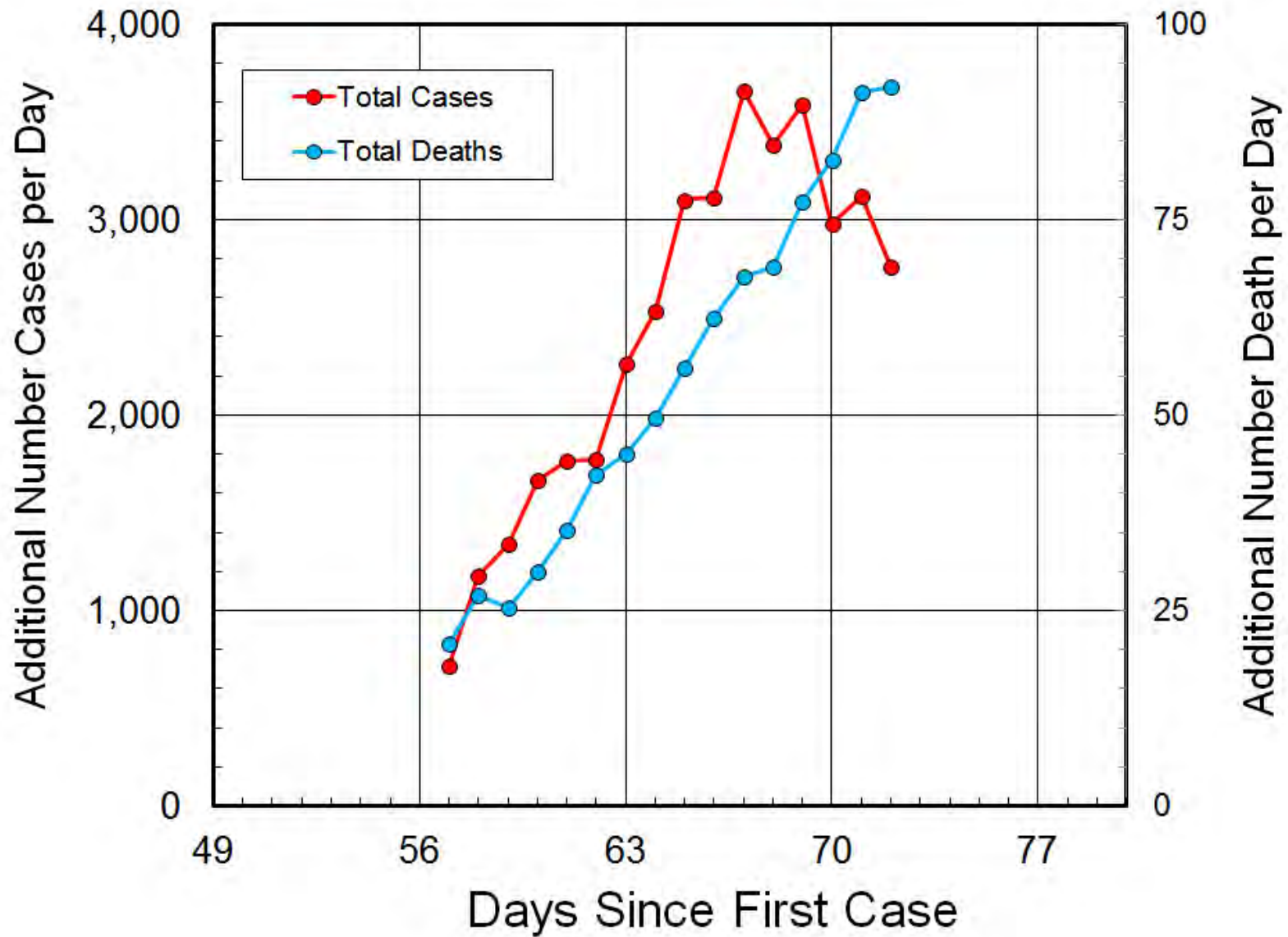


Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen (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](http://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 Deaths from the coronavirus nCoV-2019 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 18 actual Number of Deaths values to 9-Feb (red solid line) 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 on secondary axis) is well fit by the calculated Ratio (brown green line on secondary axis), which decreases in a linear fashion as assumed in **Fig. 2 (E)**. The fit for the 16, 17 or 18 values to 06-Feb, 07-Feb or 08-Feb (green dashed line) 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 below the black line that assumes 2000 total Number of Deaths.



**Figure 4.** Showing how the Additional Number of Cases per Day peaked on Day 68 (5-Feb), whereas the Additional Number of Deaths per Day may have peaked today (Day 72) or has yet to peak. 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 Cases should reach about 50,000. Interesting too is that the growth curves for deaths is shifted by at least 5 days from that of cases. This means that death occurs on average 5 after being counted as a confirmed case. The data is plotted for total Cases and Total Deaths averaged over a three days 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.

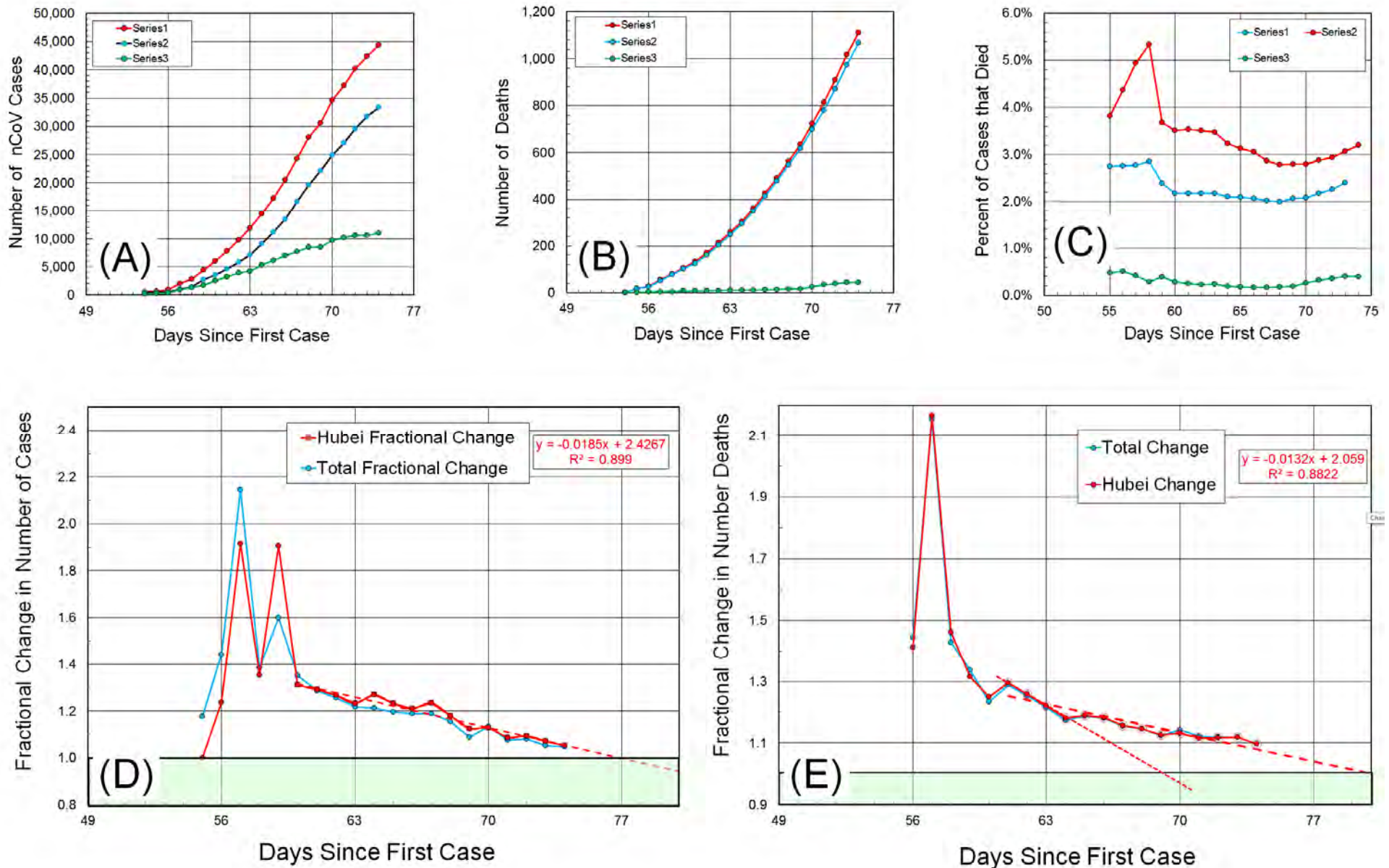


# “Analysis of nCov-2019 Data on 2/11/2020” by Michael Levitt, Stanford University,

Date	Day	Number Cases			Number Deaths			Death Rate (%)			Ratio Hubei/	Fraction Change			Fraction Change		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others
1/22/2020	54	555	444	111	0	0	0	0.00%	0.00%	0.00%	0.0						
1/23/2020	55	653	444	209	18	17	1	2.76%	3.83%	0.48%	8.0	1.177	1.000	1.883	-	-	-
1/24/2020	56	941	549	392	26	24	2	2.76%	4.37%	0.51%	8.6	1.441	1.236	1.876	1.444	1.412	2.000
1/25/2020	57	2019	1052	967	56	52	4	2.77%	4.94%	0.41%	11.9	2.146	1.916	2.467	2.154	2.167	2.000
1/26/2020	58	2794	1423	1371	80	76	4	2.86%	5.34%	0.29%	18.3	1.384	1.353	1.418	1.429	1.462	1.000
1/27/2020	59	4473	2714	1759	107	100	7	2.39%	3.68%	0.40%	9.3	1.601	1.907	1.283	1.338	1.316	1.750
1/28/2020	60	6047	3554	2493	132	125	7	2.18%	3.52%	0.28%	12.5	1.352	1.310	1.417	1.234	1.250	1.000
1/29/2020	61	7783	4586	3197	170	162	8	2.18%	3.53%	0.25%	14.1	1.287	1.290	1.282	1.288	1.296	1.143
1/30/2020	62	9776	5806	3970	213	204	9	2.18%	3.51%	0.23%	15.5	1.256	1.266	1.242	1.253	1.259	1.125
1/31/2020	63	11890	7153	4221	259	249	10	2.18%	3.48%	0.24%	14.7	1.216	1.232	1.063	1.216	1.221	1.111
2/1/2020	64	14426	9074	5352	304	294	10	2.11%	3.24%	0.19%	17.3	1.213	1.269	1.268	1.174	1.181	1.000
2/2/2020	65	17257	11177	6080	361	350	11	2.09%	3.13%	0.18%	17.3	1.196	1.232	1.136	1.188	1.190	1.100
2/3/2020	66	20522	13522	7000	426	414	12	2.08%	3.06%	0.17%	17.9	1.189	1.210	1.151	1.180	1.183	1.091
2/4/2020	67	24363	16678	7685	492	479	13	2.02%	2.87%	0.17%	17.0	1.187	1.233	1.098	1.155	1.157	1.083
2/5/2020	68	28130	19665	8465	564	549	15	2.00%	2.79%	0.18%	15.8	1.155	1.179	1.101	1.146	1.146	1.154
2/6/2020	69	30612	22112	8500	634	618	16	2.07%	2.79%	0.19%	14.8	1.088	1.124	1.004	1.124	1.126	1.067
2/7/2020	70	34662	24953	9709	724	699	25	2.09%	2.80%	0.26%	10.9	1.132	1.128	1.142	1.142	1.131	1.563
2/8/2020	71	37278	27100	10178	813	780	33	2.18%	2.88%	0.32%	8.9	1.075	1.086	1.048	1.123	1.116	1.320
2/9/2020	72	40269	29631	10638	909	871	38	2.26%	2.94%	0.36%	8.2	1.080	1.093	1.045	1.118	1.117	1.152
2/10/2020	73	42369	31728	10641	1017	974	43	2.40%	3.07%	0.40%	7.6	1.052	1.071	1.000	1.119	1.118	1.132
2/11/2020	74	44388	33366	11022	1111	1068	43	2.50%	3.20%	0.39%	8.2	1.048	1.052	1.036	1.092	1.097	1.000

**Table 1.** Showing data for New Coronavirus 2019 (nCoV) from 22 January to 11 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.

Plots of this data against time are shown in **Fig. 1**. Panel (A) shows expected exponential 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 1-Jan to 2.9% today (9-Feb.). While the Death Rate is high in Hubei at 3.2%, the non-Hubei rate is 8 times lower at 0.39%, which is comparable to that of influenza. 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 1.09 (9% more 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 deaths should not exceed 2000 and that it will reach 95% of this limiting value by 16-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 2/3/20 and gave rise to the expectation that the growth of deaths would slow soon.



Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb			31-Jan			
			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.

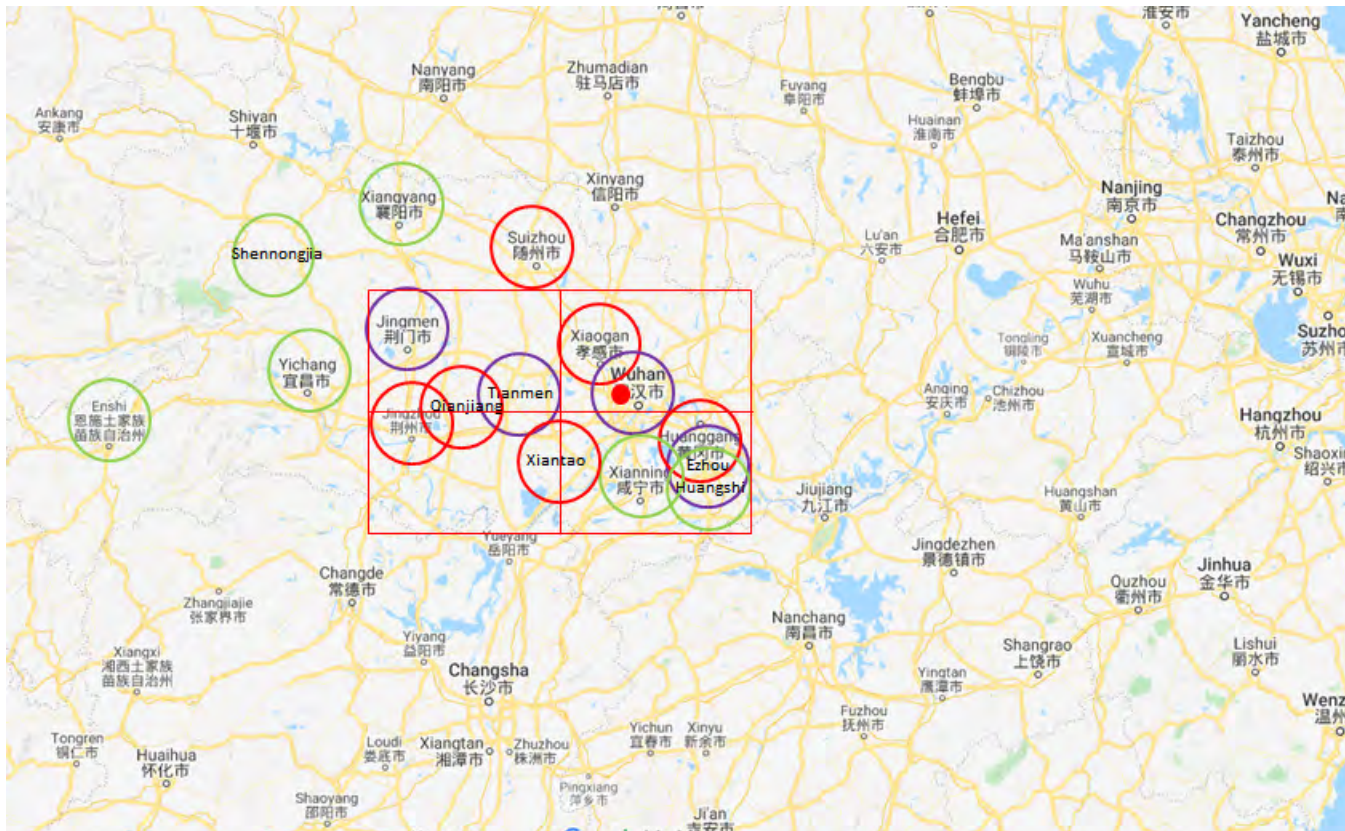
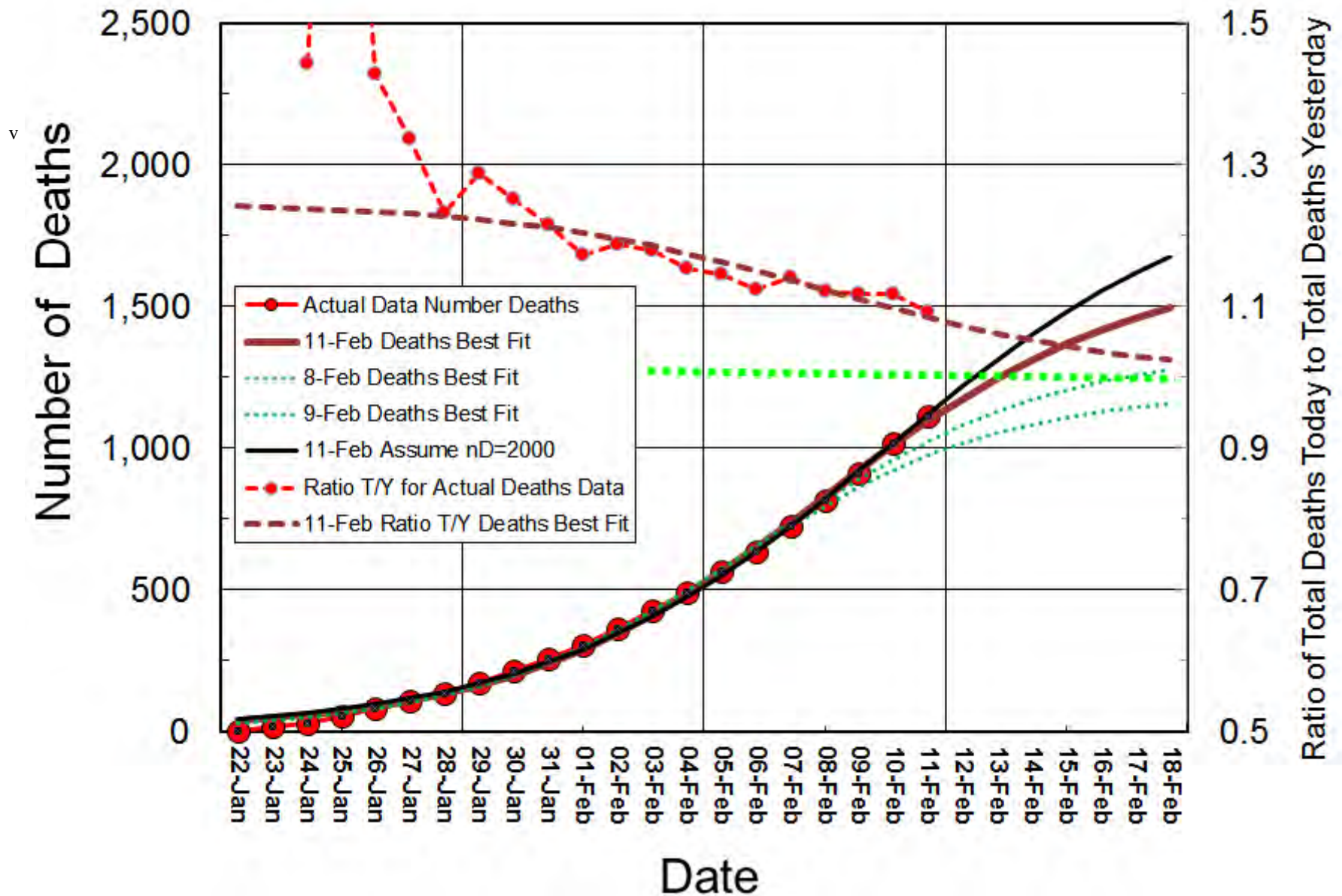


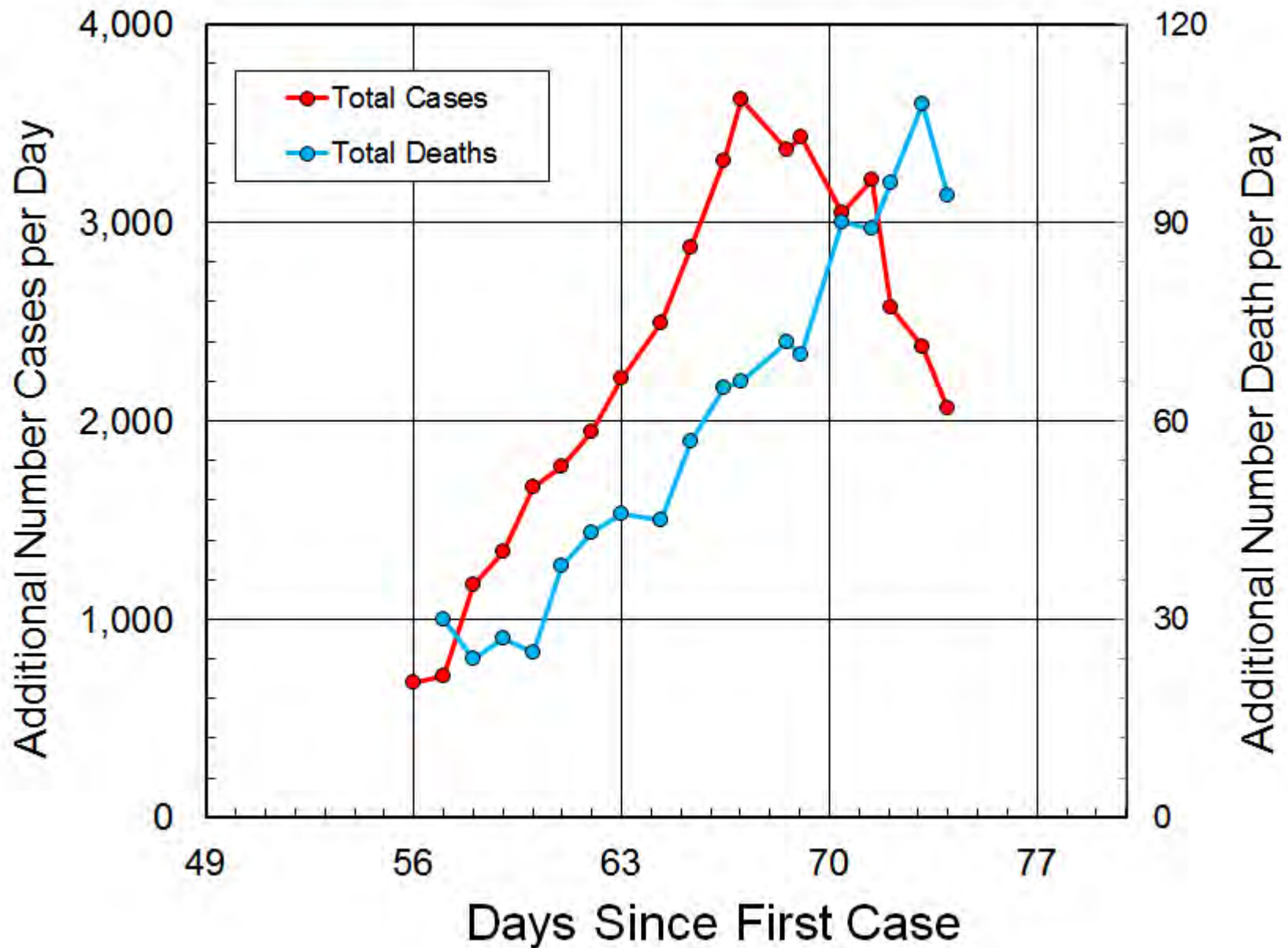
Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen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



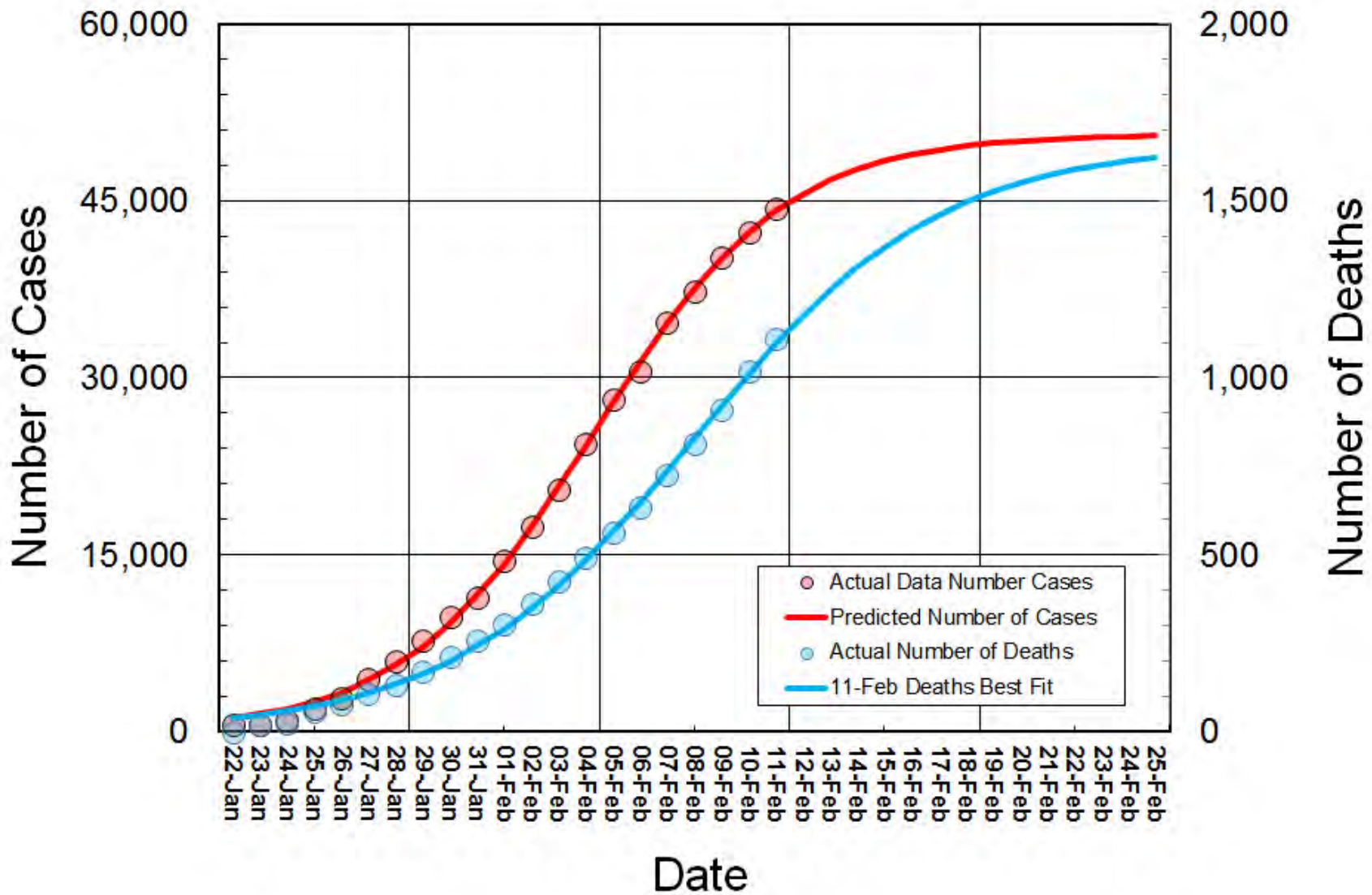


**Figure. 3.** Fit of the sigmoid function  $f(x) = 1/(1-\exp(-x))$  to the actual Total Number of Deaths from the coronavirus nCoV-2019 since 22 Jan 2020. The best fit (brown line) is obtained using Excel to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B)/C)$  so that the 18 actual Number of Deaths values to 9-Feb (red solid line) 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 on secondary axis) is well fit by the calculated Ratio (brown green line on secondary axis), which decreases in a linear fashion as assumed in Fig. 2 (E). The fit for the 18 or 19 values to 08-Feb or 09-Feb (green dashed line) 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 below the black line that assumes 2000 total Number of Deaths.





**Figure 4.** Showing how the Additional Number of Cases per Day peaked on Day 67 (4-Feb), whereas the Additional Number of 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 Cases may reach 50,000 and the Total Number of Deaths may reach 2100. 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 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, but is not used for the Additional Deaths.



**Figure 5.** Showing the extrapolation of Number of Cases and Number of Deaths 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 2000.

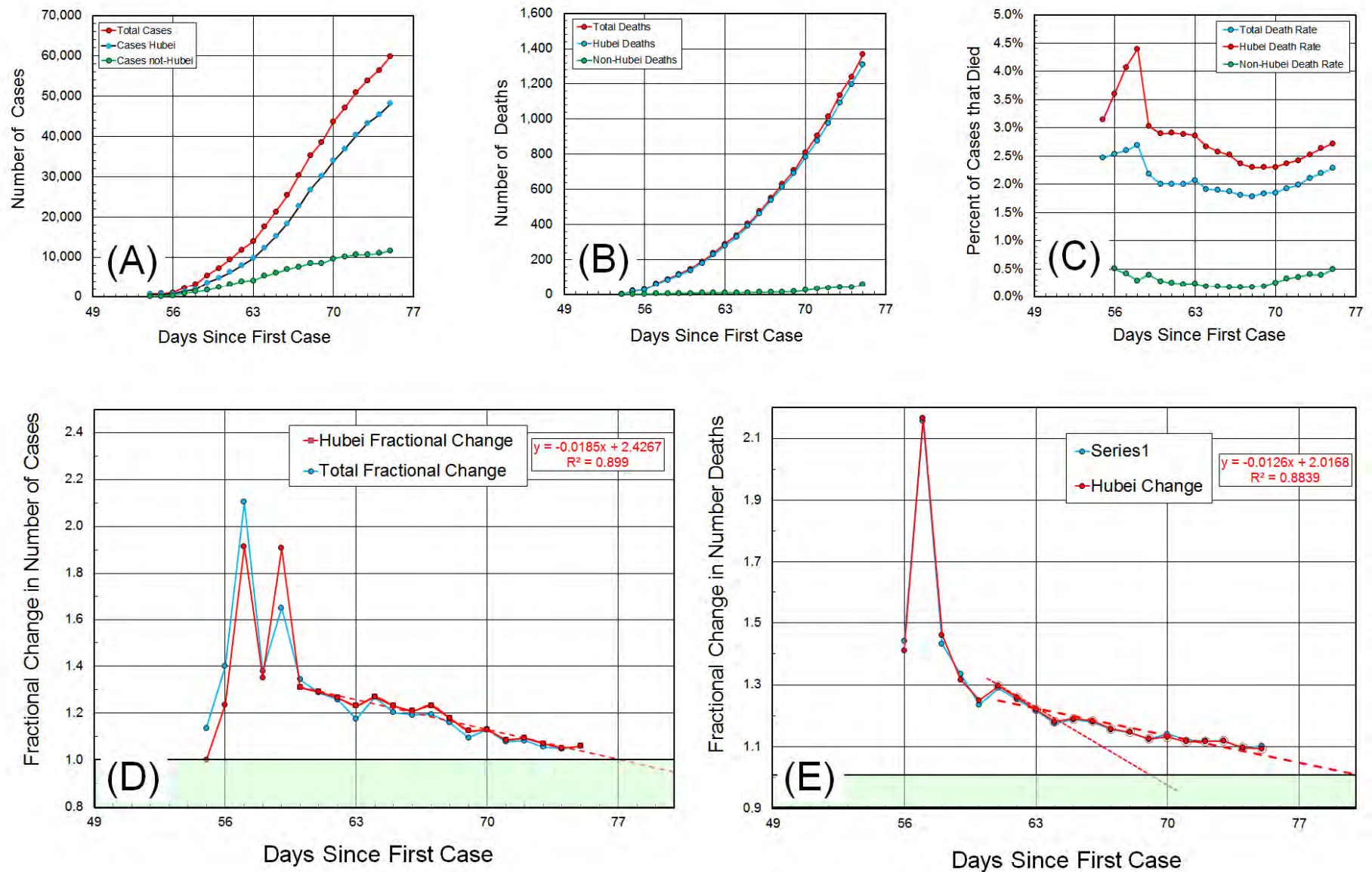


# “Analysis of nCov-2019 Data on 2/13/2020” by Michael Levitt, Stanford University, USA

Date	Day	Number Cases			Number Deaths			Death Rate (%)			Ratio Hubei/	Fraction Change Cases			Fraction Change Number		
		Total	Hubei	Others	Total	Hubei	Others	Total	Hubei	Others		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 ( $\text{Cases\_Today} / \text{Cases\_Yesterday}$ ) is increasing more and more slowly for Hubei, non-Hubei & Total. Panel (E), shows that on 28-Jan the Fractional Change in Total Deaths ( $\text{Deaths\_Today} / \text{Deaths\_Yesterday}$ ) 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.



Province or City in Hubei	Population	Deaths / million pop	6-Feb				5-Feb				4-Feb				3-Feb				2-Feb				1-Feb			31-Jan			
			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.

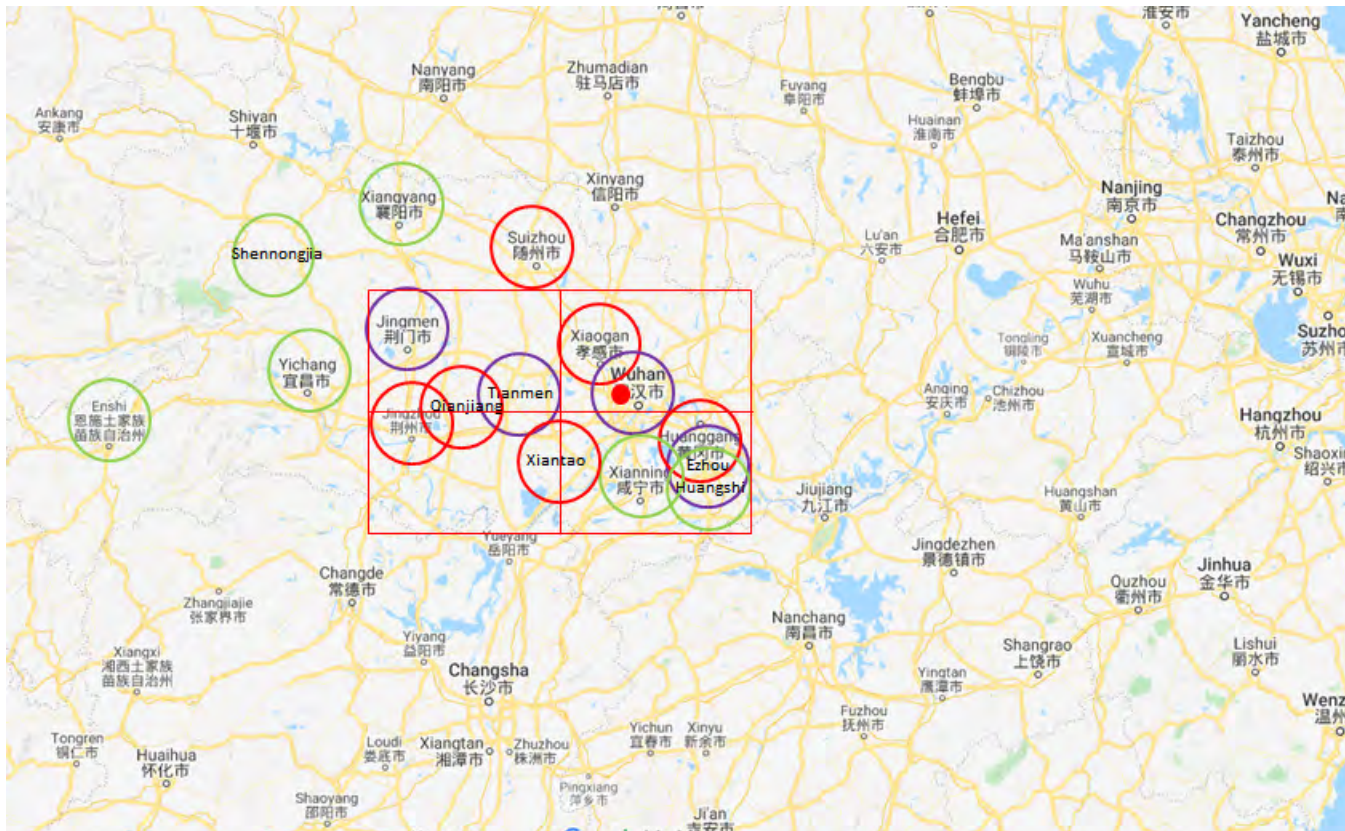
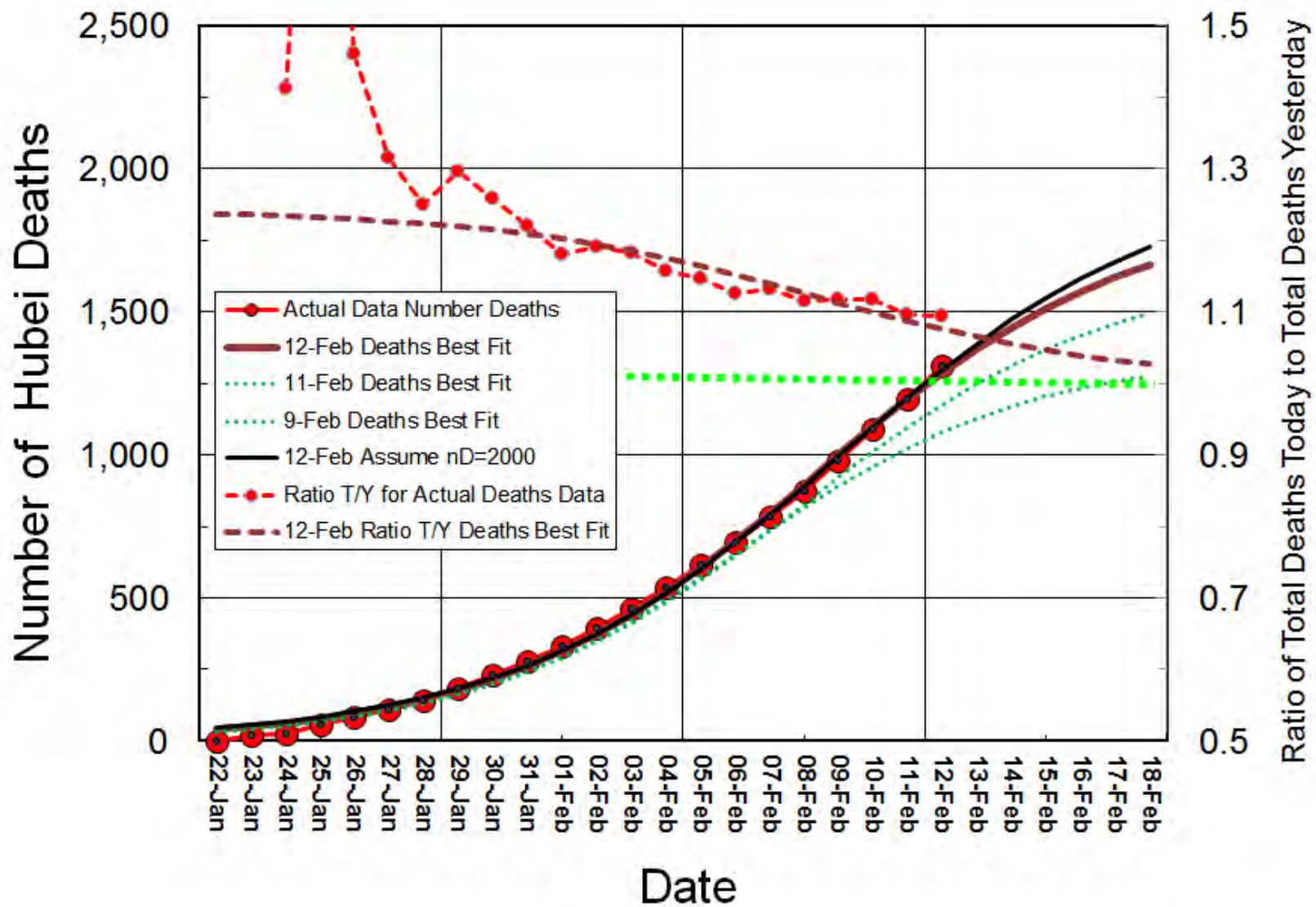


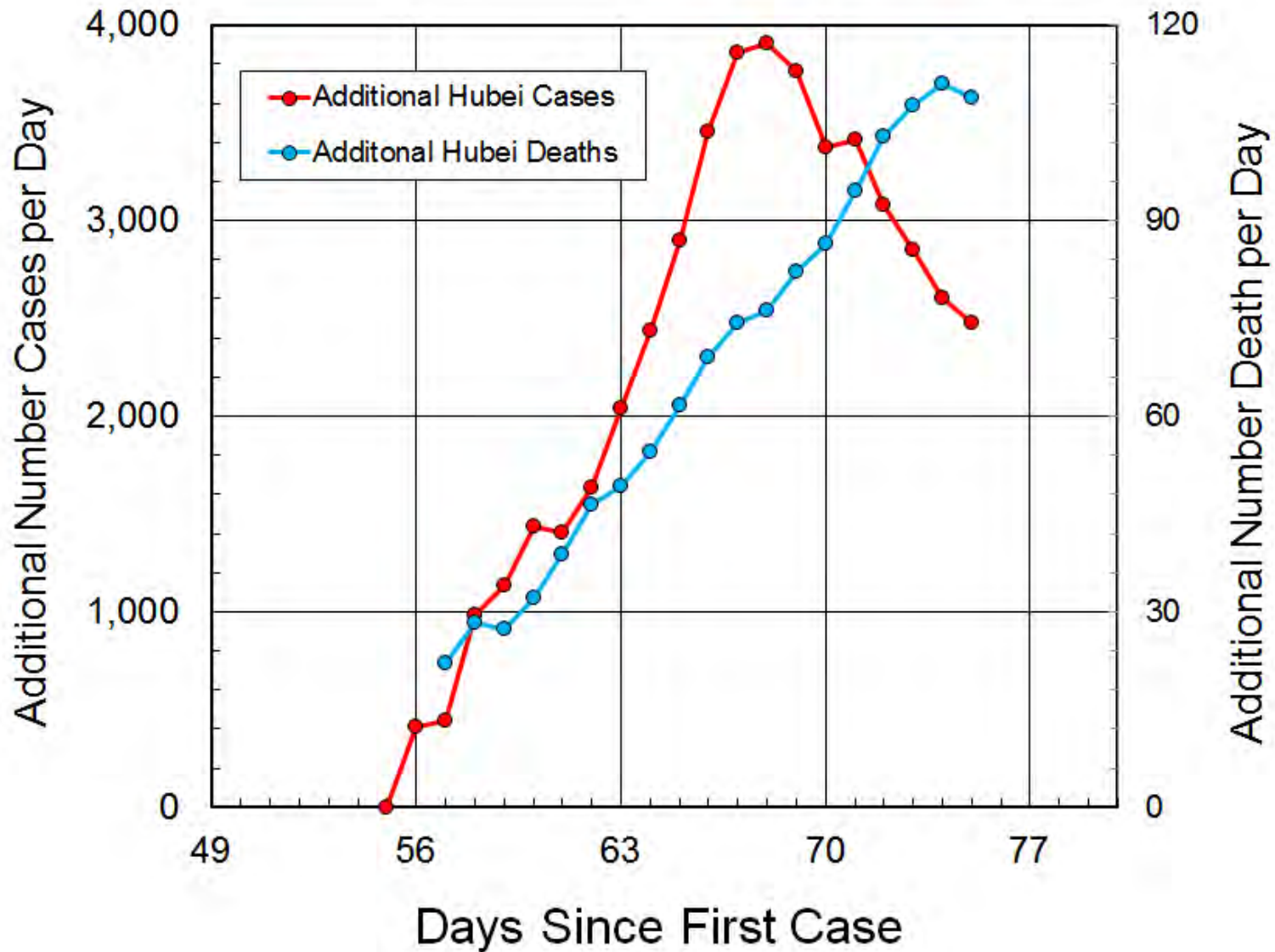
Figure 2. Map of Hubei circling in purple cities with a death rate > 3%, in red cities with a death rate > 1% and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Ezhou, Jingmen and Tianmen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



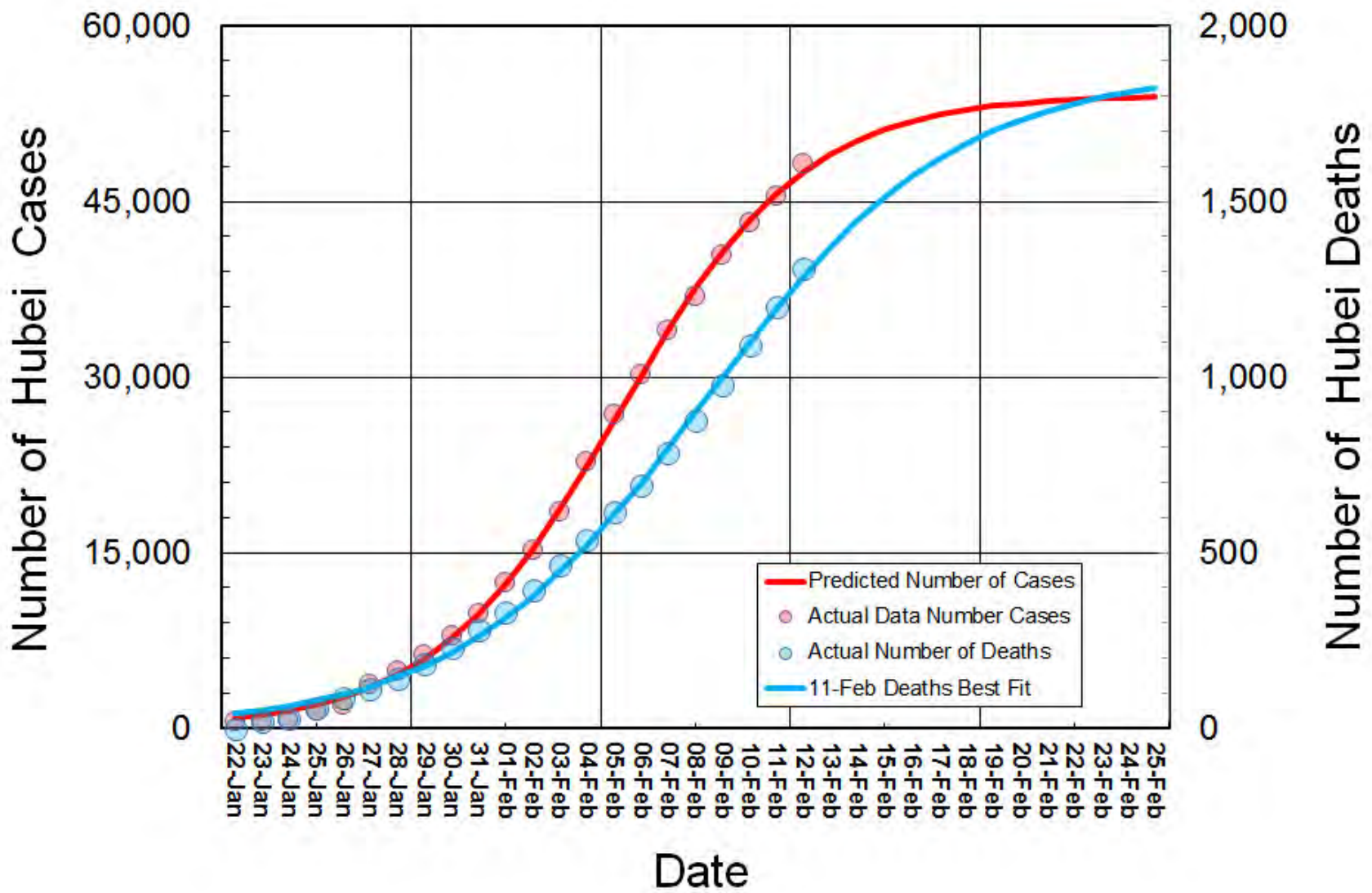


**Figure. 3.** Fit of the sigmoid function  $f(x) = 1/(1-\exp(-x))$  to the actual Total Number of Hubei Deaths from the coronavirus COVID-19 since 22 Jan 2020. The best fit (brown line) is obtained using Excel to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B))/C$  so that the 22 actual 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 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.



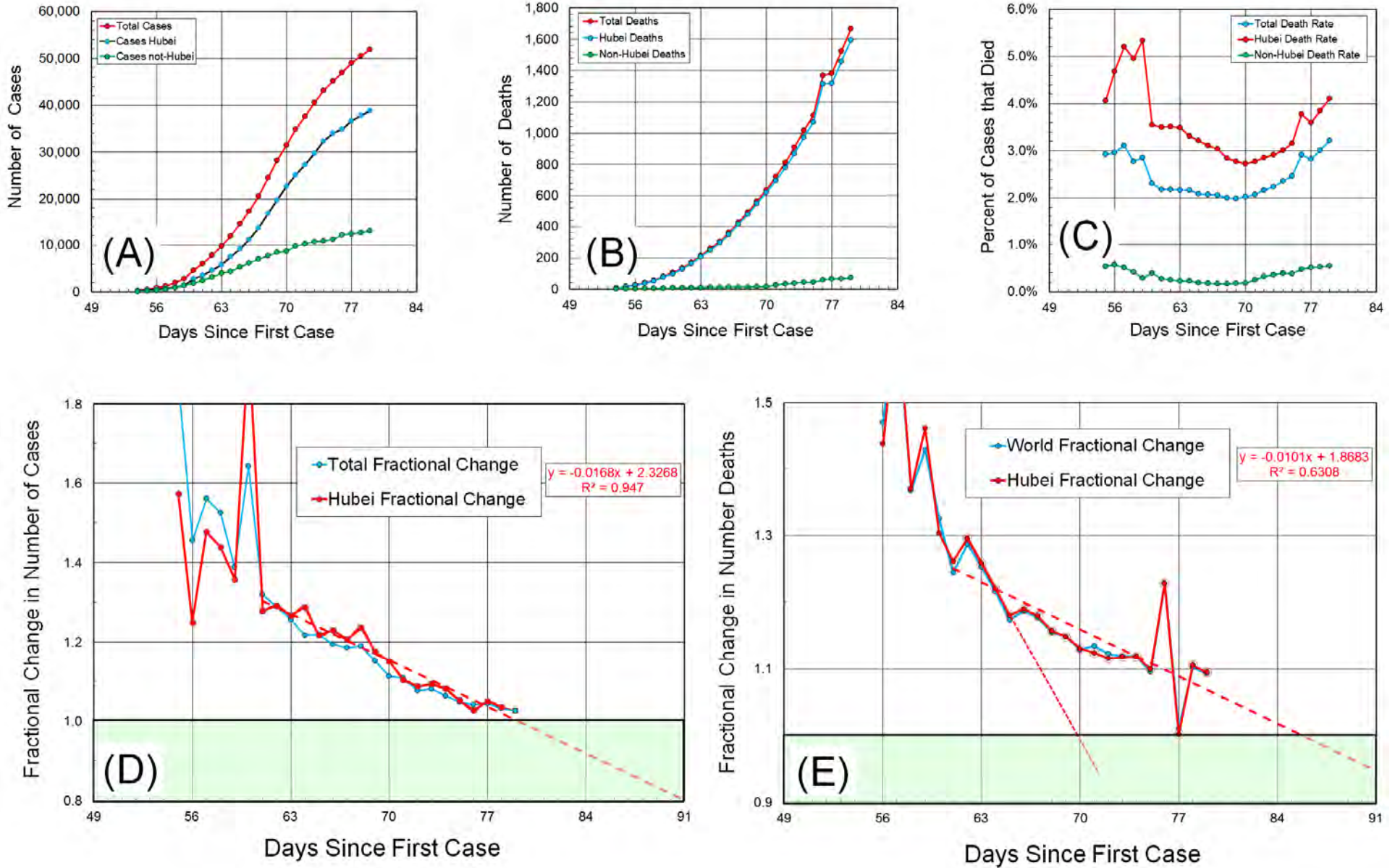
# “17. Analysis of nCov-2019 Data on 2/17/2020” by Michael Levitt, Stanford University, USA

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 Cases	Hubei Deahs
		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.

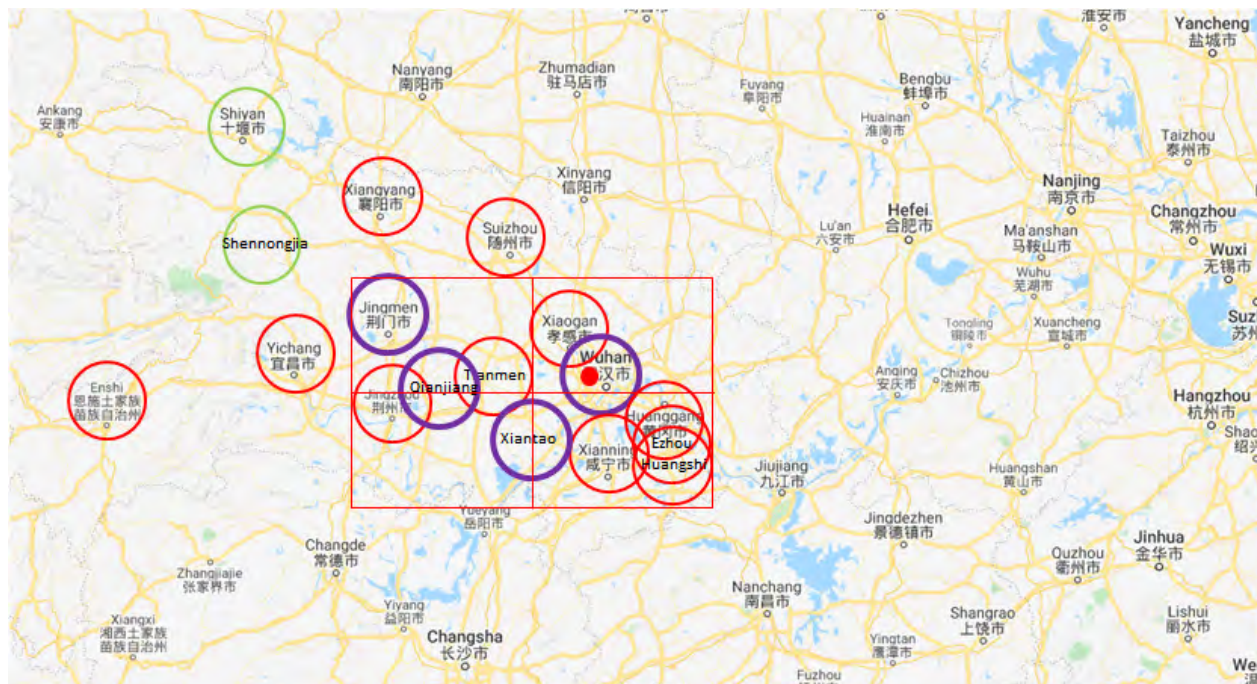


**Figure 1.** Variation of COVID-19 data against time in days since 29 Nov 2019 (guessed date of the first case). **Table 1** data is plotted from 22 January to 16 February 2020. In Panels (D) & (E) linear trend-lines are added using data from 1/29/2020. The Fraction Change for Cases is an excellent 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.

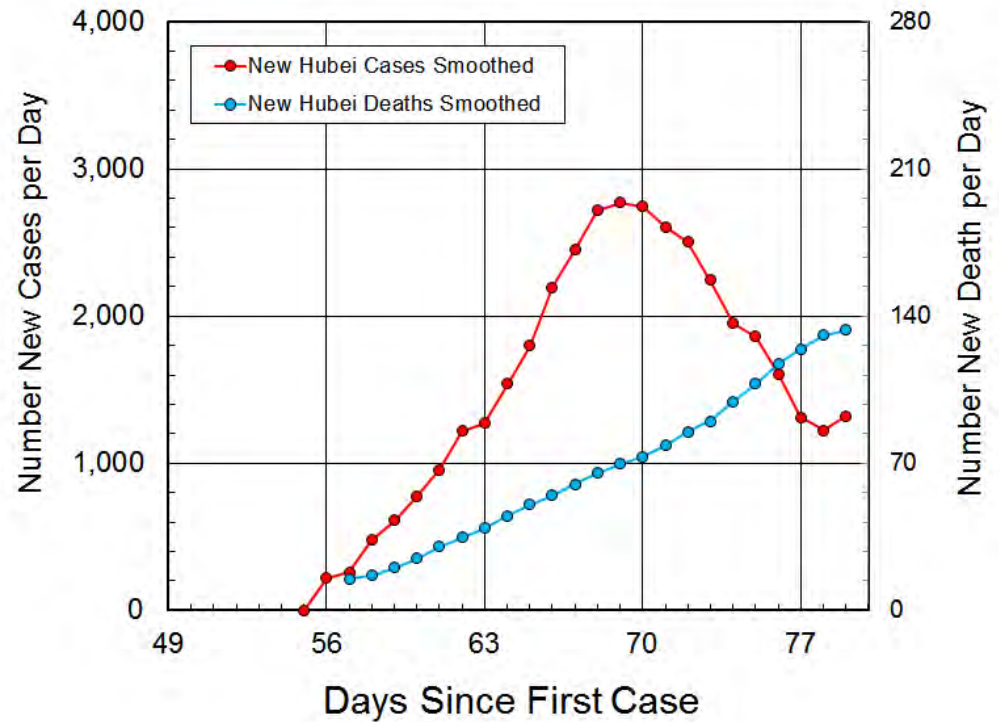
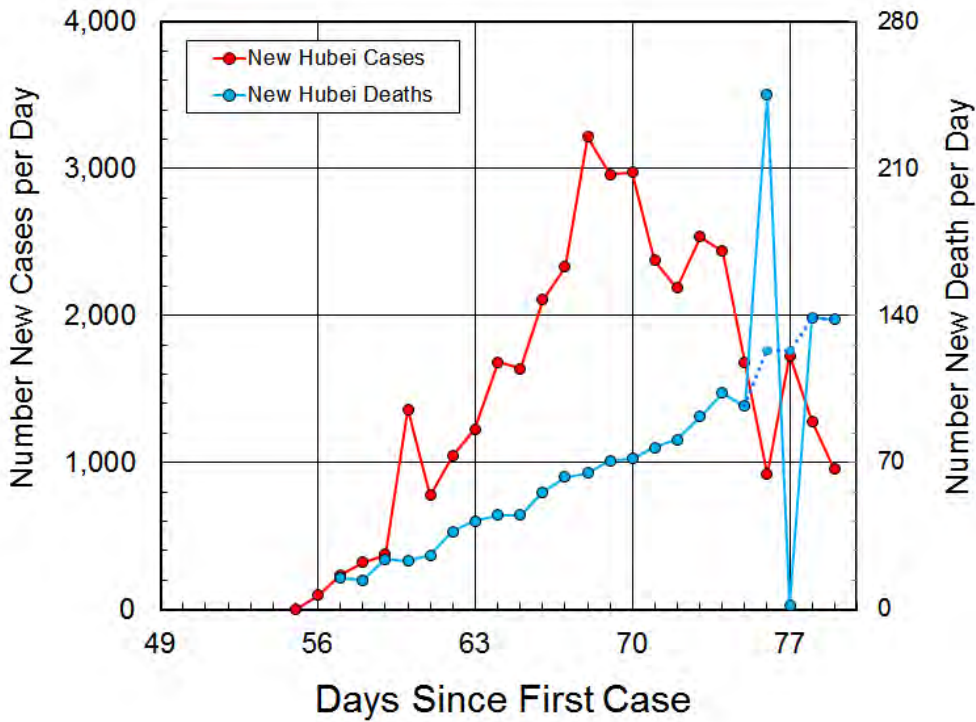


			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	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.



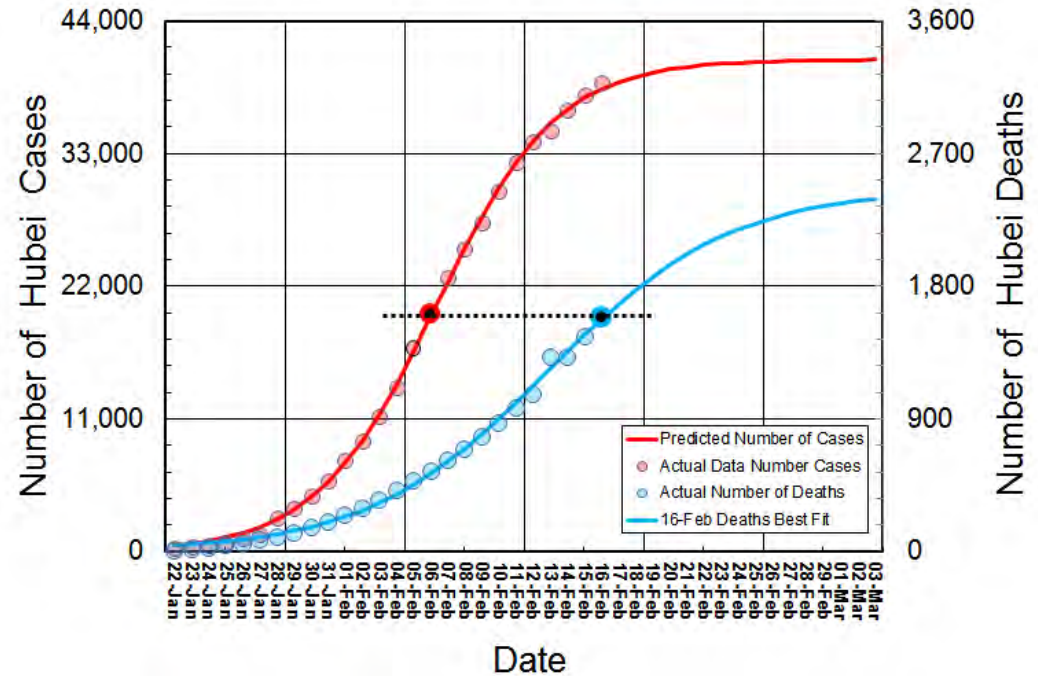
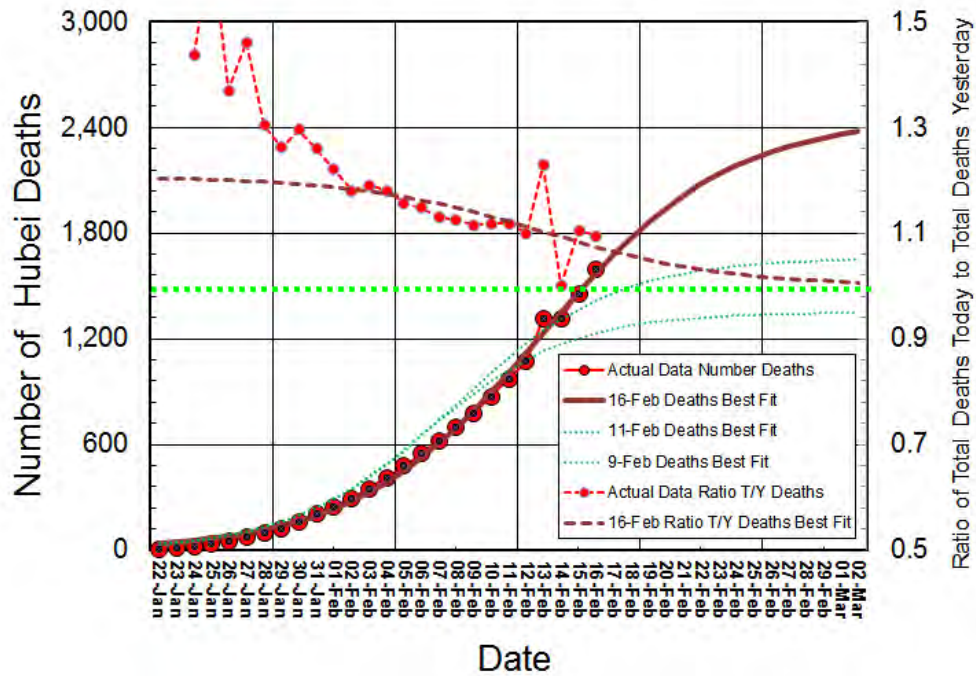
**Figure 2.** Map of Hubei circling in purple cities with a death rate of  $\geq 3\%$ , in red cities with a death rate of  $\geq 1\%$  and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Jingmen Qianjian 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.

# "18. Analysis of nCov-2019 Data on 2/18/2020" by Michael Levitt, Stanford University, USA

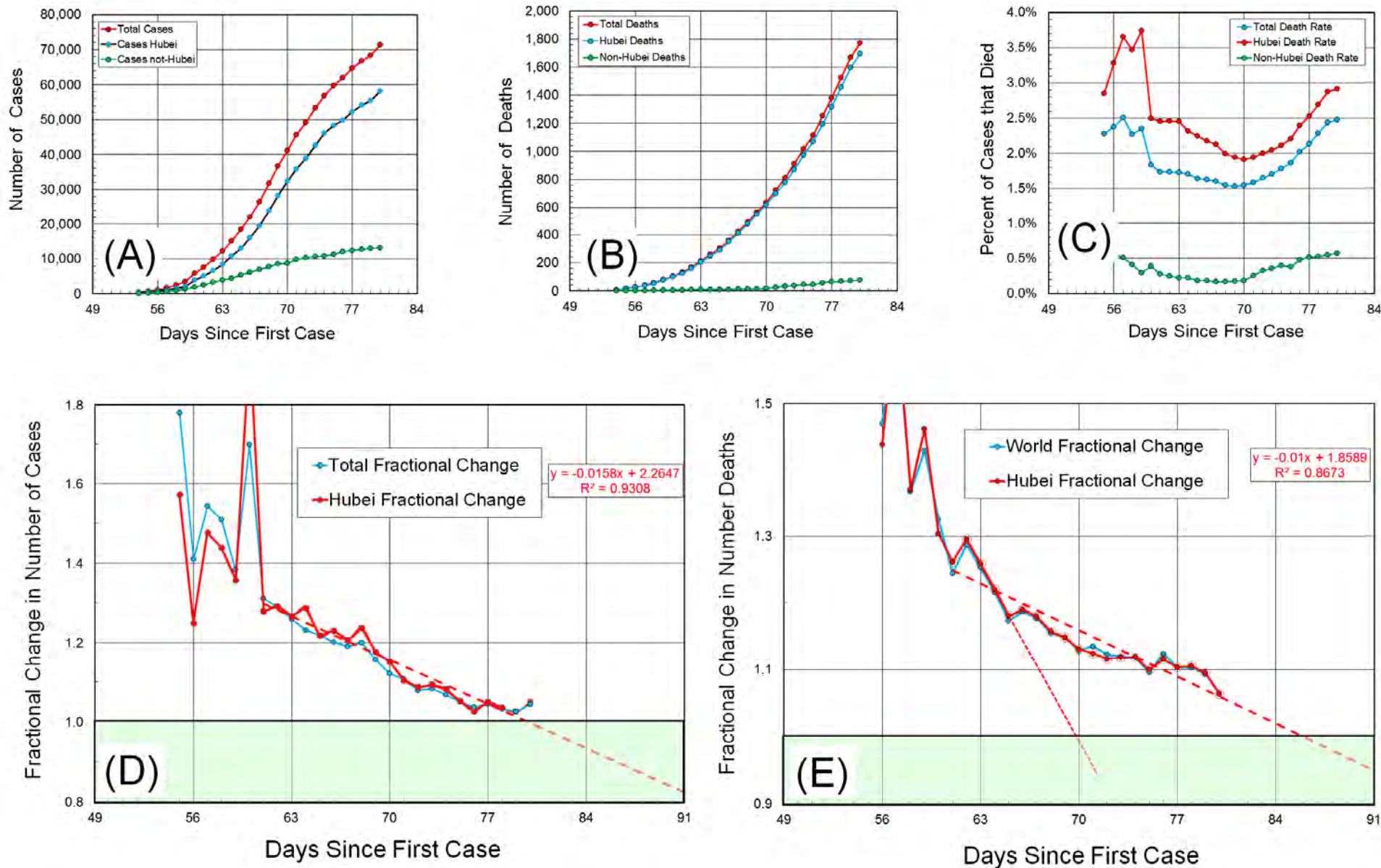
Today's report shows several optimistic signs. The number of New Hubei Deaths per Day seems to have peaked with values for the last three days of 139, 138 & 101. If this holds up for the next few days, we can estimate the Total Number of Hubei Deaths to be 3,000. The total number of Hubei cases (Clinical and Laboratory Diagnosed) is estimated to reach 60,000. The number of New non-Hubei cases peaked on 4-Feb. allowing the Total Non-Hubei Cases to be estimated to reach 15,000.

Date	Day	Total Number Cases					Total Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases			Fraction Change Deaths			New/Day in Hubei		
		Total-LC	Total-L	Hubei-LC	Hubei-L	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others	Cases	Deaths	
1/22/2020	54	421	314	358	251	63	6	6	0	1.42%	1.67%	0.00%	-									
1/23/2020	55	750	581	564	395	186	17	16	1	2.28%	2.85%	0.54%	5.3	1.780	1.573	2.961	2.843	2.676	-	205	10	
1/24/2020	56	1057	846	704	494	352	25	23	2	2.37%	3.28%	0.57%	5.8	1.410	1.249	1.895	1.470	1.437	2.000	141	7	
1/25/2020	57	1631	1320	1040	729	591	41	38	3	2.51%	3.65%	0.51%	7.2	1.544	1.477	1.677	1.633	1.645	1.500	336	15	
1/26/2020	58	2462	2014	1497	1049	965	56	52	4	2.27%	3.47%	0.41%	8.4	1.509	1.440	1.632	1.367	1.370	1.333	457	14	
1/27/2020	59	3407	2798	2034	1425	1373	80	76	4	2.35%	3.74%	0.29%	12.8	1.384	1.358	1.423	1.429	1.462	1.000	536	24	
1/28/2020	60	5786	4595	3979	2788	1807	106	99	7	1.83%	2.49%	0.39%	6.4	1.698	1.956	1.316	1.326	1.303	1.750	1945	23	
1/29/2020	61	7587	6065	5087	3565	2500	132	125	7	1.74%	2.46%	0.28%	8.8	1.311	1.279	1.384	1.245	1.262	1.000	1108	26	
1/30/2020	62	9785	7818	6574	4607	3211	170	162	8	1.74%	2.46%	0.25%	9.9	1.290	1.292	1.284	1.288	1.296	1.143	1487	37	
1/31/2020	63	12318	9826	8328	5836	3990	213	204	9	1.73%	2.45%	0.23%	10.9	1.259	1.267	1.243	1.253	1.259	1.125	1754	42	
2/1/2020	64	15163	11953	10727	7517	4436	259	249	10	1.71%	2.32%	0.23%	10.3	1.231	1.288	1.112	1.216	1.221	1.111	2399	45	
2/2/2020	65	18467	14557	13066	9156	5401	304	294	10	1.65%	2.25%	0.19%	12.2	1.218	1.218	1.217	1.174	1.181	1.000	2339	45	
2/3/2020	66	22201	17391	16074	11264	6127	361	350	11	1.63%	2.18%	0.18%	12.1	1.202	1.230	1.135	1.188	1.190	1.100	3007	56	
2/4/2020	67	26434	20630	19398	13593	7037	425	413	12	1.61%	2.13%	0.17%	12.5	1.191	1.207	1.148	1.177	1.180	1.091	3324	63	
2/5/2020	68	31731	24554	23986	16809	7745	491	478	13	1.55%	1.99%	0.17%	11.9	1.200	1.237	1.101	1.155	1.157	1.083	4589	65	
2/6/2020	69	36717	28276	28208	19767	8509	564	549	15	1.54%	1.95%	0.18%	11.0	1.157	1.176	1.099	1.149	1.148	1.154	4222	71	
2/7/2020	70	41191	31481	32450	22740	8741	637	621	16	1.55%	1.91%	0.18%	10.5	1.122	1.150	1.027	1.129	1.131	1.067	4242	72	
2/8/2020	71	45610	34886	35838	25114	9772	723	698	25	1.59%	1.95%	0.26%	7.6	1.107	1.104	1.118	1.135	1.124	1.563	3389	77	
2/9/2020	72	49217	37558	38962	27304	10254	812	779	33	1.65%	2.00%	0.32%	6.2	1.079	1.087	1.049	1.123	1.116	1.320	3124	81	
2/10/2020	73	53296	40554	42583	29841	10713	909	871	38	1.71%	2.05%	0.35%	5.8	1.083	1.093	1.045	1.119	1.118	1.152	3621	92	
2/11/2020	74	56886	43103	46060	32278	10825	1017	974	43	1.79%	2.11%	0.40%	5.3	1.067	1.082	1.010	1.119	1.118	1.132	3478	103	
2/12/2020	75	59670	45171	48453	33955	11216	1114	1071	43	1.87%	2.21%	0.38%	5.8	1.049	1.052	1.036	1.095	1.099	1.000	2393	97	
2/13/2020	76	61889	46997	49766	34874	12123	1252	1194	58	2.02%	2.40%	0.48%	5.0	1.037	1.027	1.081	1.124	1.115	1.349	1312	124	
2/14/2020	77	64682	49053	52231	36602	12451	1382	1318	64	2.14%	2.52%	0.51%	4.9	1.045	1.050	1.027	1.103	1.103	1.103	2466	124	
2/15/2020	78	66757	50580	54061	37884	12696	1524	1457	67	2.28%	2.70%	0.53%	5.1	1.032	1.035	1.020	1.103	1.105	1.047	1829	139	
2/16/2020	79	68442	51857	55424	38839	13018	1666	1595	71	2.43%	2.88%	0.55%	5.3	1.025	1.025	1.025	1.093	1.095	1.060	1363	138	
2/17/2020	80	71429	54019	58182	40772	13247	1772	1696	76	2.48%	2.91%	0.57%	5.1	1.044	1.050	1.018	1.064	1.063	1.070	2758	101	

**Table 1.** Showing data for New Coronavirus 2019 (COVID-19) from 22 January to 17 February 2020. Total Number of Cases and Deaths is 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 use <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. Starting on 17-Feb., the WHO includes cases Clinically diagnosed in addition to Laboratory diagnosed. As no date is given for these cases we assume that the Clinical Cases are a fixed percentage of the Laboratory Cases (46.2%) to get the revised Total Hubei Cases reported by WHO on 17-Feb.(58,182). For continuity between old and new data we list Hubei Cases as 'Hubei-L' for Laboratory diagnosed and 'Hubei-LC' for Laboratory and Clinically diagnosed. We divide data into Hubei and 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 is Value\_Today divided by Value\_Yesterday. We give the Number of New Cases and New Deaths in Hubei each day (subtracting yesterday from today). We replace the seemingly incorrect WHO value for Hubei Deaths on 13-Feb. (1,316) with the average of 12 and 14 Feb. values (1,194) to avoid having 245 New Deaths on 13-Feb. but just 2 on 14-Feb (pink shading).

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 2.5% on 27-Jan to 1.9% on 7-Feb. only to rise to 2.129% today. The non-Hubei death rate is much lower at 0.5%, comparable to that of influenza. Panel (D) shows that the Fractional Change in Total Cases (Cases\_Today / Cases\_Yesterday) is decreasing steadily. **Fig. 3** shows the number of New Cases and New Deaths in Hubei. While New Cases peaked on Day 69 (6-Feb.), New Deaths seems to have peaked on Day 78 (15-Feb.). This suggests that on average death occurs at 9 days after diagnosis as a confirmed case.

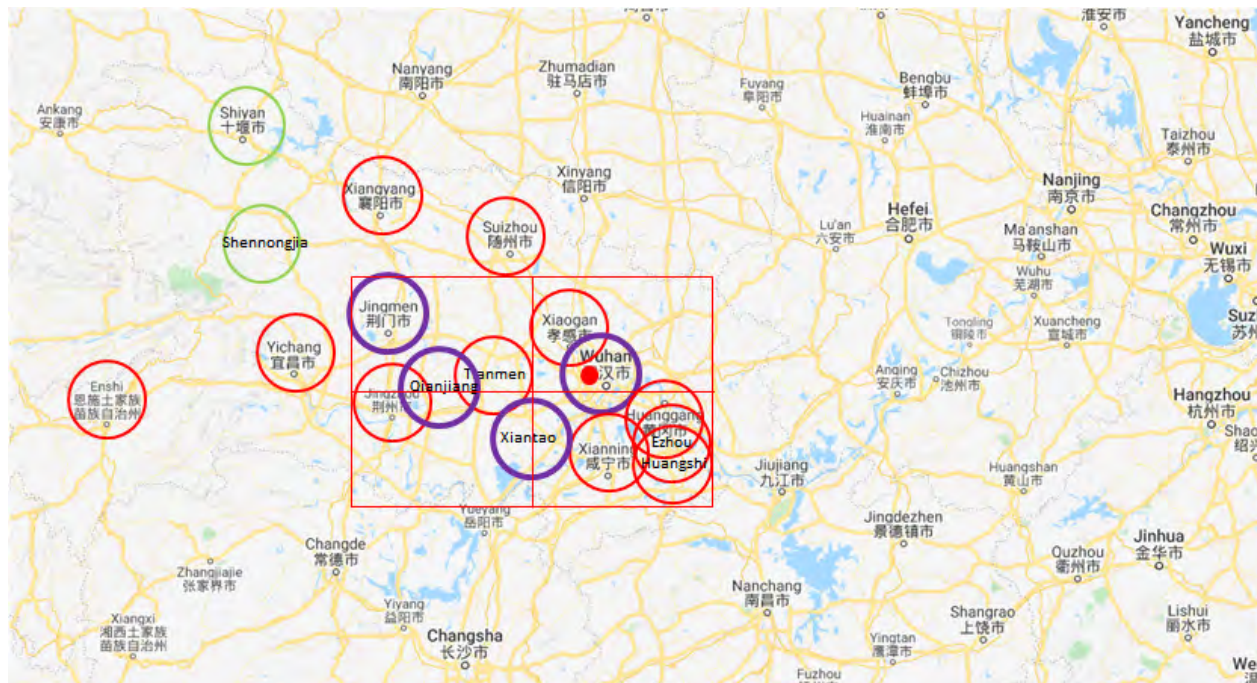




**Figure 1.** Variation of COVID-19 data against time in days since 29 Nov 2019 (guessed date of the first case). **Table 1** data is plotted from 22 January to 17 February 2020. In Panels (D) & (E) linear trend-lines are added using data from 1/29/2020. The Fraction Change for Cases and Deaths is an excellent fit to a straight line. 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 which is dated 2/2/20 and gave rise to the expectation then that the growth of deaths would slow soon.

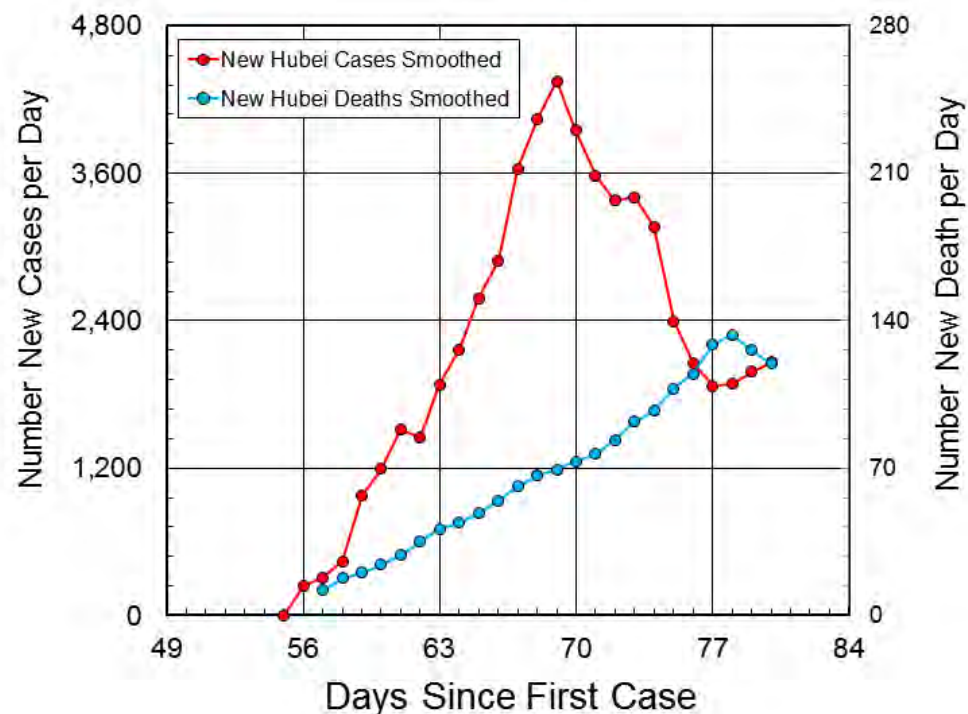
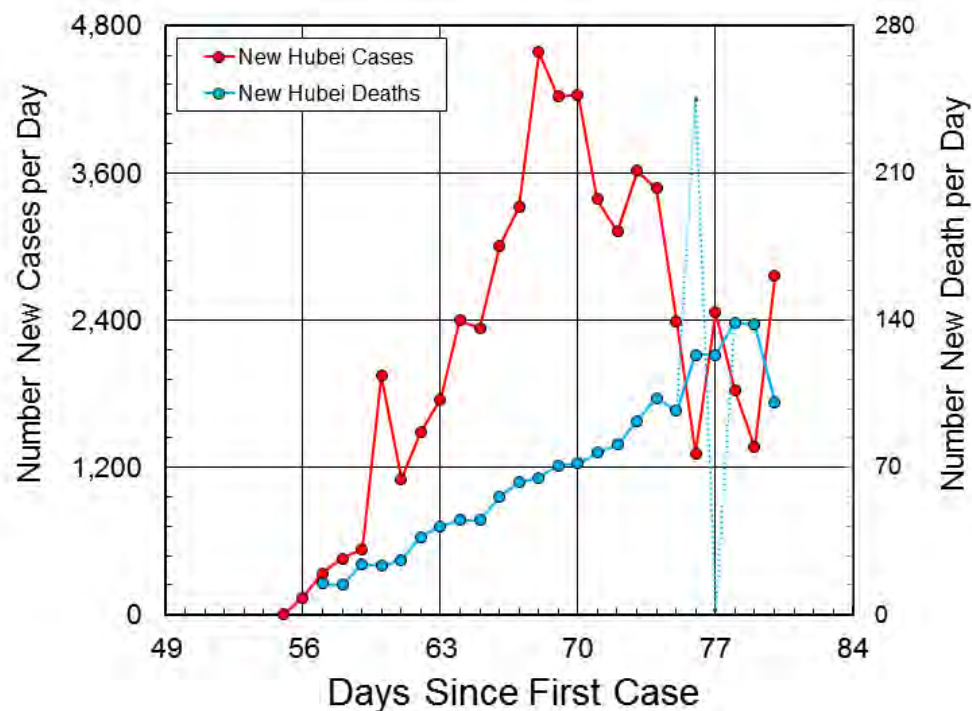
			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	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%
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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.



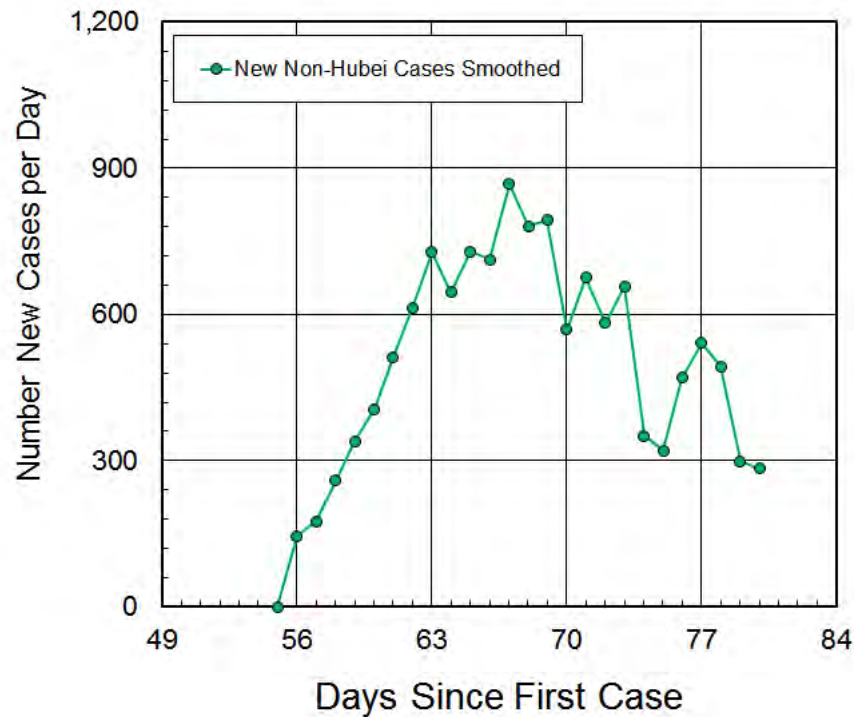
**Figure 2.** Map of Hubei circling in purple cities with a death rate of  $\geq 3\%$ , in red cities with a death rate of  $\geq 1\%$  and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Jingmen Qianjian 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.





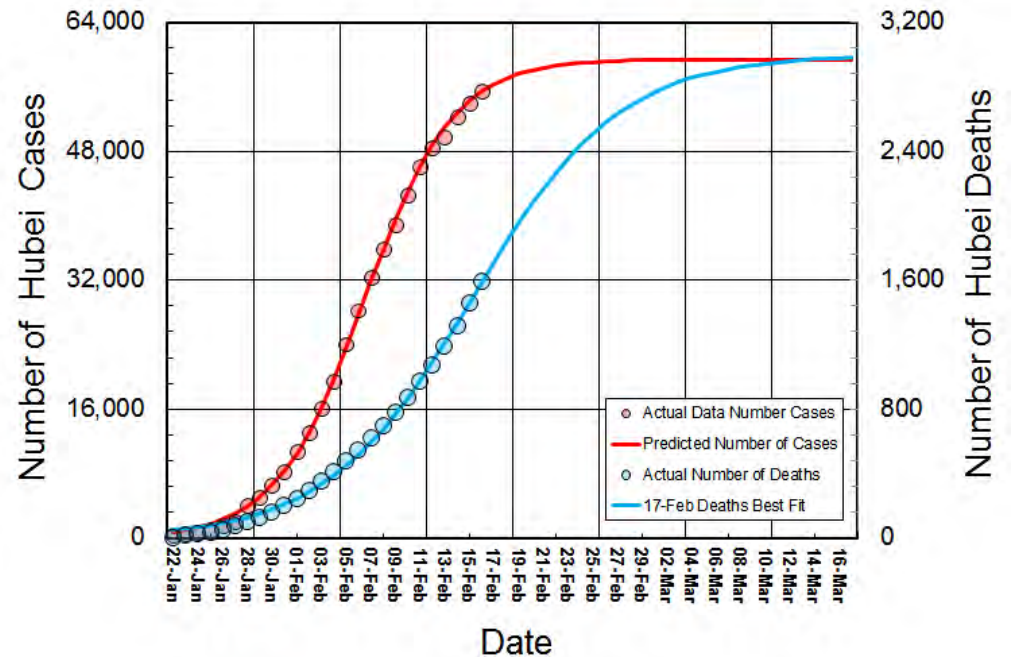
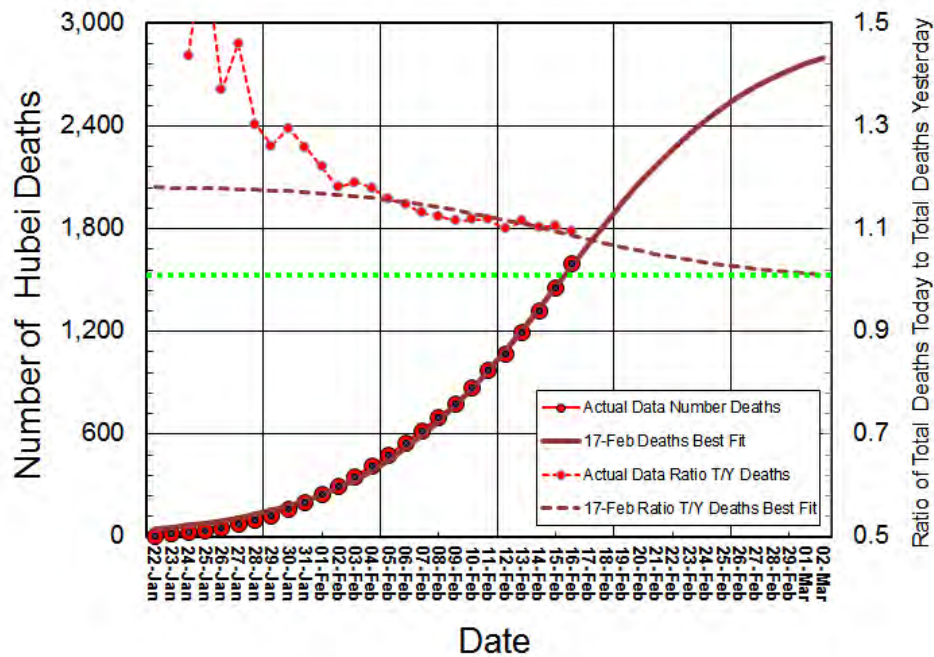
**Figure 3 A.** Showing the variation with time of Number of New Hubei Cases per Day and the Number of New Hubei Deaths per Day. For New deaths, the WHO data values fluctuated wildly on 13 and 14 Feb. as shown by blue dotted line. For this reason, the Numbers New Deaths of 245 on 13-Feb. and 2 on 14-Feb. (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 three-day window so that, for example, the value plotted on day 69 is the average of the values on days 68, 69 & 70. These smoothed curves clearly show that the Number of New Hubei Cases per Day peaked on Day 69 (6-Feb) and that the Number of New Hubei Deaths per Day may have peaked on Day 78 (15-Feb.), which is 9 days later. Note that we need a few more days of data to see if the drop in number of deaths on 17-Feb. is real or a random fluctuation. For sigmoid growth like that shown in **Fig. 4**, the number of new cases or deaths reaches a maximum midway through the curve. If this holds here, then the total Number of Hubei Cases will reach 60,000 (laboratory plus clinically diagnosed cases), which is approx. twice 28,208, the number of such cases on 6-Feb.. Were the Number of New Hubei Deaths to peak today, the number of Total Hubei Deaths will reach 3,000, which is approx. twice 1,457, the number of Hubei Deaths on 15-Feb. There is a potentially worrying increase in the Number of New Hubei Cases on 15, 6 & 17 Feb. that will need to be followed.



**Figure. 3 C.** Showing the variation with time of the smoothed Number of New Non-Hubei Cases per Day. Although smoothed by averaging over a window of three values, this data remains noisy. Nevertheless, it does indicate that a peak in the Number New Non-Hubei Deaths occurred on day 67 or 68 (4-Feb. or 5-Feb.) allowing the maximum Total Number of Non-Hubei cases to be estimated as twice 7,037 or 7,745, the values on 4-Feb. or 5-Feb. for a value of between 14,000 and 16,000. Non-Hubei deaths are too few to plot in this way but if we assume that they peaked on 12 days later day 79 or 80 (see **Fig 3B.**), the Total Number of non-Hubei Deaths can be expected to reach twice the value of 76 on 17-Feb. for a total Number of Non-Hubei Deaths of 150. This will mean an overall Non-Hubei Death Rate of 1 % (150/15,000).





**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 B & C in  $f(x) = A/(1-\exp(-x+B)/C)$ , with A set to 3,000, so that the predicted Number of Deaths first the actual values to 17-Feb (red line and circles) and also fits the estimate of the final Number of Deaths of 3,000 from the peak in new Deaths per Day (**Fig. 3B**).. 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)**.

**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 B**, the total Number of Hubei Cases will be close to 60,000, while the current estimate for Total Number of Deaths is 3,000. This will mean an overall Hubei Death Rate of 5% (3,000/60,000), which is 5 times higher than the estimated Non-Hubei Death Rate of 1%.

# "21. Analysis of nCov-2019 Data on 2/21/2020" by Michael Levitt, Stanford University, USA

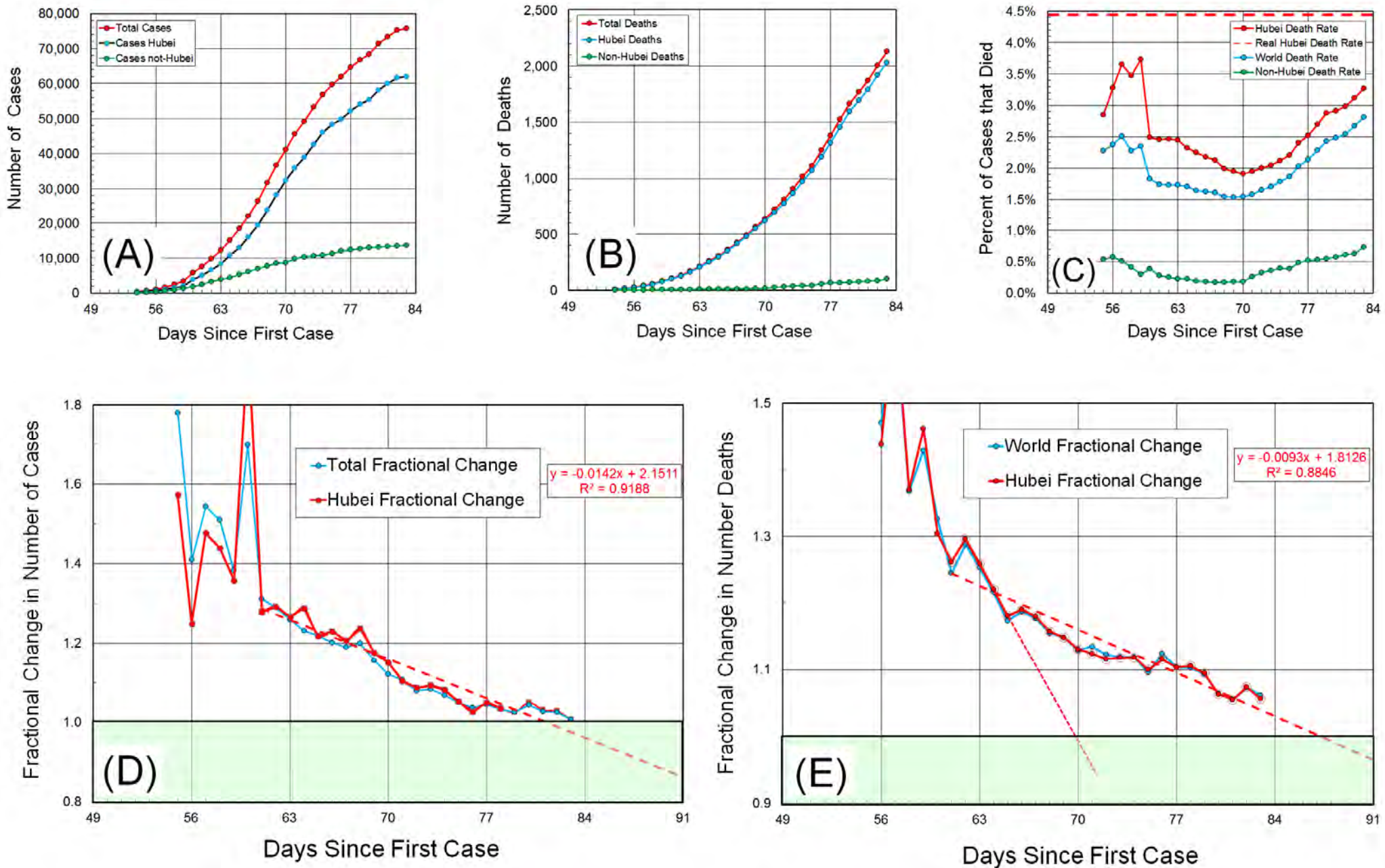
Today's report confirms the promising trend first seen two days ago: Total Number of Hubei Deaths will reach 3,000 and the estimated for the total number of Hubei cases (Clinical and Laboratory Diagnosed) will reach 64,000. The Overall Death Rate is 4.5% with most deaths occurring on Day 0 and Day 9. Non-Hubei Cases and Deaths are estimated to reach 16,000 and 160, respectively.

Date	Day	Total Number Cases					Total Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases			Fraction Change Deaths			New/Day in Hubei	
		Total-LC	Total-L	Hubei-LC	Hubei-L	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others	Cases	Deaths
1/22/2020	54	421	314	358	251	63	6	6	0	1.42%	1.67%	0.00%	-								
1/23/2020	55	750	581	564	395	186	17	16	1	2.28%	2.85%	0.54%	5.3	1.780	1.573	2.961	2.843	2.676	-	205	10
1/24/2020	56	1057	846	704	494	352	25	23	2	2.37%	3.28%	0.57%	5.8	1.410	1.249	1.895	1.470	1.437	2.000	141	7
1/25/2020	57	1631	1320	1040	729	591	41	38	3	2.51%	3.65%	0.51%	7.2	1.544	1.477	1.677	1.633	1.645	1.500	336	15
1/26/2020	58	2462	2014	1497	1049	965	56	52	4	2.27%	3.47%	0.41%	8.4	1.509	1.440	1.632	1.367	1.370	1.333	457	14
1/27/2020	59	3407	2798	2034	1425	1373	80	76	4	2.35%	3.74%	0.29%	12.8	1.384	1.358	1.423	1.429	1.462	1.000	536	24
1/28/2020	60	5786	4595	3979	2788	1807	106	99	7	1.83%	2.49%	0.39%	6.4	1.698	1.956	1.316	1.326	1.303	1.750	1945	23
1/29/2020	61	7587	6065	5087	3565	2500	132	125	7	1.74%	2.46%	0.28%	8.8	1.311	1.279	1.384	1.245	1.262	1.000	1108	26
1/30/2020	62	9785	7818	6574	4607	3211	170	162	8	1.74%	2.46%	0.25%	9.9	1.290	1.292	1.284	1.288	1.296	1.143	1487	37
1/31/2020	63	12318	9826	8328	5836	3990	213	204	9	1.73%	2.45%	0.23%	10.9	1.259	1.267	1.243	1.253	1.259	1.125	1754	42
2/1/2020	64	15163	11953	10727	7517	4436	259	249	10	1.71%	2.32%	0.23%	10.3	1.231	1.288	1.112	1.216	1.221	1.111	2399	45
2/2/2020	65	18467	14557	13066	9156	5401	304	294	10	1.65%	2.25%	0.19%	12.2	1.218	1.218	1.217	1.174	1.181	1.000	2339	45
2/3/2020	66	22201	17391	16074	11264	6127	361	350	11	1.63%	2.18%	0.18%	12.1	1.202	1.230	1.135	1.188	1.190	1.100	3007	56
2/4/2020	67	26434	20630	19398	13593	7037	425	413	12	1.61%	2.13%	0.17%	12.5	1.191	1.207	1.148	1.177	1.180	1.091	3324	63
2/5/2020	68	31731	24554	23986	16809	7745	491	478	13	1.55%	1.99%	0.17%	11.9	1.200	1.237	1.101	1.155	1.157	1.083	4589	65
2/6/2020	69	36717	28276	28208	19767	8509	564	549	15	1.54%	1.95%	0.18%	11.0	1.157	1.176	1.099	1.149	1.148	1.154	4222	71
2/7/2020	70	41191	31481	32450	22740	8741	637	621	16	1.55%	1.91%	0.18%	10.5	1.122	1.150	1.027	1.129	1.131	1.067	4242	72
2/8/2020	71	45610	34886	35838	25114	9772	723	698	25	1.59%	1.95%	0.26%	7.6	1.107	1.104	1.118	1.135	1.124	1.563	3389	77
2/9/2020	72	49217	37558	38962	27304	10254	812	779	33	1.65%	2.00%	0.32%	6.2	1.079	1.087	1.049	1.123	1.116	1.320	3124	81
2/10/2020	73	53296	40554	42583	29841	10713	909	871	38	1.71%	2.05%	0.35%	5.8	1.083	1.093	1.045	1.119	1.118	1.152	3621	92
2/11/2020	74	56886	43103	46060	32278	10825	1017	974	43	1.79%	2.11%	0.40%	5.3	1.067	1.082	1.010	1.119	1.118	1.132	3478	103
2/12/2020	75	59670	45171	48453	33955	11216	1114	1071	43	1.87%	2.21%	0.38%	5.8	1.049	1.052	1.036	1.095	1.099	1.000	2393	97
2/13/2020	76	61889	46997	49766	34874	12123	1252	1194	58	2.02%	2.40%	0.48%	5.0	1.037	1.027	1.081	1.124	1.115	1.349	1312	124
2/14/2020	77	64682	49053	52231	36602	12451	1382	1318	64	2.14%	2.52%	0.51%	4.9	1.045	1.050	1.027	1.103	1.103	1.103	2466	124
2/15/2020	78	66757	50580	54061	37884	12696	1524	1457	67	2.28%	2.70%	0.53%	5.1	1.032	1.035	1.020	1.103	1.105	1.047	1829	139
2/16/2020	79	68442	51857	55424	38839	13018	1666	1595	71	2.43%	2.88%	0.55%	5.3	1.025	1.025	1.025	1.093	1.095	1.060	1363	138
2/17/2020	80	71429	54019	58182	40772	13247	1772	1696	76	2.48%	2.91%	0.57%	5.1	1.044	1.050	1.018	1.064	1.063	1.070	2758	101
2/18/2020	81	73332	NA	59989	NA	13343	1870	1789	81	2.55%	2.98%	0.61%	4.9	1.027	1.031	1.007	1.055	1.055	1.066	1807	93
2/19/2020	82	75204	NA	61682	NA	13522	2006	1921	85	2.67%	3.11%	0.63%	5.0	1.026	1.028	1.013	1.073	1.074	1.049	1693	132
2/20/2020	83	75748	NA	62031	NA	13717	2129	2029	100	2.81%	3.27%	0.73%	4.5	1.007	1.006	1.014	1.061	1.056	1.176	349	108

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 use <https://jobtube.cn/vw/?from=groupmessage&isappinstalled=0>. Starting on 17-Feb., the WHO includes cases Clinically diagnosed in addition to Laboratory diagnosed. As no date is given for these cases we assume that the Clinical Cases are a fixed percentage of the Laboratory Cases (46.2%) to get the revised Total Hubei Cases reported by WHO on 17-Feb.(58,182). For continuity between old and new data we list Hubei Cases as 'Hubei-L' for Laboratory diagnosed and 'Hubei-LC' for Laboratory and Clinically diagnosed. We divide data into Hubei and 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 is Value\_Today divided by Value\_Yesterday. We give the Number of New Cases and New Deaths in Hubei each day (subtracting yesterday from today). We replace the seemingly incorrect WHO value for Hubei Deaths on 13-Feb. (1,316) with the average of 12 and 14 Feb. values (1,194) to avoid having 245 New Deaths on 13-Feb. but just 2 on 14-Feb (pink shading).

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 2.5% on 27-Jan. to 1.9% on 7-Feb. only to rise to 3.3% today, which it is wrongly estimated. Panels (D) and (E) shows that the Fractional Change in Total Cases (Cases\_Today / Cases\_Yesterday) is decreasing steadily. Fig. 3 shows the number of New Cases and New Deaths in Hubei. While New Cases peaked on Day 69 (6-Feb.), New Deaths peaked on Day 78 (15-Feb.). This difference shows that on-average death occurs at 9 days after diagnosis. This is confirmed by the correct distribution of Death Rate calculated in Fig. 5, which also gives a fixed Hubei Death Rate of 4.5%, much larger than currently accepted.

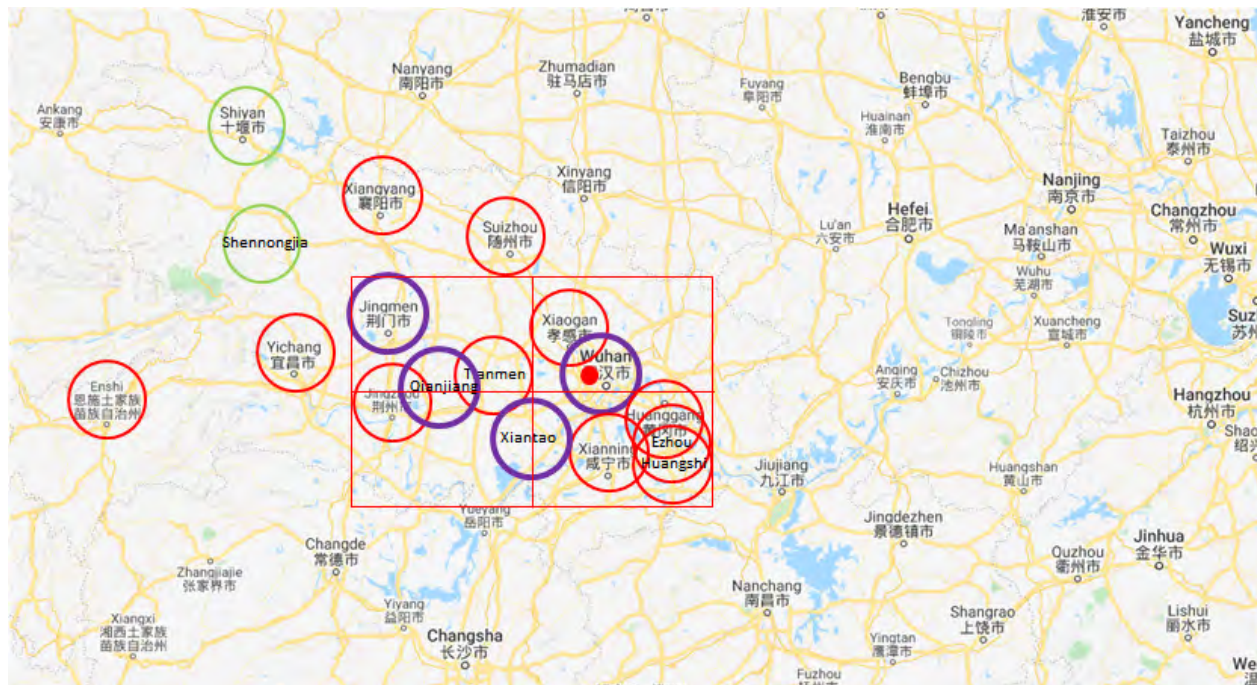




**Figure 1.** Variation of COVID-19 data against Days since 29 Nov 2019 (guessed date of the first case). **Table 1** data is plotted from 22 Jan. to 20 Feb. 2020. The rise of Hubei Death Rate in Panel (C) makes no sense as the virus is not becoming more virulent. This discrepancy arises because all Deaths do not occur on the same day a case is diagnosed. A proper Death Rate Distribution gives a real Hubei Death Rate of 4.4% (Fig. 6). In Panels (D) & (E) linear trend-lines are added using data from 1/29/2020. The Fraction Change for Cases and Deaths is an excellent fit to a straight line. In panel (E) we also show 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, giving the expectation that the growth of deaths would slow soon.

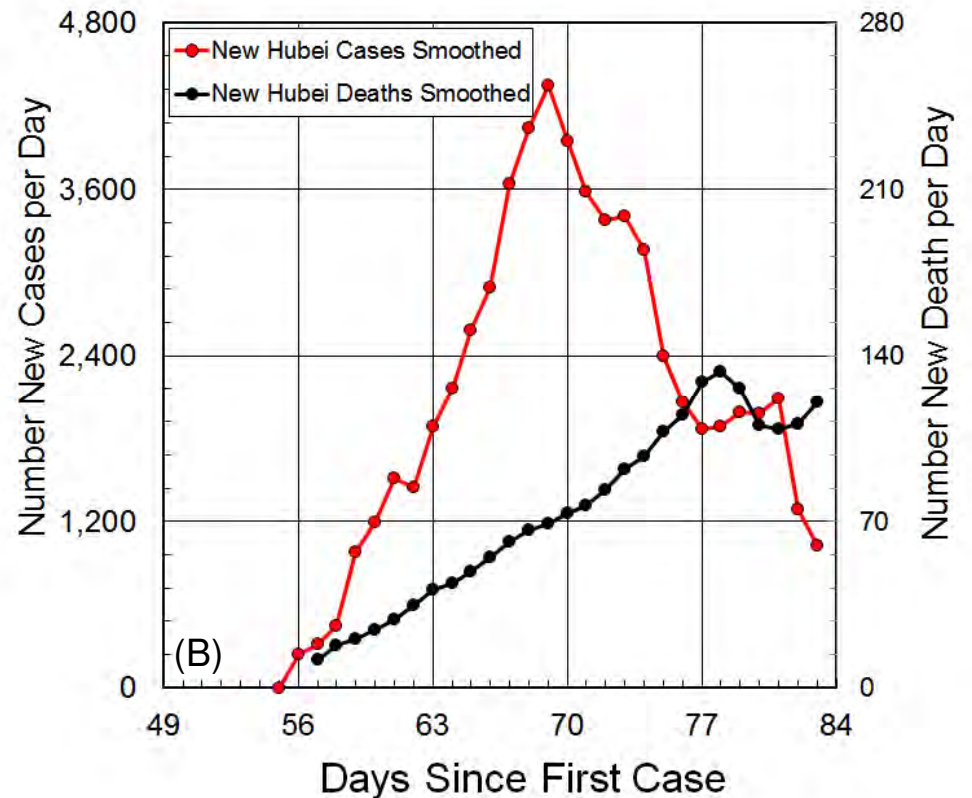
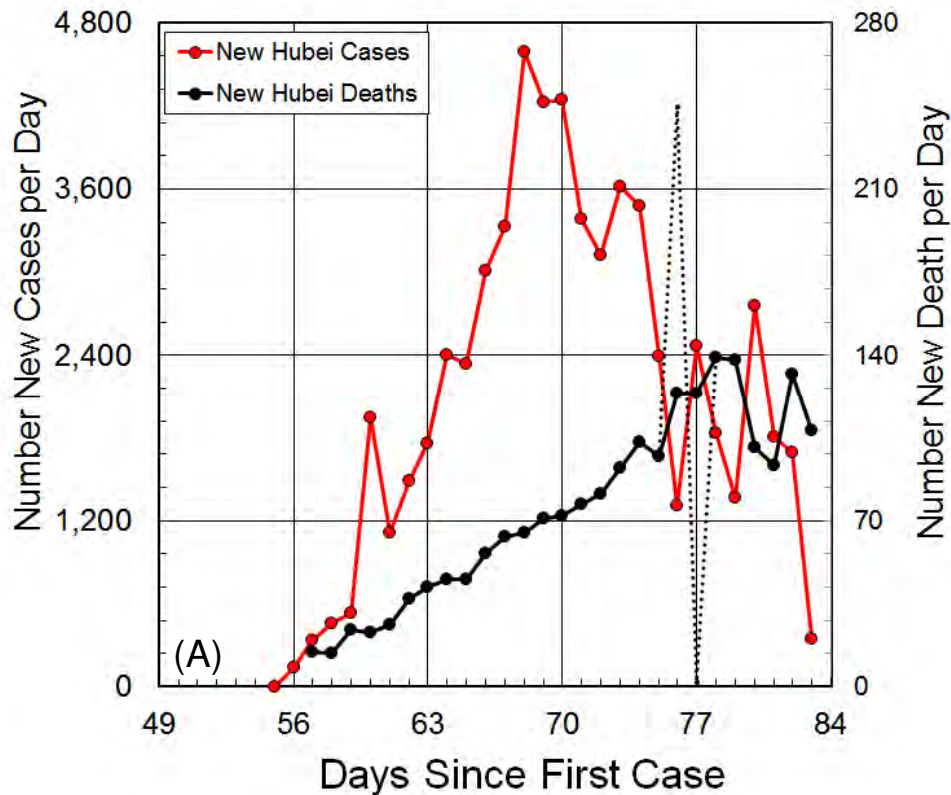
			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	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.



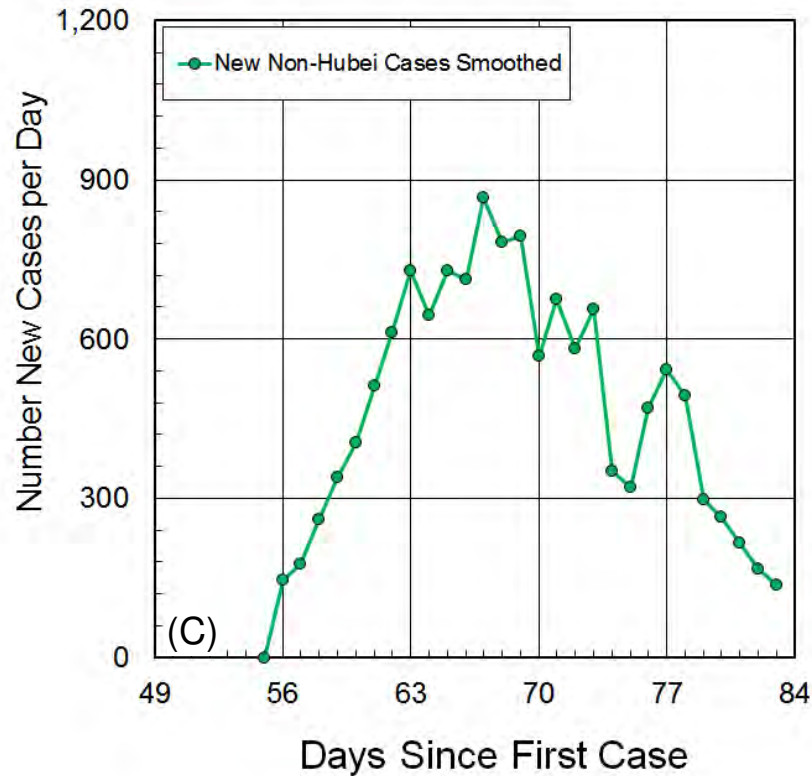
**Figure 2.** Map of Hubei circling in purple cities with a death rate of  $\geq 3\%$ , in red cities with a death rate of  $\geq 1\%$  and in green other cities for which there is data. Most deaths are localized to a 90km x 35km area centered near Tianmen and high death rates occur in four cities: Wuhan, Jingmen Qianjian 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.





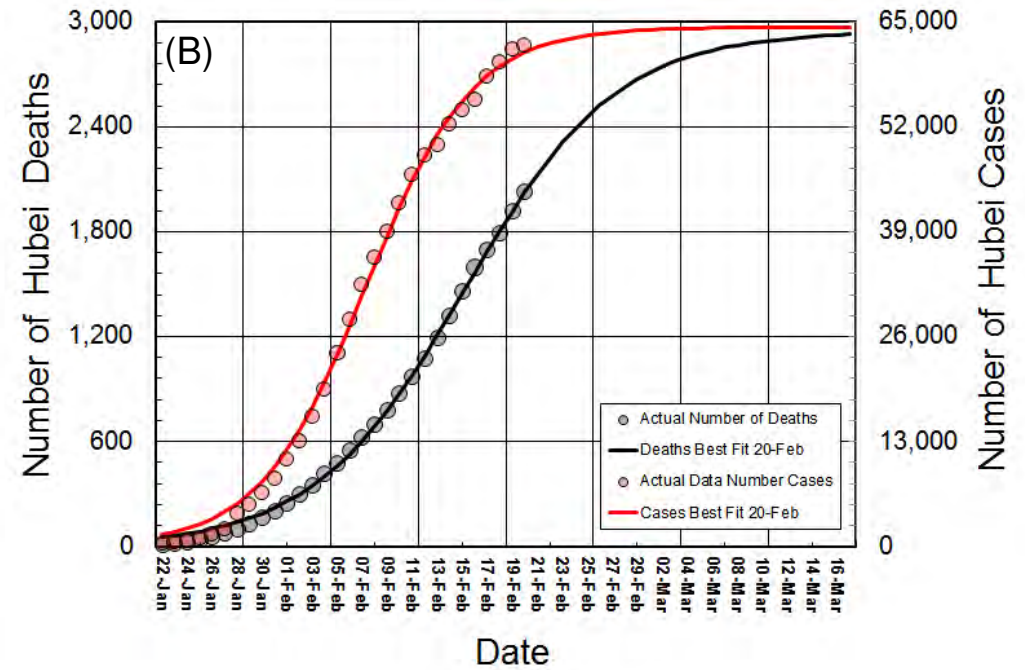
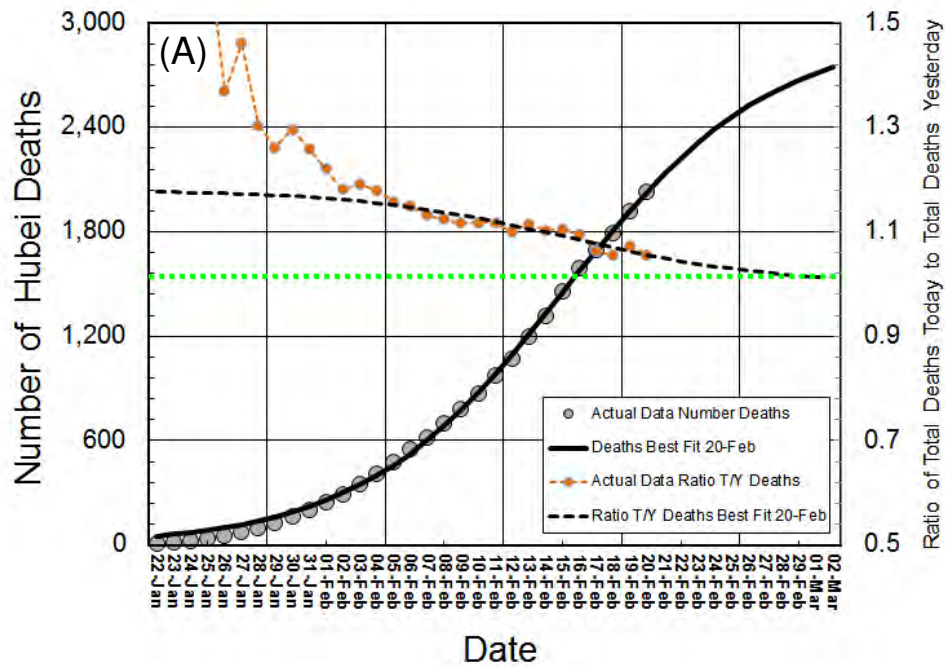
**Figure 3A.** Showing the variation with time of Number of New Hubei Cases per Day (red line) and the Number of New Hubei Deaths per Day (black line). For New deaths, the WHO data values fluctuated wildly on 13 and 14 Feb. as shown by black dotted line. For this reason, the Numbers of New Deaths of 245 on 13-Feb. and 2 on 14-Feb. (Table 1) are averaged to give 124 New Deaths on each day, correcting what may have been a typo in the value for 13-Feb. (black dashed line).

**Figure 3B.** The same data is smoothed by averaging over a three-day window so that, for example, the value plotted on day 69 is the average of the values on days 68, 69 & 70. These smoothed curves clearly show that the Number of New Hubei Cases per Day peaked on Day 69 (6-Feb) and that the Number of New Hubei Deaths per Day may have peaked on Day 78 (15-Feb.), which is 9 days later. Note that we need a few more days of data to see if the drop in number of deaths on 17-Feb. is real or a random fluctuation. For sigmoid growth like that shown in **Fig. 4**, the number of new cases or deaths reaches a maximum midway through the curve. If this holds here, then the total Number of Hubei Cases will reach 60,000 (laboratory plus clinically diagnosed cases), which is approximately twice 28,208, the number of such cases on 6-Feb.. Were the Number of New Hubei Deaths to peak today, the number of Total Hubei Deaths will reach 3,000, which is approx. twice 1,457, the number of Hubei Deaths on 15-Feb. Better analysis in Fig. 4 gives asymptotic values of 64,000 and 3,000 for Number of Cases and Deaths, respectively.



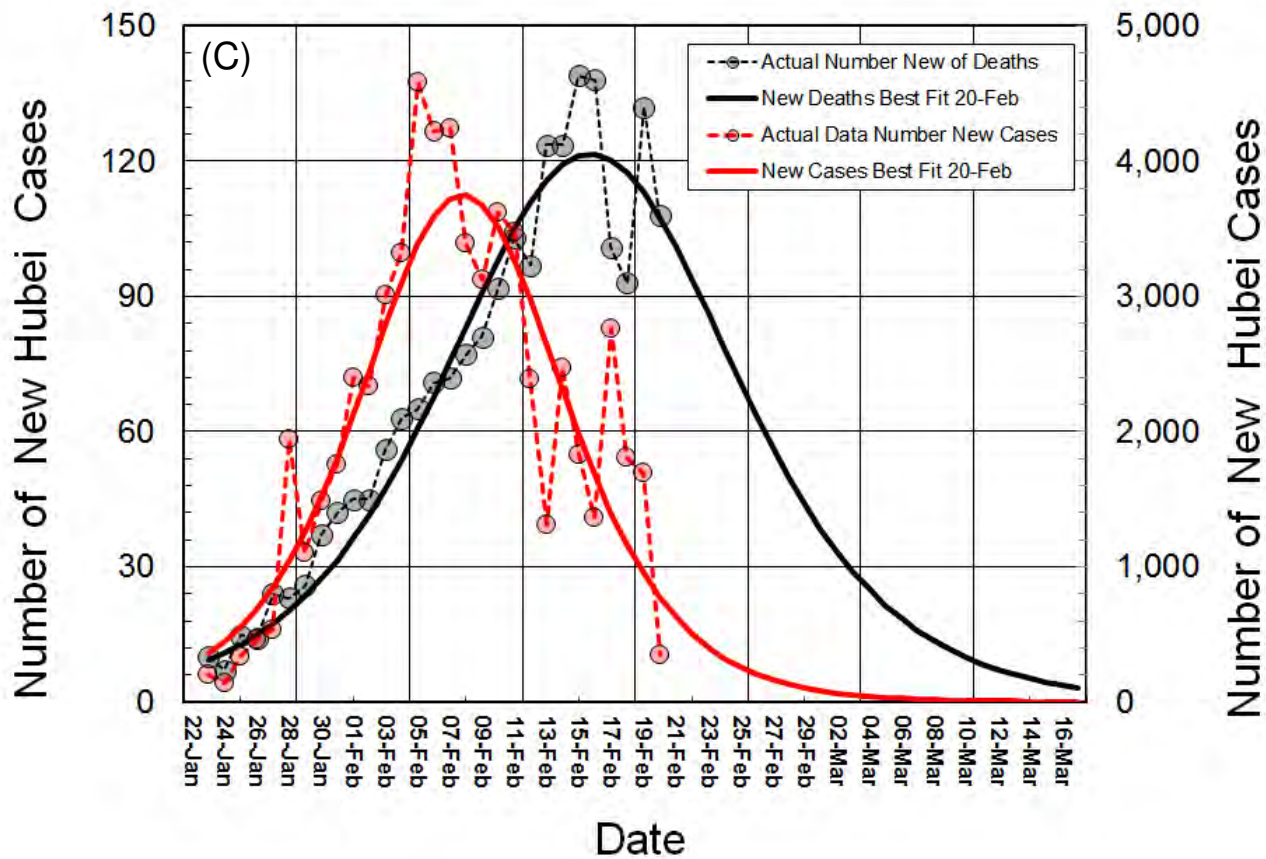
**Figure. 3C.** Showing the variation with time of the smoothed Number of New Non-Hubei Cases per Day. Although smoothed by averaging over a window of three values, this data remains noisy. Nevertheless, it does indicate that a peak in the Number New Non-Hubei Deaths occurred on day 67 or 68 (4-Feb. or 5-Feb.) allowing the maximum Total Number of Non-Hubei cases to be estimated as twice 7,037 or 7,745, the values on 4-Feb. or 5-Feb, for a value of between 14,000 and 16,000. Non-Hubei deaths are too few to plot in this way but if we assume that they peaked 9 days later day 79 or 80 (see **Fig 3B.**), the Total Number of non-Hubei Deaths can be expected to reach a total Number of Non-Hubei Deaths of 160. This will mean an overall Non-Hubei Death Rate of 1% (160/16,000).





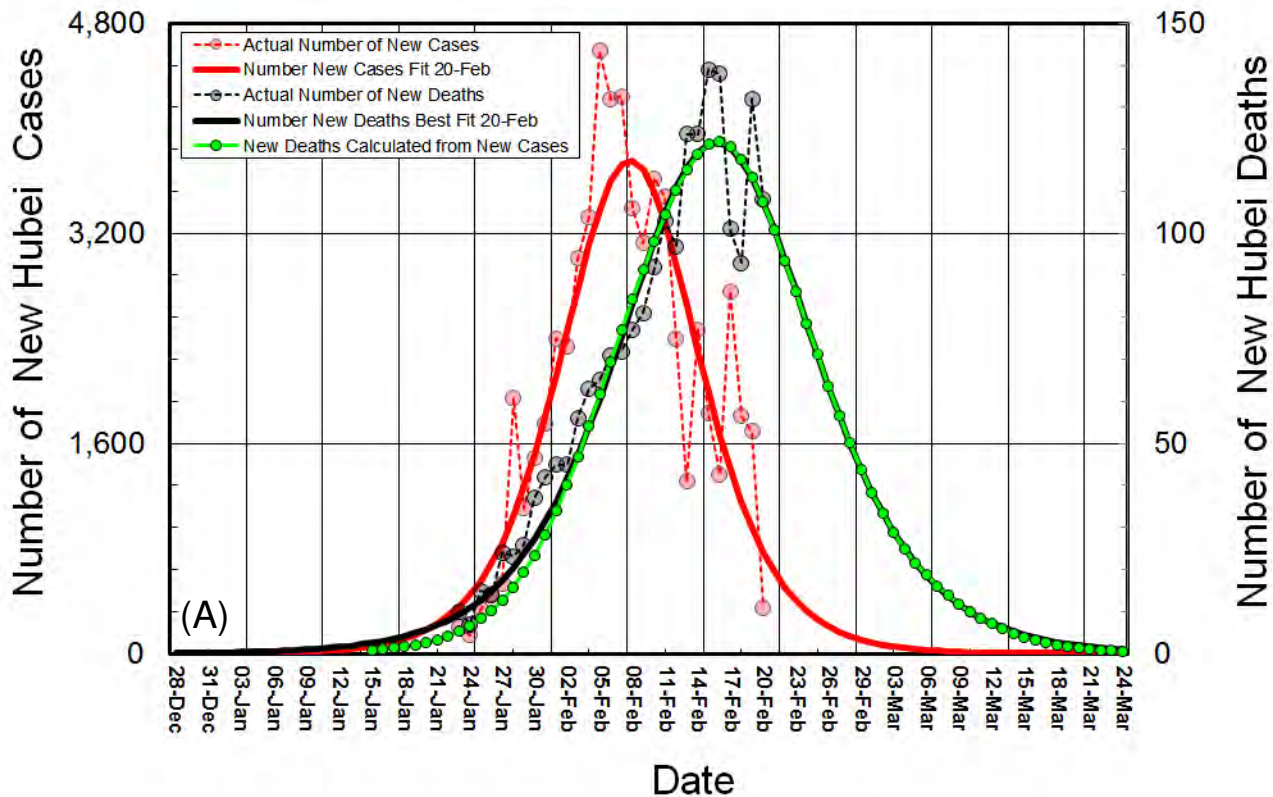
**Figure. 4A.** Fit of the sigmoid function  $f(x) = 1/(1-\exp(-x))$  to the actual Total Number of Hubei Deaths from the coronavirus COVID-19 since 22 Jan 2020. The best fit to actual values (black line) is obtained using Excel to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B))/C$  until the weighted (weight= $\sqrt{\text{Number Deaths}}$ ) difference between the calculated and actual Number of Deaths is a minimum. Particularly impressive is that the Ratio of Deaths Today to Yesterday (T/Y) from the actual data (orange dashed line and circles on secondary axis) is well fit by the calculated Ratio (black dashed line on secondary axis), which decreases in the linear fashion assumed in **Fig. 2 (E)** towards the value of 1.0 when there is no further growth in number of deaths.

**Figure. 4B.** 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. 3B**, the total Number of Hubei Cases will be close to 64,000, while the current estimate for Total Number of Deaths will be close to 3,000. This will mean an overall Hubei Death Rate of almost 5% ( $3,000/64,000$ ), which is 5 times higher than the estimated Non-Hubei Death Rate of 1%. This estimate is now confirmed by the Death Rate Distribution derived in **Fig. 5**.



**Figure. 4C.** By subtracting values for yesterday from today, the sigmoid function  $f(x) = 1/(1-\exp(-x))$  fit to the actual Total Number of Hubei Cases or Deaths shown in **Fig. 4B** can be used to get a calculated Number of New Hubei Cases or New Hubei Deaths (solid red and black lines, respectively). These curves are a good fit to the Actual Number of New Hubei Cases or Deaths (red and black transparent circles joined by dashed read and black lines, respectively), although the real data is noisy with large fluctuations.





**Figure. 5A.** The data on Number of New Cases and New Deaths each day in **Fig. 4C**. is shown again (solid red and black lines) in our attempt to relate New Cases to New Deaths by deriving a Death Rate Distribution. This distribution gives the Death Rate  $i$  days (where  $i$  is 0, 1, 2, etc.) after confirmation as a new case. It shows the progression of the disease fitting the data we have.

We assume that for each case diagnosed on day 0, there will be Death Rate  $P_i$  for death after  $i = 0, 1, 2, \dots, 29$  days (we tried  $i$  up to 44 but there was no signal for Days 30 to 44). The Number of New Deaths,  $D_n$ , on day  $n$  is the sum of deaths from  $C_{n-i}$ , the Number of New Cases on previous days:

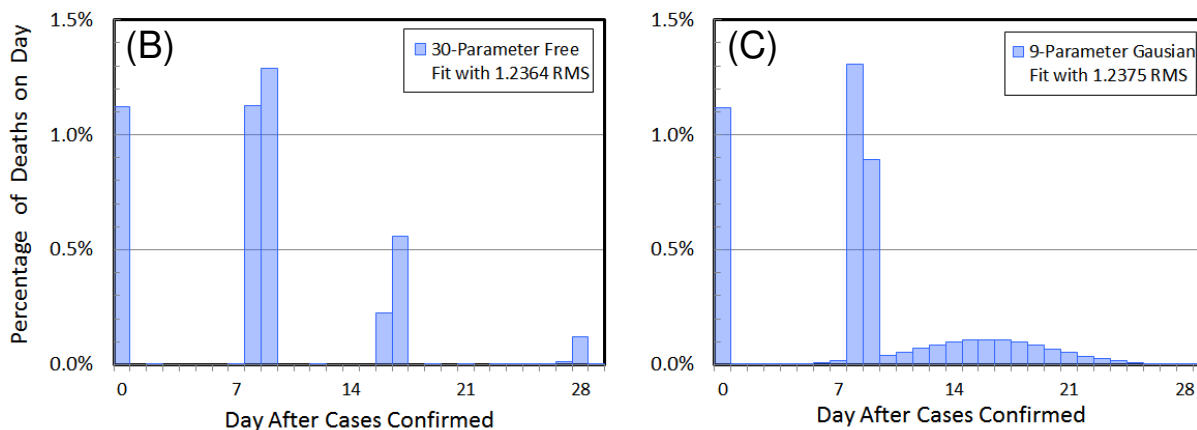
$$D_n = C_n * P_0 + C_{n-1} * P_1 + C_{n-2} * P_2 + \dots + C_{n-29} * P_{29}$$

The corresponding total Death Rate is the sum of all  $P_i$  values and will be the same for each day.

Again we use Excel Solver to determine the values for the  $P_n$  values. This is done in two ways:

- (1) With all 30 parameters, one for each  $P_n$  values.
- (2) With just 9 parameters obtained by calculating the  $P_n$  values as a sum of three Gaussian functions  $g(n) = A_i * \exp(-((n-B_i)/C_i)^2)$ , where there are 3 parameters ( $A_i, B_i, C_i$ ) for each Gaussian.

We run Solver repeatedly for the 30-parameter model always reaching the same best fit with a weighted error of 1.236 (weight is taken a  $\sqrt{D}$  where  $D$  is Number of New Deaths in **Fig. 4C**). A similar best fit is also obtained with the 9-parameter model. The Number of New Deaths from the best 30-parameter solution is shown as the green line in **Fig. 5A**. The fit is almost perfect (hiding the black line) except for 15-Jan. to 31-Jan. when it is low. This could mean that the number of Confirmed Cases was low then due to the difficult conditions in Hubei.



**Figure. 5 B.** Showing the Death Rate Distributions for 30-Parameter and 9-Parameter fits are very similar. Both have unexpected features as follows: there is a Death Rate of 1.1% on day 0, the day a case is confirmed; there is a death rate of about 2.4% summed over days 8 & 9; there is a death rate of 1.2% summed over later days. The total Death Rate is 4.46%, which is higher than that calculated in **Fig. 1C**.

## “23. Analysis of COVID-2019 Data on 2/23/2020” by Michael Levitt, Stanford University, USA

Contrary to the prevailing world hysteria, the COVID-19 epidemic is almost all over in China and likely also in the whole world. Today's analysis uses WHO data for the past 32 days to confirm trends we have shown in the 22 earlier reports. We separate Hubei from non-Hubei as most cases and deaths have occurred in Hubei (see **Fig. 2**). We estimate there will be 3,050 Total Hubei Deaths and less than 200 non-Hubei Deaths in China. There will be 65,000 Hubei Cases with a Hubei Death Rate of 4.5% (1% on Day 0 after becoming a case; 2.4% on Days 8 & 9, the remaining 1% after day 14). There will be 15,000 non-Hubei Cases in China with a death rate currently of 1%.

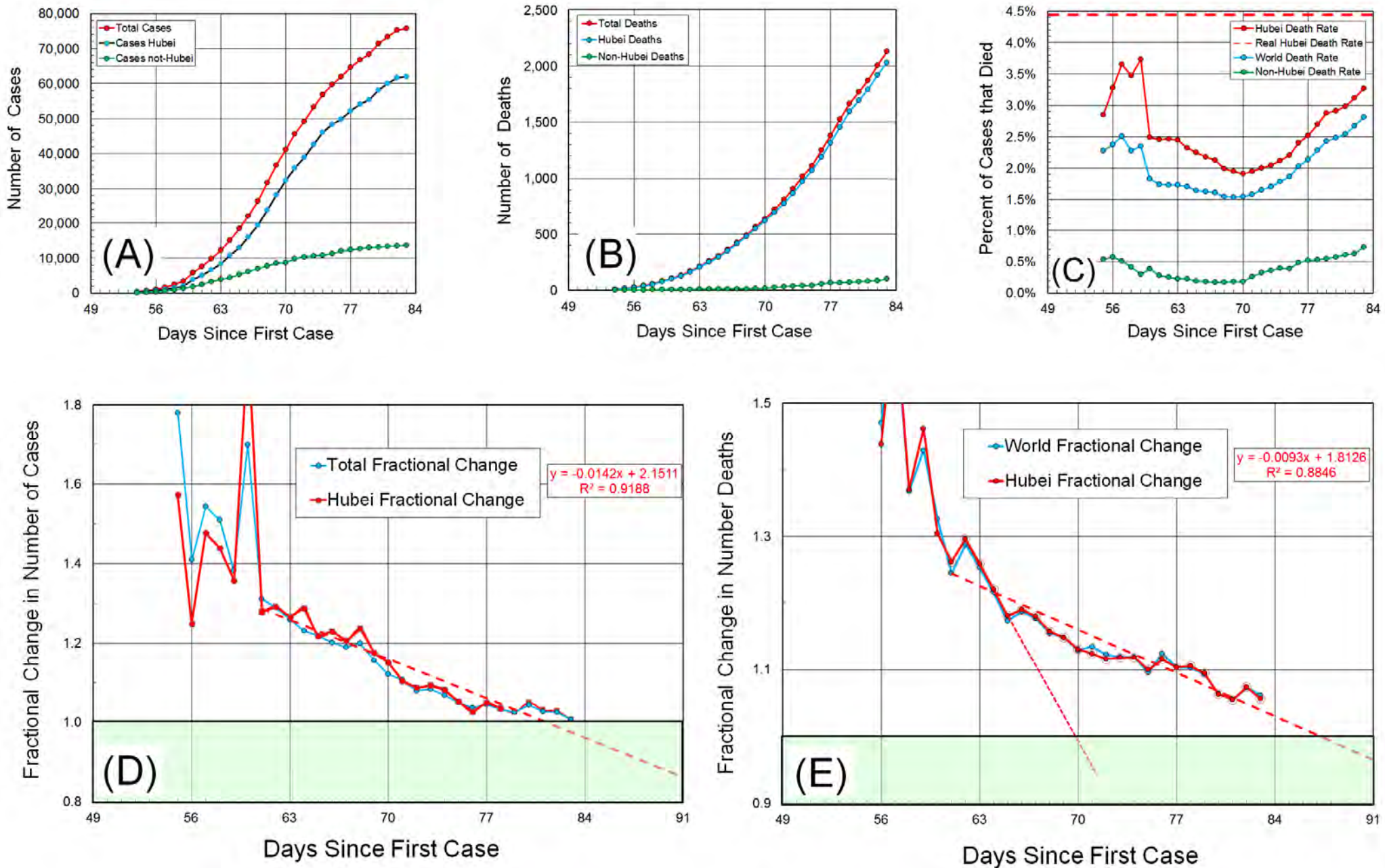
Plots of this data against date are shown in **Fig. 1**. Panel (A) shows a slowing increase in Number of Cases everywhere. Panel (B) confirms that almost all the deaths are in Hubei. Panel (C) shows that the Hubei Death Rate initially decreased from 2.5% on 27-Jan. to 1.9% on 7-Feb. only to rise to 3.6% today, but as it is wrongly estimated this is unimportant (see **Fig. 5**). Panels (D) and (E) shows that the Fractional Change in Total Cases or Deaths ( $\text{Value\_Today} / \text{Value\_Yesterday}$ ) is decreasing steadily as we expected on 2 Feb. **Fig. 3** shows the number of New Cases and New Deaths in Hubei; while New Cases peaked on Day 69 (6-Feb.), New Deaths peaked on Day 78 (15-Feb.). This difference shows that on-average death occurs at 9 days after diagnosis. In **Fig. 3C** we plot the New Cases and Deaths for non-Hubei but without non-China data. New cases have clearly peaked on Day 68 (5-Feb.) while New Deaths may well have peaked between Day 75 and Day 79. The middle of this range, Day 77 is 9 days after the new case peak, as would be expected. We fit the Total Hubei Cases and Deaths with sigmoid functions, which give final expected total numbers of Cases and Deaths of 65,060 and 3 030, respectively (**Fig. 4**). This fit allows calculation of the distribution of Death Rate shown in **Fig. 5**, it gives a fixed Hubei Death Rate of 4.5%, larger than currently accepted.

As soon as it seemed possible that the epidemic was over in China (Hubei and non-Hubei ), which was by far hit hardest with all except 11 of the 2348 deaths (99.5%), '*world panic*' was focused on the Diamond Princess cruise ship. In many ways, this ship provides a worse-case test scenario. There were 634 cases and 2 deaths for the 2,600 passengers, who were kept in close proximity on a ship 290m x 37m in size, a population density of 250,000 per square km (37 times that of Hong Kong). These passengers are much older than the general population (200 were over 80 years). The passengers were not quarantined properly but were diagnosed for COVID-18 daily by PCR (polymerase chain reaction), a sensitive amplification method that detects minuscule levels of virus. This led to the 23% infection rate, which shows that if we want to waste the money and measure the world's population each day, we may reach this level of infection. By looking at people without symptoms with a super-sensitive molecular-detection method, we will find them. Two deaths, both of people older than 80 gives a death rate of 0.07% (2/2,600) in a month. By comparison, in the USA, for people 80 and over, the death rate is 11% per year or 0.9% per month. This would mean 2 deaths a month for 200 passengers over 80. If there are no further COVID-19 deaths amongst the Diamond Princess passengers, it seems we need not worry about this disease causing widespread death worse than influenza.



Date	Day	Total Number Cases					Total Number Deaths			Death Rate (%)			Ratio Hubei/ Others	Fraction Change Cases			Fraction Change Deaths			New/Day in Hubei		
		Total-LC	Total-L	Hubei-LC	Hubei-L	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others	Cases	Deaths	
1/22/2020	54	421	314	358	251	63	6	6	0	1.42%	1.67%	0.00%	-									
1/23/2020	55	750	581	564	395	186	17	16	1	2.28%	2.85%	0.54%	5.3	1.780	1.573	2.961	2.843	2.676	-	205	10	
1/24/2020	56	1057	846	704	494	352	25	23	2	2.37%	3.28%	0.57%	5.8	1.410	1.249	1.895	1.470	1.437	2.000	141	7	
1/25/2020	57	1631	1320	1040	729	591	41	38	3	2.51%	3.65%	0.51%	7.2	1.544	1.477	1.677	1.633	1.645	1.500	336	15	
1/26/2020	58	2462	2014	1497	1049	965	56	52	4	2.27%	3.47%	0.41%	8.4	1.509	1.440	1.632	1.367	1.370	1.333	457	14	
1/27/2020	59	3407	2798	2034	1425	1373	80	76	4	2.35%	3.74%	0.29%	12.8	1.384	1.358	1.423	1.429	1.462	1.000	536	24	
1/28/2020	60	5786	4595	3979	2788	1807	106	99	7	1.83%	2.49%	0.39%	6.4	1.698	1.956	1.316	1.326	1.303	1.750	1945	23	
1/29/2020	61	7587	6065	5087	3565	2500	132	125	7	1.74%	2.46%	0.28%	8.8	1.311	1.279	1.384	1.245	1.262	1.000	1108	26	
1/30/2020	62	9785	7818	6574	4607	3211	170	162	8	1.74%	2.46%	0.25%	9.9	1.290	1.292	1.284	1.288	1.296	1.143	1487	37	
1/31/2020	63	12318	9826	8328	5836	3990	213	204	9	1.73%	2.45%	0.23%	10.9	1.259	1.267	1.243	1.253	1.259	1.125	1754	42	
2/1/2020	64	15163	11953	10727	7517	4436	259	249	10	1.71%	2.32%	0.23%	10.3	1.231	1.288	1.112	1.216	1.221	1.111	2399	45	
2/2/2020	65	18467	14557	13066	9156	5401	304	294	10	1.65%	2.25%	0.19%	12.2	1.218	1.218	1.217	1.174	1.181	1.000	2339	45	
2/3/2020	66	22201	17391	16074	11264	6127	361	350	11	1.63%	2.18%	0.18%	12.1	1.202	1.230	1.135	1.188	1.190	1.100	3007	56	
2/4/2020	67	26434	20630	19398	13593	7037	425	413	12	1.61%	2.13%	0.17%	12.5	1.191	1.207	1.148	1.177	1.180	1.091	3324	63	
2/5/2020	68	31731	24554	23986	16809	7745	491	478	13	1.55%	1.99%	0.17%	11.9	1.200	1.237	1.101	1.155	1.157	1.083	4589	65	
2/6/2020	69	36717	28276	28208	19767	8509	564	549	15	1.54%	1.95%	0.18%	11.0	1.157	1.176	1.099	1.149	1.148	1.154	4222	71	
2/7/2020	70	41191	31481	32450	22740	8741	637	621	16	1.55%	1.91%	0.18%	10.5	1.122	1.150	1.027	1.129	1.131	1.067	4242	72	
2/8/2020	71	45610	34886	35838	25114	9772	723	698	25	1.59%	1.95%	0.26%	7.6	1.107	1.104	1.118	1.135	1.124	1.563	3389	77	
2/9/2020	72	49217	37558	38962	27304	10254	812	779	33	1.65%	2.00%	0.32%	6.2	1.079	1.087	1.049	1.123	1.116	1.320	3124	81	
2/10/2020	73	53296	40554	42583	29841	10713	909	871	38	1.71%	2.05%	0.35%	5.8	1.083	1.093	1.045	1.119	1.118	1.152	3621	92	
2/11/2020	74	56886	43103	46060	32278	10825	1017	974	43	1.79%	2.11%	0.40%	5.3	1.067	1.082	1.010	1.119	1.118	1.132	3478	103	
2/12/2020	75	59670	45171	48453	33955	11216	1114	1071	43	1.87%	2.21%	0.38%	5.8	1.049	1.052	1.036	1.095	1.099	1.000	2393	97	
2/13/2020	76	61889	46997	49766	34874	12123	1252	1194	58	2.02%	2.40%	0.48%	5.0	1.037	1.027	1.081	1.124	1.115	1.349	1312	124	
2/14/2020	77	64682	49053	52231	36602	12451	1382	1318	64	2.14%	2.52%	0.51%	4.9	1.045	1.050	1.027	1.103	1.103	1.103	2466	124	
2/15/2020	78	66757	50580	54061	37884	12696	1524	1457	67	2.28%	2.70%	0.53%	5.1	1.032	1.035	1.020	1.103	1.105	1.047	1829	139	
2/16/2020	79	68442	51857	55424	38839	13018	1666	1595	71	2.43%	2.88%	0.55%	5.3	1.025	1.025	1.025	1.093	1.095	1.060	1363	138	
2/17/2020	80	71429	54019	58182	40772	13247	1772	1696	76	2.48%	2.91%	0.57%	5.1	1.044	1.050	1.018	1.064	1.063	1.070	2758	101	
2/18/2020	81	73332	NA	59989	NA	13343	1870	1789	81	2.55%	2.98%	0.61%	4.9	1.027	1.031	1.007	1.055	1.055	1.066	1807	93	
2/19/2020	82	75204	NA	61682	NA	13522	2006	1921	85	2.67%	3.11%	0.63%	5.0	1.026	1.028	1.013	1.073	1.074	1.049	1693	132	
2/20/2020	83	75748	NA	62031	NA	13717	2129	2029	100	2.81%	3.27%	0.73%	4.5	1.007	1.006	1.014	1.061	1.056	1.176	349	108	
2/21/2020	84	76769	NA	62662	NA	14107	2247	2144	103	2.93%	3.42%	0.73%	4.7	1.013	1.010	1.028	1.055	1.057	1.030	631	115	
2/22/2020	85	77794	NA	63454	NA	14340	2359	2250	109	3.03%	3.55%	0.76%	4.7	1.013	1.013	1.017	1.050	1.049	1.058	792	106	

**Table 1.** Showing data for New Coronavirus 2019 (COVID-19) from 22 January to 22 February 2020. Total Number of Cases and Deaths is 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 use <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. Starting on 17-Feb., the WHO includes cases Clinically diagnosed in addition to Laboratory diagnosed. As no date is given for these cases we assume that the Clinical Cases are a fixed percentage of the Laboratory Cases (46.2%) to get the revised Total Hubei Cases reported by WHO on 17-Feb.(58,182). For continuity between old and new data we list Hubei Cases as 'Hubei-L' for Laboratory diagnosed and 'Hubei-LC' for Laboratory and Clinically diagnosed. We divide data into Hubei and non-Hubei as most deaths are in an area centered on Wuhan in Hubei (**Fig. 2**). The Death Rate is the of Number Deaths divided by the Number of 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 is Value\_Today divided by Value\_Yesterday. We give the Number of New Cases and New Deaths in Hubei each day (subtracting yesterday from today). We replace the seemingly incorrect WHO value for Hubei Deaths on 13-Feb. (1,316) with the average of 12 and 14 Feb. values (1,194) to avoid having 245 New Deaths on 13-Feb. but just 2 New Deaths on 14-Feb (pink shading).

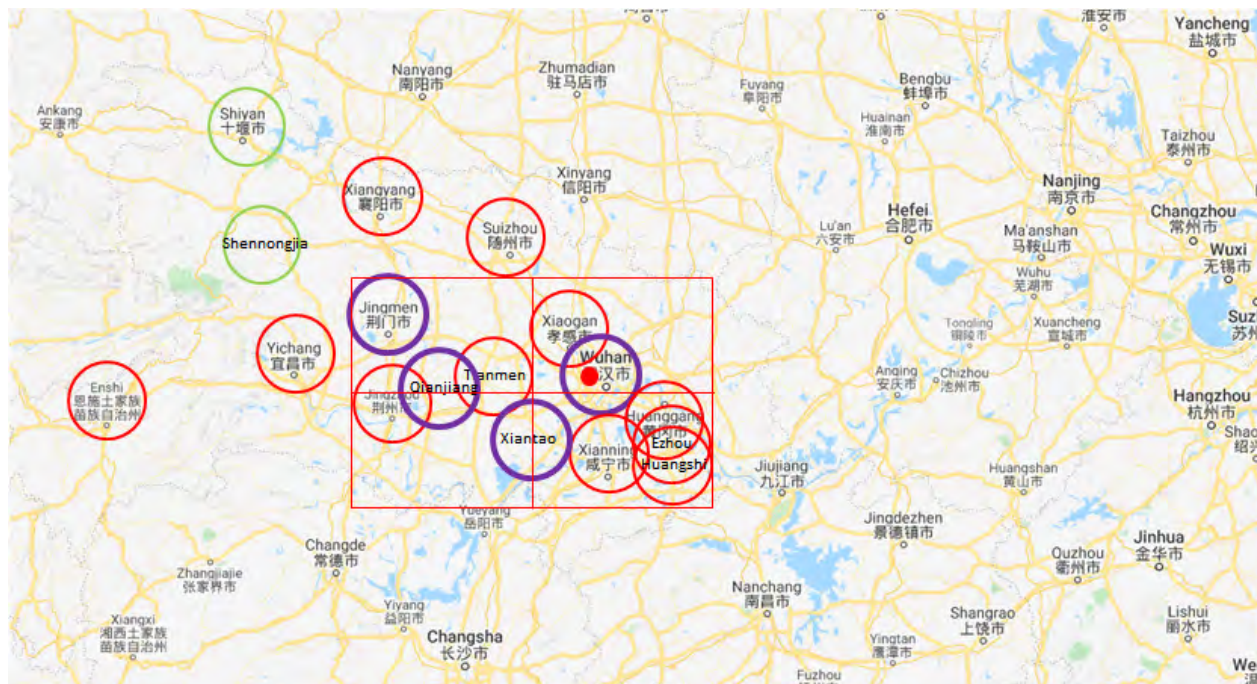


**Figure 1.** Variation of COVID-19 data against Days since 29 Nov 2019 (guessed date of the first case). **Table 1** data is plotted from 22 Jan. to 22 Feb. 2020. The rise of the Hubei Death Rate in Panel (C) makes no sense as the virus is not becoming more virulent. This discrepancy arises because all Deaths do not occur on the same day a case is diagnosed. A proper Death Rate Distribution gives a real Hubei Death Rate of 4.4% (**Fig. 5**). In Panels (D) & (E) linear trend-lines are added using data from 1/29/2020. The Fraction Change for Cases and Deaths is an excellent fit to a straight line. In panel (E) we also show 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, giving the expectation that the growth of deaths would slow soon.

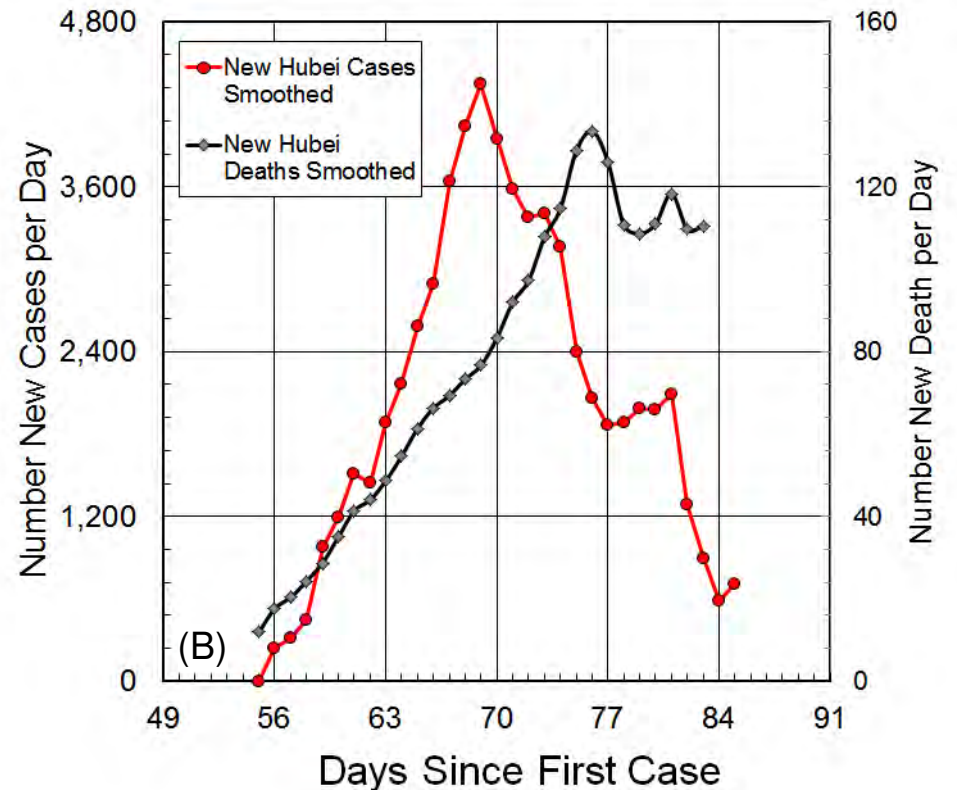
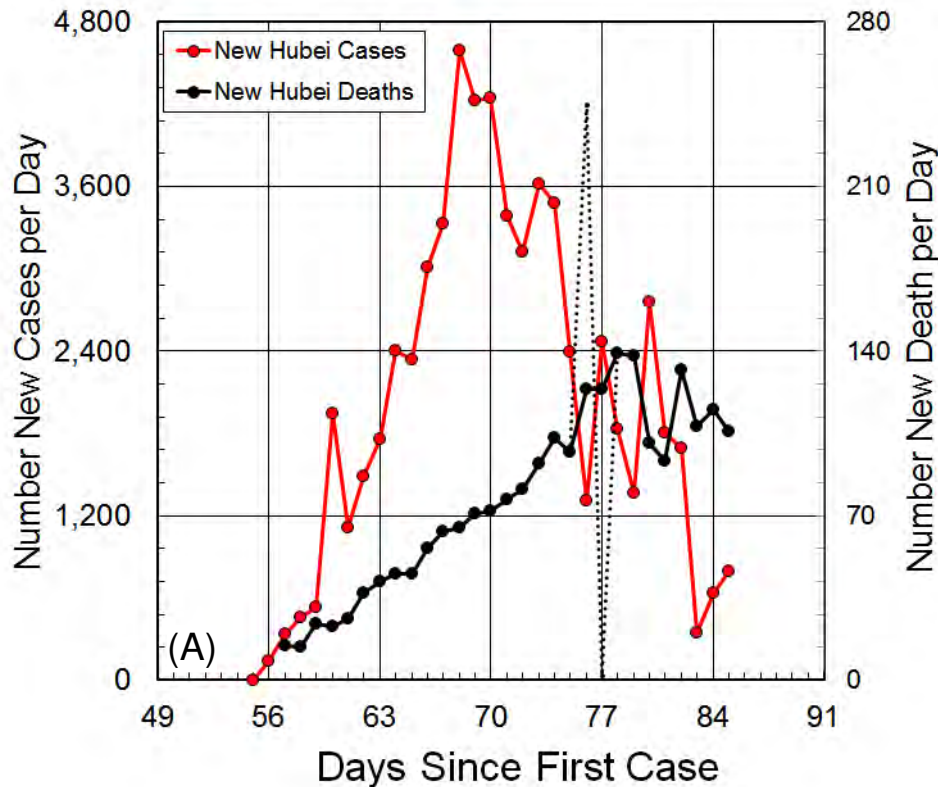


			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	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 less than 1%; by 16-Feb., there were only 2 of 17.



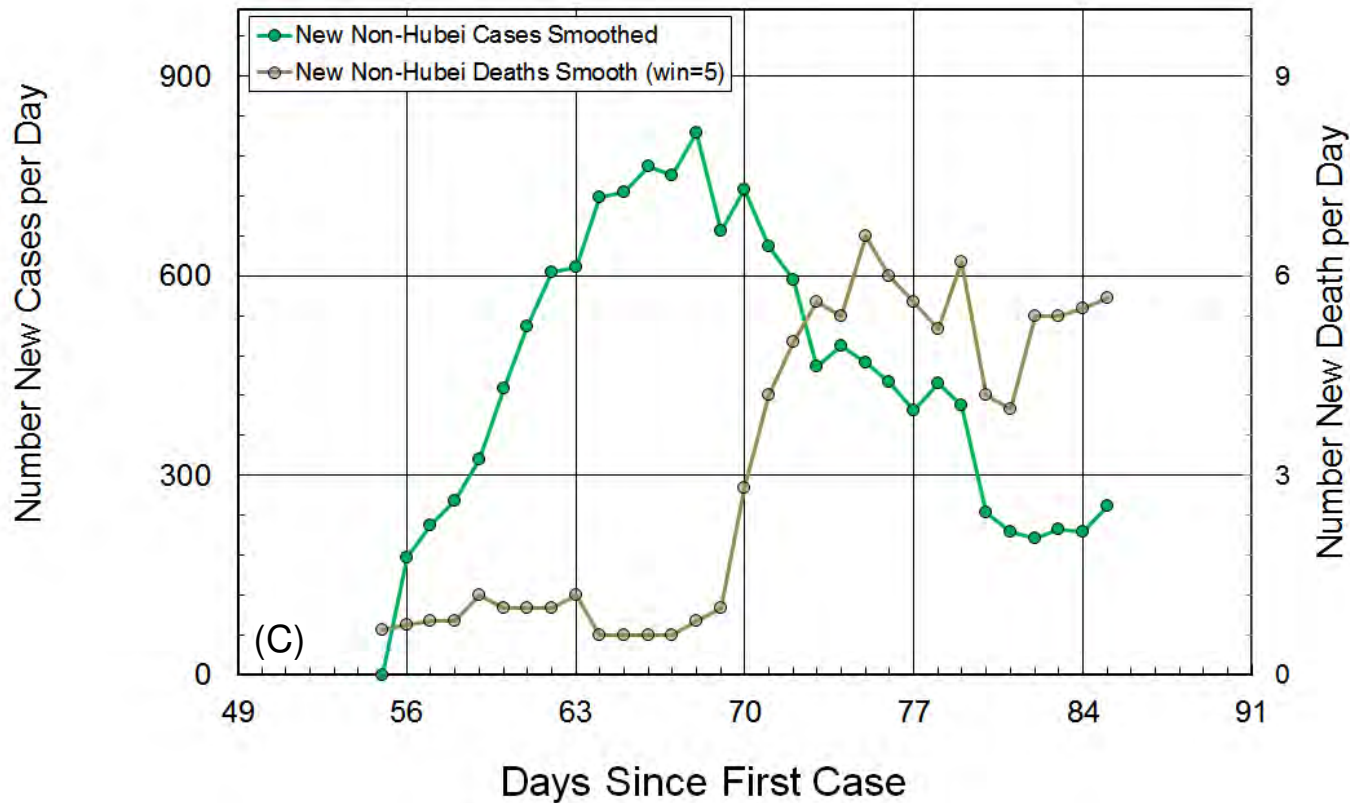
**Figure 2.** Map of Hubei circling in purple cities with a death rate of  $\geq 3\%$ , in red cities with a death rate of  $\geq 1\%$  and in green other cities for which there is data. Most deaths are localized to a 90 km x 35 km area centered near Tianmen and high death rates occur in four cities: Wuhan, Jingmen Qianjian 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 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.



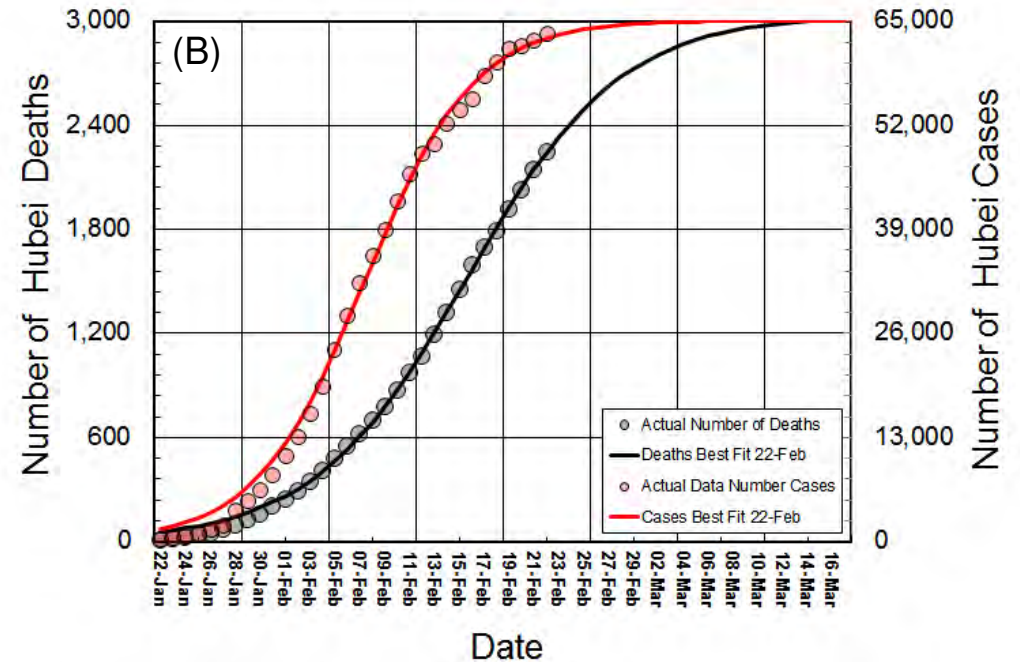
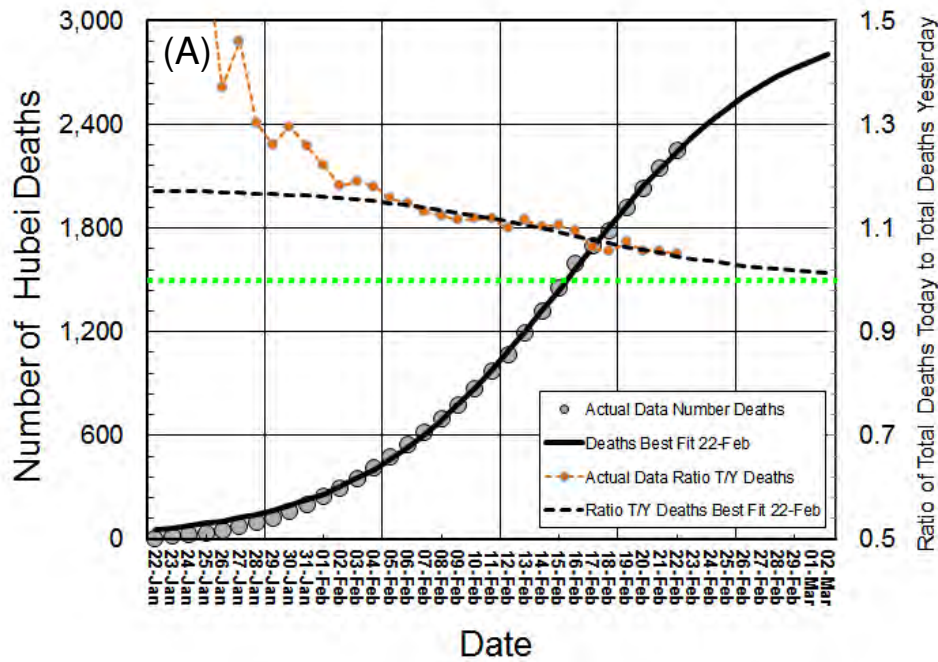
**Figure 3A.** Showing the variation with time of Number of New Hubei Cases per Day (red line) and the Number of New Hubei Deaths per Day (black line). For New deaths, the WHO data values fluctuated wildly on 13 and 14 Feb. as shown by the black dotted line. For this reason, the Numbers of New Deaths of 245 on 13-Feb. and 2 on 14-Feb. (Table 1) are averaged to give 124 New Deaths on each day, correcting what may have been a typo in the value for 13-Feb. (black dashed line).

**Figure 3B.** The same data is smoothed by averaging over a three-day window so that, for example, the value plotted on day 69 is the average of the values on days 68, 69 & 70. These smoothed curves clearly show that the Number of New Hubei Cases per Day peaked on Day 69 (6-Feb) and that the Number of New Hubei Deaths per Day peaked on Day 78 (15-Feb.), which is 9 days later. For sigmoid growth like that shown in **Fig. 4**, the number of new cases or deaths reaches a maximum midway through the curve. If this holds here, then the total Number of Hubei Cases will reach 60,000 (laboratory plus clinically diagnosed cases), which is approximately twice 28,208, the number of such cases on 6-Feb. Assuming New Hubei Deaths peaked on 15-Feb., means number of Total Hubei Deaths will reach 2,914, twice 1,457, the number of Hubei Deaths on 15-Feb. Better analysis in **Fig. 4** gives asymptotic values of 65,050 and 3,030 for Number of Cases and Deaths, respectively.





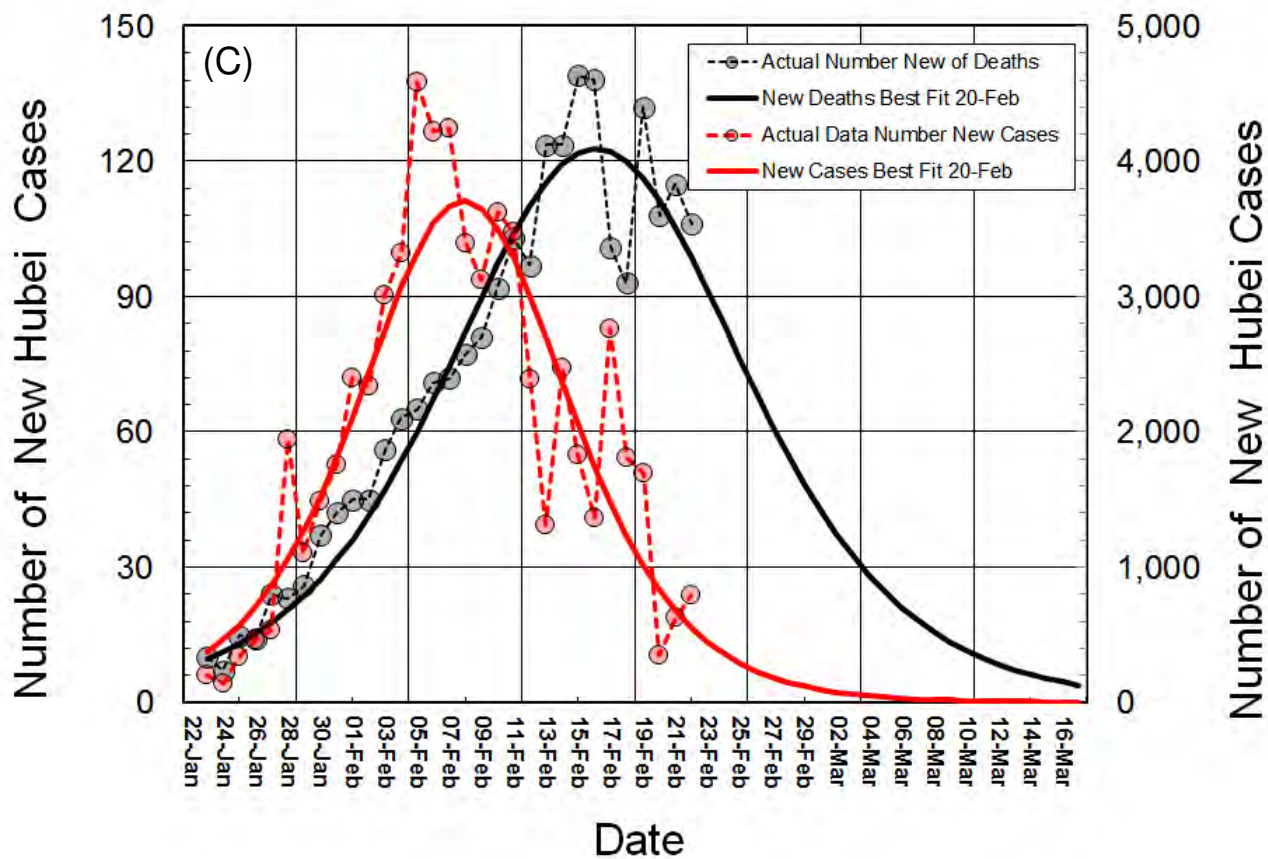
**Figure 3C.** Showing the variation with time of the smoothed Number of New Non-Hubei Cases in China per Day (green line). Although smoothed by averaging over a window of three values, this data remains noisy. Nevertheless, it does indicate that a peak in the Number New Non-Hubei Cases in China occurred on day 67 or 68 (4-Feb. or 5-Feb.) allowing the maximum Total Number of Non-Hubei cases to be estimated as twice 7,037 or 7,745, the values on 4-Feb. or 5-Feb, for a value of between 14,000 and 16,000. Although, New Non-Hubei China Deaths are few we plot them in this way (brown line). We see the expected delay between New Deaths and New Cases but the curves do not look like those for Hubei (**Fig. 3 AB**). If we assume that they peaked 9 days later on Day 79 or 80 (see **Fig 3B.**), the Total Number of non-Hubei Deaths can be expected to reach a total Number of Non-Hubei China Deaths of 160. This will mean an overall Non-Hubei Death Rate of 1% (160/16,000).



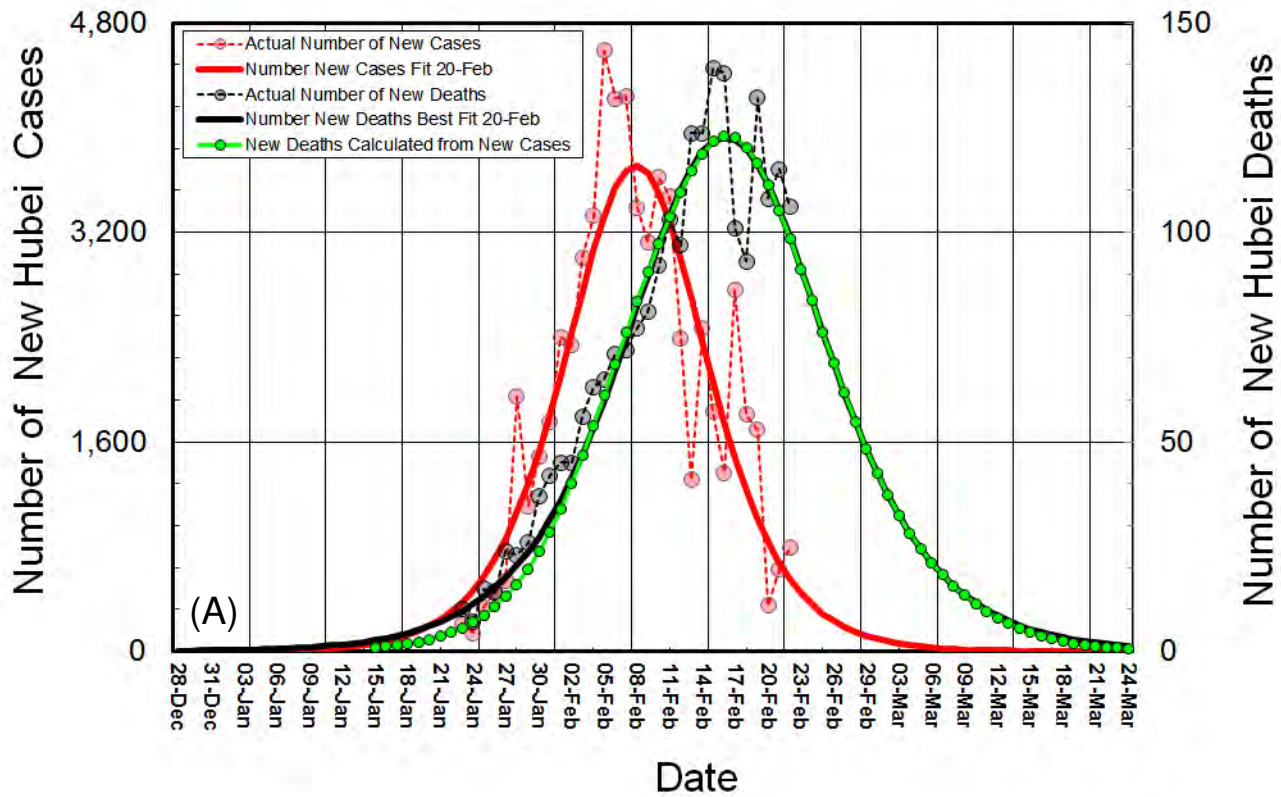
**Figure 4A.** Fit of the sigmoid function  $f(x) = 1/(1-\exp(-x))$  to the actual Total Number of Hubei Deaths from the coronavirus COVID-19 since 22 Jan 2020. The best fit to the actual values (black line) is obtained using Excel Solver to optimize the parameters A, B & C in  $f(x) = A/(1-\exp(-x+B)/C)$  until the weighted difference (weight= $\sqrt{\text{Number Deaths}}$ ) between the calculated and actual Number of Deaths is a minimum. Particularly impressive is that the Ratio of Deaths Today to Yesterday (T/Y) from the actual data (orange dashed line and circles on secondary axis) is well fit by the calculated Ratio (black dashed line on secondary axis), which decreases in the linear fashion assumed in **Fig. 2 (E)** towards the value of 1.0 when there is no further growth in number of deaths.

**Figure 4B.** 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. 3B**, the final Total Number of Hubei Cases will be close to 65,000, while the current estimate for Total Number of Deaths will be close to 3,000. This will mean an overall Hubei Death Rate of almost 5% ( $3,000/65,000=4.7\%$ ), which is 5 times higher than the estimated Non-Hubei Death Rate of 1%. This estimate is now improved by the Death Rate Distribution derived in **Fig. 5**, which gives an overall Death Rate of 4.54%.





**Figure 4C.** By subtracting values for yesterday from today, the sigmoid function  $f(x) = 1/(1-\exp(-x))$  as fitted to the actual Total Number of Hubei Cases or Deaths shown in **Fig. 4B**, can be used to get a calculated Number of New Hubei Cases or New Hubei Deaths (solid red and black lines, respectively). These curves are a good fit to the Actual Number of New Hubei Cases or Deaths (red and black transparent circles joined by dashed read and black lines, respectively), although the real data is noisy with large fluctuations. The smooth New Cases curve (solid red line) peaks at Day 70.4 and the smooth New Deaths curve (solid black line) peaks at Day 78.6).



**Figure 5A.** The data on Number of New Cases and New Deaths each day in **Fig. 4C**. is shown again (solid red and black lines) in our attempt to relate New Cases to New Deaths by deriving a Death Rate Distribution. This distribution gives the Death Rate  $i$  days after confirmation as a new case, where  $i$  is 0, 1, 2, etc.). In this way, we predict the disease progression by fitting the data.

Assume that for each case diagnosed on day 0, there will be Death Rate  $P_i$  for death after  $i = 0, 1, 2, \dots, 29$  days (we tried  $i$  up to 44 but there was no signal for Days 30 to 44). The Number of New Deaths,  $D_n$ , on day  $n$  is the sum of deaths from  $C_{n-i}$ , the Number of New Cases on previous days  $i$ :

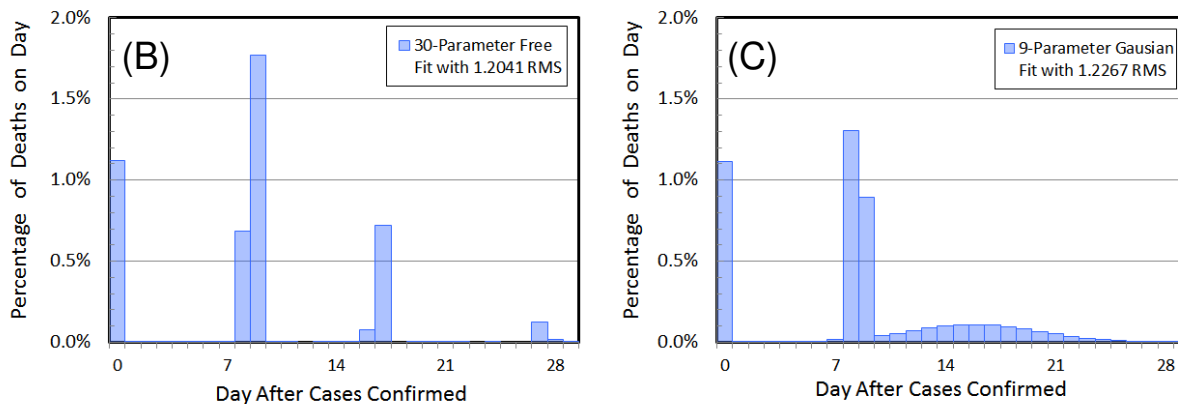
$$D_n = C_n * P_0 + C_{n-1} * P_1 + C_{n-2} * P_2 + \dots + C_{n-29} * P_{29}$$

The corresponding total Death Rate is the sum of all  $P_i$  values and is same for each day.

Again we use Excel Solver to determine the values for the  $P_n$  values. This is done in two ways:

- (1) With all 30 parameters, one for each  $P_n$  values.
- (2) With just 9 parameters obtained by calculating the  $P_n$  values as a sum of three Gaussian functions  $g(n) = A_i * \exp(-((n-B_i)/C_i)^2)$ , where there are 3 parameters ( $A_i, B_i, C_i$ ) for each Gaussian.

We run Solver with random starts for the 30-parameter model always reaching the same best fit with a weighted error of 1.204 (weight is  $\sqrt{D}$  where  $D$  is Number of New Deaths in **Fig. 4C**). A similar fit is also obtained with the 9-parameter model. The Number of New Deaths from the best 30-parameter solution is shown as the green line in **Fig. 5A**. The fit is almost perfect (hiding the black line) except for 15-Jan. to 29-Jan. when it is low. Confirming cases could have been low low then due to difficult conditions in Hubei.



**Figure 5 B.** Showing that Death Rate Distributions for 30 parameters and 9 parameters are similar. For both there is a Death Rate of 1.1% on day 0, the day a case is confirmed, a death rate of about 2.3% summed over days 7 to 10 and a death rate of about 1% summed over later days (two peaks for the 30-parameter model and a broad distribution for the 9-parameter model). The total Death Rate in both cases is 4.54%, which is higher than that calculated in **Fig. 1C**.



## “28. Analysis of COVID-2019 Data on 2/28/2020” by Michael Levitt, Stanford University, USA

Contrary to the prevailing world concern, the COVID-19 epidemic is almost all over in China. Today’s analysis uses WHO data for the past 37 days to confirm trends we have shown in reports going back to 1-Feb. We separate Hubei from non-Hubei as most cases and deaths have occurred in Hubei (**Fig. 2**). We estimate there will be 3,200 total Hubei deaths and less than 120 non-Hubei deaths in China. There will be 66,000 Hubei cases with a Hubei death rate of 4.7% (1% on Day 0 after being classified as a case; 2.4% on Days 8 & 9, the remaining 1% after day 14, **Fig. 5**). There will be 13,000 non-Hubei cases in China with a death rate of 0.85%. China Non-Hubei deaths seem to occur after 10 days, very similar to the 9 day delay most common for Hubei deaths.

As soon as it seemed possible that the epidemic was close to being over in China (Hubei and non-Hubei ), which was by far hit hardest with 94% of the deaths, concern was focused on the Diamond Princess cruise ship. In many ways, this ship provides a worse-case test scenario. There were 705 cases and 4 deaths for the 2,600 passengers and 1,100 crew, who were kept on a ship 290m x 37m in size, a population density of 250,000 per square km (37 times that of Hong Kong). These passengers are older than the general population (200 were over 80 years). The passengers were tested for COVID-19 daily using PCR (polymerase chain reaction), a sensitive DNA amplification method that detects minuscule levels of virus. This led to the 19% infection rate (705/3,700), which shows that if we want to test the world’s population each day, we may eventually reach this level of infection. A super-sensitive molecular-detection method like PCR find signs of the virus on people who are neither sick nor able to infect others. Four deaths, some of people older than 80, gives a death rate of 0.1% (4/3,700) in a month. By comparison, in the USA, for people 80 and over, the death rate is 11% per year or 0.9% per month. This would mean 2 deaths a month amongst 200 passengers over 80. If there are no further COVID-19 deaths amongst the Diamond Princess passengers, it seems we need not worry about this disease causing widespread death worse than influenza.

As data accumulates on Non-China cases, we turn our attention to their analysis. This data is very noisy as expected for the early phase and comes from different countries. Preliminary analysis (**Fig. 7**) shows no signs of slowing exponential growth of cases or deaths. More work is needed and we hope that detailed analysis of the epidemic in China will help the rest of the world.

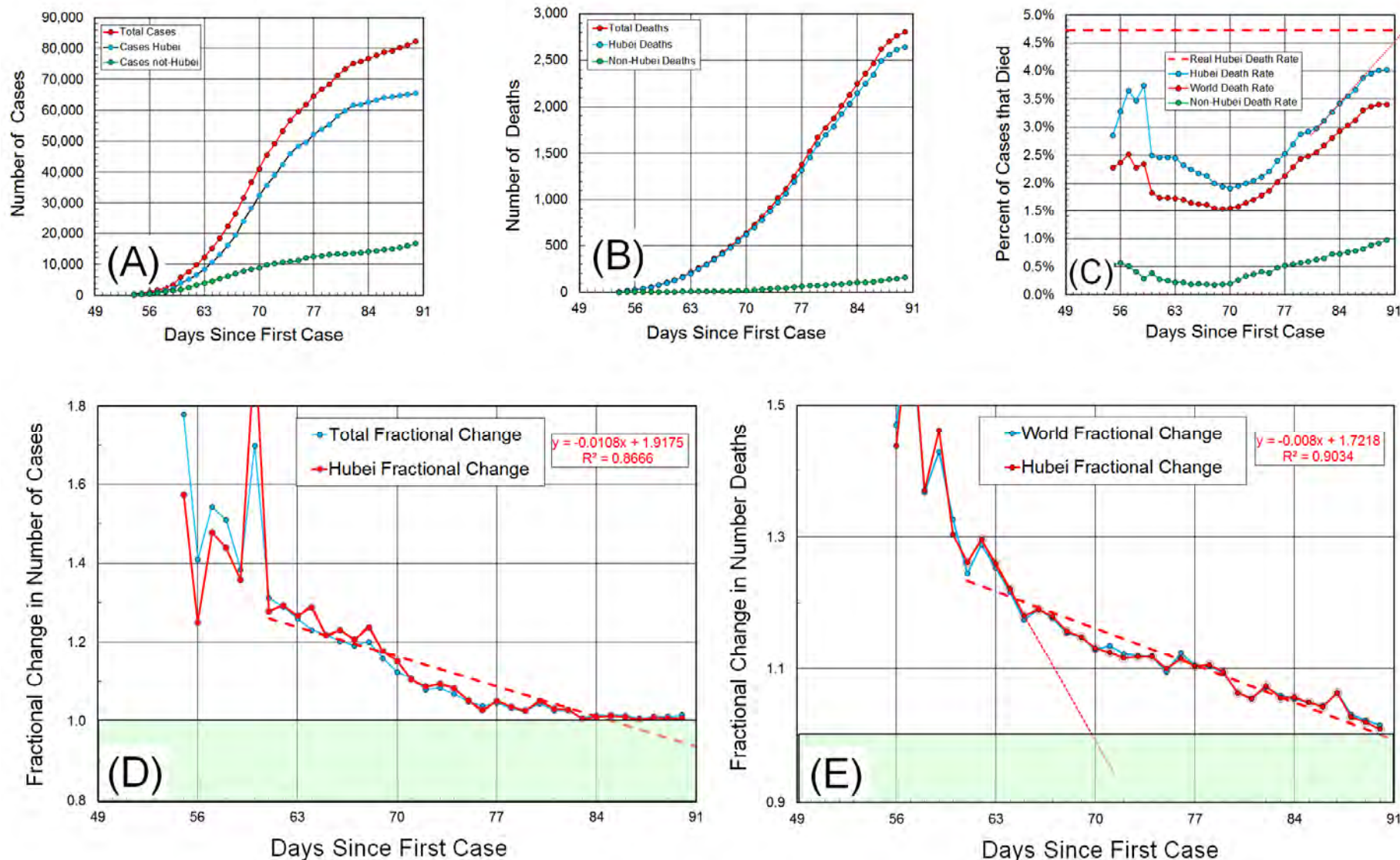
For now, I raise questions for experts who may read this analysis.

- (1) Why do most deaths in China tend to occur after 9 or 10 days from infection (**Figs. 3,4 & 5**)
- (2) Why do Hubei cases have a 1% death rate on the day case in confirmed whereas Non-Hubei cases do not (**Fig. 5**)
- (3) Why do China Non-Hubei cases and deaths both peak three days before those in Hubei? Is the explanation in **Fig. 6** crazy?
- (4) Why do death rates in different countries differ so much (**Fig. 7**). Do the high rates in Iran mean only the very ill are examined?
- (5) Did the epidemic in China slow due to stringent quarantine or rise of immunity in many of those infected but never detected as a case? Can an epidemic be stopped if we use social distancing to contact with fewer people without strict quarantine?
- (6) Could certain individuals be naturally immune due to their individual antibody repertoires?
- (7) Is what happened on the Diamond Princess a good model for what a world pandemic would be (20% infection rate, 0.1% death rate in over 65-year olds). A big unknown is the role of social distancing on the ship?

Date	Day	Total Number Cases					Total Number Deaths			Death Rate (%)			Ratio Hubei/Others	Fraction Change Cases			Fraction Change Deaths			New/Day in Hubei		Non-China	
		Total-LC	Total-L	Hubei-LC	Hubei-L	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others	Cases	Deaths	Cases	Deaths
1/22/2020	54	421	314	358	251	63	6	6	0	1.42%	1.67%	0.00%	-	1.780	1.573	2.961	2.843	2.676	-	205	10	5	0
1/23/2020	55	750	581	564	395	186	17	16	1	2.28%	2.85%	0.54%	5.3	1.410	1.249	1.895	1.470	1.437	2.000	141	7	16	0
1/24/2020	56	1057	846	704	494	352	25	23	2	2.37%	3.28%	0.57%	5.8	1.544	1.477	1.677	1.633	1.645	1.500	336	15	23	0
1/25/2020	57	1631	1320	1040	729	591	41	38	3	2.51%	3.65%	0.51%	7.2	1.509	1.440	1.632	1.367	1.370	1.333	457	14	29	0
1/26/2020	58	2462	2014	1497	1049	965	56	52	4	2.27%	3.47%	0.41%	8.4	1.584	1.440	1.632	1.367	1.370	1.333	457	14	29	0
1/27/2020	59	3407	2798	2034	1425	1373	80	76	4	2.35%	3.74%	0.29%	12.8	1.384	1.358	1.423	1.429	1.462	1.000	536	24	37	0
1/28/2020	60	5786	4595	3979	2788	1807	106	99	7	1.83%	2.49%	0.39%	6.4	1.698	1.956	1.316	1.326	1.303	1.750	1945	23	56	0
1/29/2020	61	7587	6065	5087	3565	2500	132	125	7	1.74%	2.46%	0.28%	8.8	1.311	1.279	1.384	1.245	1.262	1.000	1108	26	68	0
1/30/2020	62	9785	7818	6574	4607	3211	170	162	8	1.74%	2.46%	0.25%	9.9	1.290	1.292	1.284	1.288	1.296	1.143	1487	37	82	0
1/31/2020	63	12318	9826	8328	5836	3990	213	204	9	1.73%	2.45%	0.23%	10.9	1.259	1.267	1.243	1.253	1.259	1.125	1754	42	106	0
2/1/2020	64	15163	11953	10727	7517	4436	259	249	10	1.71%	2.32%	0.23%	10.3	1.231	1.288	1.112	1.216	1.221	1.111	2399	45	132	0
2/2/2020	65	18467	14557	13066	9156	5401	304	294	10	1.65%	2.25%	0.19%	12.2	1.218	1.218	1.217	1.174	1.181	1.000	2339	45	146	0
2/3/2020	66	22201	17391	16074	11264	6127	362	350	12	1.63%	2.18%	0.20%	11.1	1.202	1.230	1.135	1.191	1.190	1.200	3007	56	153	1
2/4/2020	67	26434	20630	19398	13593	7037	426	413	13	1.61%	2.13%	0.18%	11.6	1.191	1.207	1.148	1.177	1.180	1.081	3324	63	159	1
2/5/2020	68	31731	24554	23986	16809	7745	492	478	14	1.55%	1.99%	0.18%	11.0	1.200	1.237	1.101	1.155	1.157	1.077	4589	65	191	1
2/6/2020	69	36717	28276	28208	19767	8509	565	549	16	1.54%	1.95%	0.19%	10.4	1.157	1.176	1.099	1.148	1.148	1.145	4222	71	216	1
2/7/2020	70	41191	31481	32450	22740	8741	638	621	17	1.55%	1.91%	0.20%	9.8	1.122	1.150	1.027	1.129	1.131	1.067	4242	72	270	1
2/8/2020	71	45610	34886	35838	25114	9772	724	698	26	1.59%	1.95%	0.27%	7.3	1.107	1.104	1.118	1.135	1.124	1.521	3389	77	288	1
2/9/2020	72	49217	37558	38962	27304	10254	813	779	34	1.65%	2.00%	0.33%	6.0	1.079	1.087	1.049	1.123	1.116	1.308	3124	81	307	1
2/10/2020	73	53296	40554	42583	29841	10713	910	871	39	1.71%	2.05%	0.36%	5.6	1.083	1.093	1.045	1.119	1.118	1.148	3621	92	319	1
2/11/2020	74	56886	43103	46060	32278	10825	1018	974	44	1.79%	2.11%	0.41%	5.2	1.067	1.082	1.010	1.119	1.118	1.128	3478	103	395	1
2/12/2020	75	59670	45171	48453	33955	11216	1115	1071	44	1.87%	2.21%	0.39%	5.6	1.049	1.052	1.036	1.095	1.099	1.003	2393	97	441	1
2/13/2020	76	61889	46997	49766	34874	12123	1252	1194	58	2.02%	2.40%	0.48%	5.0	1.037	1.027	1.081	1.123	1.115	1.315	1312	124	447	1
2/14/2020	77	64682	49053	52231	36602	12451	1383	1318	65	2.14%	2.52%	0.52%	4.8	1.045	1.050	1.027	1.104	1.103	1.121	2466	124	505	2
2/15/2020	78	66757	50580	54061	37884	12696	1526	1457	69	2.29%	2.70%	0.54%	5.0	1.032	1.035	1.020	1.103	1.105	1.062	1829	139	526	2
2/16/2020	79	68442	51857	55424	38839	13018	1669	1595	74	2.44%	2.88%	0.57%	5.1	1.025	1.025	1.025	1.094	1.095	1.072	1363	138	683	3
2/17/2020	80	71429	54019	58182	40772	13247	1775	1696	79	2.48%	2.91%	0.60%	4.9	1.044	1.050	1.018	1.064	1.063	1.068	2758	101	794	3
2/18/2020	81	73332	NA	59989	NA	13343	1873	1789	84	2.55%	2.98%	0.63%	4.7	1.027	1.031	1.007	1.055	1.055	1.063	1807	93	804	3
2/19/2020	82	75204	NA	61682	NA	13522	2009	1921	88	2.67%	3.11%	0.65%	4.8	1.026	1.028	1.013	1.073	1.074	1.048	1693	132	924	3
2/20/2020	83	75748	NA	62031	NA	13717	2129	2029	100	2.81%	3.27%	0.73%	4.5	1.007	1.006	1.014	1.060	1.056	1.136	349	108	1073	8
2/21/2020	84	76769	NA	62662	NA	14107	2247	2144	103	2.93%	3.42%	0.73%	4.7	1.013	1.010	1.028	1.055	1.057	1.030	631	115	1200	8
2/22/2020	85	77794	NA	63454	NA	14340	2359	2250	109	3.03%	3.55%	0.76%	4.7	1.013	1.013	1.017	1.050	1.049	1.058	792	106	1402	11
2/23/2020	86	78811	NA	64084	NA	14727	2462	2346	116	3.12%	3.66%	0.79%	4.6	1.013	1.010	1.027	1.044	1.043	1.064	630	96	1769	17
2/24/2020	87	79331	NA	64287	NA	15044	2618	2495	123	3.30%	3.88%	0.82%	4.7	1.007	1.003	1.022	1.063	1.064	1.060	203	149	2069	23
2/25/2020	88	80239	NA	64786	NA	15453	2700	2563	137	3.36%	3.96%	0.89%	4.5	1.011	1.008	1.027	1.031	1.027	1.114	499	68	2459	34
2/26/2020	89	81109	NA	65187	NA	15922	2762	2615	147	3.41%	4.01%	0.92%	4.3	1.011	1.006	1.030	1.023	1.020	1.073	401	52	2918	44
2/27/2020	90	82294	NA	65596	NA	16698	2804	2641	163	3.41%	4.03%	0.98%	4.1	1.015	1.006	1.049	1.015	1.010	1.109	409	26	3664	57

**Table 1.** Showing data for New Coronavirus 2019 or COVID-19) from 22 January to 27 February 2020. Total number of cases and deaths is 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 use data from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. Starting on 17-Feb., the WHO includes cases clinically diagnosed in addition to those laboratory diagnosed. As no date is given for these cases, we assume that the clinical cases are a fixed percentage of the laboratory cases (46.2%) to get the revised total Hubei cases reported by the WHO on 17-Feb.(58,182). For continuity between old and new data we list Hubei cases as 'Hubei-L' for laboratory diagnosed and 'Hubei-LC' for laboratory and clinically diagnosed. We divide data into Hubei and non-Hubei as most deaths are in an area centered on Wuhan in Hubei (Fig. 2). The death rate is the number of deaths divided by the number of 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 is Value\_Today divided by Value\_Yesterday. We give the number of new cases and new deaths in Hubei each day (subtracting yesterday from today). We replace the seemingly incorrect WHO value for Hubei deaths on 13-Feb. (1,316) with the average of 12 and 14 Feb. values (1,194) to avoid having 245 new deaths on 13-Feb. but just 2 new deaths on 14-Feb (pink shading). As cases outside China have grown, we add the number of Non-China deaths and cases from the WHO data.



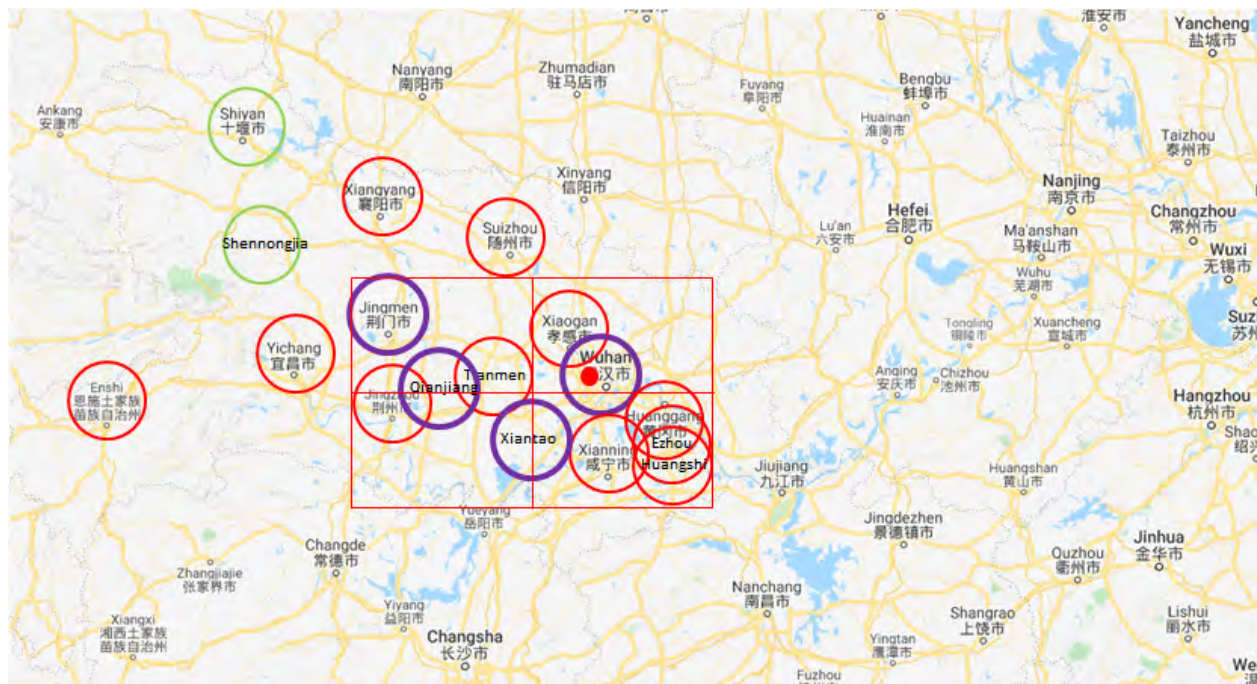


**Figure 1. Variation of COVID-19 data against days since 29 Nov 2019 (guessed date of the first case).** Data is taken from **Table 1**.

(A) shows a slowing increase in number of cases everywhere. (B) confirms that almost all the deaths are in Hubei. (C) shows that the Hubei death rate initially decreased from 2.5% on 27-Jan. to 1.9% on 7-Feb. only to rise to 4.0% today. Such a rise of the Hubei death rate in (C) makes no sense as the virus is not becoming more virulent. This discrepancy arises because all deaths do not occur on the same day a case is diagnosed. A proper death rate distribution gives a real Hubei death rate of 4.7% (**Fig. 5**). (D) and (E) show that the fractional change in total cases or deaths (Value\_Today / Value\_Yesterday) is decreasing steadily. In (D) & (E) we add linear trend-lines using data from 1/29/2020. The fractional change for cases and deaths is an excellent fit to a straight line. In (E) we also show a red short-dashed line of the linear fit to the four data points for 31-Dec to 02-Feb; this trend was seen in the first draft of this analysis dated 2/2/20, giving rise to the hope I expressed that the growth of deaths would slow soon.

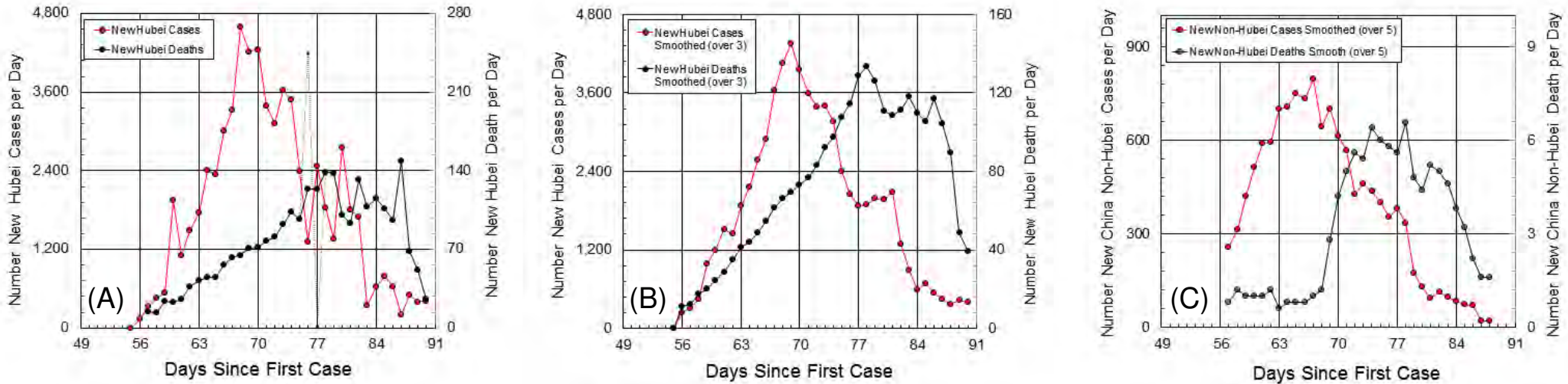
			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	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 0.37% of the Wuhan population of 11 million. On 31-Jan. there were 8 of 17 cities with death rates less than 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 in Table 2. Most deaths are localized to a 90 km x 35 km 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 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.



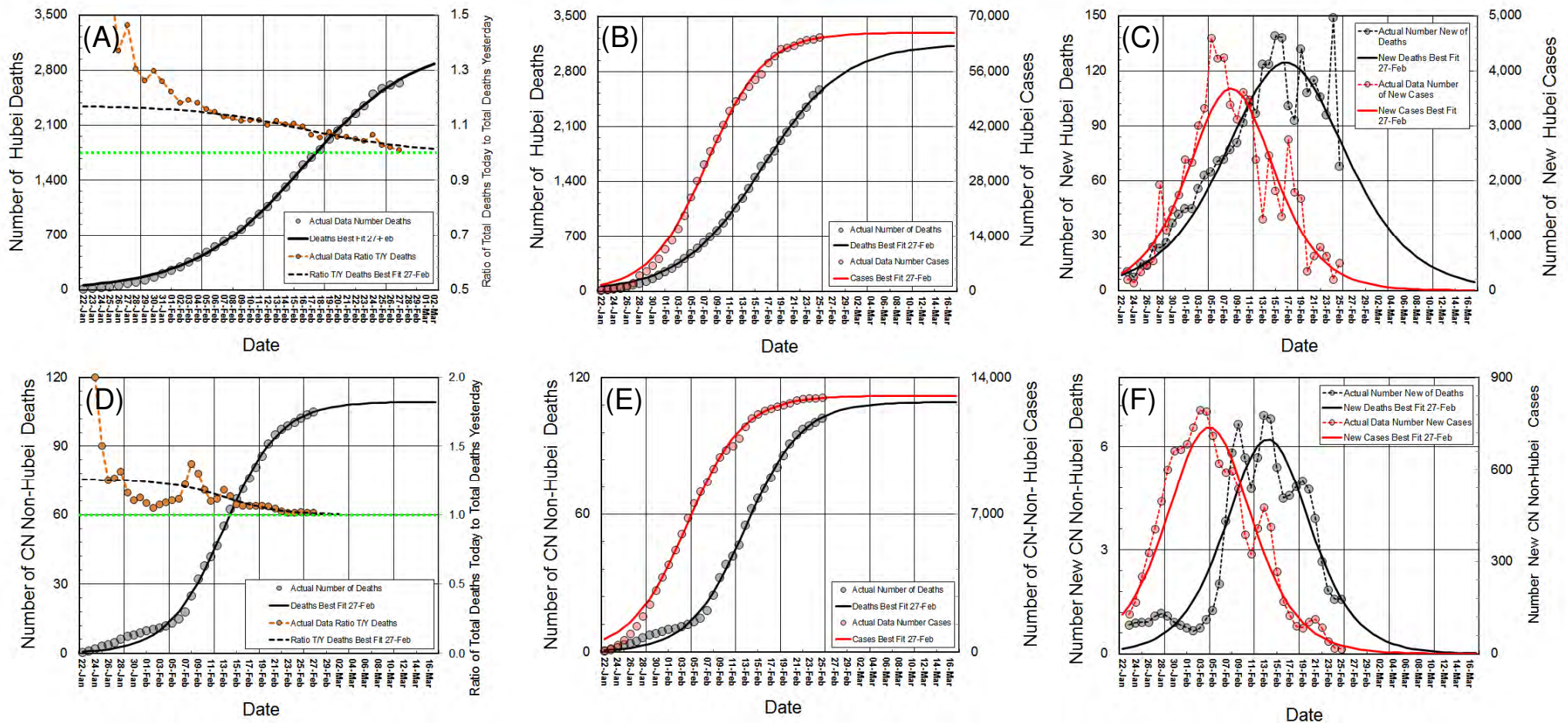


**Figure 3. Time variation of number of new cases and new deaths in China, separated into Hubei and elsewhere in mainland China (Non-Hubei).**

**(A).** Showing the number of new Hubei cases per day (red line) and the number of new Hubei deaths per day (black line). For new deaths, the WHO data values fluctuated wildly on 13 and 14 Feb. as shown by the black dotted line. For this reason, the numbers of new deaths of 245 on 13-Feb. and 2 on 14-Feb. (Table 1) are averaged to give 124 new deaths on each day, correcting what may have been a typo in the value for 13-Feb. (black dashed line).

**(B)** The same data is smoothed by averaging over a three-day window so that, for example, the value plotted on day 69 is the average of the values on days 68, 69 & 70. These smoothed curves clearly show that the number of new Hubei cases per day peaked on Day 69 (6-Feb) and that the number of new Hubei deaths per day peaked on Day 78 (15-Feb.), which is 9 days later. For sigmoid growth like that shown in **Fig. 4**, the number of new cases or deaths reaches a maximum midway through the curve. This predicts the total number of Hubei cases will reach 60,000 (laboratory plus clinically diagnosed cases), approximately twice 28,208, the number of such cases on 6-Feb. This also predicts total number of Hubei deaths will reach 2,914, twice 1,457, the number of Hubei deaths on 15-Feb. Better analysis in **Fig. 4** gives asymptotic values of 65,834 and 3,150 for number of Hubei cases and deaths, respectively.

**(C)** Showing the variation with time of the smoothed number of new Non-Hubei cases in China per day (red line). Although smoothed by averaging over a window of five values, this data remains noisy. Nevertheless, it does indicate that a peak in the number of new Non-Hubei cases in China occurred on day 67 or 68 (4-Feb. or 5-Feb.) allowing the maximum total number of Non-Hubei cases to be estimated as twice 7,037 or 7,745, the values on 4-Feb. or 5-Feb., for a value of between 14,000 and 16,000. The same argument estimates the total number of non-Hubei deaths to reach a 160. Again, **Fig. 4** gives better asymptotic values of 13,075 and 109 for the total number of Non-Hubei cases and deaths, respectively.



**Figure 4. Fit of a sigmoid function to the total number of COVID-19 cases and deaths in Hubei.** (A) The best fit (black line) to the actual deaths (black dots). The fit is obtained using Excel Solver to find parameters  $A$ ,  $B$  &  $C$  in  $f(x) = A/(1-\exp(-x+B)/C)$  that minimize the weighted RMS difference of calculated and actual number (weight= $\sqrt{\text{number deaths}}$ ). We calculate ratio of value today to those yesterday (T/Y, black dashed line) and compare with the actual data (orange dashed line and circles on secondary axis). The fit is excellent and the calculated ratio decreases approximately linearly towards a value of 1.0 as assumed in **Fig. 2 (E)**.

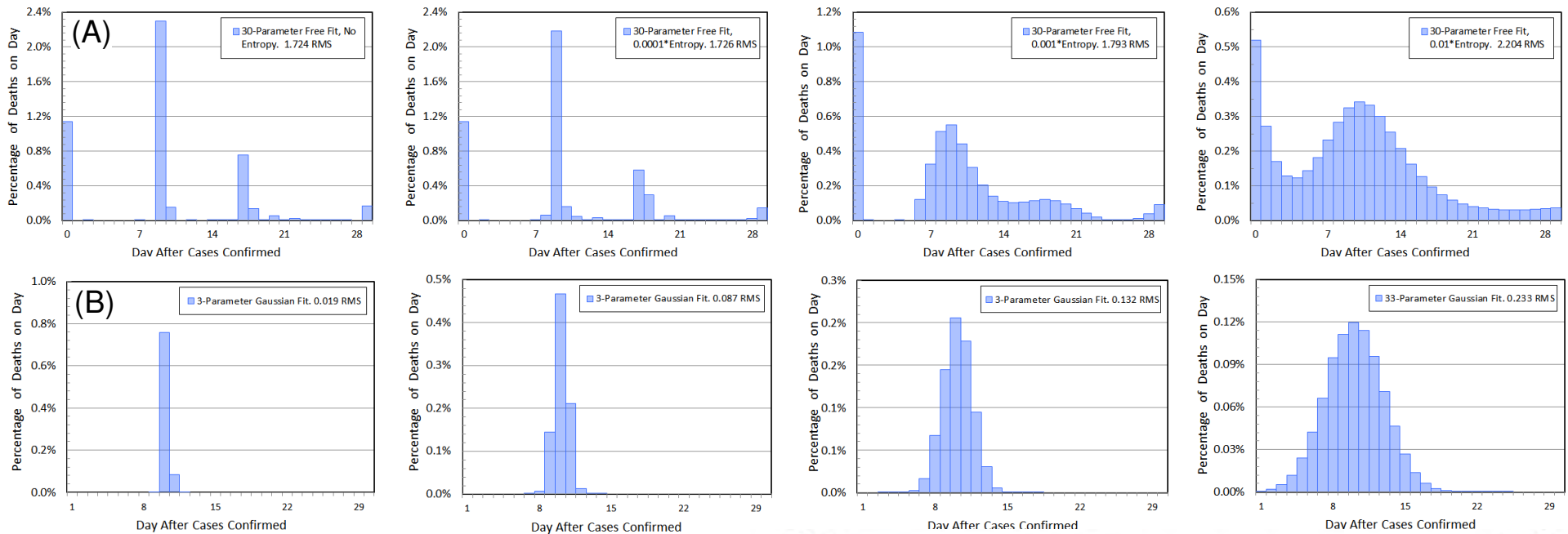
(B) Sigmoid fits to both the number of cases and number of deaths in Hubei. The final total number of Hubei cases will be close to 66,000, while the current estimate for total number of deaths will be close to 3,200. This will mean an overall Hubei death rate of almost 5% ( $3,200/66,000=4.8\%$ ).

(C) By subtracting values for yesterday from today, the sigmoid function fitted to the actual number of new Hubei cases or deaths shown in **Fig. 4B**, gives the number of new Hubei cases or new Hubei deaths (solid red and black lines, respectively). These curves are a good fit to the actual number of new Hubei cases or deaths (red and black transparent circles joined by dashed red and black lines, respectively), although the real data is noisy with large fluctuations. The smooth new cases curve (solid red line) peaks at Day 70.4 and the smooth new deaths curve (solid black line) peaks at Day 78.6).

Corresponding plots for cases and deaths in China but Non-Hubei is plotted in panels (D), (E) & (F). The Non-Hubei death rate is almost 1% ( $109/13075=0.83\%$ ), which is about 5 times lower than that in Hubei.

The  $A$ ,  $B$  &  $C$  parameters for sigmoid curves are 65834, 70.6 & 4.47 for Hubei cases; 3150, 79.1 & 6.32 for Hubei deaths; 13075, 67.0 & 4.41 for Non-Hubei cases; and 109, 76.1 & 4.39 for Non-Hubei deaths.





**Figure 5.** Relating new cases to new deaths via a death rate distribution, which gives the fraction of cases that die  $i$  days after a case is confirmed.

If  $P_i$  is fraction of cases that die after  $i =$  days, the number of new deaths on day  $n$ ,  $D_n$ , is the sum of deaths from the new cases,  $C_{n-i}$ , on previous days, where  $D_n = C_n * P_0 + C_{n-1} * P_1 + C_{n-2} * P_2 + \dots + C_{n-29} * P_{29}$ . The total death rate is  $\sum P_i$ .

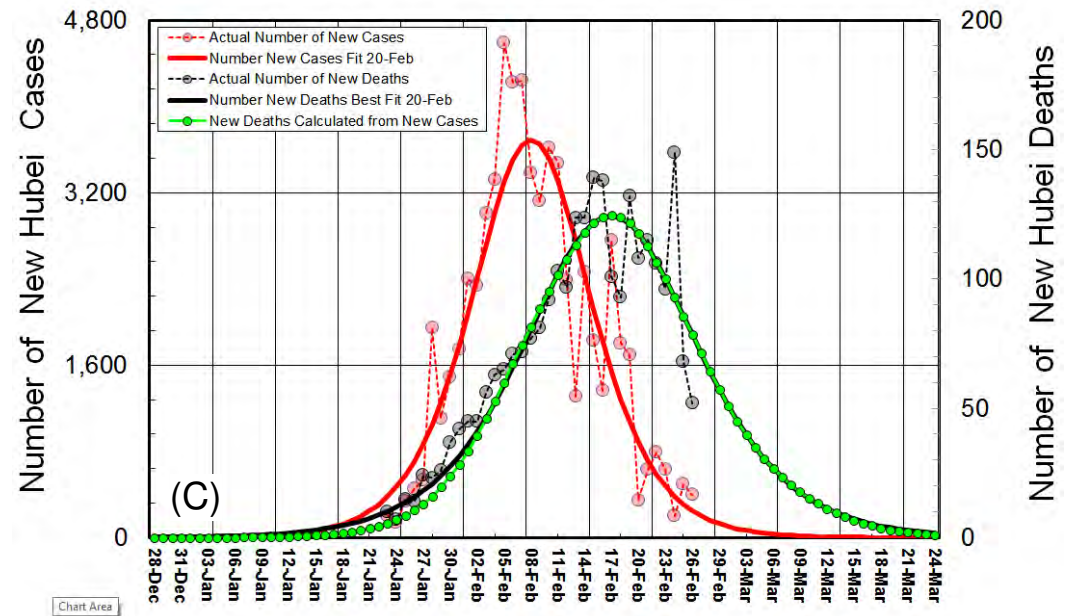
Excel Solver is used to determine values for the  $P_n$  unknowns in two ways:

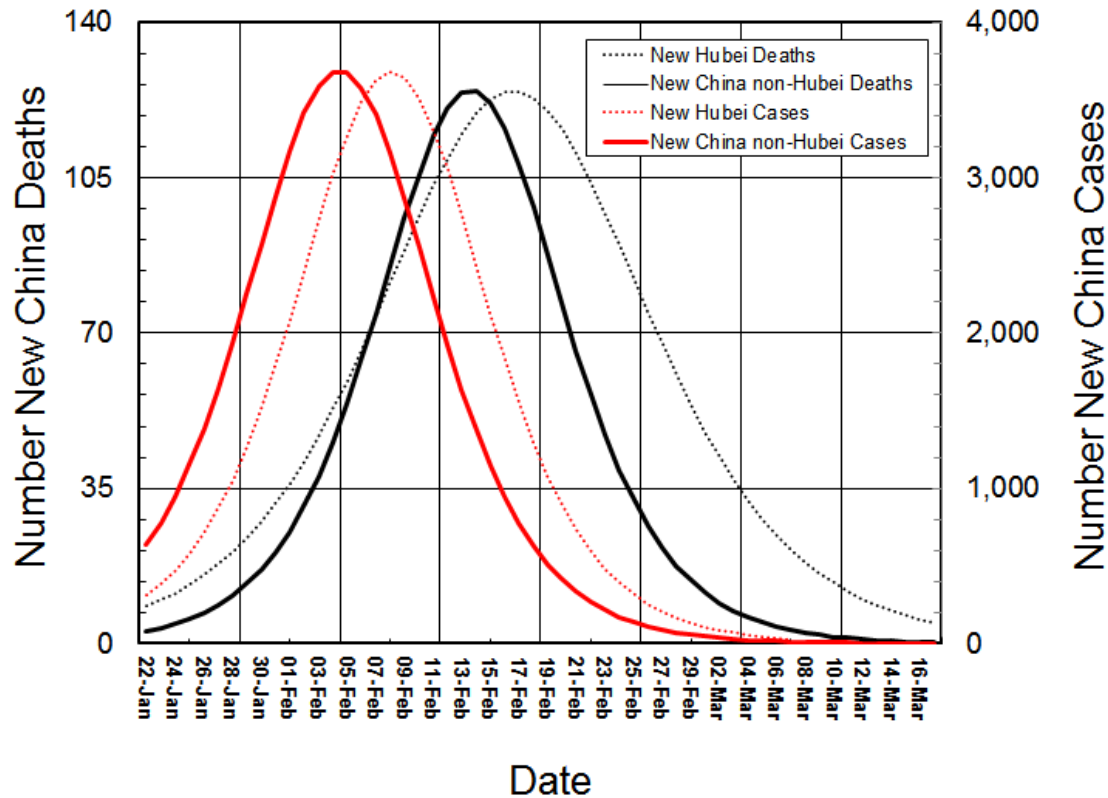
- (1) 30 parameters, one for each  $P_n$  value.
- (2) 3 parameter Gaussian  $P_n = P * \exp(-((n-Q)/R)^2)$ , a with parameters  $P$ ,  $Q$  &  $R$ . The distributions are smoothed with an entropy penalty of  $-W \sum P_n \ln(P_n n)$  added to the weighted least squares fit of predicted and actual number of new deaths.

**(A).** The death rate distribution that best fits predicted deaths to actual deaths in Hubei has 4 peaks with a death rate of 1.1% on day 0, the day a case is confirmed, of 2.4% summed over days 9 & 10 and about 1% over later days. Smoother fits found by increasing the entropy weight  $W$  are more realistic but fit slightly less well. The total death rate in all cases is 4.7%.

**(B)** A death rate distributions allows China Non-Hubei new deaths to be predicted from China Non-Hubei new cases. Single Gaussian fits broadened by added entropy all peak on Day 10. The total death rate in all cases is 0.85%. For both Hubei and Non-Hubei, the death rate is higher than in **Fig. 1C**.

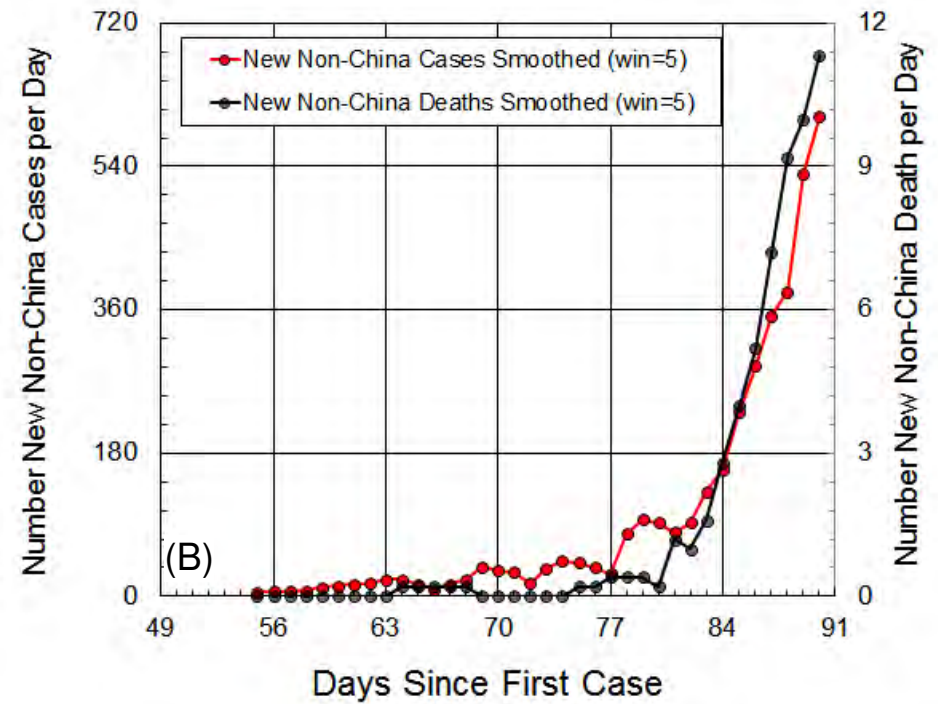
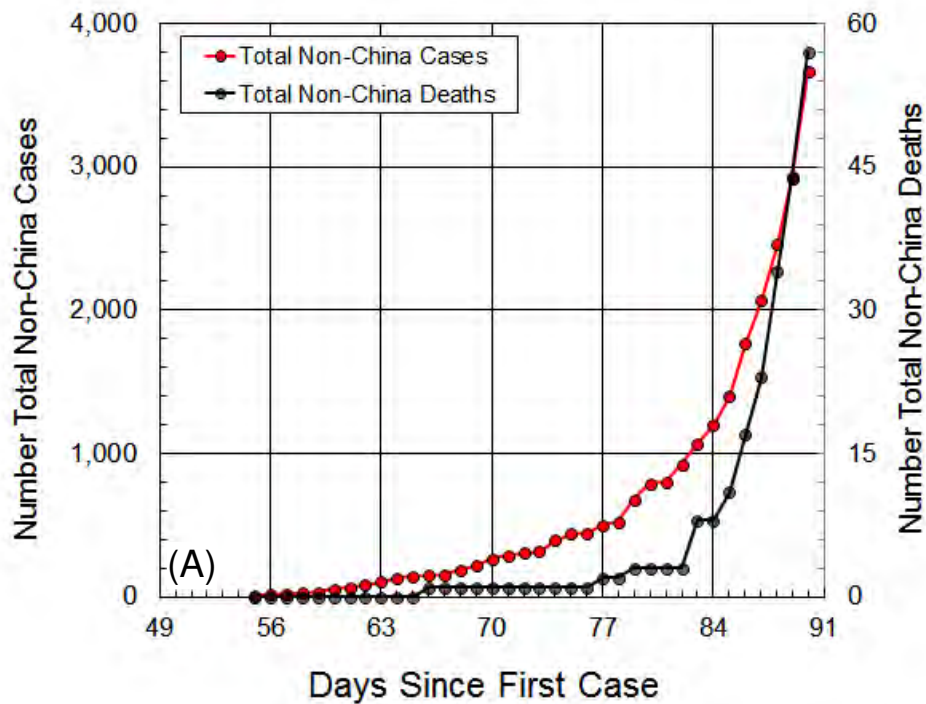
**(C)** The new deaths predicted from actual new cases (red line) is shown as a green dotted line. The fit between the predicted new deaths and the actual new deaths (black line) is excellent (hiding black line) except for 15-Jan. to 29-Jan. when it is low. In that period, the number of new cases confirmed could have been underestimated due to difficult conditions in Hubei.





**Figure 6** compares the sigmoid curves for cases and deaths in Hubei and China Non-Hubei (see **Fig. 4**) . The smaller number of Non-Hubei cases are scaled by a factor of 4.99 so they are the same height as Hubei cases. The same is done to the much smaller number of Non-Hubei deaths, which are scaled by a factor of 20.06. This shows that Non-Hubei cases peaked three days before those in Hubei, while Non-Hubei deaths peaked two days before those in Hubei. This seems impossible but I believe it may be explained if the Non-Hubei cases were all infected in Hubei three days before the majority of those infected in Hubei. This means that these Non-Hubei cases are from infected people who left Wuhan for the Spring Festival (Chinese New Year) and before the city was locked down on 23 Jan. The lack of further infection suggests that the quarantine of those coming from Hubei to other parts of China prevented any further spread of infection. This conjecture is still uncertain but illustrates just how much analysis of the data may reveal.





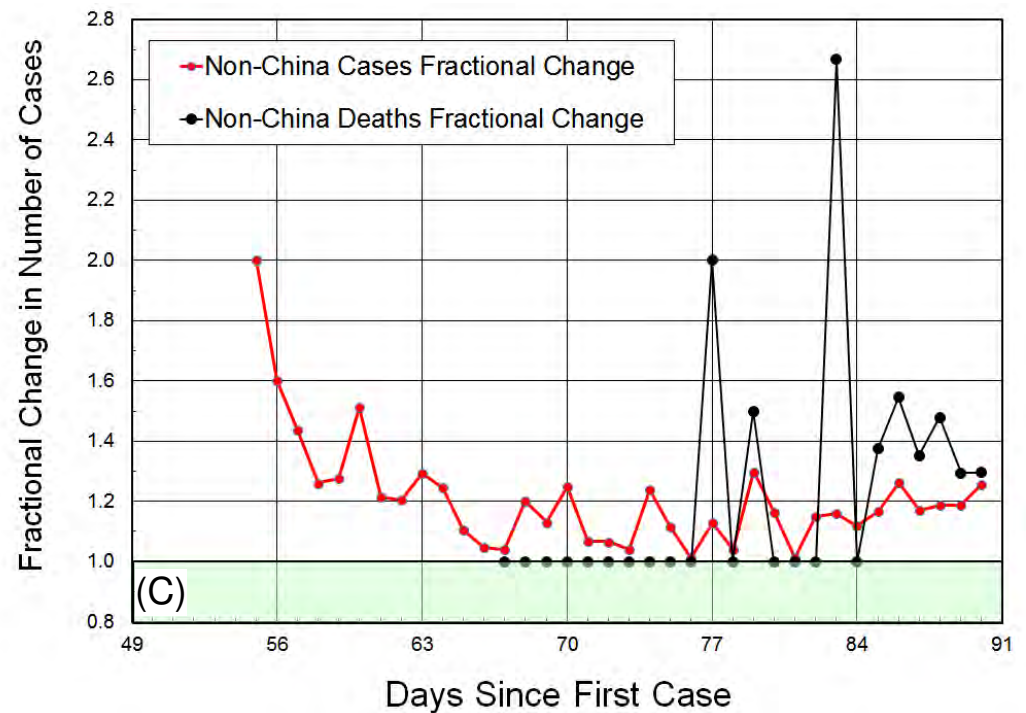
**Figure 7** shows the number of cases and deaths outside China. These plots involve small numbers and are beset by high levels of noise. Still, now is the time when prediction is important.

(A) Shows both cases and deaths are increasing rapidly.

(B) Shows that the number of new cases and new deaths per day are increasing together and without the lag seen in **Fig. 4B & E**. This suggests that many cases are not detected until symptoms are severe and patients die on the same day.

(C) Shows the fractional changes in number of cases and deaths is fluctuating widely and does NOT SHOW any slowing of exponential growth. It was this slowing shown in **Fig. 1D & E**, that suggested hope for situation in Hubei as early on 1-Feb.

We note that the data outside of China comes from very different countries with very different health systems and facilities to test for cases. This is shown by the wide range of death rates: 0.57% in for the 705 cases on the Diamond Princess, 0.74% for the 1766 cases in South Korea, 1.61% for the 186 cases in Japan, 3.0% for the 400 cases in Italy and 15.6% for the 141 cases in Iran. We are investigating this now.



## “30. Analysis of COVID-2019 Data on 3/2/2020” by Michael Levitt, Stanford University, USA

Contrary to the prevailing world concern, the COVID-19 epidemic is almost over in China. Today’s analysis uses WHO data for the past 41 days to confirm trends we have shown in reports going back to 1-Feb. We separate Hubei from non-Hubei as most cases and deaths have occurred in Hubei (**Fig. 2**). We estimate there will be 3,200 total Hubei deaths and less than 120 non-Hubei deaths in China. There will be 66,000 Hubei cases with a Hubei death rate of 4.7% (1% on Day 0 after being classified as a case; 2.4% on Days 8 & 9, the remaining 1% after day 14, **Fig. 5**). There will be 13,000 non-Hubei cases in China with a death rate of 0.85%. China Non-Hubei deaths seem to occur after 10 days, very similar to the 9 day delay most common for Hubei deaths.

As soon as it seemed possible that the epidemic was close to being over in China (Hubei and non-Hubei ), which was by far hit hardest with 94% of the deaths, concern was focused on the Diamond Princess cruise ship. In many ways, this ship provides a worse-case test scenario. There were 705 cases and 4 deaths for the 2,600 passengers and 1,100 crew, who were kept on a ship 290m x 37m in size, a population density of 250,000 per square km (37 times that of Hong Kong). These passengers are older than the general population (200 were over 80 years). The passengers were tested for COVID-19 daily using PCR (polymerase chain reaction), a sensitive DNA amplification method that detects minuscule levels of virus. This led to the 19% infection rate (705/3,700), which shows that if we want to test the world’s population each day, we may eventually reach this level of infection. A super-sensitive molecular-detection method like PCR find signs of the virus on people who are neither sick nor able to infect others. Four deaths, some of people older than 80, gives a death rate of 0.1% (4/3,700) in a month. By comparison, in the USA, for people 80 and over, the death rate is 11% per year or 0.9% per month. This would mean 2 deaths a month amongst 200 passengers over 80. If there are no further COVID-19 deaths amongst the Diamond Princess passengers, it seems we need not worry about this disease causing widespread death worse than influenza.

As data accumulates on Non-China cases, we turn our attention to their analysis. This data is very noisy as expected for the early phase and comes from different countries. Preliminary analysis (**Fig. 7**) shows no signs of slowing exponential growth of cases or deaths. More work is needed and we hope that detailed analysis of the epidemic in China will help the rest of the world.

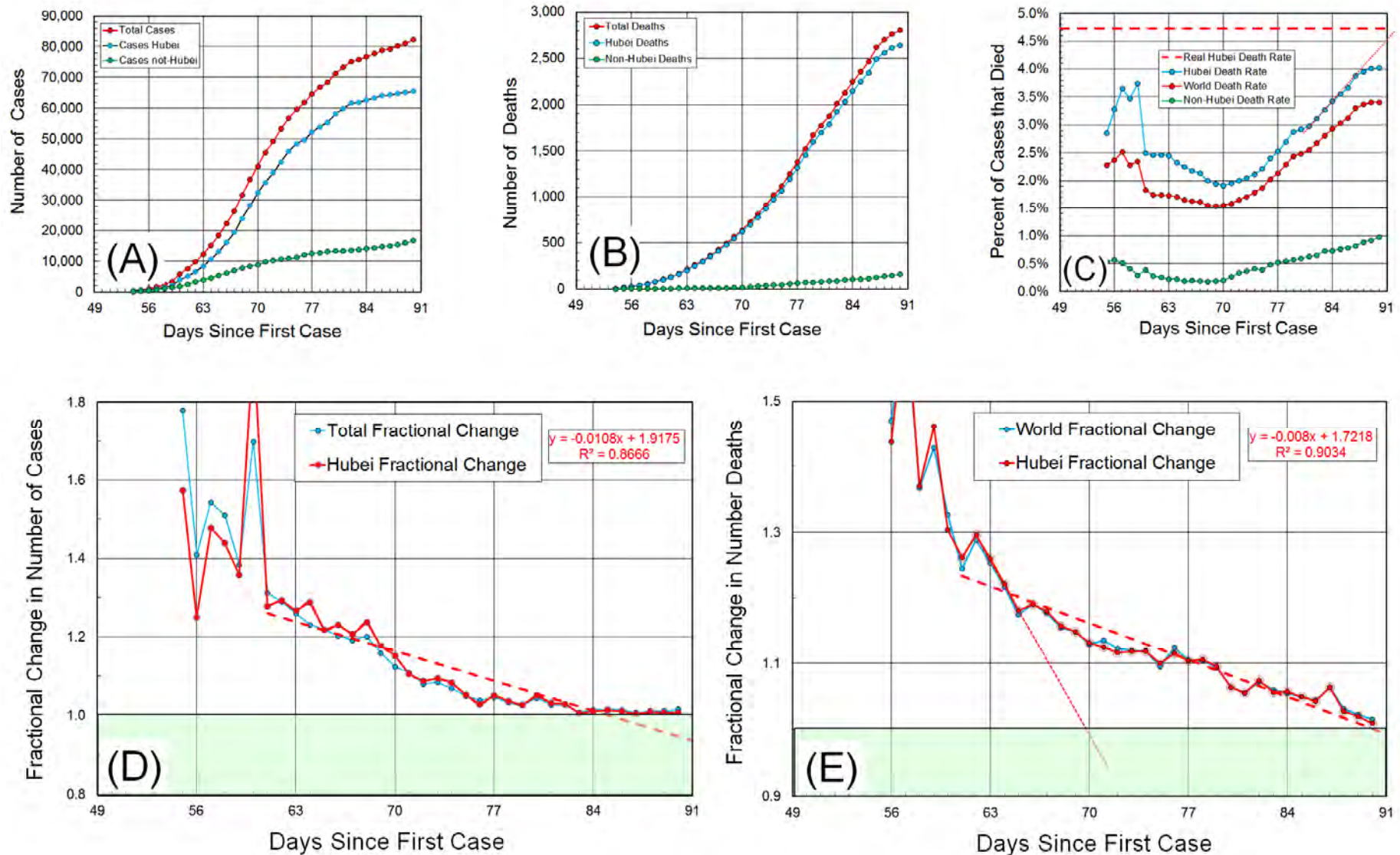
For now, I raise questions for experts who may read this analysis.

- (1) Why do most deaths in China tend to occur after 9 or 10 days from infection (**Figs. 3,4 & 5**)
- (2) Why do Hubei cases have a 1% death rate on the day case is confirmed whereas Non-Hubei cases do not (**Fig. 5**)
- (3) Why do China Non-Hubei cases and deaths both peak three days before those in Hubei? Is the explanation in **Fig. 6** crazy?
- (4) Why do death rates in different countries differ so much (**Fig. 7**). Do the high rates in Iran mean only the very ill are examined?
- (5) Did the epidemic in China slow due to stringent quarantine or rise of immunity in many of those infected but never detected as a case? Can an epidemic be stopped if we use social distancing to contact with fewer people without strict quarantine?
- (6) Could certain individuals be naturally immune due to their individual antibody repertoires?
- (7) Is what happened on the Diamond Princess a good model for what a world pandemic would be (20% infection rate, 0.1% death rate in over 65-year olds). A big unknown is the role of social distancing on the ship?



Date	Day	Total Number Cases					Total Number Deaths			Death Rate (%)			Ratio Hubei/Others	Fraction Change Cases			Fraction Change Deaths			New/Day in Hubei		Non-China		
		Total-LC	Total-L	Hubei-LC	Hubei-L	Others	Total	Hubei	Others	Total	Hubei	Others		Total	Hubei	Others	Total	Hubei	Others	Cases	Deaths	Cases	Deaths	
1/22/2020	54	421	314	358	251	63	6	6	0	1.42%	1.67%	0.00%	-										5	0
1/23/2020	55	750	581	564	395	186	17	16	1	2.28%	2.85%	0.54%	5.3	1.780	1.573	2.961	2.843	2.676	-	205	10	10	0	
1/24/2020	56	1057	846	704	494	352	25	23	2	2.37%	3.28%	0.57%	5.8	1.410	1.249	1.895	1.470	1.437	2.000	141	7	16	0	
1/25/2020	57	1631	1320	1040	729	591	41	38	3	2.51%	3.65%	0.51%	7.2	1.544	1.477	1.677	1.633	1.645	1.500	336	15	23	0	
1/26/2020	58	2462	2014	1497	1049	965	56	52	4	2.27%	3.47%	0.41%	8.4	1.509	1.440	1.632	1.367	1.370	1.333	457	14	29	0	
1/27/2020	59	3407	2798	2034	1425	1373	80	76	4	2.35%	3.74%	0.29%	12.8	1.384	1.358	1.423	1.429	1.462	1.000	536	24	37	0	
1/28/2020	60	5786	4595	3979	2788	1807	106	99	7	1.83%	2.49%	0.39%	6.4	1.698	1.956	1.316	1.326	1.303	1.750	1945	23	56	0	
1/29/2020	61	7587	6065	5087	3565	2500	132	125	7	1.74%	2.46%	0.28%	8.8	1.311	1.279	1.384	1.245	1.262	1.000	1108	26	68	0	
1/30/2020	62	9785	7818	6574	4607	3211	170	162	8	1.74%	2.46%	0.25%	9.9	1.290	1.292	1.284	1.288	1.296	1.143	1487	37	82	0	
1/31/2020	63	12318	9826	8328	5836	3990	213	204	9	1.73%	2.45%	0.23%	10.9	1.259	1.267	1.243	1.253	1.259	1.125	1754	42	106	0	
2/1/2020	64	15163	11953	10727	7517	4436	259	249	10	1.71%	2.32%	0.23%	10.3	1.231	1.288	1.112	1.216	1.221	1.111	2399	45	132	0	
2/2/2020	65	18467	14557	13066	9156	5401	304	294	10	1.65%	2.25%	0.19%	12.2	1.218	1.218	1.217	1.174	1.181	1.000	2339	45	146	0	
2/3/2020	66	22201	17391	16074	11264	6127	362	350	12	1.63%	2.18%	0.20%	11.1	1.202	1.230	1.135	1.191	1.190	1.200	3007	56	153	1	
2/4/2020	67	26434	20630	19398	13593	7037	426	413	13	1.61%	2.13%	0.18%	11.6	1.191	1.207	1.148	1.177	1.180	1.081	3324	63	159	1	
2/5/2020	68	31731	24554	23986	16809	7745	492	478	14	1.55%	1.99%	0.18%	11.0	1.200	1.237	1.101	1.155	1.157	1.077	4589	65	191	1	
2/6/2020	69	36717	28276	28208	19767	8509	565	549	16	1.54%	1.95%	0.19%	10.4	1.157	1.176	1.099	1.148	1.148	1.145	4222	71	216	1	
2/7/2020	70	41191	31481	32450	22740	8741	638	621	17	1.55%	1.91%	0.20%	9.8	1.122	1.150	1.027	1.129	1.131	1.067	4242	72	270	1	
2/8/2020	71	45610	34886	35838	25114	9772	724	698	26	1.59%	1.95%	0.27%	7.3	1.107	1.104	1.118	1.135	1.124	1.521	3389	77	288	1	
2/9/2020	72	49217	37558	38962	27304	10254	813	779	34	1.65%	2.00%	0.33%	6.0	1.079	1.087	1.049	1.123	1.116	1.308	3124	81	307	1	
2/10/2020	73	53296	40554	42583	29841	10713	910	871	39	1.71%	2.05%	0.36%	5.6	1.083	1.093	1.045	1.119	1.118	1.148	3621	92	319	1	
2/11/2020	74	56886	43103	46060	32278	10825	1018	974	44	1.79%	2.11%	0.41%	5.2	1.067	1.082	1.010	1.119	1.118	1.128	3478	103	395	1	
2/12/2020	75	59670	45171	48453	33955	11216	1115	1071	44	1.87%	2.21%	0.39%	5.6	1.049	1.052	1.036	1.095	1.099	1.003	2393	97	441	1	
2/13/2020	76	61889	46997	49766	34874	12123	1252	1194	58	2.02%	2.40%	0.48%	5.0	1.037	1.027	1.081	1.123	1.115	1.315	1312	124	447	1	
2/14/2020	77	64682	49053	52231	36602	12451	1383	1318	65	2.14%	2.52%	0.52%	4.8	1.045	1.050	1.027	1.104	1.103	1.121	2466	124	505	2	
2/15/2020	78	66757	50580	54061	37884	12696	1526	1457	69	2.29%	2.70%	0.54%	5.0	1.032	1.035	1.020	1.103	1.105	1.062	1829	139	526	2	
2/16/2020	79	68442	51857	55424	38839	13018	1669	1595	74	2.44%	2.88%	0.57%	5.1	1.025	1.025	1.025	1.094	1.095	1.072	1363	138	683	3	
2/17/2020	80	71429	54019	58182	40772	13247	1775	1696	79	2.48%	2.91%	0.60%	4.9	1.044	1.050	1.018	1.064	1.063	1.068	2758	101	794	3	
2/18/2020	81	73332	NA	59989	NA	13343	1873	1789	84	2.55%	2.98%	0.63%	4.7	1.027	1.031	1.007	1.055	1.055	1.063	1807	93	804	3	
2/19/2020	82	75204	NA	61682	NA	13522	2009	1921	88	2.67%	3.11%	0.65%	4.8	1.026	1.028	1.013	1.073	1.074	1.048	1693	132	924	3	
2/20/2020	83	75748	NA	62031	NA	13717	2129	2029	100	2.81%	3.27%	0.73%	4.5	1.007	1.006	1.014	1.060	1.056	1.136	349	108	1073	8	
2/21/2020	84	76769	NA	62662	NA	14107	2247	2144	103	2.93%	3.42%	0.73%	4.7	1.013	1.010	1.028	1.055	1.057	1.030	631	115	1200	8	
2/22/2020	85	77794	NA	63454	NA	14340	2359	2250	109	3.03%	3.55%	0.76%	4.7	1.013	1.013	1.017	1.050	1.049	1.058	792	106	1402	11	
2/23/2020	86	78811	NA	64084	NA	14727	2462	2346	116	3.12%	3.66%	0.79%	4.6	1.013	1.010	1.027	1.044	1.043	1.064	630	96	1769	17	
2/24/2020	87	79331	NA	64287	NA	15044	2618	2495	123	3.30%	3.88%	0.82%	4.7	1.007	1.003	1.022	1.063	1.064	1.060	203	149	2069	23	
2/25/2020	88	80239	NA	64786	NA	15453	2700	2563	137	3.36%	3.96%	0.89%	4.5	1.011	1.008	1.027	1.031	1.027	1.114	499	68	2459	34	
2/26/2020	89	81109	NA	65187	NA	15922	2762	2615	147	3.41%	4.01%	0.92%	4.3	1.011	1.006	1.030	1.023	1.020	1.073	401	52	2918	44	
2/27/2020	90	82294	NA	65596	NA	16698	2804	2641	163	3.41%	4.03%	0.98%	4.1	1.015	1.006	1.049	1.015	1.010	1.109	409	26	3664	57	
2/28/2020	91	83652	NA	65914	NA	17738	2858	2682	176	3.42%	4.07%	0.99%	4.1	1.017	1.005	1.062	1.019	1.016	1.080	318	41	4691	67	
2/29/2020	92	85403	NA	66337	NA	19066	2924	2727	197	3.42%	4.11%	1.03%	4.0	1.021	1.006	1.075	1.023	1.017	1.119	423	45	6009	86	
3/1/2020	93	87137	NA	66907	NA	20230	2977	2761	216	3.42%	4.13%	1.07%	3.9	1.020	1.009	1.061	1.018	1.012	1.096	570	34	7169	104	

**Table 1.** Showing data for New Coronavirus 2019 or COVID-19) from 22 January to 1 March 2020. Total number of cases and deaths is 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 use data from <https://jobtube.cn/wv/?from=groupmessage&isappinstalled=0>. Starting on 17-Feb., the WHO includes cases clinically diagnosed in addition to those laboratory diagnosed. As no date is given for these cases, we assume that the clinical cases are a fixed percentage of the laboratory cases (46.2%) to get the revised total Hubei cases reported by the WHO on 17-Feb.(58,182). For continuity between old and new data we list Hubei cases as 'Hubei-L' for laboratory diagnosed and 'Hubei-LC' for laboratory and clinically diagnosed. We divide data into Hubei and non-Hubei as most deaths are in an area centered on Wuhan in Hubei (Fig. 2). The death rate is the number of deaths divided by the number of 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 is Value\_Today divided by Value\_Yesterday. We give the number of new cases and new deaths in Hubei each day (subtracting yesterday from today). We replace the seemingly incorrect WHO value for Hubei deaths on 13-Feb. (1,316) with the average of 12 and 14 Feb. values (1,194) to avoid having 245 new deaths on 13-Feb. but just 2 new deaths on 14-Feb (pink shading). As cases outside China have grown, we add the number of Non-China deaths and cases from the WHO data.



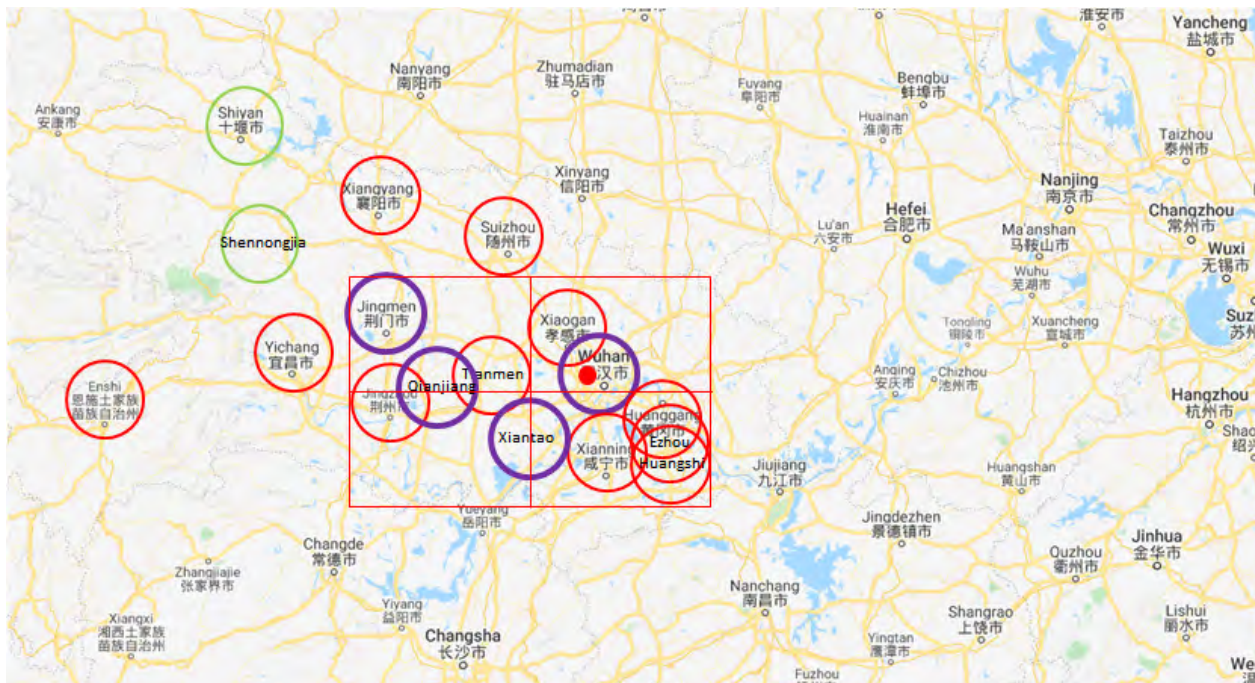
**Figure 1. Variation of COVID-19 data against days since 29 Nov 2019 (guessed date of the first case).** Data is taken from **Table 1**.

(A) shows a slowing increase in number of cases everywhere. (B) confirms that almost all the deaths are in Hubei. (C) shows that the Hubei death rate initially decreased from 2.5% on 27-Jan. to 1.9% on 7-Feb. only to rise to 4.0% today. Such a rise of the Hubei death rate in (C) makes no sense as the virus is not becoming more virulent. This discrepancy arises because all deaths do not occur on the same day a case is diagnosed. A proper death rate distribution gives a real Hubei death rate of 4.7% (**Fig. 5**). (D) and (E) show that the fractional change in total cases or deaths (Value\_Today / Value\_Yesterday) is decreasing steadily. In (D) & (E) we add linear trend-lines using data from 1/29/2020. The fractional change for cases and deaths is an excellent fit to a straight line. In (E) we also show a red short-dashed line of the linear fit to the four data points for 31-Dec to 02-Feb; this trend was seen in the first draft of this analysis dated 2/2/20, giving rise to the hope I expressed that the growth of deaths would slow soon.

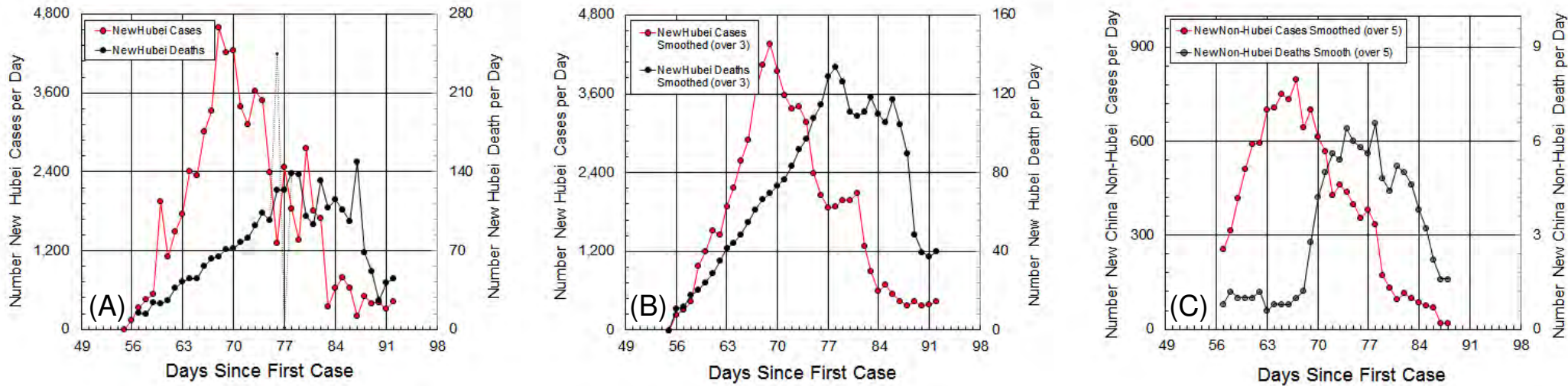


			16-Feb				12-Feb				6-Feb				4-Feb				2-Feb				31-Jan		
Province or City in Hubei	Population	Deaths / million pop	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	Death Rate	Death Ratio	Cases	Deaths	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 0.37% of the Wuhan population of 11 million. On 31-Jan. there were 8 of 17 cities with death rates less than 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 in Table 2. Most deaths are localized to a 90 km x 35 km 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 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.



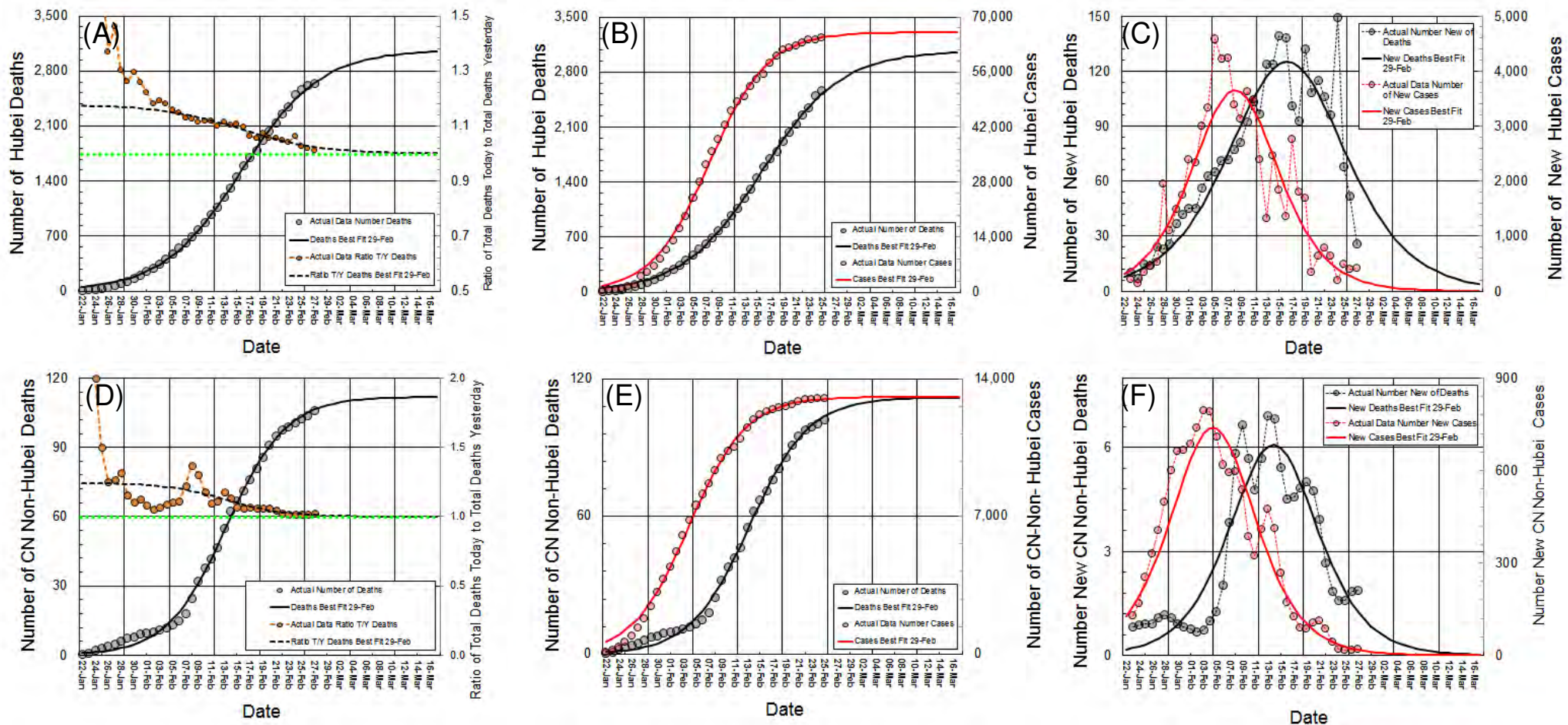
**Figure 3. Time variation of number of new cases and new deaths in China, separated into Hubei and elsewhere in mainland China (Non-Hubei).**

(A). Showing the number of new Hubei cases per day (red line) and the number of new Hubei deaths per day (black line). For new deaths, the WHO data values fluctuated wildly on 13 and 14 Feb. as shown by the black dotted line. For this reason, the numbers of new deaths of 245 on 13-Feb. and 2 on 14-Feb. (Table 1) are averaged to give 124 new deaths on each day, correcting what may have been a typo in the value for 13-Feb. (black dashed line).

(B) The same data is smoothed by averaging over a three-day window so that, for example, the value plotted on day 69 is the average of the values on days 68, 69 & 70. These smoothed curves clearly show that the number of new Hubei cases per day peaked on Day 69 (6-Feb) and that the number of new Hubei deaths per day peaked on Day 78 (15-Feb.), which is 9 days later. For sigmoid growth like that shown in **Fig. 4**, the number of new cases or deaths reaches a maximum midway through the curve. This predicts the total number of Hubei cases will reach 60,000 (laboratory plus clinically diagnosed cases), approximately twice 28,208, the number of such cases on 6-Feb. This also predicts total number of Hubei deaths will reach 2,914, twice 1,457, the number of Hubei deaths on 15-Feb. Better analysis in **Fig. 4** gives asymptotic values of 65,834 and 3,150 for number of Hubei cases and deaths, respectively.

(C) Showing the variation with time of the smoothed number of new Non-Hubei cases in China per day (red line). Although smoothed by averaging over a window of five values, this data remains noisy. Nevertheless, it does indicate that a peak in the number of new Non-Hubei cases in China occurred on day 67 or 68 (4-Feb. or 5-Feb.) allowing the maximum total number of Non-Hubei cases to be estimated as twice 7,037 or 7,745, the values on 4-Feb. or 5-Feb., for a value of between 14,000 and 16,000. The same argument estimates the total number of non-Hubei deaths to reach a 160. Again, **Fig. 4** gives better asymptotic values of 13,075 and 109 for the total number of Non-Hubei cases and deaths, respectively.





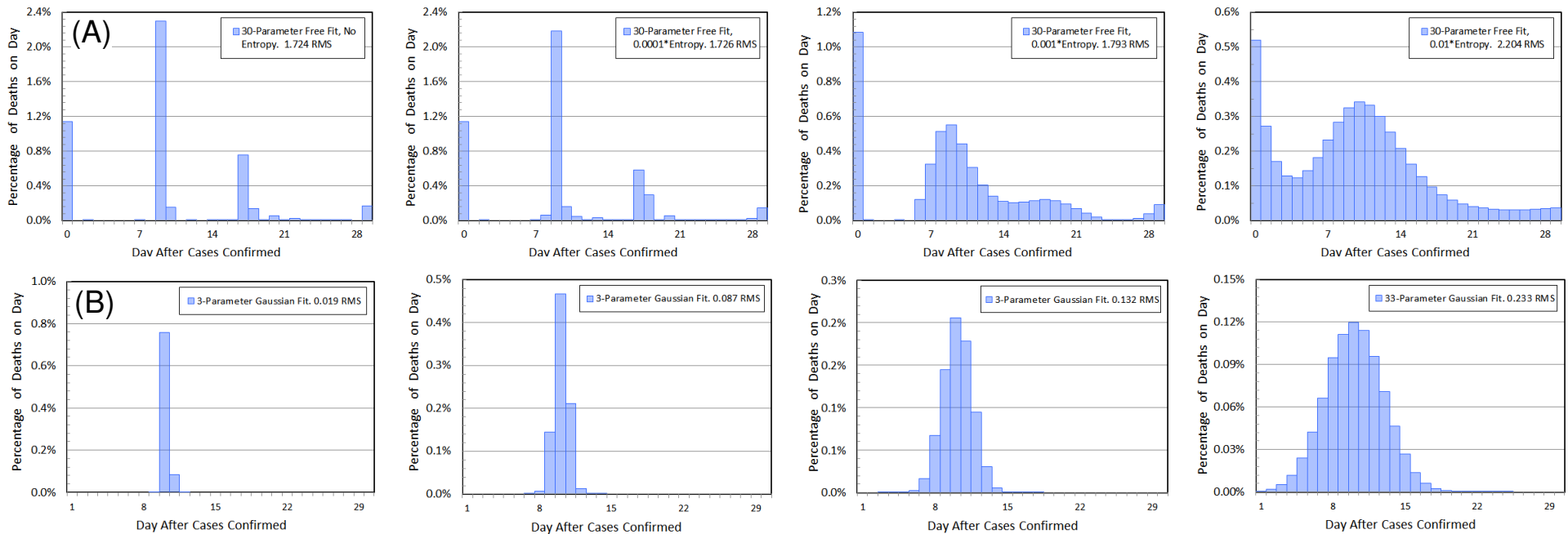
**Figure 4. Fit of a sigmoid function to the total number of COVID-19 cases and deaths in Hubei.** (A) The best fit (black line) to the actual deaths (black dots). The fit is obtained using Excel Solver to find parameters  $A$ ,  $B$  &  $C$  in  $f(x) = A/(1+exp(-(x-B)/C))$  that minimize the weighted RMS difference of calculated and actual number (weight=sqrt(number deaths)). We calculate ratio of value today to those yesterday (T/Y, black dashed line) and compare with the actual data (orange dashed line and circles on secondary axis). The fit is excellent and the calculated ratio decreases approximately linearly towards a value of 1.0 as assumed in **Fig. 2 (E)**.  $=A/(1+EXP(-(x-B)/C))$

(B) Sigmoid fits to both the number of cases and number of deaths in Hubei. The final total number of Hubei cases will be close to 66,000, while the current estimate for total number of deaths will be close to 3,200. This will mean an overall Hubei death rate of almost 5% ( $3,200/66,000=4.8\%$ ).

(C) By subtracting values for yesterday from today, the sigmoid function fitted to the actual number of new Hubei cases or deaths shown in **Fig. 4B**, gives the number of new Hubei cases or new Hubei deaths (solid red and black lines, respectively). These curves are a good fit to the actual number of new Hubei cases or deaths (red and black transparent circles joined by dashed red and black lines, respectively), although the real data is noisy with large fluctuations. The smooth new cases curve (solid red line) peaks at Day 70.4 and the smooth new deaths curve (solid black line) peaks at Day 78.6.

Corresponding plots for cases and deaths in China but Non-Hubei is plotted in panels (D), (E) & (F). The Non-Hubei death rate is almost 1% ( $109/13075=0.83\%$ ), which is about 5 times lower than that in Hubei.

The  $A$ ,  $B$  &  $C$  parameters for sigmoid curves are 66128, 70.6 & 4.52 for Hubei cases; 3069, 78.7 & 6.13 for Hubei deaths; 13081, 67.0 & 4.42 for Non-Hubei cases; and 112, 76.14 & 4.6 for Non-Hubei deaths.



**Figure 5.** Relating new cases to new deaths via a death rate distribution, which gives the fraction of cases that die  $i$  days after a case is confirmed.

If  $P_i$  is fraction of cases that die after  $i =$  days, the number of new deaths on day  $n$ ,  $D_n$ , is the sum of deaths from the new cases,  $C_{n-i}$ , on previous days, where  $D_n = C_n * P_0 + C_{n-1} * P_1 + C_{n-2} * P_2 + \dots + C_{n-29} * P_{29}$ . The total death rate is  $\sum P_i$ .

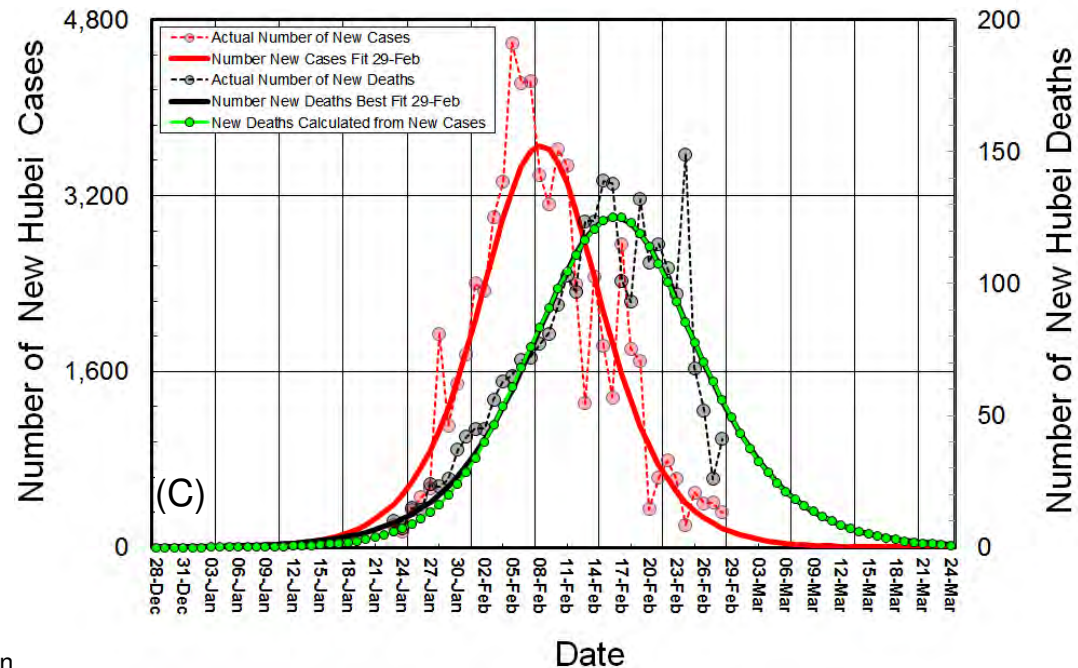
Excel Solver is used to determine values for the  $P_n$  unknowns in two ways:

- (1) 30 parameters, one for each  $P_n$  value.
- (2) 3 parameter Gaussian  $P_n = P * \exp(-((n-Q)/R)^2)$ , a with parameters  $P$ ,  $Q$  &  $R$ . The distributions are smoothed with an entropy penalty of  $-W \sum P_n \ln(P_n n)$  added to the weighted least squares fit of predicted and actual number of new deaths.

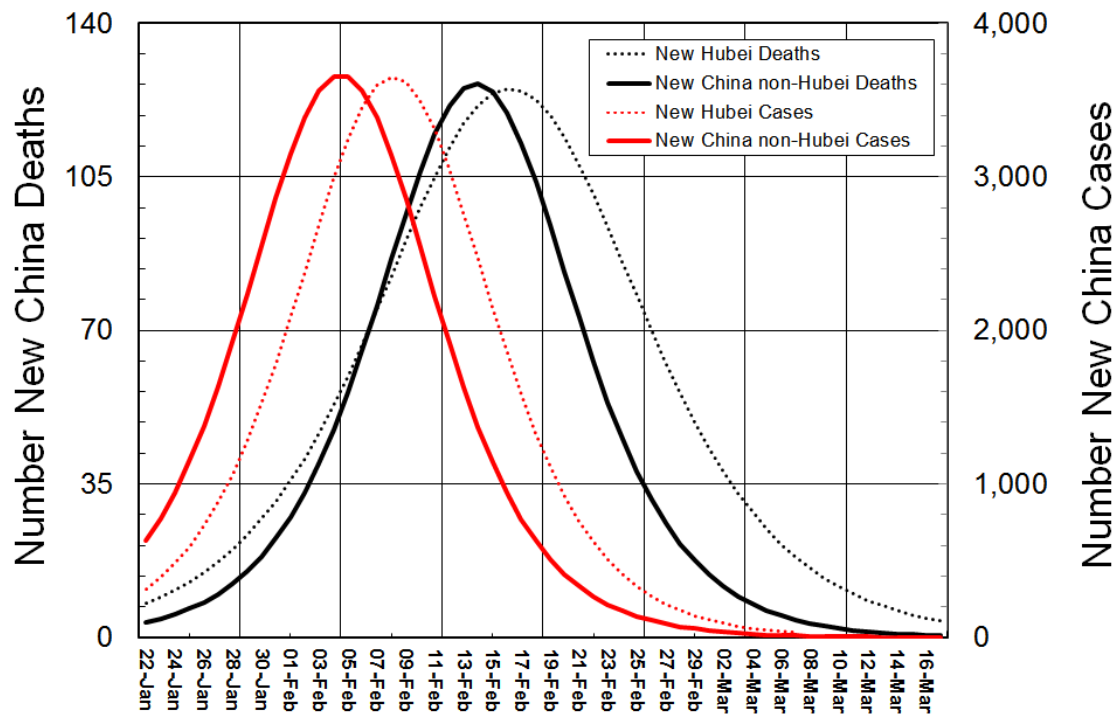
**(A).** The death rate distribution that best fits predicted deaths to actual deaths in Hubei has 4 peaks with a death rate of 1.1% on day 0, the day a case is confirmed, of 2.4% summed over days 9 & 10 and about 1% over later days. Smoother fits found by increasing the entropy weight  $W$  are more realistic but fit slightly less well. The total death rate in all cases is 4.7%.

**(B)** A death rate distributions allows China Non-Hubei new deaths to be predicted from China Non-Hubei new cases. Single Gaussian fits broadened by added entropy all peak on Day 10. The total death rate in all cases is 0.85%. For both Hubei and Non-Hubei, the death rate is higher than in **Fig. 1C**.

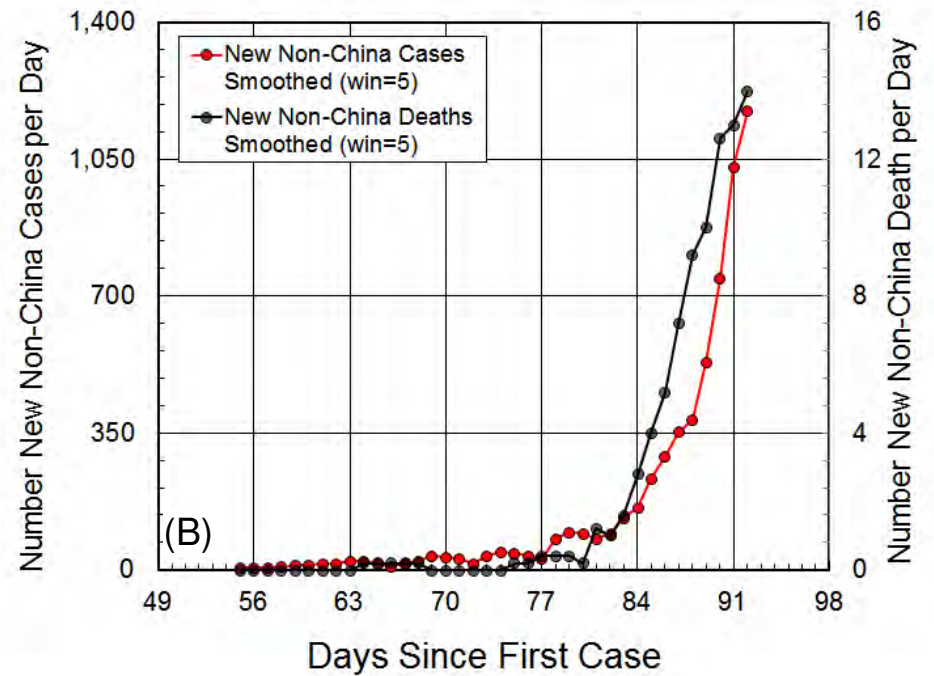
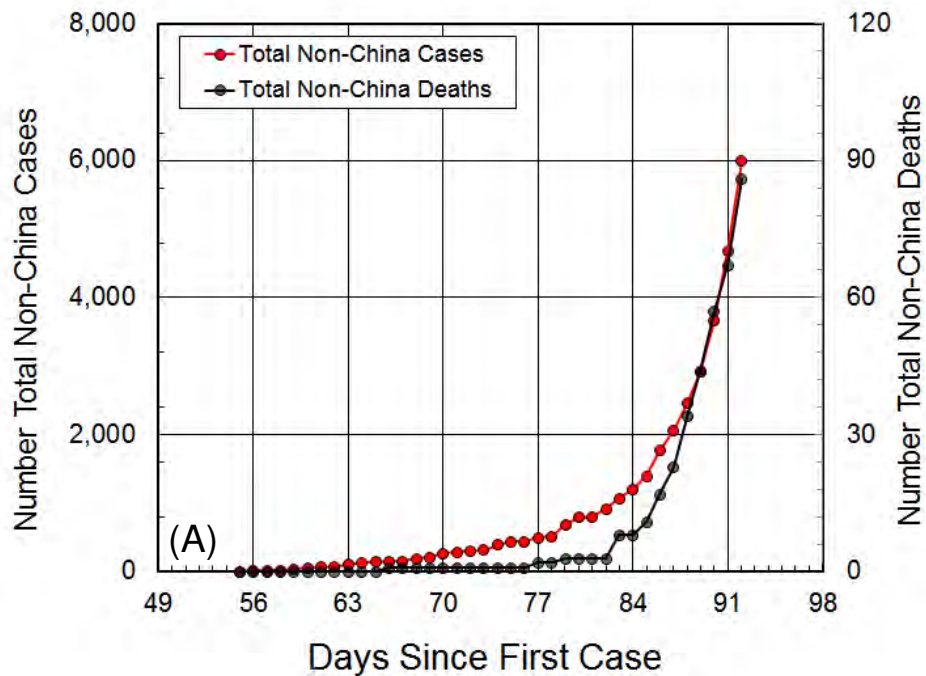
**(C)** The new deaths predicted from actual new cases (red line) is shown as a green (black line) is excellent (hiding black line) except for 15-Jan. to 29-Jan. when it is low. In that period, the number of new cases confirmed could have been underestimated due to difficult conditions in Hubei.







**Figure 6** compares the sigmoid curves for cases and deaths in Hubei and China Non-Hubei (see **Fig. 4**) . The smaller number of Non-Hubei cases are scaled by a factor of 4.99 so they are the same height as Hubei cases. The same is done to the much smaller number of Non-Hubei deaths, which are scaled by a factor of 20.06. This shows that Non-Hubei cases peaked three days before those in Hubei, while Non-Hubei deaths peaked two days before those in Hubei. This seems impossible but I believe it may be explained if the Non-Hubei cases were all infected in Hubei three days before the majority of those infected in Hubei. This means that these Non-Hubei cases are from infected people who left Wuhan for the Spring Festival (Chinese New Year) and before the city was locked down on 23 Jan. The lack of further infection suggests that the quarantine of those coming from Hubei to other parts of China prevented any further spread of infection. This conjecture is still uncertain but illustrates just how much analysis of the data may reveal.



**Figure 7** shows the number of cases and deaths outside China. These plots involve small numbers and are beset by high levels of noise. Still, now is the time when prediction is important.

(A) Shows both cases and deaths are increasing rapidly.

(B) Shows that the number of new cases and new deaths per day are increasing together and without the lag seen in **Fig. 4B & E**. This suggests that many cases are not detected until symptoms are severe and patients die on the same day.

(C) Shows the fractional changes in number of cases and deaths is fluctuating widely and does NOT SHOW any slowing of exponential growth. It was this slowing shown in **Fig. 1D & E**, that suggested hope for situation in Hubei as early on 1-Feb.

We note that the data outside of China comes from very different countries with very different health systems and facilities to test for cases. This is shown by the wide range of death rates: 0.48% for the 3,736 cases in South Korea, 0.85% for the 705 cases on the Diamond Princess, 2.09% for the 239 cases in Japan, 2.57% for the 1,128 cases in Italy and 7.25% for the 593 cases in Iran. At present, the number of cases outside China is still too small to allow any prediction.

