

Supplementary Materials

Rapid Control of a SARS-CoV-2 B.1.617.2 (Delta) variant COVID-19 Community Outbreak: the Successful Experience in Pingtung County of Taiwan

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The environmental factors in relation to the delta-SARS-CoV-2 spread in Taiwan

A review article reported by Dr. Srivastava was conducted that the increased PM_{2.5}, PM₁₀, and NO₂ was positively associated with the increased morbidity and mortality of COVID-19 cases and the decrease in the confirmed COVID-19 cases was related with the rising temperature and solar radiation from the several published data [25]. The implementation of lockdown was demonstrated to improve the air quality in the regions during the duration of COVID-19 [25]. In our previous study [26], the reduction of PM_{2.5} by 10.6% in northern Taiwan and 3.70% in southern Taiwan between January and March from 2019 to 2020 was observed due to the decreased PM_{2.5} emissions from restricted activities in the local areas and the long-range transport of reduced PM_{2.5} through winter monsoon from the mainland China during the COVID-19 issue. After the restricted activities or lockdown in Taiwan since 2020, the air quality was improved. According to Table 1 and Table S1 and S2, the decline of PM_{2.5}, PM₁₀, and NO₂ in 2021 was probably associated with restricted activities in the domestic areas and lockdown implementation after the Pingtung outbreak. The air pollution like PM_{2.5} and NO₂ is proved as a main contribution to trigger the COVID-19 spread and lethality based on the evidence of airborne transmission [27]. The delta variant of SARS-CoV-2 is infected faster than the wild-type SARS-CoV-2 via airborne transmission [28]. The Pingtung outbreak of delta variant was rapidly controlled within 3 weeks and the alpha variant outbreak in Taipei and New Taipei City was continuously transmitted between May and August in 2021. Whether can we use the air quality to explain the rapid control of delta variant? The answer might be not the main contributor, but good air quality possibly provides the positively minor effect. The air pollutants of CO, NO, NO₂, SO₂, PM₁₀, and PM_{2.5} in Hengchun (the rural areas) were significantly lower than those in Taipei or New Taipei City (the urban areas), indicating that the more human and economic activities are produced the more air pollutants. The air pollution was significantly decreased during implementation of lockdown compared with those in the same areas without lockdown [29, 30]. According to the previous studies[25, 31-33], the positive associations of the air pollutants with SARS-CoV-2 infection mortality was mainly due to combination of COVID-19 and air pollution related comorbidities. The British study indicated the NO₂ and PM_{2.5} increase of every 1.00 µg/m³ to enhance 0.5 and 1.4% increase in COVID-19 mortality risk, respectively, by Bayesian hierarchical models after the confounders of meteorological (e.g., temperature and relative humidity), spatial (e.g., urban and rural areas), healthcare (e.g., occupational exposure and intensive care beds), and health (e.g., obesity and smoking) confounders were adjusted [32]. Local meteorological data in the delta-SARS-CoV-2 pandemic areas were similar to those in Taipei and New Taipei City due to the summer season in Taiwan. Local meteorology might play an important role in the SARS-CoV-2 spread and COVID-19 mortality, such as the negative associations of high temperature and relative humidity and solar radiation with the corona virus spread and inversely, acceleration of the COVID-19 spread by the strong wind speed [25, 34, 35]. Compared with the continuous alpha variant of SARS-CoV-2 spread and outbreak in Taipei and New Taipei City from May to August, the quick cease of the delta-SARS-CoV2 spread in Pingtung within 19 days (from June 22 to July 10) was probably associated with low levels of air pollutants, particularly for PM_{2.5} and the obvious direction of land-sea breeze, low population density, and local geography (e.g., rural area on the coast near the mountains).

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Table S1. Average of air-quality at Hengchun stations form June 14th to July 11th between 2019 and 2021 in Pingtung.

Location	Years	Air pollutants						
		CO (ppm)	O ₃ (ppb)	NO (ppb)	NO ₂ (ppb)	SO ₂ (ppb)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)
		Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)
Pingtung								
Hengchun	2021	0.0785 ± 0.0170 (0.047 – 0.108)	26.7 ± 7.51 (14.4 – 40.8)	1.23 ± 0.571 (0.312 – 2.88)	1.40 ± 0.468 (0.335 – 2.45)	1.10 ± 0.390 (0.267 – 1.92)	12.9 ± 5.58 (6.17 – 27.9)	4.13 ± 2.17 (1.46 – 10.2)
	2020	0.0516 ± 0.000408 (0.05 – 0.07)	21.9 ± 2.88 (15.2 – 30.6)	1.20 ± 0.49 (0.40 – 2.43)	0.903 ± 0.43 (0.34 – 2.34)	0.700 ± 0.258 (0.48 – 1.42)	7.40 ± 2.58 (4.58 – 14.9)	4.16 ± 0.979 (2.54 – 6.39)
	2019	0.0517 ± 0.0265 (0.05 – 0.1248)	25.1 ± 3.04 (19 – 31.1)	0.852 ± 0.276 (0.333 – 1.34)	1.42 ± 0.32 (0 – 2.00)	1.35 ± 0.439 (0.500 – 2.10)	13.0 ± 9.75 (0 – 36.9)	6.24 ± 3.09 (0 – 10.6)

Table S2. Average of air-quality at Shilin, Wanhua, and Songshan stations from June 14th to July 11th between 2019 and 2021 in Taipei.

Location	Years	Air pollutants						
		CO (ppm)	O ₃ (ppb)	NO (ppb)	NO ₂ (ppb)	SO ₂ (ppb)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)
		Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)
Taipei								
Shilin	2021	0.207 ± 0.052 (0.089 – 0.34)	26.7 ± 6.97 (2.20 – 35.1)	2.04 ± 0.890 (0.180 – 3.89)	8.81 ± 2.61 (4.17 – 15.3)	8.81 ± 2.61 (1.23 – 4.15)	21.6 ± 5.29 (9.88 – 29.6)	9.04 ± 2.40 (3.67 – 14.7)
		2020	0.289 ± 0.0356 (0.241 – 0.386)	23.8 ± 4.11 (15.5 – 32.0)	2.88 ± 1.12 (0.779 – 5.40)	12.4 ± 1.63 (9.43 – 15.4)	2.33 ± 0.515 (1.44 – 3.11)	24.2 ± 2.97 (16.2 – 29.6)
	2019	0.315 ± 0.0639 (0.216 – 0.454)	28.7 ± 10.6 (16.2 – 62.1)	2.98 ± 1.49 (0.34 – 6.38)	12.5 ± 2.35 (7.36 – 17.0)	2.12 ± 0.431 (1.16 – 2.94)	19.2 ± 10.2 (3.33 – 36.4)	12.1 ± 2.90 (5.71 – 17.7)
Wanhua	2021	0.274 ± 0.0670 (0.164 – 0.468)	25.4 ± 4.06 (16.7 – 36.2)	2.57 ± 1.01 (0.81 – 4.93)	10.8 ± 3.60 (5.25 – 20.5)	2.06 ± 0.598 (1.17 – 3.20)	19.6 ± 3.49 (12.2 – 25.3)	9.71 ± 2.49 (4.80 – 15.2)
		2020	0.372 ± 0.0412 (0.302 – 0.489)	23.0 ± 3.71 (16.1 – 29.3)	4.19 ± 1.72 (1.80 – 10.1)	14.5 ± 2.21 (11.4 – 19.6)	1.75 ± 0.555 (0.575 – 2.94)	22.2 ± 1.65 (17.2 – 24.4)
	2019	0.437 ± 0.065 (0.345 – 0.563)	22.0 ± 9.9 (10.1 – 52.6)	4.70 ± 1.29 (1.98 – 7.88)	17.3 ± 3.18 (12.3 – 23.0)	1.84 ± 0.59 (0.75 – 3.02)	20.8 ± 7.0 (4.58 – 29.5)	10.0 ± 2.68 (5.38 – 15.5)
Songshan	2021	0.272 ± 0.0576 (0.147 – 0.372)	25.7 ± 5.50 (14.1 – 38.3)	3.51 ± 1.90 (0.800 – 7.64)	11.2 ± 2.59 (4.82 – 16)	2.35 ± 0.599 (0.929 – 3.37)	19.4 ± 5.14 (10.2 – 28.7)	9.36 ± 2.87 (3.50 – 16.6)
		2020	0.36 ± 0.0556 (0.256 – 0.505)	24.2 ± 4.42 (16.6 – 33.7)	6.15 ± 2.35 (2.74 – 10.6)	15.6 ± 2.64 (9.82 – 21.6)	2.09 ± 0.628 (0.5 – 3.05)	23.3 ± 1.97 (18.4 – 26)
	2019	0.378 ± 0.0644 (0.234 – 0.492)	24.4 ± 10.1 (11.8 – 58.6)	6.17 ± 3.09 (1.64 – 16.2)	16.2 ± 3.31 (9.52 – 23.6)	2.27 ± 0.63 (0.35 – 3.27)	19.4 ± 11.3 (0 – 37)	12 ± 2.54 (6 – 16.9)

Table S3. Average of air-quality at Yonghe, Banqiao, and Xinzhung stations form June 14th to July 11th between 2019 and 2021 in New Taipei.

Location	Years	Air pollutants							
		CO (ppm)	O ₃ (ppb)	NO (ppb)	NO ₂ (ppb)	SO ₂ (ppb)	PM ₁₀ (µg/m ³)	PM _{2.5} (µg/m ³)	
		Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	Mean ± SD (min – Max)	
New Taipei									
Yonghe	2021	0.440 ± 0.133 (0.24 – 0.808)	24.1 ± 4.08 (15.2 – 32.9)	5.53 ± 2.16 (1.87 – 2.04)	11.2 ± 3.81 (2.49 – 11.8)	1.91 ± 0.719 (0.89 – 3.78)	20.5 ± 3.92 (11.7 – 26.3)	9.87 ± 2.61 (5.33 – 15.3)	
		2020	0.577 ± 0.0798 (0.744 – 0.453)	22.6 ± 3.24 (28.5 – 17.4)	8.08 ± 1.97 (12.2 – 4.97)	14 ± 2.19 (19.2 – 9.52)	1.56 ± 0.617 (2.85 – 0.932)	19 ± 1.49 (23.6 – 16.5)	10.1 ± 1.29 (12.7 – 6.33)
	2019		0.67 ± 0.131 (0.432 – 0.892)	23 ± 10.1 (11.6 – 55.6)	9.21 ± 2.83 (3.49 – 14.9)	16.9 ± 3.6 (10.8 – 26.1)	1.96 ± 0.658 (0.704 – 2.92)	23 ± 9.77 (0 – 36)	10.4 ± 5.28 (2.71 – 23.1)
		Banqiao	2021	0.234 ± 0.0663 (0.153 – 0.400)	23.3 ± 3.69 (15.0 – 30.7)	1.67 ± 0.459 (1.83 – 1.98)	9.83 ± 2.88 (0.833 – 2.62)	2.72 ± 0.832 (0.89 – 3.89)	20.1 ± 3.93 (11.7 – 27.8)
	2020		0.328 ± 0.0622 (0.259 – 0.510)	22.6 ± 3.21 (16.7 – 28.2)	3.24 ± 1.28 (1.38 – 6.5)	13.8 ± 2.09 (10.7 – 18.2)	2.69 ± 0.910 (0.500 – 5.70)	21.4 ± 2.04 (17.0 – 25.1)	8.57 ± 1.41 (5.96 – 12.1)
		2019	0.421 ± 0.107 (0.242 – 0.658)	23.9 ± 8.89 (13.9 – 54.8)	3.71 ± 1.48 (1.42 – 7.35)	16.8 ± 3.80 (8.96 – 24.7)	2.76 ± 0.89 (1.36 – 4.85)	23.8 ± 6.5 (14.4 – 34.4)	13.5 ± 2.86 (8.46 – 19.2)
Xinzhuang	2021		0.254 ± 0.0677 (0.143 – 0.392)	26.0 ± 3.83 (18.9 – 36.4)	1.86 ± 0.621 (1.00 – 3.19)	9.23 ± 2.78 (4.93 – 14.6)	3.22 ± 0.845 (1.72 – 4.74)	18.6 ± 3.76 (9.40 – 25.2)	10.8 ± 2.74 (5.83 – 15.8)
		2020	0.323 ± 0.054 (0.243 – 0.460)	24.0 ± 3.86 (15.1 – 31.5)	3.29 ± 1.25 (1.38 – 5.97)	12.7 ± 2.01 (8.49 – 17.6)	3.46 ± 0.98 (1.38 – 5.17)	24.4 ± 2.6 (20.0 – 30.7)	10.1 ± 1.80 (6.92 – 15.6)
	2019		0.415 ± 0.111 (0.250 – 0.607)	25.9 ± 11.3 (8.20 – 55.9)	4.63 ± 2.54 (1.90 – 11.84)	15.7 ± 3.94 (8.51 – 22.1)	2.98 ± 0.83 (1.94 – 4.36)	16.7 ± 9.75 (0 – 36.5)	11.3 ± 3.10 (5.54 – 17.3)

Table S4. Measurement of the meteorological stations compared the COVID-19 pandemic among the 2021-2019.

Location	Years	Temperature (°C)	Rainfall (mm)	Average Relative humidity (%)	Pressure (HPa)	Rainy days (> 0.1 mm)	Insolation duration (Hours)
June							
Hengchun	2021	28.2	589.5	85	1005	23	140.7
	2020	29.6	80.0	86	1006	10	260.2
	2019	28.9	215.5	84	1004	15	94.5
Taipei	2021	29.3	316.5	74	1003	10	152.4
	2020	30.5	117.9	68	1004	8	150.6
	2019	28.5	419.5	77	1003	16	91.4
Banqiao	2021	29.0	291.5	83	1005	13	179.6
	2020	30.0	108.3	71	1007	6	222.5
	2019	28.1	452.3	76	1005	16	127.9
July							
Hengchun	2021	28.8	402.0	83	1002	18	214.7
	2020	29.8	246.5	85	1006	13	284.2
	2019	28.9	587.5	86	1004	23	87.1
Taipei	2021	30.3	288.0	72	1001	13	217.2
	2020	30.9	133.5	67	1004	9	160.3
	2019	30.3	439.3	73	1002	16	145.5
Banqiao	2021	30.0	421.5	72	1003	15	221.5
	2020	30.4	256.0	70	1006	8	220.5
	2019	29.9	362.7	73	1004	16	195.3

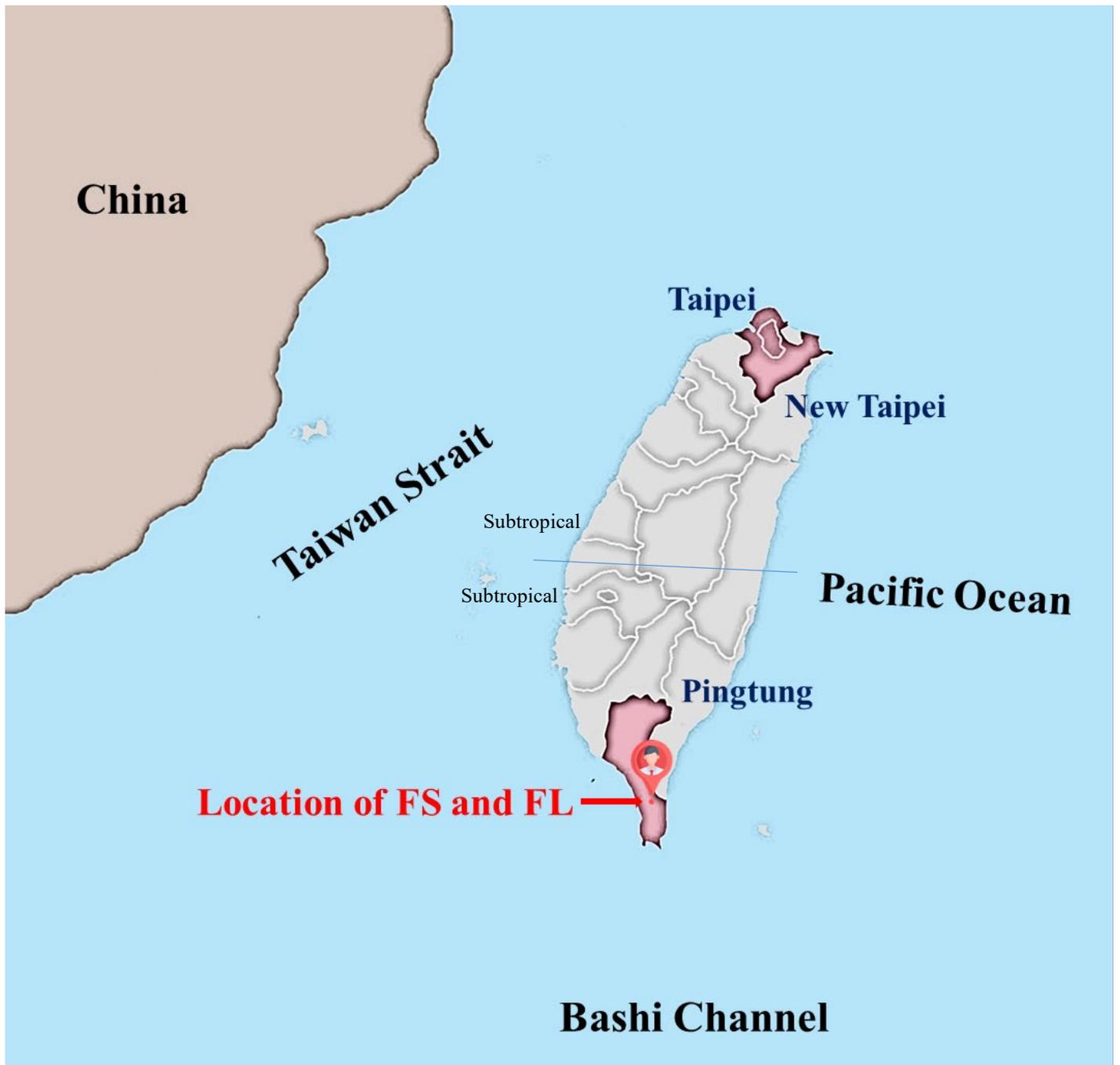


Figure S1. The relative position of Taipei, New Taipei, and Pingtung in Taiwan. The pandemic delta-SARS-CoV-2 began in FS and FL in Pingtung.