

1 **SARS-CoV-2 and other airborne respiratory viruses in**  
2 **outdoor aerosols in three Swiss cities before and during**  
3 **the first wave of the COVID-19 pandemic**

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10  
11 **Abstract**

12 **Caused by the SARS-CoV-2 virus, Coronavirus disease 2019 (COVID-19) has been affecting the**  
13 **world since the end of 2019. While virus-laden particles have been commonly detected and studied**  
14 **in the aerosol samples from indoor healthcare settings, studies are scarce on air surveillance of the**  
15 **virus in outdoor non-healthcare environments, including the correlations between SARS-CoV-2**  
16 **and other respiratory viruses, between viruses and environmental factors, and between viruses and**  
17 **human behavior changes due to the public health measures against COVID-19. Therefore, in this**  
18 **study, we collected airborne particulate matter (PM) samples from November 2019 to April 2020**  
19 **in Bern, Lugano, and Zurich. Among 14 detected viruses, influenza A, HCoV-NL63, HCoV-HKU1,**  
20 **and HCoV-229E were abundant in air. SARS-CoV-2 and enterovirus were moderately common,**  
21 **while the remaining viruses occurred only in low concentrations. SARS-CoV-2 was detected in**  
22 **PM<sub>10</sub> (PM below 10 µm) samples of Bern and Zurich, and PM<sub>2.5</sub> (PM below 2.5 µm) samples of**  
23 **Bern which exhibited a concentration positively correlated with the local COVID-19 case number.**  
24 **The concentration was also correlated with the concentration of enterovirus which raised the**  
25 **concern of coinfection. The estimated COVID-19 infection risks of an hour exposure at these two**  
26 **sites were generally low but still cannot be neglected. Our study demonstrated the potential**  
27 **functionality of outdoor air surveillance of airborne respiratory viruses, especially at**  
28 **transportation hubs and traffic arteries.**

29 **Keywords: SARS-CoV-2, COVID-19, airborne respiratory virus, bioaerosol, air pollution,**  
30 **surveillance**

## Supplementary Tables

Table 1. Primers list of this study

Target virus	Classification	Primer name	Primer sequence (5'-3')	Size(bp)	T <sub>m</sub> (°C) <sup>a</sup>	Reference								
Influenza A	Influenza A	InfA-F	GACCRATCCTGTACCTCTGAC	106	55	[1]								
		InfA-R	AGGGCATTYTGACAAAKCGTCTA											
Influenza B	Influenza B	InfB-F	TCCTCAAYTCACTCTTCGAGCG	102		55	[2]							
		InfB-R	CGGTGCTCTTGACCAAATTGG											
HCoV-NL63	Coronavirus	Cov-NL63-F	GTTCTGATAAGGCACCATATAGG	143			55	[3]						
		Cov-NL63-R	TTTAGGAGGCAAATCAACACG											
HCoV-OC43	Coronavirus	CoV-OC43-F	CATACTCTGACGGTCACAATAATA	100					55	[3]				
		CoV-OC43-R	ACCTTAGCAACAGTCATATAAGC											
HCoV-HKU1	Coronavirus	CoV-HKU1-F	TCCTACTAYTCAAGAAGCTATCC	147							55	[3]		
		CoV-HKU1-R	AATGAACGATTATTGGGTCCAC											
HCoV-229E	Coronavirus	CoV-229E-F	CATACTATCAACCCATTCAACAAG	137	55								[3]	
		CoV-229E--R	CACGGCAACTGTCATGTATT											
SARS-CoV-2	Coronavirus	ORF1ab-F	CCCTGTGGGTTTTACTTAA	129		55								[4]
		ORF1ab-R	ACGATTGTGCATCAGCTGA											
RSVA	RSV	RSVA1-F	AGATCAACTTCTGTCATCCAGCAA	56			60	[5]						
		RSVA1-R	ATTGATACTCCTAATTATGATGTGC											
RSVB	RSV	RSVB1-F	AAGATGCAAATCATAAATTCACAGGA	61				60	[5]					
		RSVB1-R	CACTATAAAGATACTTAAAGATGCTGGATATCA											

Enterovirus	Enterovirus	417EAVs	CATCTCTTGCTTTGCTCCTTAG	134	55	[3]
		418EVAas	AGCCGCACCTTCACATTG			
Rhinovirus	Enterovirus	1039HRVs	GACATGGTGTGAAGATCT	142		
		1037HRVas	ACACGGACACCCAAAGTAGT			
HPIV1	HPIV	1101PIV1s	AAAAACTTAGGGTTAAAGACAATCCA	164		
		1102PIV1as	GCCAGATGTRTGTCYTTCTGCTGGT			
HPIV2	HPIV	231PIV2s	CCATTACCTAAGTGATGGAA	113		
		232PIV2as	CGTGGCATAATCTTCTTTTT			
HPIV3	HPIV	1106PIV3s	CAGGAAGCATTGTRTCATCTGT	154		
		1107PIV3as	ATAGTGTGTAATGCAGCTYGT			
HPIV4	HPIV	264PIV4	CCTGGAGTCCCATCAAAAGT	200		
		1071PIV4as	GCATCTATACGAACRCCTGCT			
HMPV	HMPV	342MPVs	CATGCCCACTATAAAAGGTCAG	170		
		343MPVas	CACCCCAGTCTTTCTTGAAA			

<sup>a</sup> T<sub>m</sub>: melting temperature for PCR and SYBR Green-based qPCR.

Table 2. Viral parameters for risk estimation

Target virus	$\alpha$	N50	Unit of $\alpha$ & N50	Reference of $\alpha$ & N50	$\lambda$	Reference of $\lambda$	copies per PFU <sup>b</sup>	Reference of copies per PFU <sup>b</sup>	TCID50 <sup>a</sup> per PFU <sup>b</sup>	Reference of TCID50 <sup>a</sup> per PFU <sup>b</sup>
Influenza A	0.38841	490325.5	TCID50a	[6]	5.10%	[7]	23044.91	[8-10]	0.695	[11]
Influenza	/	/	/	/	3.20%	[7]	28840.32	[8]	0.7	[12]

B										
HCoV 229E	1.2337	10.805	TCID50a	[13]			30000	[9]	0.7	[12]
SARS	665.14	281.46	PFU <sup>b</sup>	[13]	6.67%	[14-19]	300	[20]	0.7	[12]

<sup>a</sup> TCID50: 50% Tissue Culture Infectious Dose; <sup>b</sup> PFU: Plaque Forming Unit.

Table 3. The P values of Shapiro-Wilk test on different viral abundances of different cities during different time periods

city	time	PM	influe nza A	influe nza B	HCoV- NL63	HCoV- OC43	HCoV- HKU1	HCoV- 229E	Entero virus	Rhino virus	HP IV 1	HP IV 2	HP IV 3	HP IV 4	H MP V	SARS- CoV-2
Bern	All	2.5	0.6029	1.00E-05 ***	0.4419	5.55E-05 ***	0.1793	0.244	5.57E-05 ***	1.16E-05 ***	1.21E-06 ***	0***	1.21E-06 ***	0***	0***	6.13E-05 ***
Lugano	All	2.5	0.4065	0.0002236 **	0.08221	1.07E-05 ***	0.6253	0.0006191 ***	0.0004424 **	1.21E-06 ***	0***	0***	1.21E-06 ***	1.21E-06 ***	0.00071	0***
Zurich	All	2.5	0.4822	0.0001049 **	0.929	1.21E-06 ***	0.08476	0.002751 ***	1.04E-05 ***	1.02E-05 ***	0***	1.21E-06 ***	1.02E-05 ***	1.21E-06 ***	1.16E-05 ***	0***
Bern	All	10	0.8997	1.30E-05 ***	0.96	0***	0.0005875 ***	0.001356 **	0.0003849 *	0***	0***	0***	0***	1.21E-06 ***	1.13E-05 ***	0.02083 *
Lugano	All	10	0.03711 *	1.21E-06 ***	0.4865	1.21E-06 ***	0.4681	0.7937	1.21E-06 ***	1.21E-06 ***	0***	0***	1.38E-05 ***	0.00040	0***	1.08E-05 ***
Zurich	All	10	0.3521	0.0006612 **	0.4255	0***	0.9998	0.0005499 ***	0.000811 ***	1.11E-05 ***	0***	0***	0***	0***	1.21E-06 ***	0.4831
Bern	Before the outbreak	2.5	0.4632	0***	0.4535	4.14E-06 ***	0.6671	0.8346	0.0004199 *	0.0004566 **	4.14E-06 ***	0***	0***	0***	0***	0***

Lugano	Before the outbreak	2.5	0.7454	0.0006417** *	0.258	0***	0.4595	0.02275*	0.003697**	0***	0***	0***	4.14E-06	4.14E-06	0.00978**	0***
Zurich	Before the outbreak	2.5	0.9518	0.001059**	0.732	4.14E-06***	0.4489	0.9291	0.0003321** *	4.14E-06***	0***	4.14E-06***	4.14E-06***	0***	4.14E-06***	0***
Bern	Before the outbreak	10	0.6149	4.14E-06***	0.6273	0***	0.02903*	0.02931*	0.0007818** *	0***	0***	0***	0***	0***	4.14E-06***	0.117
Lugano	Before the outbreak	10	0.3063	0***	0.2759	0***	0.3483	0.09701	0***	4.14E-06***	0***	0***	4.14E-06	0.00340** 3	0***	0.0003663***
Zurich	Before the outbreak	10	0.3688	0.002867**	0.7027	0***	0.9873	5.49E-05***	0.01141*	0.0004037** *	0***	0***	0***	0***	0***	0.7508
Bern	During the outbreak	2.5	0.6931	0.007058**	0.9446	0.008731**	0.3796	0.7823	0.000131***	0***	0***	0***	0.000131***	0***	0***	0.02807*
Lugano	During the outbreak	2.5	0.6357	0.007561**	0.7703	0.009401**	0.409	0.1993	0.01105*	0.000131** *	0***	0***	0***	0***	0.00265** 7	0***
Zurich	During the outbreak	2.5	0.336	0.000131***	0.6018	0***	0.1494	0.02353*	0***	0.000131** *	0***	0***	0.000131***	0.000131***	0.000131***	0***
Bern	During the outbreak	10	0.8754	0.000131***	0.3817	0***	0.8507	0.0007339***	0.01402*	0***	0***	0***	0***	0.000131***	0.000131***	0.2146
Lugano	During the outbreak	10	0.8299	0.000131***	0.6221	0.000131***	0.5943	0.6857	0.000131***	0***	0***	0***	0.000131***	0.0094**	0***	0***
Zurich	During the outbreak	10	0.8285	0.01123* *	0.2424	0***	0.8864	0***	0.0004411** *	0***	0.000131***	0***	0***	0***	0.000131***	0.2306
Bern	Before the lockdown	2.5	0.8783	3.22E-07***	0.5609	3.22E-07***	0.1868	0.5878	0.0002499** *	2.46E-05***	3.22E-07***	0***	0***	0***	0***	3.22E-07***
Lugano	Before the lockdown	2.5	0.4375	0.0003679** *	0.7127	0***	0.4453	0.004384**	0.0003015** *	0***	0***	0***	3.22E-07***	3.22E-07***	0.00264** 5	0***

Zurich	Before the lockdown	2.5	0.5959	4.34E-05***	0.7462	3.22E-07***	0.8296	0.945	1.94E-05***	3.22E-07***	0***	3.22E-07***	3.22E-07***	-	3.22E-07***	0***
Bern	Before the lockdown	10	0.5541	3.22E-07***	0.7847	0***	0.002127**	0.004739**	4.98E-05***	0***	0***	0***	0***	0***	3.22E-07***	0.08695
Lugano	Before the lockdown	10	0.02335	3.22E-07***	0.4392	3.22E-07***	0.5742	0.1276	0***	3.22E-07***	0***	0***	3.74E-05***	0.0002845***	0***	2.09E-05***
Zurich	Before the lockdown	10	0.7655	0.0002499***	0.5254	0***	0.9453	0.0005753***	0.003315**	2.24E-05***	3.22E-07***	0***	0***	0***	0***	0.2742
Bern	After the lockdown	2.5	0.7654	< 2.2E-16***	0.5891	0.06488	0.2176	0.4454	0***	0***	0***	0***	< 2.2E-16***	0***	0***	0.2361
Lugano	After the lockdown	2.5	0.6269	< 2.2E-16***	0.7895	0.08186	0.09639	0.1493	0.1207	< 2.2E-16***	0***	0***	0***	0***	0.4379	0***
Zurich	After the lockdown	2.5	0.744	< 2.2E-16***	0.3012	0***	0.2272	< 2.2E-16***	0***	< 2.2E-16***	0***	0***	< 2.2E-16***	< 2.2E-16***	< 2.2E-16***	0***
Bern	After the lockdown	10	0.1671	< 2.2E-16***	0.1689	0***	0.6754	0.07263	< 2.2E-16***	0***	0***	0***	0***	< 2.2E-16***	< 2.2E-16***	0.02188*
Lugano	After the lockdown	10	0.8287	0***	0.3374	0***	0.9513	0.716	< 2.2E-16***	0***	0***	0***	0***	0.08184	0***	0***
Zurich	After the lockdown	10	0.498	0.1246	0.2275	0***	0.8774	0***	0.5637	0***	0***	0***	0***	0***	< 2.2E-16***	0.5536
Bern	During semesters	2.5	0.8468	2.07E-05***	0.6203	2.07E-05***	0.8354	0.7334	0.008712**	0.00245**	2.07E-05***	0***	0***	0***	0***	2.07E-05***
Bern	During semesters	10	0.5512	0***	0.4276	0***	0.0524	0.01376*	0.0002939***	0***	0***	0***	0***	0***	0***	0.3968
Bern	During the semester before the outbreak	2.5	0.8328	0***	0.5634	0.001241**	0.7476	0.9569	0.05075	0.05851	0.001241**	0***	0***	0***	0***	0***

Bern	During the semester before the outbreak	10	0.6395	0***	0.3003	0***	0.5527	0.08235	0.01693	0***	0***	0***	0***	0***	0***	0.8989
Bern	During the vacation	2.5	0.6905	0***	0.6556	0***	0.2596	0.3614	0***	0***	0***	0***	0***	0***	0***	0***
Bern	During the vacation	10	0.7954	< 2.2E-16***	0.1282	0***	0.3737	0.7313	0.5396	0***	0***	0***	0***	0***	< 2.2E-16***	0.1024
Bern	During the vacation and after the lockdown	2.5	0.3502	2.07E-05***	0.6577	0.001733**	0.2278	0.3906	0***	0***	0***	0***	0***	0***	0***	0.003032**
Bern	During the vacation and after the lockdown	10	0.9732	0.003879**	0.9132	0***	0.6465	0.02669*	0.01932*	0***	0***	0***	2.07E-05***	2.07E-05***	0.00226**	0.09709
Lugano	During semesters	2.5	0.8464	0.002949**	0.3797	2.07E-05***	0.1734	0.02182*	2.07E-05***	0***	0***	0***	0***	2.07E-05***	0.002168**	0***
Lugano	During semesters	10	0.01969*	2.07E-05***	0.4588	0***	0.4358	0.01087*	0***	0***	0***	0***	0.004894**	0***	0***	2.07E-05***
Lugano	During the semester before the outbreak	2.5	0.8296	0.001241	0.7156	0***	0.09189	0.1688	0.001241**	0***	0***	0***	0***	0.001241**	0.001241**	0***
Lugano	During the semester before the outbreak	10	0.2707	0***	0.2771	0***	0.8729	0.4485	0***	0***	0***	0***	0.001241	0***	0***	0.001241**
Lugano	During the vacation	2.5	0.8745	< 2.2E-16***	0.2476	0***	0.4902	0.3236	0.2213	0***	0***	0***	0***	0***	0.946	0***

Lugano	During the vacation	10	0.3173	0***	2.07E-05***	0***	0.8482	0.5707	0***	< 2.2E-16***	0***	0***	0***	< 2.2E-16***	0***	< 2.2E-16***
Lugano	During the vacation and after the lockdown	2.5	0.442	0.002066**	0.3381	0***	0.5196	0.0015**	0.008225**	2.07E-05***	0***	0***	0***	0***	0.4424	0***
Lugano	During the vacation and after the lockdown	10	0.07977	0***	0.3819	0.001843	0.4767	0.2679	2.07E-05***	2.07E-05***	0***	0***	0***	0.01045*	0***	2.07E-05***
Zurich	During semesters	2.5	0.9063	0.006817**	0.5081	2.07E-05***	0.5067	0.9979	2.07E-05***	0***	0***	2.07E-05***	0***	0***	0***	0***
Zurich	During semesters	10	0.7179	0.008736**	0.6947	0***	0.3366	0.004809	0.01745*	0***	0***	2.07E-05***	0***	0***	0***	0.09721
Zurich	During the semester before the outbreak	2.5	0.9702	0.2425	0.985	0.001241**	0.2249	0.9213	0.001241**	0***	0***	0.001241**	0***	0***	0***	0***
Zurich	During the semester before the outbreak	10	0.2687	0.01059*	0.8494	0***	0.9341	0.395	0.06889	0***	0***	0***	0***	0***	0***	0.3915
Zurich	During the vacation	2.5	0.1948	0***	0.3194	0***	0.9115	0.5735	< 2.2E-16***	< 2.2E-16***	0***	0***	< 2.2E-16***	0***	< 2.2E-16***	< 2.2E-17***
Zurich	During the vacation	10	0.0004639***	0***	0.2139	0***	0.5491	0.1346	< 2.2E-16***	0.1218	0***	0***	0***	0***	0***	0.9895
Zurich	During the vacation and after the lockdown	2.5	0.741	2.07E-05***	0.2662	0***	0.06451	0.01593*	2.07E-05***	0.001563***	0***	0***	0.001571**	2.07E-05***	0.002481**	0.002481**



Zurich	During the vacation and after the lockdown	10	0.00226**	0.00214**	0.1792	0***	0.09527	0.002213**	0.009149**	0.00212**	0***	0***	0***	0***	2.07E-05***	0.2695
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\*: P<0.05; \*\*: P<0.01; \*\*\*: P<0.001.

Table 4. The average of different viral abundances and P values of post-hoc analysis of Friedman test on them (Friedman chi-squared = 581.52, df = 13, p-value < 2.2e-16\*\*\*)

	Entero virus	HCoV-229E	HCoV-HKU1	HCoV-NL63	HCoV-OC43	HMPV	HPIV1	HPIV2	HPIV3	HPIV4	influenza A	influenza B	Rhinovirus	SARS-CoV-2
Average	1.155723	3.418171	1.657353	3.06306	0.327067	0.065831	0.031146	0.214062	0.365354	0.493949	2.5603	0.705678	0.291623	1.022463
HCoV-229E	0.8799													
HCoV-HKU1	2.00E-13***	1.80E-08***	-	-	-	-	-	-	-	-	-	-	-	-
HCoV-NL63	4.80E-09***	0.00016***	0.9482	-	-	-	-	-	-	-	-	-	-	-
HCoV-OC43	0.06333	3.50E-05***	< 2e-16***	1.40E-13***	-	-	-	-	-	-	-	-	-	-
HMPV	0.1696	0.00021***	6.80E-14***	1.20E-13***	1	-	-	-	-	-	-	-	-	-
HPIV1	0.00232**	2.10E-07***	< 2e-16***	1.30E-13***	0.9998	0.9929	-	-	-	-	-	-	-	-
HPIV2	0.00145**	1.10E-07***	< 2e-16***	1.40E-13***	0.9992	0.9848	1	-	-	-	-	-	-	-
HPIV3	0.01693**	4.10E-06***	< 2e-16***	1.10E-13***	1	0.9999	1	1	-	-	-	-	-	-
HPIV4	0.1153	0.0001***	2.80E-14***	1.00E-13***	1	1	0.9979	0.9948	1	-	-	-	-	-
influenza A	0.00112**	0.3667	0.01053**	0.62137	2.20E-12***	3.30E-11***	1.30E-13***	1.20E-13***	2.70E-13***	1.10E-11***	-	-	-	-
influenza B	0.7793	0.01177**	1.40E-13***	1.30E-13***	0.9912	0.9997	0.6287	0.5468	0.9188	0.9984	2.20E-08***	-	-	-
Rhinovirus	0.04953*	2.30E-05***	< 2e-16***	1.20E-13***	1	1	0.9999	0.9997	1	1	1.20E-12***	0.9848	-	-

SARS-  
CoV-2

0.9999      0.4361      1.10E-13\*\*\*      4.40E-11\*\*\*      0.3339      0.5917      0.02948\*\*      0.02021\*\*      0.1351      0.4798      4.60E-05\*\*\*      0.9898      0.2849

\*: P<0.05; \*\*: P<0.01; \*\*\*: P<0.001.

Table 5. The average of viral abundances in different PM and cities and their P values of paired T test or Randomization test, and post-hoc analysis of Friedman test on them

		Bern	Lugano	Zurich	Friedman test	P value post-hoc analysis of Friedman test		
						between Bern and Lugano	between Bern and Zurich	between Lugano and Zurich
Influenza A	P value							
	PM2.5	2.315968	3.304902	3.243323	8.84E-05***	0.00013***	0.00313**	0.69278
	PM10	1.974187	2.139601	2.383821	0.004828**	0.2317	0.0031**	0.2317
	paired T test	0.006769**	-	3.12E-06***	-	-	-	-
	paired Randomization test	-	7.00E-04***	-	-	-	-	-
Influenza B	P value							
	PM2.5	0.5659977	1.035394	0.7934723	0.7376	0.87	0.99	0.91
	PM10	0.430493	0.3187717	1.089942	0.2444	0.91	0.75	0.5
	paired Randomization test	0.7496	0.2527	0.6302	-	-	-	-
HCoV-NL63	P value							
	PM2.5	3.13066	3.416032	3.294861	0.3385	0.33	0.91	0.56
	PM10	2.656905	2.900023	2.979881	0.02778*	0.232	0.022*	0.564

	P value	paired T test	0.003571**	0.004107**	0.004004**	-	-	-	-
HCoV-OC43		PM2.5	0.8723385	0.2646062	0.2538026	0.4493	0.81	0.81	1
		PM10	0	0.5716539	0	0.1353	0.81	1	0.81
	P value	paired Randomization test	0.2497	0.4987	1	-	-	-	-
HCoV-HKU1		PM2.5	3.295556	3.759511	3.781532	0.0004307***	0.0062**	0.0007***	0.8134
		PM10	3.2456	3.171228	3.255597	0.1054	1	0.16	0.16
	P value	paired Randomization test	0.7372	-	-	-	-	-	-
HCoV-229E		PM2.5	1.870468	1.531872	1.620951	0.2636	0.69	0.69	0.23
		PM10	1.401285	2.347188	1.172357	0.0004063	0.001	0.9122	0.0044
	P value	paired Randomization test	0.1873	0***	0.2159	-	-	-	-
Enterovirus		PM2.5	0.6761924	1.114479	0.3526199	0.4095	0.87	0.87	0.56
		PM10	2.343837	0.2632303	2.18398	0.005028**	0.022*	0.994	0.029*
	P value	paired Randomization test	0.0104*	0.0623	0.009**	-	-	-	-
Rhinovirus		PM2.5	0.3958501	0.2435959	0.4426857	0.926	0.98	0.99	0.99
		PM10	0	0.2139692	0.4536341	0.1561	0.98	0.75	0.87

	p value	paired Randomization test	0.498	0.4965	0.8677	-	-	-	-
HPIV1		PM2.5	0.1955926	0	0	0.3679	0.95	0.95	1
		PM10	0	0	0.199395	0.3679	1	0.95	0.95
	p value	paired Randomization test	1	2	1	-	-	-	-
HPIV2		PM2.5	0	0	0.1868781	0.3679	1	0.95	0.95
		PM10	0	0	0	NA	1	1	1
	p value	paired Randomization test	2	2	1	-	-	-	-
HPIV3		PM2.5	0	0.2162443	0.4374321	0.3679	0.95	0.81	0.95
		PM10	0.2475997	0.3830936	0	0.3679	0.95	0.95	0.81
	p value	paired Randomization test	1	0.7524	0.4949	-	-	-	-
HPIV4		PM2.5	0	0.2442832	0.2499287	0.6065	0.95	0.95	1
		PM10	0.2525512	1.445361	0	0.008652**	0.33	0.98	0.23
	p value	paired Randomization test	1	0.0651	1	-	-	-	-
HMPV		PM2.5	0	2.050006	0.4663806	0.0005322***	0.022*	0.912	0.064
		PM10	0.2875642	0	0.1597438	0.3679	0.81	0.95	0.95

	P value	paired Randomization test	0.5035	0.0073**	0.494	-	-	-	-
SARS-CoV-2		PM2.5	0.4448611	0	0	0.04979*	0.63	0.63	1
		PM10	2.712063	0.2988824	2.678971	0.0001135***	0.00031***	0.91224	0.00151**
	P value	paired Randomization test	8.00E-04***	0.5033	8.00E-04***	-	-	-	-

\*: P<0.05; \*\*: P<0.01; \*\*\*: P<0.001.

Table 6. The Spearman's correlation coefficient (r) of viral co-occurrence in PM2.5

	Influenz a A	Influenz a B	HCoV- NL63	HCoV- OC43	HCoV- HKU1	HCoV- 229E	Enterov irus	Rhinovi rus	HPIV1	HPIV2	HPIV3	HPIV4	HMPV
Influenza B	0.2833												
HCoV- NL63	0.3656*	0.3141*											
HCoV- OC43	-0.02654	0.1424	0.2375										
HCoV- HKU1	0.7315*	0.2406	0.2561	-0.09631									
HCoV- 229E	-0.03992	0.2765	0.2422	0.1011	0.1223								
Enterovirus	-0.05656	0.1957	0.2833	-0.0244	0.1100	-0.04412							
Rhinovirus	-0.1104	-0.03658	0.03125	0.04484	-0.07105	-0.005568	0.2913						
HPIV1	-0.2197	-0.09628	-0.2685	-0.06764	-0.2847	-0.02442	0.2576	0.3923*					
HPIV2	-0.1058	0.2033	-0.1058	-0.06764	0.1058	0.2687	0.1751	-0.06764	-0.02857				

HPIV3	0.1605	-0.1715	0.06120	-0.1205	0.08859	-0.2216	-0.01598	-0.1205	-0.05091	-0.05091			
HPIV4	0.08298	-0.1381	-0.1883	-0.09702	0.002917	-0.3736	-0.1478	-0.09702	-0.04098	-0.04098	0.4023*		
HMPV	0.5245*	0.05186	0.1385	-0.2439	0.4449*	-0.001957	0.2386	-0.03252	-0.1030	-0.1030	-0.1836	0.06054	
SARS-CoV-2	-0.2582	-0.1715	-0.001074	0.5053*	-0.3087	0.1042	-0.1836	-0.1205	-0.05091	-0.05091	-0.09071	-0.07302	-0.18357

\*:  $|r| > 0.3$ .

Table 7. The P value of viral co-occurrence in PM2.5

	Influenz a A	Influenz a B	HCoV- NL63	HCoV- OC43	HCoV- HKU1	HCoV- 229E	Enterov irus	Rhinovi rus	HPIV1	HPIV2	HPIV3	HPIV4	HMPV
Influenza B	9.4084E-02												
HCoV- NL63	2.8490E-02*	6.2106E-02											
HCoV- OC43	8.7790E-01	4.0743E-01	1.6299E-01										
HCoV- HKU1	4.0118E-07***	1.5743E-01	1.3163E-01	5.7634E-01									
HCoV- 229E	8.1718E-01	1.0255E-01	1.5461E-01	5.5749E-01	4.7719E-01								
Enterovirus	7.4320E-01	2.5277E-01	9.4112E-02	8.8771E-01	5.2300E-01	7.9836E-01							
Rhinovirus	5.2142E-01	8.3225E-01	8.5644E-01	7.9511E-01	6.8050E-01	9.7429E-01	8.4707E-02						
HPIV1	1.9801E-01	5.7645E-01	1.1337E-01	6.9507E-01	9.2329E-02	8.8757E-01	1.2937E-01	1.7950E-02*					
HPIV2	5.3927E-01	2.3446E-01	5.3927E-01	6.9507E-01	5.3927E-01	1.1313E-01	3.0691E-01	6.9507E-01	8.6862E-01				
HPIV3	3.4965E-01	3.1712E-01	7.2289E-01	4.8382E-01	6.0741E-01	1.9397E-01	9.2631E-01	4.8382E-01	7.6810E-01	7.6810E-01			
HPIV4	6.3043E-01	4.2189E-01	2.7137E-01	5.7351E-01	9.8653E-01	2.4786E-02*	3.8975E-01	5.7351E-01	8.1243E-01	8.1243E-01	1.5011E-02*		
HMPV	1.0248E-03**	7.6388E-01	4.2037E-01	1.5168E-01	6.5461E-03**	9.9096E-01	1.6110E-01	8.5064E-01	5.4988E-01	5.4988E-01	2.8385E-01	7.2576E-01	

SARS-  
CoV-2

1.2834E-01 3.1712E-01 9.9504E-01 1.6699E-03\*\* 6.6965E-02 5.4524E-01 2.8385E-01 4.8382E-01 7.6810E-01 7.6810E-01 5.9881E-01 6.7215E-01 2.8385E-01

\*: P<0.05; \*\*: P<0.01; \*\*\*: P<0.001.

Table 8. The Spearman's correlation coefficient (r) of viral co-occurrence in PM10

	Influenz a A	Influenz a B	HCoV- NL63	HCoV- OC43	HCoV- HKU1	HCoV- 229E	Enterov irus	Rhinovi rus	HPIV1	HPIV2	HPIV3	HPIV4	HMPV
Influenza B	0.3331*												
HCoV- NL63	0.3709*	0.01397											
HCoV- OC43	0.2764	-0.1283	0.3624*										
HCoV- HKU1	0.3544*	0.08364	0.2180	0.1562									
HCoV- 229E	-0.3281*	-0.06523	-0.05344	0.05815	-0.5033*								
Enterovirus	0.1497	0.08042	0.04306	-0.0001732	0.1901	-0.3547							
Rhinovirus	-0.06550	-0.15933	0.1449	-0.07301	-0.02040	0.2759	-0.1498						
HPIV1	0.1546	-0.08942	0.04068	-0.04098	0.1383	-0.2214	0.2174	-0.05091					
HPIV2	NA	NA	NA	NA	NA	NA	NA	NA	NA				
HPIV3	0.1659	0.3994*	-0.07570	-0.07301	-0.1117	-0.002164	-0.2789	-0.09071	-0.05090	NA			
HPIV4	-0.001189	-0.2353	-0.2512	0.2504	-0.1871	0.2366	-0.4119	-0.1340	-0.07519	NA	0.1120		
HMPV	-0.009127	0.2818	-0.001074	-0.07301	0.003221	-0.1683	0.3036*	-0.09070	-0.05090	NA	-0.09070	-0.1340	
SARS- CoV-2	0.2174	0.2569	-0.06335	-0.3067	0.2049	-0.6294	0.5875*	0.002171	0.1233	NA	-0.006512	-0.4146	0.1612

\*:  $|r| > 0.3$ ; NA: not available.

Table 9. The P value of viral co-occurrence in PM10

	Influenz a A	Influenz a B	HCoV- NL63	HCoV- OC43	HCoV- HKU1	HCoV- 229E	Enterov irus	Rhinovi rus	HPIV1	HPIV2	HPIV3	HPIV4	HMPV
Influenza B	0.04709*												
HCoV- NL63	0.02594*	0.9355											
HCoV- OC43	0.1026	0.45560	0.02986*										
HCoV- HKU1	0.03392*	0.6277	0.2015	0.3629									
HCoV- 229E	0.05070	0.7055	0.7569	0.7362	0.001756**								
Enterovirus	0.3836	0.6410	0.8031	0.9992	0.2667	0.03382*							
Rhinovirus	0.7043	0.3533	0.3989	0.6721	0.9060	0.1033	0.3833						
HPIV1	0.3680	0.6040	0.8138	0.8124	0.4211	0.1944	0.2028	0.7681					
HPIV2	NA	NA	NA	NA	NA	NA	NA	NA	NA				
HPIV3	0.3335	0.01580*	0.6608	0.6721	0.5167	0.9900	0.09952	0.5988	0.7681	NA			
HPIV4	0.9945	0.1671	0.1395	0.1409	0.2744	0.1648	0.01255*	0.4360	0.6630	NA	0.5153		
HMPV	0.9579	0.09592	0.9950	0.6721	0.9851	0.3266	0.07188	0.5988	0.7681	NA	0.5988	0.4360	
SARS- CoV-2	0.2028	0.1303	0.7136	0.068890	0.2306	0.00003913**	0.0001649***	0.9900	0.4735	NA	0.9699	0.011939*	0.3477

\*:  $P < 0.05$ ; \*\*:  $P < 0.01$ ; \*\*\*:  $P < 0.001$ ; NA: not available.

Table 10. The Spearman's correlation coefficient (r) of the co-occurrence of viruses and environmental factors in PM2.5



	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	EC in PM <sub>2.5</sub>	PNC	NMVOC	NO <sub>x</sub>	T	PREC	RAD	New COVID-19 Cases
Influenza A	0.3663*	-0.3498*	0.1078	-0.3644*	-0.1079	0.02368	-0.53967*	-0.3896*	0.1136	-0.5506*	0.5030*	-0.1295	0.2703	0.2566
Influenza B	0.1669	-0.07006	0.1667	-0.04164	0.06997	-0.02065	-0.04806	-0.2263	0.1849	-0.1073	0.2048	-0.01929	0.1337	0.08543
HCoV-NL63	0.2994	-0.2512	0.06174	-0.3350*	0.05628	0.02986	-0.3062*	-0.3983*	0.07600	-0.3423*	0.2574	-0.1458	0.2039	0.1090
HCoV-OC43	0.09716	0.02440	0.07615	0.1565	0.4259*	0.2829	0.1909	-0.1205	0.2231	0.07191	-0.02183	-0.2526	0.08175	0.1618
HCoV-HKU1	0.2214	-0.2262	0.2113	-0.2189	-0.03760	0.1346	-0.4155*	-0.1574	0.09828	-0.4062*	0.2546	-0.1349	0.1264	0.1613
HCoV-229E	0.3517	-0.2377	-0.08976	-0.2726	-0.007350	-0.03232	-0.2151	-0.2975	-0.1744	-0.2471	0.1052	-0.1947	0.3287*	0.1979
Enterovirus	0.01809	0.1512	0.3085*	0.1442	0.03487	0.07497	0.1153	0.06269	0.2588	0.07171	-0.1173	-0.05721	-0.07334	-0.1145
Rhinovirus	0.1853	-0.2204	-0.3071*	-0.2338	-0.1429	-0.2667	-0.1828	0.01664	-0.3678*	-0.1541	0.1395	0.2008	0.08860	-0.01482
HPIV1	-0.05695	0.08949	NA	0.1546	-0.07509	-0.1220	0.2197	0.1958	NA	0.2197	-0.07322	-0.008137	-0.1058	-0.1363
HPIV2	-0.04068	-0.008136	-0.1958	-0.05696	-0.1609	-0.07322	-0.1709	NA	-0.01513	-0.04068	-0.1709	-0.07323	-0.2359	-0.1363
HPIV3	-0.02523	-0.08859	-0.06656	-0.07787	-0.006172	-0.1009	-0.1871	-0.1355	-0.09270	-0.09986	-0.01450	0.02255	-0.006442	0.03058
HPIV4	0.006807	-0.06288	0.03536	-0.02821	-0.05092	-0.1352	-0.1196	-0.01506	-0.1343	-0.1089	0.1037	0.09660	-0.02723	0.1260
HMPV	0.2575	-0.02559	0.5796*	-0.0003261	0.1485	0.3240*	-0.1024	-0.08341	0.4062*	-0.2455	0.2384	-0.2597	0.3014*	0.1948
SARS-CoV-2	0.2529	-0.06335	NA	-0.06525	0.3037*	0.09503	0.1122	-0.3010*	NA	-0.01342	0.08375	-0.1165	0.3012*	0.3358*
O <sub>3</sub>		-0.7411*	-0.1922	-0.7679*	0.1773	-0.08777	-0.6343*	-0.7643*	-0.4875*	-0.8296*	0.7804*	-0.2201	0.8994*	0.8617*
NO <sub>2</sub>			0.6461*	0.8395*	0.08209	0.2939	0.8233*	0.9130*	0.7417*	0.8736*	-0.7477*	-0.1149	-0.5470*	-0.7165*
SO <sub>2</sub>				0.7323*	0.5233*	0.6522*	0.8139*	0.9371*	0.8360*	0.4696*	-0.1339	-0.2805	0.03478	-0.1699
CO					0.3354*	0.5075*	0.8805*	0.8564*	0.8314*	0.8321*	-0.6749*	-0.1086	-0.5649*	-0.6080*
PM <sub>10</sub>						0.8977*	0.4500*	-0.03308	0.24160	0.07319	-0.01758	-0.6426*	0.3028*	0.3434*
PM <sub>2.5</sub>							0.4643*	0.1609	0.4726*	0.1974	-0.2098	-0.6723*	0.1269	0.1002
EC in PM <sub>2.5</sub>								0.8478*	0.8474*	0.8970*	-0.6541*	-0.1019	-0.4095*	-0.4890*
PNC									0.7684*	0.8504*	-0.8348*	-0.2165	-0.6878*	-0.8260*
NMVOC										0.6316*	-0.2407	-0.07776	-0.3389*	-0.4689*
NO <sub>x</sub>											-0.8510*	0.02162	-0.6690*	-0.7433*

T  
PREC  
RAD

0.1169      0.6667\*      0.6940\*  
-0.32707\*      -0.2132  
0.8554\*

\*:  $|r| > 0.3$ ; NA: not available.

Table 11. The P value of the co-occurrence of viruses and environmental factors in PM2.5

	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	EC in PM <sub>2.5</sub>	PNC	NMVO C	NO <sub>x</sub>	T	PREC	RAD	New COVID-19 Cases
Influenza A	2.8012E-02*	3.6496E-02*	6.1602E-01	2.8869E-02*	5.7035E-01	8.9096E-01	6.8166E-04***	5.9875E-02	5.9725E-01	5.0263E-04***	1.7692E-03**	4.5164E-01	1.1089E-01	1.3090E-01
Influenza B	3.3072E-01	6.8472E-01	4.3622E-01	8.0945E-01	7.1332E-01	9.0487E-01	7.8073E-01	2.8757E-01	3.8711E-01	5.3340E-01	2.3092E-01	9.1107E-01	4.3696E-01	6.2032E-01
HCoV-NL63	7.6117E-02	1.3942E-01	7.7443E-01	4.5829E-02*	7.6767E-01	8.6276E-01	6.9332E-02	5.3915E-02	7.2412E-01	4.0975E-02*	1.2963E-01	3.9606E-01	2.3304E-01	5.2703E-01
HCoV-OC43	5.7294E-01	8.8768E-01	7.2359E-01	3.6209E-01	1.8946E-02*	9.4527E-02	2.6471E-01	5.7486E-01	2.9461E-01	6.7685E-01	8.9944E-01	1.3725E-01	6.3550E-01	3.4574E-01
HCoV-HKU1	1.9447E-01	1.8454E-01	3.2161E-01	1.9972E-01	8.4363E-01	4.3375E-01	1.1738E-02*	4.6265E-01	6.4777E-01	1.3969E-02*	1.3405E-01	4.3280E-01	4.6265E-01	3.4738E-01
HCoV-229E	3.5423E-02*	1.6266E-01	6.7660E-01	1.0767E-01	9.6925E-01	8.5154E-01	2.0776E-01	1.5806E-01	4.1495E-01	1.4619E-01	5.4139E-01	2.5505E-01	5.0338E-02	2.4724E-01
Enterovirus	9.1659E-01	3.7856E-01	1.4242E-01	4.0145E-01	8.5487E-01	6.6387E-01	5.0303E-01	7.7106E-01	2.2199E-01	6.7768E-01	4.9549E-01	7.4031E-01	6.7077E-01	5.0610E-01
Rhinovirus	2.7918E-01	1.9640E-01	1.4439E-01	1.7001E-01	4.5133E-01	1.1593E-01	2.8598E-01	9.3849E-01	7.7055E-02	3.6957E-01	4.1699E-01	2.4036E-01	6.0735E-01	9.3164E-01

HPIV1	7.4147E-01	6.0373E-01	NA	3.6791E-01	6.9331E-01	4.7831E-01	1.9798E-01	3.5919E-01	NA	1.9801E-01	6.7128E-01	9.6244E-01	5.3927E-01	4.2800E-01
HPIV2	8.1378E-01	9.6244E-01	3.5919E-01	7.4141E-01	3.9564E-01	6.7128E-01	3.1909E-01	NA	9.4406E-01	8.1378E-01	3.1912E-01	6.7124E-01	1.6596E-01	4.2800E-01
HPIV3	8.8386E-01	6.0741E-01	7.5731E-01	6.5170E-01	9.7418E-01	5.5806E-01	2.7450E-01	5.2769E-01	6.6660E-01	5.6227E-01	9.3313E-01	8.9613E-01	9.7025E-01	8.5947E-01
HPIV4	9.6857E-01	7.1561E-01	8.6972E-01	8.7028E-01	7.8931E-01	4.3188E-01	4.8715E-01	9.4431E-01	5.3143E-01	5.2721E-01	5.4718E-01	5.7515E-01	8.7475E-01	4.6409E-01
HMPV	1.2946E-01	8.8224E-01	2.9932E-03**	9.9849E-01	4.3345E-01	5.3878E-02	5.5248E-01	6.9841E-01	4.8865E-02*	1.4904E-01	1.6137E-01	1.2605E-01	7.4082E-02	2.5498E-01
SARS-CoV-2	1.3675E-01	7.1357E-01	NA	7.0538E-01	1.0273E-01	5.8143E-01	5.1466E-01	1.5288E-01	NA	9.3807E-01	6.2722E-01	4.9857E-01	7.4249E-02	4.5264E-02*
O <sub>3</sub>	2.3554E-07***	3.6832E-01	4.6035E-08***	3.4858E-01	6.1072E-01	3.2692E-05***	1.3735E-05***	1.5689E-02*	4.0163E-10***	1.9892E-08***	1.9708E-01	9.1187E-14***	1.50E-11	
NO <sub>2</sub>		6.4835E-04***	1.5788E-10***	6.6628E-01	8.1835E-02	7.0416E-10***	4.9324E-10***	3.3620E-05***	3.5672E-12***	1.5978E-07***	5.0443E-01	5.5651E-04***	8.88E-07	
SO <sub>2</sub>			4.7320E-05***	1.7893E-02*	5.5353E-04***	1.3124E-06***	6.9932E-06***	3.6475E-07***	2.0610E-02*	5.3274E-01	1.8430E-01	8.7182E-01	4.27E-01	
CO				7.0026E-02	1.5826E-03**	1.4492E-12***	9.3525E-08***	4.8408E-07***	3.1793E-10***	6.3316E-06***	5.2838E-01	3.3166E-04***	8.39E-05	
PM <sub>10</sub>					1.7923E-11***	1.2579E-02*	8.8988E-01	3.0479E-01	7.0070E-01	9.2656E-01	1.2882E-04***	1.0387E-01	6.32E-02	
PM <sub>2.5</sub>						4.3411E-03**	4.5269E-01	1.9697E-02*	2.4844E-01	2.1945E-01	7.1041E-06***	4.6081E-01	5.61E-01	
EC in PM <sub>2.5</sub>							1.6970E-07***	1.7515E-07***	1.3330E-13***	1.5143E-05***	5.5408E-01	1.3121E-02*	2.47E-03	

PNC	3.5018E-03**	1.4211E-07***	3.9327E-07***	3.0952E-01	2.0367E-04***	6.67E-07
NMVOC		9.3246E-04***	2.5729E-01	7.1797E-01	1.0519E-01	2.08E-02
NO <sub>x</sub>			4.9008E-11***	9.0038E-01	8.1824E-06***	2.07E-07
T				4.9724E-01	9.0252E-06***	2.68E-06
PREC					5.1525E-02	2.12E-01
RAD						3.04E-11

\*: P<0.05; \*\*: P<0.01; \*\*\*: P<0.001; NA: not available.

Table 12. The Spearman's correlation coefficient (r) of the co-occurrence of viruses and environmental factors in PM10

	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	EC in PM <sub>2.5</sub>	PNC	NMVOC	NO <sub>x</sub>	T	PREC	RAD	New COVID-19 Cases
Influenza A	0.4085*	-0.5792*	-0.5104*	-0.5539*	-0.1484	-0.2999	-0.6020*	-0.4617*	-0.5940*	-0.5622*	0.4507*	0.0689	0.2281	0.3923*
Influenza B	0.09566	-0.1027	-0.2349	-0.08172	0.2799	0.2912	-0.1546	0.03177	-0.1946	-0.1650	0.01291	-0.4425*	0.05888	0.2021
HCoV-NL63	0.3187*	-0.4077*	-0.1452	-0.3180*	0.03359	-0.03655	-0.4219*	-0.4165*	-0.2953	-0.4541*	0.2402	0.1337	0.1887	0.3724*
HCoV-OC43	0.2924	-0.3744*	-0.004533	-0.2420	0.1625	0.1339	-0.2243	-0.4796*	-0.1129	-0.3744*	0.3164*	0.1002	0.2577	0.3356*
HCoV-HKU1	0.3359*	-0.3699*	-0.3339*	-0.3018*	0.02024	-0.02188	-0.2574	0.05130	-0.5438*	-0.2795	0.2010	-0.0738	0.2613	0.3047*
HCoV-229E	-0.3520*	0.3668*	0.4631*	0.3269*	-0.1220	0.1528	0.09754	0.06701	0.6730*	0.1551	-0.1821	0.0006486	-0.3870*	-0.4511*
Enterovirus	0.1387	-0.2517	-0.5549*	-0.2892	-0.0630	-0.2960	-0.1157	-0.07427	-0.5594*	-0.009905	-0.0146	0.1409	0.0652	0.1370
Rhinovirus	-0.1911	0.2738	0.1740	0.2100	NA	0.09342	0.06067	0.3464*	0.1185	0.1772	-0.3925*	-0.2795	-0.1133	-0.2428
HPIV1	0.1220	-0.2197	-0.2560	-0.2848	-0.3111*	-0.2847	-0.2848	NA	-0.2875	-0.2197	0.1383	0.1546	0.05695	0.1000
HPIV2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HPIV3	0.03436	0.04671	0.2847	0.1332	0.2209	0.1836	0.09342	-0.1467	0.2755	-0.0467	0.1063	-0.05692	0.04725	0.1319

HPIV4	0.1822	-0.1897	0.3233*	-0.07882	0.1573	0.1584	-0.1479	-0.4001*	0.3081*	-0.2849	0.4250*	-0.1121	0.1762	0.1776
HMPV	0.07731	-0.04778	-0.1054	0.03088	0.1877	0.05745	0.006443	-0.01723	-0.3177*	-0.0387	0.03436	-0.07598	0.2056	0.1925
SARS-CoV-2	0.1207	-0.1698	-0.6990*	-0.2286	0.06201	-0.1904	-0.09000	0.1209	-0.7265*	0.04111	-0.1852	-0.09400	0.08950	0.1850
O <sub>3</sub>		-0.7411*	-0.1922	-0.7679*	0.1773	-0.08777	-0.6343*	-0.7643*	-0.4874*	-0.8296*	0.7804*	-0.2201	0.8994*	0.8617*
NO <sub>2</sub>			0.6461*	0.8395*	0.08209	0.2940	0.8233*	0.9130*	0.7417*	0.8736*	-0.7477*	-0.1149	-0.5470*	-0.7165*
SO <sub>2</sub>				0.7323*	0.5233*	0.6522*	0.8139*	0.9371*	0.8360*	0.4696*	-0.1339	-0.2805	0.03478	-0.1699
CO					0.3354*	0.5075*	0.8805*	0.8564*	0.8314*	0.8321*	-0.6749*	-0.1086	-0.5649*	-0.6080*
PM <sub>10</sub>						0.8977*	0.4501*	-0.0331	0.2416	0.0732	-0.01758	-0.6426*	0.3028*	0.3434*
PM <sub>2.5</sub>							0.4643*	0.1609	0.4726*	0.1974	-0.2098	-0.6723*	0.1269	0.1002
EC in PM <sub>2.5</sub>								0.8478*	0.8474*	0.8970*	-0.6541*	-0.1020	-0.4096*	-0.4890*
PNC									0.7684*	0.8504*	-0.8348*	-0.2165	-0.6878*	-0.8260*
NMVOC										0.6316*	-0.2407	-0.07776	-0.3389*	-0.4689*
NO <sub>x</sub>											-0.8510*	0.02162	-0.6690*	-0.7433*
T												0.1169	0.6667*	0.6940*
PREC													-0.3271*	-0.2132
RAD														0.8554*

\*:  $|r| > 0.3$ ; NA: not available.

Table 13. The P value of the co-occurrence of viruses and environmental factors in PM10

	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	CO	PM <sub>10</sub>	PM <sub>2.5</sub>	EC in PM <sub>2.5</sub>	PNC	NMVO C	NO <sub>x</sub>	T	PREC	RAD	New COVID-19 Cases
Influenza A	1.3382E-02*	2.1487E-04***	1.0817E-02*	4.5663E-04***	4.3388E-01	7.5589E-02	1.0279E-04***	2.3124E-02*	2.2091E-03**	3.5947E-04***	5.8047E-03**	6.8984E-01	1.8098E-01	1.7968E-02*

Influenza B	5.7889E-01	5.5101E-01	2.6920E-01	6.3565E-01	1.3405E-01	8.4829E-02	3.6810E-01	8.8285E-01	3.6208E-01	3.3627E-01	9.4044E-01	6.8868E-03**	7.3301E-01	2.3710E-01
HCoV-NL63	5.8198E-02	1.3575E-02*	4.9838E-01	5.8775E-02	8.6012E-01	8.3239E-01	1.0377E-02*	4.2901E-02*	1.6129E-01	5.4084E-03**	1.5830E-01	4.3680E-01	2.7045E-01	2.5293E-02*
HCoV-OC43	8.3572E-02	2.4483E-02*	9.8323E-01	1.5498E-01	3.9084E-01	4.3635E-01	1.8844E-01	1.7719E-02*	5.9930E-01	2.4483E-02*	6.0145E-02	5.6106E-01	1.2919E-01	4.5404E-02*
HCoV-HKU1	4.5184E-02*	2.6392E-02*	1.1079E-01	7.3686E-02	9.1544E-01	8.9921E-01	1.2960E-01	8.1182E-01	6.0200E-03**	9.8712E-02	2.3973E-01	6.6902E-01	1.2378E-01	7.0745E-02
HCoV-229E	3.5247E-02*	2.7770E-02*	2.2669E-02*	5.1620E-02	5.2074E-01	3.7366E-01	5.7142E-01	7.5570E-01	3.1387E-04***	3.6631E-01	2.8778E-01	9.9700E-01	1.9700E-02*	5.7563E-03**
Enterovirus	4.1994E-01	1.3858E-01	4.8908E-03**	8.7093E-02	7.4081E-01	7.9590E-02	5.0161E-01	7.3016E-01	4.4804E-03**	9.5428E-01	9.3273E-01	4.1246E-01	7.0556E-01	4.2569E-01
Rhinovirus	2.6415E-01	1.0611E-01	4.1623E-01	2.1902E-01	NA	5.8788E-01	7.2521E-01	9.7264E-02	5.8119E-01	3.0127E-01	1.7907E-02*	9.8779E-02	5.1065E-01	1.5354E-01
HPIV1	4.7831E-01	1.9801E-01	2.2718E-01	9.2242E-02	9.4269E-02	9.2329E-02	9.2307E-02	NA	1.7315E-01	1.9801E-01	4.2115E-01	3.6797E-01	7.4147E-01	5.6192E-01
HPIV2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HPIV3	8.4231E-01	7.8677E-01	1.7759E-01	4.3873E-01	2.4085E-01	2.8374E-01	5.8786E-01	4.9385E-01	1.9257E-01	7.8677E-01	5.3720E-01	7.4161E-01	7.8438E-01	4.4312E-01
HPIV4	2.8759E-01	2.6777E-01	1.2337E-01	6.4772E-01	4.0655E-01	3.5619E-01	3.8935E-01	5.2729E-02	1.4296E-01	9.2188E-02	9.7681E-03**	5.1503E-01	3.0388E-01	3.0018E-01
HMPV	6.5403E-01	7.8198E-01	6.2393E-01	8.5811E-01	3.2051E-01	7.3929E-01	9.7025E-01	9.3633E-01	1.3027E-01	8.2289E-01	8.4231E-01	6.5963E-01	2.2893E-01	2.6073E-01
SARS-CoV-2	4.8309E-01	3.2224E-01	1.4457E-04***	1.7999E-01	7.4477E-01	2.6588E-01	6.0156E-01	5.7348E-01	5.8230E-05***	8.1185E-01	2.7941E-01	5.8554E-01	6.0369E-01	2.7998E-01

O <sub>3</sub>	2.3554E-07***	3.6832E-01	4.6035E-08***	3.4858E-01	6.1072E-01	3.2692E-05***	1.3735E-05***	1.5689E-02**	4.0163E-10***	1.9892E-08***	1.9708E-01	9.1187E-14***	1.4951E-11***
NO <sub>2</sub>		6.4835E-04***	1.5788E-10***	6.6628E-01	8.1835E-02	7.0416E-10***	4.9324E-10***	3.3620E-05***	3.5672E-12***	1.5978E-07***	5.0443E-01	5.5651E-04***	8.8769E-07***
SO <sub>2</sub>			4.7320E-05***	1.7893E-02*	5.5353E-04***	1.3124E-06***	6.9932E-06***	3.6475E-07***	2.0610E-02**	5.3274E-01	1.8430E-01	8.7182E-01	4.2736E-01
CO				7.0026E-02	1.5826E-03**	1.4492E-12***	9.3525E-08***	4.8408E-07***	3.1793E-10***	6.3316E-06***	5.2838E-01	3.3166E-04***	8.3886E-05***
PM <sub>10</sub>					1.7923E-11***	1.2579E-02*	8.8988E-01	3.0479E-01	7.0070E-01	9.2656E-01	1.2882E-04***	1.0387E-01	6.3192E-02
PM <sub>2.5</sub>						4.3411E-03**	4.5269E-01	1.9697E-02*	2.4844E-01	2.1945E-01	7.1041E-06***	4.6081E-01	5.6099E-01
EC in PM <sub>2.5</sub>							1.6970E-07***	1.7515E-07***	1.3330E-13***	1.5143E-05***	5.5408E-01	1.3121E-02*	2.4727E-03**
PNC								3.5018E-03**	1.4211E-07***	3.9327E-07***	3.0952E-01	2.0367E-04***	6.6719E-07***
NMVOC									9.3246E-04***	2.5729E-01	7.1797E-01	1.0519E-01	2.0815E-02*
NO <sub>x</sub>										4.9008E-11***	9.0038E-01	8.1824E-06***	2.0726E-07***
T											4.9724E-01	9.0252E-06***	2.6832E-06***
PREC												5.1525E-02	2.1187E-01
RAD													3.0389E-11***

\*: P<0.05; \*\*: P<0.01; \*\*\*: P<0.001; NA: not available.

# Supplementary Figure

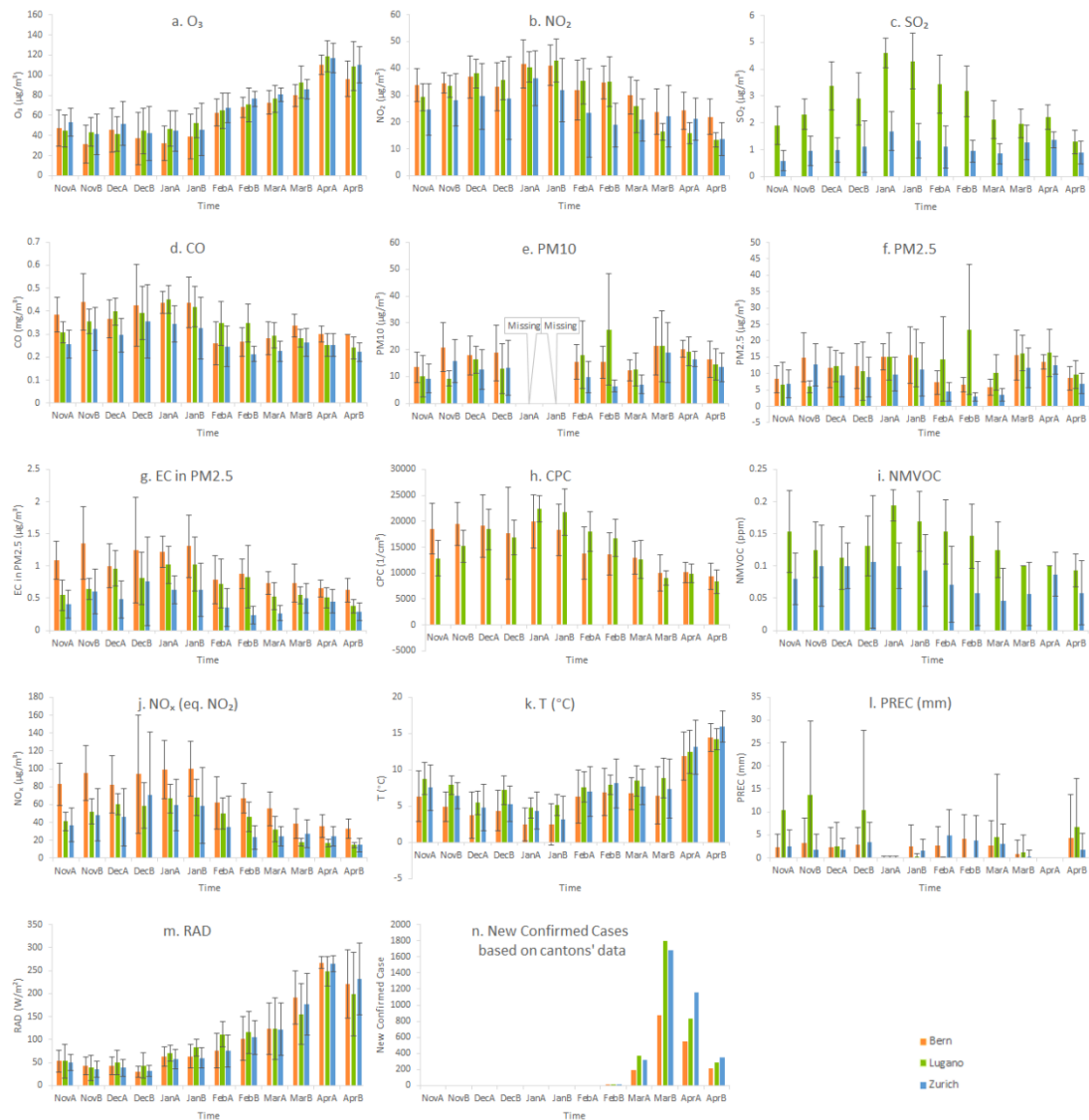


Fig. 1 The temporal variations of air environmental factors in three cities

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