
Multiple Sequence Alignment of SARS-CoV-2 genes

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Coronaviruses (CoVs) are named after the crown-like spikes present on their surface. The coronaviruses that affect humans were first identified in the 1960s. The human coronaviruses identified so far are: **SARS-CoV** (Severe Acute Respiratory Syndrome Coronavirus); **NL63** (Human Coronavirus NL63 Amsterdam 1); **OC43** (Organ Culture 43); 229E (Human Coronavirus 229E); **MERS-CoV** (Middle East Respiratory Syndrome Coronavirus); and the novel coronavirus, **COVID-19** (Coronavirus Disease 2019) (1). People around the globe typically get infected with human coronaviruses NL63, OC43, and 229E. However, as is in the case of SARS-CoV, MERS-CoV, and COVID-19 some viruses that only affect animals can evolve to infect humans. (2)

This assignment is to discover similar genes within the novel coronavirus. SARS-CoV-2 (Severe acute respiratory syndrome coronavirus 2) protein sequences were downloaded from NCBI GenBank database at <https://www.ncbi.nlm.nih.gov/genbank/sars-cov-2-seqs/>. This work includes the following SARS-CoV-2: E, M, N, ORF1AB, ORF3, ORF8, and S. Protein sequences were collected from different places and different times, as detailed in Table S1.

Sequences were grouped by protein and then inputted to three Multiple Sequence Alignment tools (Clustal Omega, MUSCLE, and webPRANK) available in the European Bioinformatics Institute (EBI) website <https://www.ebi.ac.uk/services>. Subsequently, the alignment tool output was processed with MView (also available in EBI's website) to better visualize the sequences and calculate the percentage coverage (Equation (1)) and percentage identity (Equation (2)) of each sequence. MView calculates percent coverage and percent identity of every sequence with respect to a reference sequence (by default the first row of a sequence alignment). For more information visit the MView API documentation at <https://desmid.github.io/mview/index.html>.

$$cov = \frac{\text{number of residues in row aligned with reference row}}{\text{length of ungapped reference row}} \times 100 \quad (1)$$

$$pib = \frac{\text{number of identical residues}}{\text{length of ungapped reference row over align region}} \times 100 \quad (2)$$

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From the resulted alignments, general similarities between the sequences were discovered. Even though the sampled sequences came from different locations and times, the founded similarities are expected since the aligned sequences correspond to the same gene and the early discovery of SARS-CoV-2 hence the time gap is only of approximately three months.

In order to verify the well functionality of the EBI's tools, Middle East Respiratory Syndrome Coronavirus genes (MERS) were added to each sequence set with the expectation of finding differences. Figure 1 and Figure 2 summarize the sequence alignments.

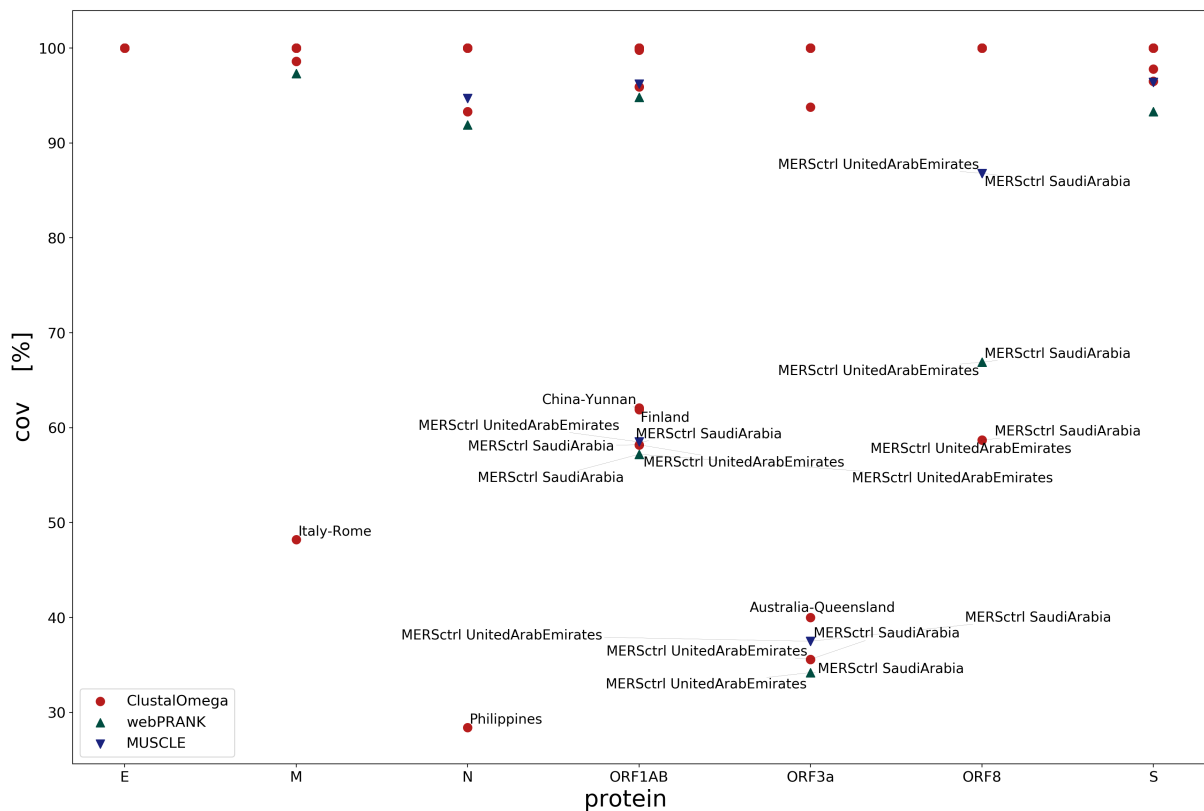


FIGURE 1

cov values calculated with MView for all sequences of each protein sequence, using China's Dec2019 sequence as reference with Equation (1).

As detailed in Figure 1, the MERS sequences have a low percentage coverage in relation to the SARS-CoV-2 sequences with in about 60% values. Some other SARS-CoV-2 sequences share low percentage values with the MERS sequences, following are some explanations:

- The EBI's database stores a short sequence of M_Italy-Rome_Jan2020, for that reason the alignment added a sequence of gaps in order to match the alignment. M_Italy-Rome_Jan2020 covers a small fragment of the hole sequence, hence the small cover-

age value. Similar cases apply for N_Philippines_2020Jan23, N_Philippines_2020Jan26, N_Philippines_2020Feb06, and ORF3a_Australia-Queensland_Feb2020

- ORF1a_Finland_29Jan2020, and ORF1a_China-Yunnan_17Jan2020 were expected to have a low coverage as the reference sequence assess protein ORF1ab (not ORF1a). They were added to confirm the difference and discard a possible typo mistake.

In summary, the *cov* parameter describes how many 'gaps' are added to the alignment to achieve a better fit.

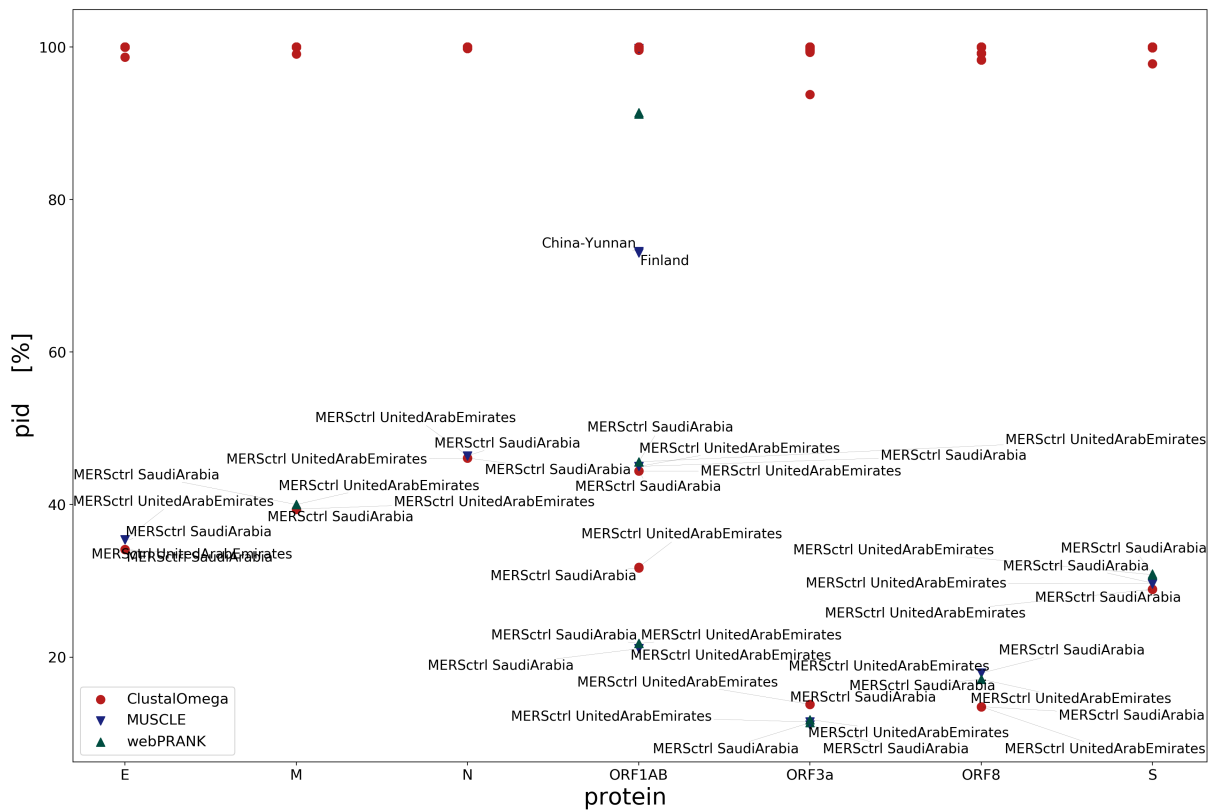


FIGURE 2

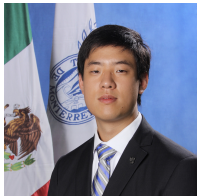
pid values calculated with MView for all sequences of each protein sequence, using China's Dec2019 sequence as reference with Equation (2).

Figure 2 plots the *pid* calculations. As expected, only the MERS sequences have low identification values (confirming that they are different from the SARS-CoV-2). ORF1a_Finland_29Jan2020, and ORF1a_China-Yunnan_17Jan2020 also share a low *pid*, further explaining Figure 1's conclusion.

References

- [1] Mark J.G. Bakkers, Yifei Lang, Louris J. Feitsma, Ruben J.G. Hulswit, Stefanie A.H. de Poot, Arno L.W. van Vliet, Irina Margine, Jolanda D.F. de Groot-Mijnes, Frank J.M. van Kuppeveld, Martijn A. Langereis, Eric G. Huizinga, and Raoul J. de Groot. Betacoronavirus Adaptation to Humans Involved Progressive Loss of Hemagglutinin-Esterase Lectin Activity. *Cell Host & Microbe*, 21(3):356–366, mar 2017. 10.1016/j.chom.2017.02.008
- [2] CDC. Coronavirus | Human Coronavirus Types, Centers for Disease Control and Prevention, 2020. <https://www.cdc.gov/coronavirus/types.html>

Author biography



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TABLE S1: collection of SARS-CoV-2 protein sequences with percentage coverage and percent identity Mview calculations of three Multiple Sequence Alignment tools with China:01-Dec-19 as the reference sequence.

protein country		collectionDate	cov_ClustalOmega	pid_ClustalOmega	cov_webPRANK	pid_webPRANK	cov_MUSCLE	pid_MUSCLE
E	Australia-Victoria	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	Brazil	28-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China	11-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China	08-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China	02-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China	01-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-GuangdongGuangzhou	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Guangzhou	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Guangzhou	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Hangzhou	20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Hubei-Wuhan	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Hubei-Wuhan	23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Shenzhen	10-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Wuhan	30-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	China-Yunnan	17-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	Finland	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	Japan	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	MERSctrl SaudiArabia	01-May-13	100.00%	34.10%	100.00%	35.40%	100.00%	35.40%
E	MERSctrl UnitedArabEmirat	05-Jul-05	100.00%	34.10%	100.00%	35.40%	100.00%	35.40%
E	Nepal	13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	SouthKorea	01-Jan-20	100.00%	98.70%	100.00%	98.70%	100.00%	98.70%
E	Sweden	07-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	Taiwan	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	Taiwan	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA	19-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-AZ	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-CA	23-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-CA	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-CA	06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-CA	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

E	USA-CA	23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-CA	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-IL	28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-Illinois	21-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-MA	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-TX	11-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-WA	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
E	Vietnam	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Australia-Victoria	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Brazil	28-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China	11-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China	08-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China	02-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China	01-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-GuangdongGuangzhou	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Guangzhou	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Guangzhou	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Hangzhou	20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Hubei-Wuhan	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Hubei-Wuhan	23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Shenzhen	10-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Wuhan	30-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	China-Yunnan	17-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Finland	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Italy-Rome	01-Jan-20	48.20%	100.00%	48.20%	100.00%	48.20%	100.00%
M	Japan	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	MERSctrl SaudiArabia	01-May-13	98.60%	39.40%	97.30%	40.00%	98.60%	39.40%
M	MERSctrl UnitedArabEmirat	05-Jul-05	98.60%	39.40%	97.30%	40.00%	98.60%	39.40%
M	Nepal	13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	SouthKorea	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Sweden	07-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Taiwan	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Taiwan	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

M	USA	19-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-AZ	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-CA	23-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-CA	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-CA	06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-CA	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-CA	23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-CA	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-IL	28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-Illinois	21-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-MA	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-TX	11-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-WA	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
M	Vietnam	10-Feb-20	100.00%	99.10%	100.00%	99.10%	100.00%	99.10%
N	Australia-Victoria	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Brazil	28-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China	11-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China	08-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China	02-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China	01-Dec-19	100.00%	100.00%	0.00%	100.00%	100.00%	100.00%
N	China-GuangdongGuangzhou	05-Feb-20	100.00%	99.80%	100.00%	99.80%	100.00%	99.80%
N	China-Guangzhou	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-Guangzhou	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-Hangzhou	20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	30-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	26-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-HuaShang	22-Jan-20	100.00%	99.80%	100.00%	99.80%	100.00%	99.80%
N	China-Hubei-Wuhan	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

N	China-Hubei-Wuhan	23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-Shenzhen	10-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-Wuhan	30-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	China-Yunnan	17-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Finland	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Japan	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	MERSctrl SaudiArabia	01-May-13	93.30%	46.10%	91.90%	46.10%	94.70%	46.40%
N	MERSctrl UnitedArabEmirat	05-Jul-05	93.30%	46.10%	91.90%	46.10%	94.70%	46.40%
N	Nepal	13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Philippines	06-Feb-20	28.40%	100.00%	28.40%	100.00%	28.40%	100.00%
N	Philippines	26-Jan-20	28.40%	100.00%	28.40%	100.00%	28.40%	100.00%
N	Philippines	23-Jan-20	28.40%	100.00%	28.40%	100.00%	28.40%	100.00%
N	SouthKorea	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Sweden	07-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Taiwan	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Taiwan	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA	19-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-AZ	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-CA	23-Feb-20	100.00%	99.80%	100.00%	99.80%	100.00%	99.80%
N	USA-CA	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-CA	06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-CA	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-CA	23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-CA	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-IL	28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-Illinois	21-Jan-20	100.00%	99.80%	100.00%	99.80%	100.00%	99.80%
N	USA-MA	29-Jan-20	100.00%	99.80%	100.00%	99.80%	100.00%	99.80%
N	USA-TX	11-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-WA	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
N	Vietnam	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1a	China-Yunnan	17-Jan-20	62.10%	99.90%	62.10%	91.40%	62.10%	73.20%
ORF1a	Finland	29-Jan-20	61.90%	99.60%	61.90%	91.20%	61.90%	73.00%
ORF1a	MERSctrl SaudiArabia	01-May-13	58.20%	31.70%	57.20%	21.80%	58.50%	21.10%

ORF1a	MERSctrl	UnitedArabEmirat	05-Jul-05	58.20%	31.80%	57.20%	21.80%	58.50%	21.10%
ORF1AB	Australia-Victoria		25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	Brazil		28-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China		11-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China		08-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China		02-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China		01-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Guangdong	Guangzhou	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Guangzhou		29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Guangzhou		27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Hangzhou		20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Hubei-Wuhan		01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Hubei-Wuhan		23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Shenzhen		10-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Wuhan		30-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	China-Yunnan		17-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	Finland		29-Jan-20	99.80%	99.80%	99.80%	99.80%	99.80%	99.80%
ORF1AB	Japan		10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	MERSctrl	SaudiArabia	01-May-13	95.90%	44.40%	94.80%	45.60%	96.20%	45.00%
ORF1AB	MERSctrl	UnitedArabEmirat	05-Jul-05	95.90%	44.40%	94.80%	45.60%	96.20%	45.00%
ORF1AB	Nepal		13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	SouthKorea		01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	Sweden		07-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	Taiwan		05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	Taiwan		31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA		19-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-AZ		22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-CA		23-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-CA		10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-CA		06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-CA		27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-CA		23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-CA		22-Jan-20	99.90%	99.90%	99.90%	99.90%	99.90%	99.80%
ORF1AB	USA-IL		28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

ORF1AB	USA-Illinois	21-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-MA	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-TX	11-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-WA	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF1AB	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3	China-Shenzhen	10-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3	MERSctrl SaudiArabia	01-May-13	35.60%	13.80%	34.20%	11.40%	37.50%	11.10%
ORF3	MERSctrl UnitedArabEmirat	05-Jul-05	35.60%	13.80%	34.20%	11.80%	37.50%	11.50%
ORF3a	Australia-Queensland	01-Feb-20	40.00%	100.00%	40.00%	100.00%	40.00%	100.00%
ORF3a	Australia-Victoria	25-Jan-20	100.00%	99.60%	100.00%	99.60%	100.00%	99.60%
ORF3a	Brazil	28-Feb-20	100.00%	99.60%	100.00%	99.60%	100.00%	99.60%
ORF3a	China	11-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China	01-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-GuangdongGuangzhou	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-Guangzhou	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-Guangzhou	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-Hangzhou	20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-Hubei-Wuhan	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-Hubei-Wuhan	23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	China-Yunnan	17-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	Finland	29-Jan-20	93.80%	93.80%	93.80%	93.80%	93.80%	93.80%
ORF3a	Japan	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	Nepal	13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	SouthKorea	01-Jan-20	100.00%	99.30%	100.00%	99.30%	100.00%	99.30%
ORF3a	Sweden	07-Feb-20	100.00%	99.60%	100.00%	99.60%	100.00%	99.60%
ORF3a	Taiwan	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	Taiwan	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA	19-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-AZ	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-CA	23-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-CA	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-CA	06-Feb-20	100.00%	99.60%	100.00%	99.60%	100.00%	99.60%
ORF3a	USA-CA	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-CA	23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

ORF3a	USA-CA	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-IL	28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-Illinois	21-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-MA	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-TX	11-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-WA	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF3a	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	Australia-Victoria	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	Brazil	28-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China	11-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	China	01-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China-GuangdongGuangzhou	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China-Guangzhou	29-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	China-Guangzhou	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China-Hangzhou	20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China-Hubei-Wuhan	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China-Hubei-Wuhan	23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	China-Shenzhen	10-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	China-Yunnan	17-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	Finland	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	Japan	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	MERSctrl SaudiArabia	01-May-13	58.70%	13.50%	66.90%	17.10%	86.80%	17.90%
ORF8	MERSctrl UnitedArabEmirat	05-Jul-05	58.70%	13.50%	66.90%	17.10%	86.80%	17.90%
ORF8	Nepal	13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	SouthKorea	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	Sweden	07-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	Taiwan	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	Taiwan	31-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	USA	19-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	USA-AZ	22-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	USA-CA	23-Feb-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	USA-CA	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	USA-CA	06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	USA-CA	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

ORF8	USA-CA	23-Jan-20	100.00%	98.30%	100.00%	98.30%	100.00%	98.30%
ORF8	USA-CA	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	USA-IL	28-Jan-20	100.00%	98.30%	100.00%	98.30%	100.00%	98.30%
ORF8	USA-Illinois	21-Jan-20	100.00%	98.30%	100.00%	98.30%	100.00%	98.30%
ORF8	USA-MA	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
ORF8	USA-TX	11-Feb-20	100.00%	98.30%	100.00%	98.30%	100.00%	98.30%
ORF8	USA-WA	25-Jan-20	100.00%	99.20%	100.00%	99.20%	100.00%	99.20%
ORF8	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	Australia-Victoria	25-Jan-20	100.00%	99.90%	100.00%	99.90%	100.00%	99.90%
S	Brazil	28-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China	11-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China	08-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China	02-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-GuangdongGuangzhou	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Guangzhou	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Guangzhou	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Hangzhou	20-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Hubei-Wuhan	01-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Hubei-Wuhan	23-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Shenzhen	10-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Wuhan	30-Dec-19	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	China-Yunnan	17-Jan-20	100.00%	99.90%	100.00%	99.90%	100.00%	99.90%
S	Finland	29-Jan-20	97.80%	97.80%	97.80%	97.80%	97.80%	97.80%
S	Japan	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	MERSctrl SaudiArabia	01-May-13	96.50%	28.90%	93.30%	30.90%	96.40%	29.70%
S	MERSctrl UnitedArabEmirat	05-Jul-05	96.50%	28.90%	93.30%	30.80%	96.40%	29.60%
S	Nepal	13-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	SouthKorea	01-Jan-20	100.00%	99.90%	100.00%	99.90%	100.00%	99.90%
S	Sweden	07-Feb-20	100.00%	99.90%	100.00%	99.90%	100.00%	99.90%
S	Taiwan	05-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	Taiwan	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA	19-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-AZ	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-CA	23-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

S	USA-CA	10-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-CA	06-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-CA	27-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-CA	23-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-CA	22-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-IL	28-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-Illinois	21-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-MA	29-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-TX	11-Feb-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-WA	25-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
S	USA-WI	31-Jan-20	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%