SARS-CoV-2 lineage B.1.526 emerging in the New York region detected by software utility created to query the spike mutational landscape

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Abstract

Wide-scale SARS-CoV-2 genome sequencing is critical to monitoring and understanding viral evolution during the ongoing pandemic. Variants first detected in the United Kingdom, South Africa, and Brazil have spread to multiple countries. We have developed a software tool, Variant Database (VDB), for quickly examining the changing landscape of spike mutations. Using this tool, we detected an emerging lineage of viral isolates in the New York region that shares mutations with previously reported variants. The most common sets of spike mutations in this lineage (now designated as B.1.526) are L5F, T95I, D253G, E484K or S477N, D614G, and A701V. This lineage appeared in late November 2020, and isolates from this lineage account for ~25% of coronavirus genomes sequenced and deposited from New York during February 2021.

After the early months of the SARS-CoV-2 pandemic, the vast majority of sequenced isolates contained spike mutation D614G (along with 3 separate nucleotide changes) (Korber *et al.*, 2020). Following a period of slower change, the fourth quarter of 2020 witnessed the emergence of several variants containing multiple mutations, seemingly focused on the spike protein (Rambaut *et al*., 2020b; Faria *et al*., 2021; Tegally *et al*., 2020; Zhang *et al*., 2021). Multiple lines of evidence support escape from antibody selective pressure as a driving force for the development of these variants (Cele *et al.,* 2021; Greaney *et al.,* 2021; Wang *et al.,* 2021; Wibner *et al*., 2021). Considerations about the potential effects of these mutations on the effectiveness of passive antibody therapies and on the ability of vaccines to prevent mild or moderate COVID-19 have driven genomic surveillance programs to monitor the evolution of SARS-CoV-2. Analysis of this wealth of genomic sequences requires a variety of bioinformatics techniques. Here we developed a simple and fast utility that permits rapid inspection of the mutational landscape revealed by these sequences. This tool uncovered several groups of recent isolates that contain mutation patterns with changes at critical antibody binding sites.

Methods

We have developed a software tool named VDB (Variant Database). This tool consists of two Unix command line utilities: (1) **vdb**, a program for examining spike mutation patterns in a collection of sequenced isolates, and (2) **vdbCreate**, a program for generating a list of isolate spike mutations from a multiple sequence alignment for use by **vdb**. The design goal for the query program **vdb** is to provide a fast, lightweight, and natural means to examine the

landscape of SARS-CoV-2 spike mutations. These programs are written in Swift and are available for MacOS and Linux from the authors, and these will be placed on the Github repository.

The **vdb** program implements a mutation pattern query language (see Supplemental Method) as a command shell. The first-class objects in this environment are a collection of isolates (a "cluster") and a group of spike mutations (a "pattern"). These objects can be assigned to variables and are the return types of various commands. Generally, clusters can be obtained from searches for patterns, and patterns can be found by examining a given cluster. Clusters can be filtered by geographical location, collection date, mutation count, or the presence or absence of a mutation pattern. The geographic or temporal distribution of clusters can be listed.

Results presented here are based on a multiple sequence alignment from GISAID (Elbe and Buckland-Merrett, 2017; Shu and McCauley, 2017) downloaded on February 10, 2021. Additional sequences downloaded from GISAID on February 22, 2021, were aligned with MAFFT v7.464 (Katoh and Standley, 2013).

Phylogenetic Analysis

Multiple sequence alignments were performed with MAFFT v7.464 (Katoh and Standley, 2013). The phylogenetic tree was calculated by IQ-TREE (Nguyen *et al.*, 2015), and the tree diagram was generated using iTOL (Interactive Tree of Life) (Letunic and Bork, 2006). The Pango lineage nomenclature system (Rambaut *et al.*, 2020a) provides systematic names for SARS-CoV-2 lineages. The Pango lineage designation for B.1.526 was supported by the phylogenetic tree shown in **Figure 1**.

Results

Using the **vdb** tool, we detected several clusters of isolates (unrelated to variants B.1.1.7, B.1.351, B.1.1.248, and B.1.429; Rambaut *et al*., 2020b; Faria *et al*., 2021; Tegally *et al*., 2020; Zhang *et al*., 2021) with spike mutations at sites known to be associated with resistance to antibodies against SARS-CoV-2 (Gaebler *et al.*, 2021; Wang et al., 2021) (**Table 1**). This program can find clusters of isolates sharing identical sets of spike mutations, and then these patterns can be used to find potentially related isolates. One notable cluster of isolates was collected from the New York region and represents a distinct lineage, now designated as B.1.526 (**Figure 1**). There are two main branches of this lineage, one having E484K and the other including S477N, both located within the receptor-binding domain (RBD) of spike (**Figure 2 and Supplementary Table S1**). Regarding four of the mutations in isolates in this lineage: (1) E484K is known to attenuate neutralization of multiple anti-SARS-CoV-2 antibodies, particularly those found in Class 2 (Gaebler *et al.*, 2021), and is also present in variants B.1.351 (Tegally *et al*., 2020) and P.1/B.1.1.248 (Faria *et al*., 2021), (2) D253G has been reported as an escape mutation from antibodies against the N-terminal domain (McCallum *et al.,* 2021), (3) S477N has been identified in several earlier lineages (Hodcroft *et al.,* 2020), is near the binding site of multiple antibodies (Barnes *et al.,* 2020), and has been implicated to increase viral infectivity through enhanced interactions with ACE2 (Chen *et al*., 2020; Ou *et al*., 2020), and (4) A701V sits adjacent to the S2' cleavage site of the neighboring protomer and is shared with variant B.1.351 (Tegally *et al*., 2020). The overall pattern of mutations in this lineage (**Figure 2**) suggests that it arose in part in response to selective pressure from antibodies. Based on the dates of collection

of these isolates, it appears that the frequency of lineage B.1.526 has increased rapidly in New York (**Table 2**).

Acknowledgments

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Tables

Table 1. Mutation patterns of isolates with mutations at select Spike positions, excluding isolates related to variants B.1.1.7, B.1.351, B.1.1.248, and B.1.429. Mutations included in this analysis were E484K, N501Y, K417T, K417N, L452R, and A701V. In this table isolates are only included if their spike mutation pattern exactly matches the given pattern. Note about P681H/P681R: variant B.1.1.7 has P681H. Note about W152L: variant B.1.429 has W152C

Pattern	Number of isolates	Top Locations	First collection date
L5F T95I D253G E484K D614G A701V	**243**	**US(240; NY 235)**	**12/16/2020**
E484K D614G V1176F	235	Brazil(132), US(40)	4/15/2020
W152L E484K D614G G769V	49	US(32)	11/1/2020
E484K D614G P681H	37	US(37; MD 27)	11/18/2020
R102I F157L V367F E484K Q613H P681R	36	England(35)	12/27/2020
Q52R A67V H69-V70- Y144- E484K D614G Q677H F888L	36	England(22)	12/15/2020

Table 2. Counts of isolates in lineage B.1.526 by month in New York state. The total number of sequenced isolates examined from GISAID from New York during these time periods is also listed. *Latest isolate collection date was Feb. 15, 2021. Note that geographic sampling may have varied over time as genome sequencing increased.

Isolates containing spike mutations T95I and D253G (earliest collection date Nov. 23, 2020)

Month	count	total sequences	fraction
Nov. 2020	1	469	0.2%
Dec. 2020	40	2200	1.8%
Jan. 2021	169	2956	5.7%
Feb. 2021*	337	1211	27.8%

Isolates containing spike mutations L5F, T95I, D253G, E484K, D614G, and A701V (earliest collection date Dec. 16, 2020)

Month	count	total sequences	fraction
Nov. 2020	0		
Dec. 2020	19	2200	0.9%
Jan. 2021	81	2956	2.7%
Feb. 2021*	168	1211	13.9%

Figure 1. Phylogenetic tree of lineage B.1.526 indicating spike mutations. The inset lists non-spike mutations common in this lineage.

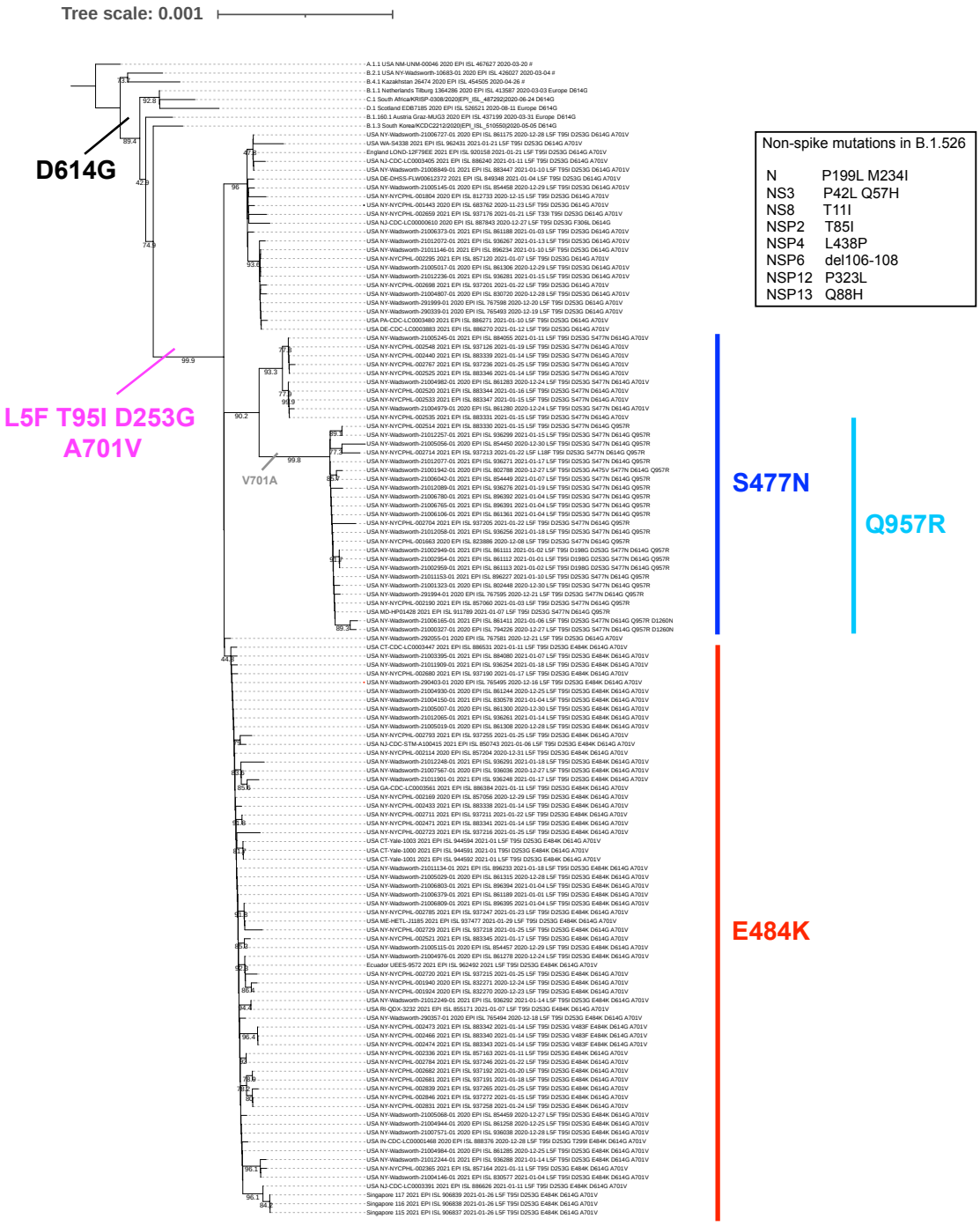
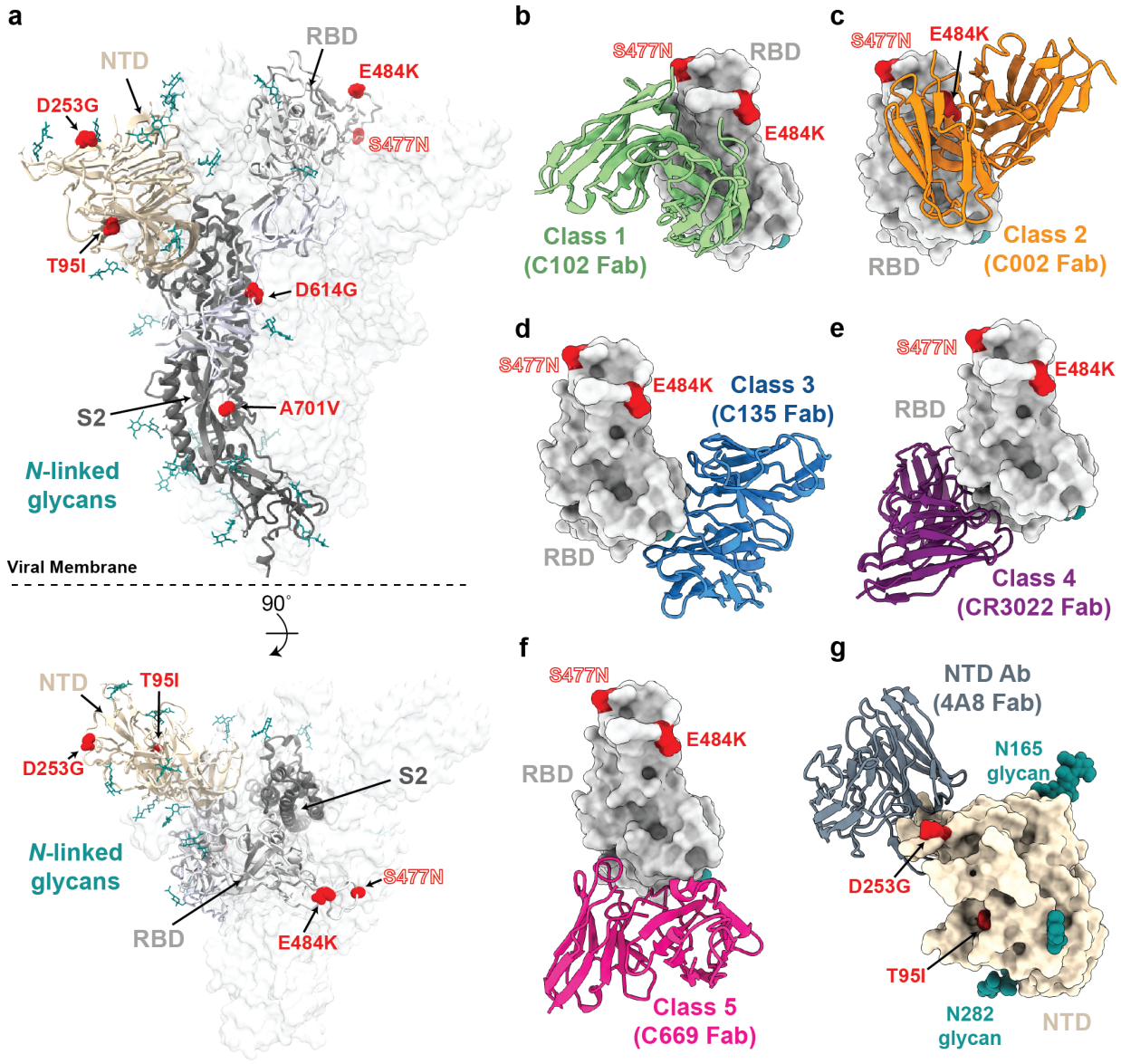


Figure 2. Structural locations of the spike mutations of lineage B.1.526.



a, Side and top views of the SARS-CoV-2 spike trimer (PDB 7JJI) with mutations of lineage B.1.526 shown as spheres. **b-g**, Models of representative neutralizing antibodies (cartoon, VH-VL domain only) bound to RBD (**b-f**, gray surface) or NTD (**g**, wheat surface). Sites for B.1.526 lineage mutations are shown as red spheres. The S477N site is also shown for the branch containing this mutation instead of the E484K mutation (see **Figure 1**); **b**, Class 1 (PDB

7K8M); **c**, Class 2 (PDB 7K8S); **d**, Class 3 (PDB 7K8Z); **e**, Class 4 (PDB 6W41); **f**, Class 5 (Wang *et al*., 2021); **g**, NTD-specific antibody 4A8 (PDB 7C2L).

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Supplementary Material

Methods.

Commands for the program **vdb**, implementing a mutation pattern query language:

Notation

cluster = group of isolates < > = user input n = an integer
pattern = group of mutations [ ] = optional ( ) = explanation of command
"world" = all isolates in database -> result

To define a variable for a cluster or pattern: <name> = cluster or pattern
Set operations +, -, and * (intersection) can be applied to clusters or patterns
If no cluster is entered, all isolates will be used ("world")

Filter commands

<cluster> from <country or state> -> cluster
<cluster> containing [<n>] <pattern> -> cluster alias with (matches for >=n mutations)
<cluster> not containing <pattern> -> cluster alias without (considers whole pattern)
<cluster> before <date> -> cluster
<cluster> after <date> -> cluster
<cluster> > or < <n> -> cluster (filter by number of mutations)

Commands to find mutation patterns

consensus [for] <cluster or country or state> -> pattern
patterns [in] [<n>] <cluster> -> pattern (lists n patterns)

Listing commands

list [<n>] <cluster>
[list] countries [for] <cluster>
[list] states [for] <cluster>
[list] frequencies [for] <cluster> alias freq (frequency of individual mutations)
[list] monthly [for] <cluster> [<cluster2>] (number of isolates per month or week)
[list] weekly [for] <cluster> [<cluster2>] (as a fraction of number of isolates in cluster2)
[list] patterns (list built-in and user-defined patterns)
[list] clusters (list built-in and user-defined clusters)

Other commands

sort <cluster> (by date)
help
history
quit

Supplementary Table S1. List of 124 isolates (with their accession number, location, collection date, and spike mutations) in lineage B.1.526. Mutations E484K, S477N, Q957R are highlighted in red, blue, and cyan, respectively.

EPI_ISL_683762, USA/NY-NYCPHL-001443/2020-11-23 : L5F T95I D253G D614G A701V
EPI_ISL_823886, USA/NY-NYCPHL-001663/2020-12-08 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_812733, USA/NY-NYCPHL-001804/2020-12-15 : L5F T95I D253G D614G A701V
EPI_ISL_765495, USA/NY-Wadsworth-290403-01/2020-12-16 : L5F T95I D253G E484K D614G A701V
EPI_ISL_765494, USA/NY-Wadsworth-290357-01/2020-12-18 : L5F T95I D253G E484K D614G A701V
EPI_ISL_765493, USA/NY-Wadsworth-290339-01/2020-12-19 : L5F T95I D253G D614G A701V
EPI_ISL_767598, USA/NY-Wadsworth-291999-01/2020-12-20 : L5F T95I D253G D614G A701V
EPI_ISL_767581, USA/NY-Wadsworth-292055-01/2020-12-21 : L5F T95I D253G D614G A701V
EPI_ISL_767595, USA/NY-Wadsworth-291994-01/2020-12-21 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_832270, USA/NY-NYCPHL-001924/2020-12-23 : L5F T95I D253G E484K D614G A701V
EPI_ISL_832271, USA/NY-NYCPHL-001940/2020-12-24 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861278, USA/NY-Wadsworth-21004976-01/2020-12-24 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861280, USA/NY-Wadsworth-21004979-01/2020-12-24 : L5F T95I D253G S477N D614G A701V
EPI_ISL_861283, USA/NY-Wadsworth-21004982-01/2020-12-24 : L5F T95I D253G S477N D614G A701V
EPI_ISL_861258, USA/NY-Wadsworth-21004944-01/2020-12-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861285, USA/NY-Wadsworth-21004984-01/2020-12-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861244, USA/NY-Wadsworth-21004930-01/2020-12-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_802788, USA/NY-Wadsworth-21001942-01/2020-12-27 : L5F T95I D253G A475V S477N D614G Q957R
EPI_ISL_794226, USA/NY-Wadsworth-21000327-01/2020-12-27 : L5F T95I D253G S477N D614G Q957R D1260N
EPI_ISL_936036, USA/NY-Wadsworth-21007567-01/2020-12-27 : L5F T95I D253G E484K D614G A701V
EPI_ISL_854459, USA/NY-Wadsworth-21005068-01/2020-12-27 : L5F T95I D253G E484K D614G A701V
EPI_ISL_887843, USA/NJ-CDC-LC00000610/2020-12-27 : L5F T95I D253G F306L D614G
EPI_ISL_861315, USA/NY-Wadsworth-21005029-01/2020-12-28 : L5F T95I D253G E484K D614G A701V
EPI_ISL_888376, USA/IN-CDC-LC00001468/2020-12-28 : L5F T95I D253G T299I E484K D614G A701V
EPI_ISL_830720, USA/NY-Wadsworth-21004807-01/2020-12-28 : L5F T95I D253G D614G A701V
EPI_ISL_861308, USA/NY-Wadsworth-21005019-01/2020-12-28 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861175, USA/NY-Wadsworth-21006727-01/2020-12-28 : L5F T95I D253G D614G A701V
EPI_ISL_936038, USA/NY-Wadsworth-21007571-01/2020-12-28 : L5F T95I D253G E484K D614G A701V
EPI_ISL_854458, USA/NY-Wadsworth-21005145-01/2020-12-29 : L5F T95I D253G D614G A701V
EPI_ISL_854457, USA/NY-Wadsworth-21005115-01/2020-12-29 : L5F T95I D253G E484K D614G A701V
EPI_ISL_857056, USA/NY-NYCPHL-002169/2020-12-29 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861306, USA/NY-Wadsworth-21005017-01/2020-12-29 : L5F T95I D253G D614G A701V
EPI_ISL_802448, USA/NY-Wadsworth-21001323-01/2020-12-30 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_861300, USA/NY-Wadsworth-21005007-01/2020-12-30 : L5F T95I D253G E484K D614G A701V
EPI_ISL_854450, USA/NY-Wadsworth-21005056-01/2020-12-30 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_857204, USA/NY-NYCPHL-002114/2020-12-31 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861112, USA/NY-Wadsworth-21002954-01/2021-01-01 : L5F T95I D198G D253G S477N D614G Q957R
EPI_ISL_861189, USA/NY-Wadsworth-21006379-01/2021-01-01 : L5F T95I D253G E484K D614G A701V
EPI_ISL_944591, USA/CT-Yale-1000/2021-01-01 : T95I D253G E484K D614G A701V
EPI_ISL_944592, USA/CT-Yale-1001/2021-01-01 : L5F T95I D253G E484K D614G A701V
EPI_ISL_944594, USA/CT-Yale-1003/2021-01-01 : L5F T95I D253G E484K D614G A701V
EPI_ISL_962492, Ecuador/UEES-9572/2021-01-01 : L5F T95I D253G E484K D614G A701V
EPI_ISL_962493, Ecuador/UEES-9602/2021-01-01 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861113, USA/NY-Wadsworth-21002959-01/2021-01-02 : L5F T95I D198G D253G S477N D614G Q957R
EPI_ISL_861111, USA/NY-Wadsworth-21002949-01/2021-01-02 : L5F T95I D198G D253G S477N D614G Q957R
EPI_ISL_857060, USA/NY-NYCPHL-002190/2021-01-03 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_861188, USA/NY-Wadsworth-21006373-01/2021-01-03 : L5F T95I D253G D614G A701V
EPI_ISL_896394, USA/NY-Wadsworth-21006803-01/2021-01-04 : L5F T95I D253G E484K D614G A701V

EPI_ISL_849348, USA/DE-DHSS-FLW00612372/2021-01-04 : L5F T95I D253G D614G A701V
EPI_ISL_896391, USA/NY-Wadsworth-21006765-01/2021-01-04 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_896392, USA/NY-Wadsworth-21006780-01/2021-01-04 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_830577, USA/NY-Wadsworth-21004146-01/2021-01-04 : L5F T95I D253G E484K D614G A701V
EPI_ISL_896395, USA/NY-Wadsworth-21006809-01/2021-01-04 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861361, USA/NY-Wadsworth-21006106-01/2021-01-04 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_830578, USA/NY-Wadsworth-21004150-01/2021-01-04 : L5F T95I D253G E484K D614G A701V
EPI_ISL_861411, USA/NY-Wadsworth-21006165-01/2021-01-06 : L5F T95I D253G S477N D614G Q957R D1260N
EPI_ISL_850743, USA/NJ-CDC-STM-A100415/2021-01-06 : L5F T95I D253G E484K D614G A701V
EPI_ISL_854449, USA/NY-Wadsworth-21006042-01/2021-01-07 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_911789, USA/MD-HP01428/2021-01-07 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_857120, USA/NY-NYCPHL-002295/2021-01-07 : L5F T95I D253G D614G A701V
EPI_ISL_855171, USA/RI-QDX-3232/2021-01-07 : L5F T95I D253G E484K D614G A701V
EPI_ISL_884080, USA/NY-Wadsworth-21003395-01/2021-01-07 : L5F T95I D253G E484K D614G A701V
EPI_ISL_896234, USA/NY-Wadsworth-21011146-01/2021-01-10 : L5F T95I D253G D614G A701V
EPI_ISL_883447, USA/NY-Wadsworth-21008849-01/2021-01-10 : L5F T95I D253G D614G A701V
EPI_ISL_896227, USA/NY-Wadsworth-21011153-01/2021-01-10 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_886271, USA/PA-CDC-LC0003480/2021-01-10 : L5F T95I D253G D614G A701V
EPI_ISL_886626, USA/NJ-CDC-LC0003391/2021-01-11 : L5F T95I D253G E484K D614G A701V
EPI_ISL_857164, USA/NY-NYCPHL-002365/2021-01-11 : L5F T95I D253G E484K D614G A701V
EPI_ISL_886531, USA/CT-CDC-LC0003447/2021-01-11 : L5F T95I D253G E484K D614G A701V
EPI_ISL_857163, USA/NY-NYCPHL-002336/2021-01-11 : L5F T95I D253G E484K D614G A701V
EPI_ISL_886240, USA/NJ-CDC-LC0003405/2021-01-11 : L5F T95I D253G D614G A701V
EPI_ISL_884055, USA/NY-Wadsworth-21005245-01/2021-01-11 : L5F T95I D253G S477N D614G A701V
EPI_ISL_886384, USA/GA-CDC-LC0003561/2021-01-11 : L5F T95I D253G E484K D614G A701V
EPI_ISL_886270, USA/DE-CDC-LC0003883/2021-01-12 : L5F T95I D253G D614G A701V
EPI_ISL_936267, USA/NY-Wadsworth-21012072-01/2021-01-13 : L5F T95I D253G D614G A701V
EPI_ISL_936292, USA/NY-Wadsworth-21012249-01/2021-01-14 : L5F T95I D253G E484K D614G A701V
EPI_ISL_936261, USA/NY-Wadsworth-21012065-01/2021-01-14 : L5F T95I D253G E484K D614G A701V
EPI_ISL_883338, USA/NY-NYCPHL-002433/2021-01-14 : L5F T95I D253G E484K D614G A701V
EPI_ISL_883342, USA/NY-NYCPHL-002473/2021-01-14 : L5F T95I D253G V483F E484K D614G A701V
EPI_ISL_883339, USA/NY-NYCPHL-002440/2021-01-14 : L5F T95I D253G S477N D614G A701V
EPI_ISL_883340, USA/NY-NYCPHL-002466/2021-01-14 : L5F T95I D253G V483F E484K D614G A701V
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EPI_ISL_883343, USA/NY-NYCPHL-002474/2021-01-14 : L5F T95I D253G V483F E484K D614G A701V
EPI_ISL_883346, USA/NY-NYCPHL-002525/2021-01-14 : L5F T95I D253G S477N D614G A701V
EPI_ISL_883341, USA/NY-NYCPHL-002471/2021-01-14 : L5F T95I D253G E484K D614G A701V
EPI_ISL_883330, USA/NY-NYCPHL-002514/2021-01-15 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_883347, USA/NY-NYCPHL-002533/2021-01-15 : L5F T95I D253G S477N D614G A701V
EPI_ISL_936299, USA/NY-Wadsworth-21012257-01/2021-01-15 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_883331, USA/NY-NYCPHL-002535/2021-01-15 : L5F T95I D253G S477N D614G A701V
EPI_ISL_937272, USA/NY-NYCPHL-002846/2021-01-15 : L5F T95I D253G E484K D614G A701V
EPI_ISL_936281, USA/NY-Wadsworth-21012236-01/2021-01-15 : L5F T95I D253G D614G A701V
EPI_ISL_883344, USA/NY-NYCPHL-002520/2021-01-16 : L5F T95I D253G S477N D614G A701V
EPI_ISL_937190, USA/NY-NYCPHL-002680/2021-01-17 : L5F T95I D253G E484K D614G A701V
EPI_ISL_883345, USA/NY-NYCPHL-002521/2021-01-17 : L5F T95I D253G E484K D614G A701V
EPI_ISL_936248, USA/NY-Wadsworth-21011901-01/2021-01-17 : L5F T95I D253G E484K D614G A701V
EPI_ISL_936271, USA/NY-Wadsworth-21012077-01/2021-01-17 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_936256, USA/NY-Wadsworth-21012058-01/2021-01-18 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_936254, USA/NY-Wadsworth-21011909-01/2021-01-18 : L5F T95I D253G E484K D614G A701V
EPI_ISL_936291, USA/NY-Wadsworth-21012248-01/2021-01-18 : L5F T95I D253G E484K D614G A701V
EPI_ISL_896233, USA/NY-Wadsworth-21011134-01/2021-01-18 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937191, USA/NY-NYCPHL-002681/2021-01-18 : L5F T95I D253G E484K D614G A701V

EPI_ISL_936276, USA/NY-Wadsworth-21012089-01/2021-01-19 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_937126, USA/NY-NYCPHL-002548/2021-01-19 : L5F T95I D253G S477N D614G A701V
EPI_ISL_937192, USA/NY-NYCPHL-002682/2021-01-20 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937176, USA/NY-NYCPHL-002659/2021-01-21 : L5F T33I T95I D253G D614G A701V
EPI_ISL_920158, England/LOND-12F79EE/2021-01-21 : L5F T95I D253G D614G A701V
EPI_ISL_962431, USA/WA-S4338/2021-01-21 : L5F T95I D253G D614G A701V
EPI_ISL_937205, USA/NY-NYCPHL-002704/2021-01-22 : L5F T95I D253G S477N D614G Q957R
EPI_ISL_937211, USA/NY-NYCPHL-002711/2021-01-22 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937201, USA/NY-NYCPHL-002698/2021-01-22 : L5F T95I D253G D614G A701V
EPI_ISL_937213, USA/NY-NYCPHL-002714/2021-01-22 : L5F L18F T95I D253G S477N D614G Q957R
EPI_ISL_937246, USA/NY-NYCPHL-002784/2021-01-22 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937247, USA/NY-NYCPHL-002785/2021-01-23 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937258, USA/NY-NYCPHL-002831/2021-01-24 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937236, USA/NY-NYCPHL-002767/2021-01-25 : L5F T95I D253G S477N D614G A701V
EPI_ISL_937218, USA/NY-NYCPHL-002729/2021-01-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937216, USA/NY-NYCPHL-002723/2021-01-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937265, USA/NY-NYCPHL-002839/2021-01-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937215, USA/NY-NYCPHL-002720/2021-01-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937255, USA/NY-NYCPHL-002793/2021-01-25 : L5F T95I D253G E484K D614G A701V
EPI_ISL_906839, Singapore/117/2021-01-26 : L5F T95I D253G E484K D614G A701V
EPI_ISL_906838, Singapore/116/2021-01-26 : L5F T95I D253G E484K D614G A701V
EPI_ISL_906837, Singapore/115/2021-01-26 : L5F T95I D253G E484K D614G A701V
EPI_ISL_937477, USA/ME-HETL-J1185/2021-01-29 : L5F T95I D253G E484K D614G A701V