

What is claimed is:

1. A peptide comprising one or more of the epitopes listed in Tables 1-4.
2. The peptide of claim 1, wherein the one or more epitopes comprises a JC virus (JCV) epitope listed in Table 1.
3. The peptide of claim 1 or 2, wherein the one or more epitopes comprises JCV epitopes set forth in SEQ ID NOs: 1-21.
4. The peptide of claim 1, wherein the one or more epitopes comprises a JC virus (JCV) epitope listed in Table 2 and/or Table 3.
5. The peptide of claim 1, wherein the one or more epitopes comprises a hybrid epitope according to Table 4.
6. The peptide of any one of claims 1 to 5, wherein the peptide comprises a plurality of epitopes listed in Tables 1-4.
7. The peptide of claim 6, wherein the plurality of epitopes comprise a plurality of JCV epitopes listed in Table 1.
8. The peptide of claim 7, wherein the plurality of epitopes comprise a plurality of JCV epitopes set forth in SEQ ID NOs: 1-21.
9. The peptide of claim 5, wherein the plurality of epitopes comprise a plurality of JCV epitopes listed in Table 2 and/or Table 3.
10. The peptide of claim 6, wherein the plurality of epitopes comprise a JVC epitope listed in Table 1 and a JCV epitope listed in Table 2 and/or Table 3.
11. The peptide of any one of claims 6 to 10, further comprising an intervening amino acid sequence between at least two of the plurality of epitopes.
12. The peptide of any one of claims 1 to 11, wherein the peptide is capable of eliciting an immune response upon administration to a subject.
13. The peptide of any one of claims 1 to 12, wherein the epitopes are selected to provide broad coverage of the human population.

14. The peptide of claim 13, wherein the epitopes have HLA class II restrictions to HLA-DP, -DM, -DOA, -DOB, -DQ, or -DR.
15. The peptide of claim 14, wherein the epitopes have HLA class II restrictions to HLA-DRB or -DQB.
16. The peptide of any one of claims 1 to 15, comprising each of the epitope amino acid sequences set forth in SEQ ID NOs: 1-21.
17. The peptide of any one of claims 1 to 16, consisting essentially of the epitope amino acid sequences set forth in SEQ ID NOs: 1-21.
18. The peptide of any one of claims 1 to 17, wherein the peptide consists of epitope amino acid sequences set forth in SEQ ID NOs: 1-21.
19. The peptide of any one of claims 1 to 18, wherein the peptide further comprises one or more epitopes from Merkel cell virus (MCV).
20. The peptide of any one of claims 1 to 19, further comprising one or more epitopes from a non-polyomavirus.
21. The peptide of claim 20, wherein the one or more epitopes from a non-polyomavirus comprise one or more epitopes from adenovirus (ADV), Epstein Barr virus (EBV) or cytomegalovirus (CMV).
22. An isolated nucleic acid encoding the peptide of any one of the preceding claims.
23. An expression construct comprising the isolated nucleic acid of claim 22.
24. A host cell comprising the expression construct of claim 23.
25. A method of producing peptide, said method comprising expressing the peptide in the host cell of claim 24 and at least partly purifying the peptide.
26. A pharmaceutical composition comprising the peptide of any one of claims 1 to 21 and a pharmaceutically acceptable carrier.
27. A pharmaceutical composition comprising the isolated nucleic acid of claim 22.

28. A vaccine composition comprising the peptide of any one of claims 1 to 21 and a pharmaceutically acceptable carrier.
29. The vaccine composition of claim 28, further comprising an adjuvant.
30. A method of treating or preventing a polyomavirus infection in a subject, comprising administering to the subject the pharmaceutical composition of claim 26 or 27 or the vaccine composition of claim 28 or 29.
31. The method of claim 29, wherein the polyomavirus infection is a JC virus (JCV) infection.
32. The method of claim 30 or 31, wherein the subject is suffering from JCV granule cell layer neuronopathy (JCV GCN), JCV encephalopathy (JCVE), JCV meningitis (JCVM), and/or progressive multifocal leukoencephalopathy (PML).
33. A method of treating or preventing a polyomavirus-associated cancer in a subject, comprising administering to the subject the pharmaceutical composition of claim 26 or 27 or the vaccine composition of claim 28 or 29.
34. The method of claim 33, wherein the polyomavirus-associated cancer is a JCV-associated cancer.
35. The method of claim 33 or 34, wherein the polyomavirus-associated cancer is a gastrointestinal malignancy, such as colon cancer, gastric cancer, and/or gastrointestinal tumors
36. The method of claim 33 or 34, wherein the polyomavirus-associated cancer is a central nervous system (CNS) malignancy, such as gliomas, medulloblastomas, primitive neuroectodermal tumors, and/or neuroblastomas.
37. A method of inducing a T-cell immune response in a subject, comprising administering to the subject the pharmaceutical composition of claim 26 or 27 or the vaccine composition of claim 28 or 29.
38. A pool of immunogenic peptides comprising HLA class I and/or class II-restricted JCV peptide epitopes capable of inducing proliferation of peptide-specific T cells, wherein the peptide pool comprises at least one of the epitope amino acid sequences set forth in

SEQ ID NOs. 1-21, or combinations thereof.

39. The pool of immunogenic peptides of claim 38, further comprising at least one of the JCV peptide epitope amino acid sequences set forth in Table 1, or a combination thereof.

40. The pool of immunogenic peptides of claim 38 or 39, comprising each of the JCV peptide epitope amino acid sequences set forth in SEQ ID NOs: 1-21.

41. The pool of immunogenic peptides of any one of claims claim 38 to 40, wherein the epitopes have HLA class II restrictions to HLA-DP, -DM, -DOA, -DOB, -DQ, or -DR.

42. The pool of immunogenic peptides of claim 41, wherein the epitopes have HLA class II restrictions to HLA-DRB or -DQB.

43. The pool of immunogenic peptides of any one of claims 38 to 42, wherein each of the epitopes are restricted by any one of the HLA specificities selected from DRB1*01:01, DRB1*03:01, DRB1*04:01, DRB1*10:01, DRB1*11:01, DRB1*13:01, DRB1*14:04, DRB1*15:01, DRB1*16:01, DQB1*02:02, or DQB1*05:03.

44. The pool of immunogenic peptides of any one of claims 38 to 43, wherein the peptide-specific T cells exhibit a polyfunctional immune effector profile.

45. The pool of immunogenic peptides of any one of claims 38 to 44, wherein the immunogenic peptides are capable of inducing proliferation of peptide-specific cytotoxic T cells (CTLs).

46. The pool of immunogenic peptides of claim 45, wherein the peptide-specific cytotoxic T cells (CTLs) exhibit a polyfunctional immune effector profile.

47. A method of expanding JC virus-specific T cells for adoptive immunotherapy, comprising:

(i) contacting one or more cells isolated from a subject with the peptide of any one of claims 1 to 21 or the pool of immunogenic peptides of any one of claims 38 to 46; and

(ii) culturing the one or more cells under conditions such that JC virus-specific T-cells are expanded from said one or more cells.

48. The method of claim 47, wherein the peptide or pool of immunogenic peptides consists essentially of each of the JCV peptide epitope amino acid sequences set forth in SEQ ID NOs. 1-21.
49. The method of claim 47 or 46, wherein the one or more cells isolated from the subject comprises peripheral blood mononuclear cells (PBMCs) from a healthy donor.
50. The method of claim 47 or 46, wherein the one or more cells isolated from the subject comprises PBMCs from an immunocompromised donor.
51. The method of claim 50, wherein the donor is undergoing immunosuppressive therapy.
52. The method of any one of claims 50 or 51, wherein the donor is an organ transplant recipient.
53. The method of any one of claims 50 to 52, wherein the donor is a donor receiving anti-viral therapy.
54. The method of any one of claims 47 to 53, wherein the JC virus-specific T cells exhibit a polyfunctional immune effector profile.
55. The method of any one of claims 47 to 54, further comprising administering the JC virus-specific T cells to a subject suffering from a JCV infection.
56. A method of treating or preventing JCV infection in a subject, comprising administering to the subject the JC virus-specific T cells of any one of claims 47 to 54.
57. CTLs prepared by the method of any one of claims 47 to 54.
58. A method of treating or preventing JCV infection in a subject, comprising administering to the subject the CTLs of claim 57.
59. The method of claim 58, wherein exposure to the immunogenic peptide or pool of immunogenic peptides induces stimulation and proliferation of JCV peptide-specific T cells.
60. The method of claim 58, wherein the CTLs administered to the subject are

autologous.

61. The method of claim 58, wherein the CTLs administered to the subject are not autologous.

62. The method of any one of claims 56 to 61, wherein the infection is a recurrent JCV infection.

63. The method of any one of claims 56 to 62, wherein the JCV infection is drug-resistant.

64. The method of any one of claims 56 to 63, wherein the subject is the recipient of an organ transplant.

65. The method of any one of claims 56 to 64, wherein the subject is suffering from JCV granule cell layer neuronopathy (JCV GCN), JCV encephalopathy (JCVE), JCV meningitis (JCV M), and/or progressive multifocal leukoencephalopathy (PML).

66. A method of treating or preventing a polyomavirus-associated cancer in a subject, comprising administering the expanded JC virus-specific T lymphocytes of any one of claims 45 to 54 to the subject.

67. The method of claim 66, wherein the polyomavirus-associated cancer is a JCV-associated cancer.

68. A method of detecting a JC virus infection in a subject, the method comprising detecting the presence of JCV-specific T lymphocytes by contacting T lymphocytes isolated from the subject with the peptide of any one of claims 1 to 21.

69. The method of claim 68, further comprising detecting JCV-specific DNA in a sample of cerebrospinal fluid isolated from the subject.

70. The method of claim 69, wherein the JCV-specific DNA comprises absence of sequence *b* and *d* and duplication of sequence *a-c-e* of the noncoding control region (NCCR).

71. The method of any one of claims 68 to 70, further comprising administering to the subject an adoptive immunotherapy composition comprising JC virus-specific T cells which

target any one of the epitope amino acid sequences set forth in SEQ ID NOs: 1-21, or combinations thereof.

72. The method of any one of the preceding claims, wherein the subject is a mammal.

73. The method of claim 72, wherein the subject is human.

74. The method of claim 72 or 73, wherein the subject is immunocompromised.

75. A method of treating or preventing a cancer in a subject, the method comprising administering to the subject a pharmaceutical composition comprising cytotoxic T cells (CTLs) comprising T cell receptors (TCRs) that recognize one or more epitopes listed in Tables 1-4.

76. The method of claim 75, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 1.

77. The method of claim 75, wherein the one or more epitopes comprise a JC virus (JCV) epitope set forth in SEQ ID Nos: 1-21.

78. The method of claim 75 or 76, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 2 and/or Table 3.

79. The method of any one of claims 76 to 78, wherein the one or more epitopes comprise a hybrid epitope according to Table 4.

80. The method of any one of claims 76 to 79, wherein the cancer is a polyomavirus associated cancer.

81. The method of claim 80, wherein the polyomavirus is a JC virus (JCV).

82. The method of claim 80 or 81, wherein the polyomavirus-associated cancer is a gastrointestinal malignancy, such as colon cancer, gastric cancer, and/or gastrointestinal tumors

83. The method of claim 80 or 81, wherein the polyomavirus-associated cancer is a central nervous system (CNS) malignancy, such as gliomas, medulloblastomas, primitive neuroectodermal tumors, and/or neuroblastomas.

84. A method of treating or preventing a polyomavirus infection in a subject, the method comprising administering to the subject a pharmaceutical composition comprising cytotoxic T cells (CTLs) comprising T cell receptors (TCRs) that recognize one or more epitopes listed in Tables 1-4.

85. The method of claim 84, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 1.

86. The method of claim 85, wherein the one or more epitopes comprise a JC virus (JCV) epitope set forth in SEQ ID Nos: 1-21.

87. The method of any one of claims 84 to 86, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 2 and/or Table 3.

88. The method of any one of claims 84 to 87, wherein the one or more epitopes comprise a hybrid epitope according to Table 4.

89. The method of any one of claims 84 to 88, wherein the polyomavirus is a JC virus (JCV).

90. The method of any one of claims 75 to 89, wherein at least one of the TCRs recognizes a VP1 epitope from JCV.

91. The method of any one of claims 75 to 90, wherein at least one of the TCRs recognizes a LTA epitope from JCV.

92. The method of any one of claims 75 to 91, wherein at least one of the TCRs recognizes a STA epitope from JCV.

93. The method of any one of claims 75 to 92, wherein the CTLs collectively comprise TCRs that recognize at least two of the epitopes set forth in SEQ ID NOs: 1-21.

94. The method of claim 93, wherein the CTLs collectively comprise TCRs that recognize at least five of the epitopes set forth in SEQ ID NOs: 1-21.

95. The method of claim 94, wherein the CTLs collectively comprise TCRs that recognize at least ten of the epitopes set forth in SEQ ID NOs: 1-21.

96. The method of claim 95, wherein the CTLs collectively comprise TCRs that recognize each of the epitopes set forth in SEQ ID NOs: 1-21.
97. The method of any one of claims 75 to 96, wherein the TCRs collectively recognize epitopes from at least two different viruses.
98. The method of claim 97, wherein the TCRs collectively recognize epitopes from at least three different viruses.
99. The method of claim 98, wherein the TCRs collectively recognize epitopes from at least four different viruses.
100. The method of claim 99, wherein the TCRs collectively recognize epitopes from at least five different viruses.
101. The method of any one of claims 75 to 100, wherein the TCRs collectively recognize one or more epitopes from a non-polyomavirus.
102. The method of claim 101, wherein the one or more epitopes from a non-polyomavirus comprise one or more epitopes from adenovirus (ADV), Epstein Barr virus (EBV) or cytomegalovirus (CMV).
103. The method of any one of claims 75 to 102, wherein the subject expresses a human leukocyte antigen (HLA) to which the one or more epitopes is restricted.
104. The method of any one claims 75 to 103, wherein the CTLs are autologous to the subject.
105. The method of any one of claims 75 to 103, wherein the CTLs are not autologous to the subject.
106. The method of claim 105, wherein the CTLs are obtained from a CTL library or bank.
107. The method of any one of claims 75 to 106, wherein the subject is immunocompromised.

108. The method of any one of claims 75 to 107, wherein the CTLs exhibit a polyfunctional immune effector profile.
109. A method of inducing proliferation of polyomavirus-specific cytotoxic T cells (CTLs), comprising contacting CTLs with antigen-presenting cells (APCs) that present one or more polyomavirus peptides comprising any one of the epitopes listed in Tables 1-4.
110. The method of claim 109, wherein the one or more peptides comprise a JC virus (JCV) epitope listed in Table 1.
111. The method of claim 110, wherein the one or more peptides comprise a JC virus (JCV) epitope selected from any one of SEQ ID Nos: 1-21.
112. The method of any one of claims 109 to 111, wherein the one or more peptides comprise a JC virus (JCV) epitope listed in Table 2 and/or Table 3.
113. The method of any one of claims 109 to 112, wherein the one or more peptides comprise a hybrid epitope according to Table 4.
114. The method of any one of claims 109 to 113, wherein CTLs are contacted with the APCs *in vitro*.
115. The method of any one of claims 109 to 114, wherein the one or more peptides comprise one or more epitopes from a non-polyomavirus.
116. The method of claim 115, wherein the one or more peptides from a non-polyomavirus comprise one or more epitopes from adenovirus (ADV), Epstein Barr virus (EBV) or cytomegalovirus (CMV).
117. The method of any one of claims 109 to 116, wherein the CTLs are contacted by the APCs in the presence of one or more cytokines.
118. The method of any one of claims 109 to 117, wherein the APCs comprise B cells.
119. The method of any one of claims 109 to 118, wherein the APCs comprise antigen-presenting T-cells.

120. The method of any one of claims 109 to 119, wherein the APCs comprise dendritic cells.
121. The method of any one of claims 109 to 120, wherein the APCs comprise aK562 cells.
122. The method of any one of claims 109 to 121, wherein the CTLs are from a sample of peripheral blood mononuclear cells (PBMCs).
123. The method of any one of claims 109 to 122, wherein the polyomavirus-specific cytotoxic T cells are stored in a CTL library or bank.
124. The method of any one of claims 109 to 123, wherein the polyomavirus-specific cytotoxic T cells exhibit a polyfunctional immune effector profile.
125. A method of treating or preventing a cancer in a subject, the method comprising administering to the subject a vaccine composition comprising one or more epitopes listed in Tables 1-4.
126. The method of claim 125, wherein the one or more epitopes comprise a JC virus (JVC) epitope listed in Table 1.
127. The method of claim 126, wherein the one or more epitopes comprise a JC virus (JVC) epitope set forth in SEQ ID NOs: 1-21.
128. The method of any one of claims 125 or claim 127, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 2 and/or Table 3.
129. The method of any one of claims 125 to 128, wherein the one or more epitopes comprise a hybrid epitope according to Table 4.
130. The method of any one of claims 125 to 129, wherein the cancer is a polyomavirus-associated cancer.
131. The method of claim 130, wherein the polyomavirus-associated cancer is a gastrointestinal malignancy, such as colon cancer, gastric cancer, and/or gastrointestinal tumors

132. The method of claim 130, wherein the polyomavirus-associated cancer is a central nervous system (CNS) malignancy, such as gliomas, medulloblastomas, primitive neuroectodermal tumors, and/or neuroblastomas.
133. The method of any one of claims 130 to 132, wherein the polyomavirus is a JC virus (JCV).
134. A method of treating or preventing a polyomavirus infection in a subject, the method comprising administering to the subject a vaccine composition comprising one or more epitopes listed in Tables 1-4.
135. The method of claim 134, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 1.
136. The method of claim 135, wherein the one or more epitopes comprise a JC virus (JCV) epitope set forth in SEQ ID NOs: 1-21.
137. The method of any one of claims 134 to 136, wherein the one or more epitopes comprise a JC virus (JCV) epitope listed in Table 2 and/or Table 3.
138. The method of any one of claims 134 to 137, wherein the one or more epitopes comprise a hybrid epitope according to Table 4.
139. The method of any one of claims 134 to 138, wherein the polyomavirus is a JC virus (JCV).
140. The method of any one of claims 125 to 139, wherein the vaccine composition further comprises one or more epitopes from a non-polyomavirus.
141. The method of claim 140, wherein the one or more epitopes from a non-polyomavirus comprise one or more epitopes from adenovirus (ADV), Epstein Barr virus (EBV) or cytomegalovirus (CMV).
142. The method of any one of claims 125 to 141, wherein the one or more epitopes comprise at least two of the epitopes set forth in SEQ ID NOs: 1-21.
143. The method of claim 142, wherein the one or more epitopes comprise at least five of the epitopes set forth in SEQ ID NOs: 1-21.

144. The method of claim 143, wherein the one or more epitopes comprise at least ten of the epitopes set forth in SEQ ID NOs: 1-21.
145. The method of claim 144, wherein the one or more epitopes comprise at least each of the epitopes set forth in SEQ ID NOs: 1-21.
146. The method of any one of claims 125 to 145, wherein the subject expresses a human leukocyte antigen (HLA) to which the one or more epitopes is restricted.
147. The method of any one of claims 125 to 146, wherein the vaccine composition further comprises an adjuvant.
148. The method of any one of claims 125 to 147, wherein the subject is immune-deficient, immuno-incompetent, or immuno-compromised.
149. The method of any one of claims 75 to 148, wherein the subject is human.
150. The method of claim 47, wherein the cells are cultured in the presence of IL-2.
151. The method of claim 150, wherein the IL-2 is present at a concentration of about 120IU/ml.
152. The method of any one of claims 109 to 123, further comprising culturing the CTLs in the presence of IL-2.
153. The method of claim 152 wherein the IL-2 is present at a concentration of about 120IU/ml.