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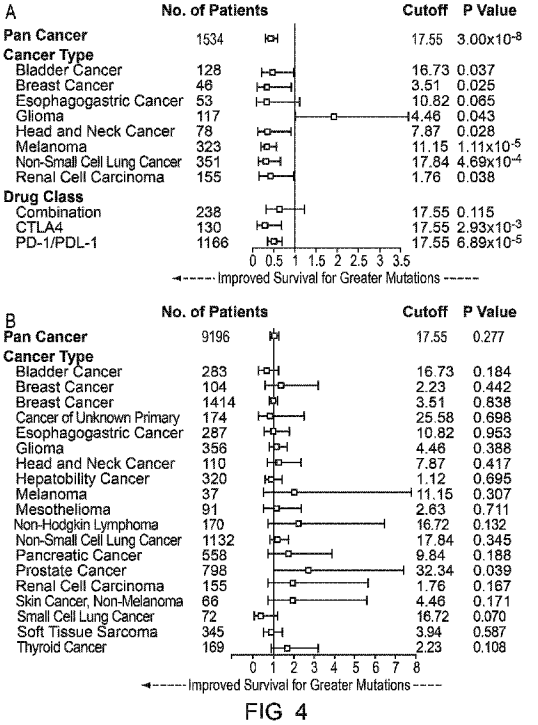


FIG 4

(57) Abrégé/Abstract:
The present invention encompasses the discovery that the likelihood of a favorable response to cancer immunotherapy for a wide range of different cancers can be predicted through definition of a tumor mutational load threshold for the tumor (and/or the relevant immunotherapy).

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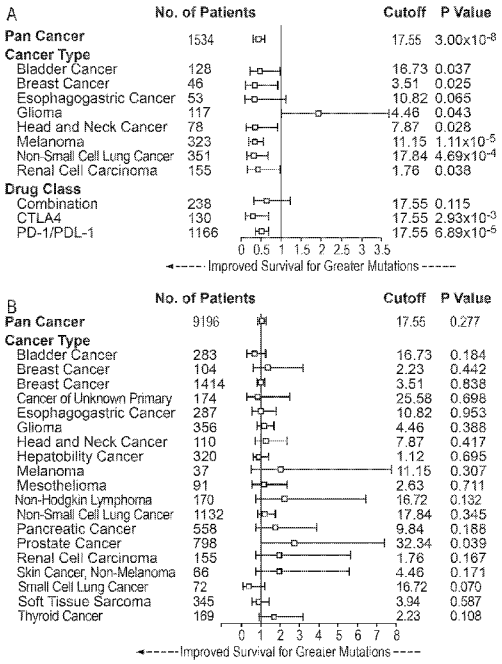


FIG. 4

(57) Abstract: The present invention encompasses the discovery that the likelihood of a favorable response to cancer immunotherapy for a wide range of different cancers can be predicted through definition of a tumor mutational load threshold for the tumor (and/or the relevant immunotherapy).

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TUMOR MUTATIONAL LOAD

BACKGROUND

[0001] Cancer immunotherapy involves the attack of cancer cells by a patient's immune system. Regulation and activation of T lymphocytes depends on signaling by the T cell receptor and also cosignaling receptors that deliver positive or negative signals for activation. Immune responses by T cells are controlled by a balance of costimulatory and inhibitory signals, called immune checkpoints. It is predicted that worldwide cancer spending will exceed $150 billion by 2020, in significant part due to immunotherapy drug development.

SUMMARY

[0002] In recent years, immune checkpoint modulators have revolutionized treatment for patients with advanced stage solid tumors. These agents include antibodies that act as a CTLA-4 blockade or a PD-1/PD-L1 blockade, which can modulate immunoregulatory signals.[1]

[0003] The present disclosure recognizes the source of a problem that can arise with respect to immunotherapy regimens. In particular, it has been observed that durable benefit is often achieved in only a subset of patients.

[0004] Recent work has discovered that likelihood of a favorable response to cancer immunotherapy can often be predicted.[2] *See,* International Patent Application WO2016/081947 to Chan *et al* of the Memorial Sloan Kettering Cancer Center, incorporated herein by reference. In particular, it has been demonstrated that, for certain cancers, tumor mutational load can correlate with likely responsiveness to a particular therapy (*e.g.,* to immunotherapy, and in particular to immune checkpoint modulator therapy), and also that certain cancer cells may harbor somatic mutations that result in neoepitopes that are recognizable by a patient's immune system as non-self, and that presence and/or identity of such neoepitopes may correlate with responsiveness to particular therapy. Further, the ability to present neoepitopes to the immune system, particularly through diverse HLA molecules, may correlate with responsiveness to particular therapy. Certain characteristics and/or mutational "signatures" that can be detected to predict responsiveness to immunotherapy, were defined, including specifically for lung cancer (*e.g.,* small cell or non-small-cell carcinoma) and melanoma.

[0005] The present invention encompasses a discovery that likelihood of a favorable response to cancer immunotherapy for a wide range of different cancers can be predicted through definition of a tumor mutational load threshold for the tumor (and/or the relevant immunotherapy); in some embodiments, the present disclosure defines such thresholds and/or provides technologies that achieve such definition.

[0006] Moreover, in some embodiments, the present invention establishes that likelihood of durable responsiveness to cancer immunotherapy (and/or to a specific immunotherapy agent and/or regimen) can be predicted for tumors that have already been treated with prior immunotherapy. In particular, the present disclosure demonstrates that tumor mutational load thresholds can be defined for tumors that have already received prior immunotherapy, and that predict likely responsiveness to continued (and/or additional, extended, or modified) immunotherapy.

[0007] The present invention encompasses a discovery that likelihood of a favorable response to cancer immunotherapy for a wide range of different cancers can be predicted through HLA heterozygosity. In some embodiments, HLA heterozygosity alone is sufficient to determine likelihood of a favorable response to cancer immunotherapy. In some embodiments, HLA heterozygosity and tumor mutational load can be used in combination to determine likelihood of a favorable response to cancer immunotherapy.

[0008] Among other things, in some embodiments, the present disclosure provides technologies for defining tumor mutational load thresholds (and/or other characteristics – e.g., nature, level and/or frequency of neoantigens mutations) that predict ongoing responsiveness and/or durability of response to cancer immunotherapy. In some embodiments, the present disclosure defines such thresholds. Moreover, in some embodiments, the present disclosure provides technologies for treating tumors that have been exposed to cancer immunotherapy, for example by administering (e.g., continuing, supplementing, and/or initiating new) cancer immunotherapy to those tumors that display a mutational load characteristic (i.e., tumor mutational load above a defined threshold and/or neoantigen nature, level, and/or frequency) as described herein. In many embodiments, tumors that display a tumor mutational load above a threshold that has been correlated with a statistically significant probability of responding to

immunotherapy are treated with such immunotherapy; in some embodiments, the tumors had previously been exposed to (the same or different) immunotherapy.

[0009] In some embodiments, the present disclosure provides technologies for treating tumors in subjects with a particular HLA class I genotype or HLA class I heterozygosity. Additionally, in some embodiments, the present disclosure provides technologies for treating tumors that have been exposed to cancer immunotherapy, for example by administering (e.g., continuing, supplementing, and/or initiating new) cancer immunotherapy to those tumors that display a mutational load characteristic (i.e., tumor mutational load above a defined threshold and/or neoantigen nature, level, and/or frequency) as described herein and are in a subject with a particular HLA class I genotype or HLA class I heterozygosity.

[0010] In some embodiments, a tumor mutational load characteristic may comprise (e.g., in addition or as an alternative to tumor mutational load) nature (e.g., identity or type), level, and/or frequency of neoepitopes that are recognizable by a patient's immune system as non-self. The present disclosure defines certain characteristics of particular tumor cells (e.g., cells that have been previously treated with cancer immunotherapy) that can be detected to predict responsiveness (e.g., continued responsiveness and/or durability of responsiveness) to immunotherapy, and particularly to therapy with immune checkpoint modulators. Among other things, the present disclosure provides tools and technologies that can be practically applied to define, characterize, and/or detect one or more tumor mutational load characteristics (e.g., tumor mutational load thresholds, neoepitope identity, type, level, and/or frequency, etc).

[0011] In some embodiments, HLA class I heterozygosity may comprise heterozygosity at a single HLA class I locus, two HLA class I loci, or at three HLA class I loci. In some embodiments, maximal heterozygosity is heterozygosity at three HLA class I loci (i.e., A, B, and C).

[0012] Among other things, the present disclosure demonstrates that a relevant tumor mutational load can be determined and/or detected using targeted gene panel technologies (*e.g.,* assessed with next-generation sequencing), and do not necessarily require whole exome sequencing. The present disclosure recognizes the source of a problem with certain prior technologies for assessing tumor mutational load to the extent that they relied on and/or required

whole exome sequencing, which is typically not broadly performed as part of routine clinical care.

[0013] In some embodiments of the present invention, tumor mutational load is or was determined and/or detected by use of a targeted sequence panel. In some embodiments, tumor mutational load is measured using next-generation sequencing. In some embodiments, tumor mutational load is measured using an Integrated Mutation Profiling of Actionable Cancer Targets (MSK-IMPACT) assay.[8,17]

[0014] In some embodiments, the step of determining comprises detecting at least one mutation characteristic by nucleic acid sequencing. In some embodiments, nucleic acid sequencing is or comprises whole exome sequencing. In some embodiments, nucleic acid sequencing does not involve whole exome sequencing. In some embodiments, nucleic acid sequencing is or comprises next generation sequencing.

[0015] In some embodiments, the present disclosure relates to administration of immunotherapy to a subject. In some embodiments, administration comprises steps of detecting a tumor mutational load characteristic (e.g., a tumor mutational load level relative to a threshold) in a cancer sample from a subject; and identifying the subject as a candidate for treatment (e.g. continued and/or extended or modified treatment) with an immunotherapy. In some embodiments, a tumor mutational load threshold is used to determine if a subject is a candidate for treatment (*e.g.,* continued treatment and/or extended or modified treatment) with an immunotherapy. In some embodiments, the invention provides methods for detecting a low tumor mutational load, or a tumor mutational load below the defined tumor mutational load threshold, in a cancer sample from a subject; and identifying the subject as a poor candidate for treatment (e.g. continued treatment and/or extended or modified treatment) with an immune checkpoint modulator. In some embodiments, the step of detecting comprises sequencing one or more exomes from the cancer sample. In some embodiments, the step of detecting doesn't involve sequencing one or more exomes.

[0016] In some embodiments, the present disclosure relates to administration of immunotherapy to a subject. In some embodiments, such immunotherapy is or comprises immune checkpoint modulation therapy. In some embodiments, immunotherapy involves

administration of one or more immunomodulatory agents; in some embodiments an immunomodulatory agent is or comprises an immune checkpoint modulator. In some embodiments, an immune checkpoint modulator is an agent (e.g., an antibody agent) that targets (i.e., specifically interacts with) an immune checkpoint target. In some embodiments, an immune checkpoint target is or comprises one or more of CTLA-4, PD-1, PD-L1, GITR, OX40, LAG-3, KIR, TIM-3, CD28, CD40, and CD137; in some embodiments, immune checkpoint modulator therapy is or comprises administration of an antibody agent that targets one or more such immune checkpoint targets. In some embodiments, the immune checkpoint modulator interacts with cytotoxic T-lymphocyte antigen 4 (CTLA4) or its ligands, and/or programmed death 1 (PD-1) or its ligands. In some embodiments, the antibody agent is or comprises a monoclonal antibody or antigen binding fragment thereof. In some embodiments, the antibody is selected from the group comprising of atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab, and combinations therein.

[0017] In some embodiments, a cancer is selected from the group consisting of bladder cancer, bone cancer, breast cancer, cancer of unknown primary, esophagogastric cancer, gastrointestinal cancer, glioma, head and neck cancer, hepatobiliary cancer, melanoma, mesothelioma, non-hodgkin lymphoma, non-small cell lung cancer, pancreatic cancer, prostate cancer, renal cell carcinoma, skin cancer (non-melanoma), small cell lung cancer, soft tissue sarcoma, thyroid cancer, and combinations thereof.

[0018] In some embodiments, a cancer is selected from the group consisting of bladder cancer, breast cancer, esophagogastric cancer, glioma, head and neck cancer, melanoma, non-small cell lung cancer, renal cell carcinoma, and combinations thereof.

BRIEF DESCRIPTION OF THE DRAWING

[0019] The following figures are presented for the purpose of illustration only, and are not intended to be limiting.

[0020] **Figure 1** shows a Consolidated Standard of Reporting Trials (CONSORT) diagram demonstrating the flow of patient selection for analysis.

[0021] **Figure 2** shows the effect of tumor mutational load on overall survival after immune checkpoint modulator therapy. Kaplan-Meier curves are shown for the number of patients with the indicated number of mutations (1-15, 16-25, or greater than 25) identified from MSK-IMPACT testing. Overall survival is determined from the first dose of immune checkpoint modulator therapy. M, months. $P < 0.05$ for all pairwise comparisons.

[0022] **Figure 3A-3B** shows overall survival in relation to pan-cancer tumor mutational load threshold (A) with and (B) without immune checkpoint modulator (ICM) therapy. Kaplan-Meier curves are shown for patients who were treated with ICM or never treated with ICM with the indicated number of normalized mutations identified on MSK-IMPACT testing. Overall survival is determined starting from the first dose of ICM or first dose of any chemotherapy.

[0023] **Figure 4A-4B** shows the effect of tumor mutational load on overall survival (A) after ICM therapy by cancer subtype and drug class. A Forest plot is shown for all patients in the identified cohort ("Pan Cancer") or individual cancer subtypes. Indicated are the number of patients and hazard ratio. Horizontal lines represent the 95% confidence interval. The threshold used of normalized tumor mutational load from MSK-IMPACT for that particular subtype to select high tumor mutational load is shown, as well as the log-rank p value for the comparison of high and low tumor mutational load survival curves. All cancer types tested with a patient number of $N > 35$ are displayed. (B) shows the effect of tumor mutational load on overall survival by cancer subtype without ICM therapy. A Forest plot is shown for all patients in the cohort of patients who did not receive ICM ("Pan Cancer") or individual cancer subtypes. Indicated are the number of patients and hazard ratio. Horizontal lines represent the 95% confidence interval. The thresholds used are the optimal cutoff for that particular subtype in the ICM cohort. Log-rank p value are indicated for the comparison of high and low tumor mutational load survival curves. All cancer types tested with a patient number of $N > 35$ are displayed. In both panels A and B, the term "cutoff" is used to denote a tumor mutational load threshold determined herein.

[0024] **Figure 5** shows selection of tumor mutational load threshold values used for analysis. (A) demonstrates the use of maximum chi-squared analysis for optimal threshold with

individual cut points of normalized tumor mutational load on the x-axis and the p value. (B) demonstrates the hazard ratio at each cut point.

[0025] **Figure 6A-6H** shows the effect of tumor mutational load on overall survival after ICM therapy organized by cancer subtype. The first column in panels A-H demonstrates the distribution of normalized tumor mutational load frequency over subsets of tumor mutational load. The second column in panels A-H demonstrates Kaplan-Meier curves for patients who were treated with ICM therapy, with the indicated number of normalized mutations identified on MSK-IMPACT testing. Each panel represents a cancer subtype, with (A) bladder cancer, (B) breast cancer, (C) esophagogastric cancer, (D) glioma, (E) head and neck cancer, (F) melanoma, (G) non-small cell lung cancer (NSCLC), and (H) renal cell carcinoma.

[0026] **Figure 7** shows a funnel plot of hazard ratio for all cancer subtypes. The funnel plot is of the reciprocal of the number of patients (y-axis) and hazard ratios for normalized tumor mutational load (x-axis) as a continuous variable for particular histologies.

[0027] **Figure 8A-8I** shows the Effect of HLA class I homozygosity on survival in patients treated with immune check point modulator. (A) Association between homozygosity in at least one HLA class I locus and reduced overall survival in cohort 1, composed of 369 patients with melanoma or NSCLC treated with ICM therapy. (B) Association between homozygosity in at least one HLA class I locus and reduced survival in cohort 2, composed of 1,166 patients representing different cancer types treated with ICM therapy. (C) Association between homozygosity at one or more class I loci and for individual loci (HLA-A, HLA-B, and HLA-C) with decreased overall survival from all 1,535 patients. Indicated are the number of patients and hazard ratio (HR). Horizontal lines represent the 95% confidence interval. P value was calculated using the Log-rank test. Patients were divided into: individuals who were heterozygous at all three class I loci; individuals homozygous at one or more class I loci; individuals homozygous at the specified locus, but heterozygous at both of the other two loci; and individuals homozygous at the specified locus and also at one of the other two loci, but heterozygous at the other one. Homozygosity at HLA-A and HLA-B and homozygosity at HLA-A and HLA-C were rare in these patients, which limited the interpretability of analyses involving combinations of loci. (D) Improved survival in cohort 1 patients with heterozygosity at all HLA class I loci and a high

tumor mutational load compared to patients that are homozygous for at least one HLA class I locus and have a low tumor mutational load. Mutational load was calculated from the total nonsynonymous mutational count from whole exome sequencing. High mutational load is defined here as tumors with >113 mutations. (E) Improved survival in cohort 2 patients with heterozygosity at all HLA class I loci and a high tumor mutational load compared to patients that are homozygous in at least one HLA class I locus and have a low tumor mutational load. Mutational load was calculated from the total nonsynonymous mutational count from MSK-IMPACT. High mutational load is defined here as tumors with >16.72 mutations. (F and G) Box plots illustrating the distribution of hazard ratios resulting from the survival analyses using a range of cutoffs to stratify patients based on their tumor mutational load. This analysis shows that the combined effect of HLA class I heterozygosity at all loci and mutation load on improved survival was greater compared to simply considering tumor mutational load alone in cohort 1 (F) and cohort 2 (G). For this analysis, we used a range of cutoffs across the quartiles of mutation load. P values were calculated using the Wilcoxon-rank sum test. (H) Survival analysis showing that LOH of heterozygous germline HLA class I is associated with decreased overall survival in patients treated with ICM immunotherapy. The number of patients who are of heterozygous germline at all HLA class I loci and without LOH is 199; the number of patients with heterozygous germline at all HLA class I loci and with LOH is 32. (I) Survival analysis showing that the effect of LOH of heterozygous germline HLA class I is enhanced in tumors with low mutation burden compared to tumors with high mutation load and without LOH. High mutation load is defined here as in (D). The number of patients who are of heterozygous germline at each HLA class I locus, without LOH, and with tumors containing high mutation load is 142; the number of patients with heterozygous germline at all HLA class I loci, with LOH, and with tumors having low mutation burden is 8.

[0028] **Figures 9A-9J** show the influence of HLA B44 supertype on survival in patients with advanced melanoma treated with ICM. (A) Prevalence of the different HLA supertypes in patients with melanoma from cohort 1. (B) Prevalence of the different HLA supertypes in the patients with melanoma from cohort 2. (C and D) Survival analysis showing the overall survival of advanced melanoma patients treated with ICM therapy possessing the B44 supertype [B44 (+)] compared with patients without the B44 supertype [B44 (-)] from cohort 1 (C) and cohort 2

(D). (E and F) Survival analysis of patients with the B44 supertype and high mutation burden versus patients without B44 and with low mutation burden, from cohort 1 (E) and cohort 2 (F). (G and H) Box plots illustrating the distribution of hazard ratios resulting from the survival analyses using different cutoffs to stratify patients based on their tumor mutational burden. This analysis shows that the combined effect of B44 and mutation load on increased survival was greater compared to simply considering tumor mutational load alone in patients with melanoma treated with ICM therapy from cohort 1 (G) and cohort 2 (H). For this analysis, we used a range of cutoffs across the quartiles of mutation load. P values were calculated using the Wilcoxon-rank sum test. (I) Survival analysis of melanoma patients with and without the B44 supertype from the TCGA cohort. (J) Left: Example of peptide motif common among B44 HLA alleles, docked in complex with HLA-B*44:02 based on an available crystal structure (PDB: 1M6O). The five common residues (E2, I3, P4, V6, and Y9) of the motif were reported in (45). Peptide residues are colored according to their properties as basic, acidic, polar, or hydrophobic. Center: Close up view of example peptide conforming to the B44 motif reported in the literature. Residues at positions 2 and 9 are particularly important for anchoring the peptide in the HLA peptide-binding groove. Right: Alignment between B44 peptide motif and known immunogenic neoantigens (table 8) within the B44 supertype expressed by melanomas. All neoepitopes feature a glutamate at position 2; neoantigens are also either identical or similar to the motif at one or two additional positions. The second neoantigen (FAM3C: TESPFEQHI) was identified in a melanoma patient with a long-term response to anti-CTLA-4 from cohort 1. Sequence similarity was determined using standard residue classes (GAVLI, FYW, CM, ST, KRH, DENQ, and P).

[0029] **Figure 10A-10E** shows the effect of the HLA-B*15:01 allele on overall survival in patients with melanoma treated with ICM therapy. (A) Survival analysis showing reduced survival in ICM-treated melanoma patients from cohort 1 with and without the HLA-B*15:01 allele. (B) Overview of the three-dimensional structure of the peptide-binding groove of HLA-B*15:01, light purple; bound peptide, yellow; bridging residues, light pink. (C) Side view of the bridge-sequestration effect over bound-peptide residue positions P2 and P3 (light blue and red, respectively). (D) MD simulation snapshots of both the isolated HLA B*15:01 molecule and its complex with a 9-mer peptide; each trajectory was run over the course of 500 ns of simulation time. (E) Observables from the MD simulations described in (D). The mean bridge distances in

the HLA-B*15:01 molecule and in the HLA-B*15:01-peptide complex are comparable. The residue-position root mean square fluctuations (RMSFs) indicate that each of the bridging residues becomes more rigid in the presence of the peptide.

[0030] **Figures 11A-11B** show the number of somatic coding mutations in the tumors between patients who were homozygous for at least one HLA class I locus and patients who are heterozygous at each class I locus in cohort 1 and cohort 2, respectively. The P value was calculated by Wilcoxon-rank sum test.

[0031] **Figures 12A-12D show** molecular dynamics simulations for HLA-B*07:02 and HLA-B*53:01. (A and C) MD simulation snapshots of both the isolated HLA B*07:02 and HLA B*53:01 molecules, respectively, and their complexes with a 9-mer peptide; each trajectory was run over the course of 300 ns of simulation time. (B and D) Observables from the MD simulations described in (A and C). Both mean bridge distances and bridging residues RMSFs in the HLA B*07:02 and HLA B*53:01 molecules and in their corresponding HLA-peptide complexes are shown.

[0032] **Figure 13** shows a Consolidated Standard of Reporting Trials (CONSORT) diagram demonstrating the flow of patient selection for analysis for a confirmatory cohort.

[0033] **Figures 14A and 14B** show effect of mutational load on overall survival after ICI treatment. A. Kaplan-Meier curves for patients with tumors falling into the depicted deciles of tumor mutational burden (TMB) within each histology. TMB is defined as normalized somatic mutations per MB identified on MSK-IMPACT testing. Overall survival is from the first dose of ICI. Log-rank p value indicated for all patients, with univariate Cox regression hazard ratio of 0.76 (95% CI 0.62-0.94) and 0.52 (95% CI 0.42-0.64) for the 10-20% and Top10% groups, respectively, compared to Bottom80% group. m, months B. Cox regression hazard ratios for overall survival, at depicted cutoffs of tumor mutational burden (TMB) measured in mutations per MB across all cancer subtypes. Solid black circles represent hazard ratios with p-values <.05.

[0034] **Figure 15** demonstrates he distribution of cancer types within the groups demonstrated in Figure 14A.

[0035] **Figures 16A-16D** demonstrates overall survival of high TMB patients by quantiles across cancer types. Kaplan Meier survival analysis of high vs. low TMB defined by the top indicated percentage of patients from each cancer type. P values indicate log rank test.

[0036] **Figure 17** demonstrates effect of non-synonymous mutational load on overall survival after ICI Treatment by cancer subtype and drug class. Forest plot for all patients in the identified cohort or individual cancer subtypes. Indicated are the number of patients and hazard ratio comparing overall survival after ICI in patients in the highest 20th percentile TMB within each histology. Horizontal lines represent the 95% confidence interval. The cutoff defining top 20% of normalized mutational burden from MSK-IMPACT for each cancer type is shown, as well as the log-rank p value for the comparison of high and low mutational burden survival curves. All cancer types in analysis are displayed.

[0037] **Figures 18A and 18B** show forest plot for all patients in the cohort and individual cancer histologies. Indicated are the number of patients and hazard ratio comparing overall survival after ICI in patients with ≥ 10% highest TMB (A) or 30% (B) for each histology . Horizontal lines represent the 95% confidence interval. The cutoff used of normalized mutational burden from MSK-IMPACT for that particular subtype to select high mutational burden is shown, as well as the log-rank p value for the comparison of high and low mutational burden survival curves.

[0038] **Figure 19** shows effect of non-synonymous mutational load on overall survival after ICI Treatment, or in non-ICI treated patients, by cancer subtype. Individual plots for all patients in the identified cohort ("All cancer types") or individual cancer subtypes. The first column demonstrates the distribution of normalized mutational load frequency. The second column demonstrates Kaplan-Meier curves for patients who were treated with ICI with the top20% TMB within each histology identified on MSK-IMPACT testing. The third column represents OS comparing the top 20% of tumors in the cohort of patients never treated with ICI from date of diagnosis.

[0039] **Figure 20** shows forest plot depicting the Cox proportional hazards model across all cancer types and individual histologies demonstrating the hazard ratio for TMB as a continuous variable.

[0040] **Figures 21A-21C** show TMB as a predictor of clinical response to ICI. Pie charts demonstrating the relative proportion of patients with a clinical benefit (defined as radiographic response or stable disease for $\geq$ 6 months) with low or high TMB in A. NSCLC, B.Head and Neck, and C. Esophagogastric cancer. Fisher's exact test p values indicated. Similar data for the association between TMB and tumor response in MSK-IMPACT sequenced NSCLC patients have also been separately published.

[0041] **Figures 22A-22D** show TMB predicts for progression free survival progression free survival (A,B,C) or time to next treatment (D) in patients with high and low TMB (Top20%) tumors in the indicated cancer types. Log-rank p values indicated.

[0042] **Figure 23** shows effect of non-synonymous mutational load on OS by cancer Subtype in Patients Not Treated with ICI. Forest plot for all metastatic patients in the cohort of patients who did not receive ICI ("All cancer types") or individual cancer subtypes. Indicated are the number of patients and hazard ratio. Horizontal lines represent the 95% confidence interval. The cutoffs used are the top 20% in this cohort. Log-rank p value are indicated for the comparison of high and low mutational burden survival curves.

[0043] **Figure 24** shows modified versions of Figure 17 and Figure 23, with the TMB cutoff instead defined as the top 20% among all patients in both ICI-treated and non-ICI treated cohorts.

[0044] **Figure 25** shows a modified version of Figure 19, with TMB cutoff instead defined as the top 20% from all patients in both the ICI-treated and non-ICI treated cohorts. The first column demonstrates the distribution of normalized mutational load frequency across the combined ICI treated and non-ICI treated cohorts in that histology. The second column demonstrates Kaplan-Meier curves for patients who were treated with ICI with the top20% TMB (across the combined cohorts) within each histology identified on MSK-IMPACT testing. The third column represents OS comparing the top 20% TMB (across the combined cohorts) in the cohort of patients never treated with ICI from date of diagnosis.

DEFINITIONS

[0045] In order for the present invention to be more readily understood, certain terms are defined below. Those skilled in the art will appreciate that definitions for certain terms may be provided elsewhere in the specification, and/or will be clear from context.

[0046] *Administration*: As used herein, the term "administration" refers to the administration of a composition to a subject. Administration may be by any appropriate route. For example, in some embodiments, administration may be bronchial (including by bronchial instillation), buccal, enteral, interdermal, intra-arterial, intradermal, intragastric, intramedullary, intramuscular, intranasal, intraperitoneal, intrathecal, intravenous, intraventricular, mucosal, nasal, oral, rectal, subcutaneous, sublingual, topical, tracheal (including by intratracheal instillation), transdermal, vaginal and vitreal.

[0047] *Affinity*: As is known in the art, "affinity" is a measure of the tightness with a particular ligand binds to its partner. Affinities can be measured in different ways. In some embodiments, affinity is measured by a quantitative assay. In some such embodiments, binding partner concentration may be fixed to be in excess of ligand concentration so as to mimic physiological conditions. Alternatively or additionally, in some embodiments, binding partner concentration and/or ligand concentration may be varied. In some such embodiments, affinity may be compared to a reference under comparable conditions (e.g., concentrations).

[0048] *Amino acid*: As used herein, term "amino acid," in its broadest sense, refers to any compound and/or substance that can be incorporated into a polypeptide chain. In some embodiments, an amino acid has the general structure H2N–C(H)(R)–COOH. In some embodiments, an amino acid is a naturally occurring amino acid. In some embodiments, an amino acid is a synthetic amino acid; in some embodiments, an amino acid is a d-amino acid; in some embodiments, an amino acid is an l-amino acid. "Standard amino acid" refers to any of the twenty standard l-amino acids commonly found in naturally occurring peptides. "Nonstandard amino acid" refers to any amino acid, other than the standard amino acids, regardless of whether it is prepared synthetically or obtained from a natural source. As used herein, "synthetic amino acid" encompasses chemically modified amino acids, including but not limited to salts, amino acid derivatives (such as amides), and/or substitutions. Amino acids, including carboxy- and/or amino-terminal amino acids in peptides, can be modified by methylation, amidation, acetylation,

protecting groups, and/or substitution with other chemical groups that can change the peptide's circulating half-life without adversely affecting their activity. Amino acids may participate in a disulfide bond. Amino acids may comprise one or posttranslational modifications, such as association with one or more chemical entities (e.g., methyl groups, acetate groups, acetyl groups, phosphate groups, formyl moieties, isoprenoid groups, sulfate groups, polyethylene glycol moieties, lipid moieties, carbohydrate moieties, biotin moieties, etc.). The term "amino acid" is used interchangeably with "amino acid residue," and may refer to a free amino acid and/or to an amino acid residue of a peptide. It will be apparent from the context in which the term is used whether it refers to a free amino acid or a residue of a peptide.

[0049] *Antibody agent*: As used herein, the term "antibody agent" refers to an agent that specifically binds to a particular antigen. In some embodiments, the term encompasses any polypeptide with immunoglobulin structural elements sufficient to confer specific binding. Suitable antibody agents include, but are not limited to, human antibodies, primatized antibodies, chimeric antibodies, bi-specific antibodies, humanized antibodies, conjugated antibodies (*i.e.*, antibodies conjugated or fused to other proteins, radiolabels, cytotoxins), Small Modular Immuno Pharmaceuticals ("SMIPs™"), single chain antibodies, cameloid antibodies, and antibody fragments. As used herein, the term "antibody agent" also includes intact monoclonal antibodies, polyclonal antibodies, single domain antibodies (e.g., shark single domain antibodies (e.g., IgNAR or fragments thereof)), multispecific antibodies (*e.g.* bi-specific antibodies) formed from at least two intact antibodies, and antibody fragments so long as they exhibit the desired biological activity. In some embodiments, the term encompasses stapled peptides. In some embodiments, the term encompasses one or more antibody-like binding peptidomimetics. In some embodiments, the term encompasses one or more antibody-like binding scaffold proteins. In come embodiments, the term encompasses monobodies or adnectins. In many embodiments, an antibody agent is or comprises a polypeptide whose amino acid sequence includes one or more structural elements recognized by those skilled in the art as a complementarity determining region (CDR); in some embodiments an antibody agent is or comprises a polypeptide whose amino acid sequence includes at least one CDR (e.g., at least one heavy chain CDR and/or at least one light chain CDR) that is substantially identical to one found in a reference antibody. In some embodiments an included CDR is substantially identical to a reference CDR in that it is

either identical in sequence or contains between 1-5 amino acid substitutions as compared with the reference CDR. In some embodiments an included CDR is substantially identical to a reference CDR in that it shows at least 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100% sequence identity with the reference CDR. In some embodiments an included CDR is substantially identical to a reference CDR in that it shows at least 96%, 96%, 97%, 98%, 99%, or 100% sequence identity with the reference CDR. In some embodiments an included CDR is substantially identical to a reference CDR in that at least one amino acid within the included CDR is deleted, added, or substituted as compared with the reference CDR but the included CDR has an amino acid sequence that is otherwise identical with that of the reference CDR. In some embodiments an included CDR is substantially identical to a reference CDR in that 1-5 amino acids within the included CDR are deleted, added, or substituted as compared with the reference CDR but the included CDR has an amino acid sequence that is otherwise identical to the reference CDR. In some embodiments an included CDR is substantially identical to a reference CDR in that at least one amino acid within the included CDR is substituted as compared with the reference CDR but the included CDR has an amino acid sequence that is otherwise identical with that of the reference CDR. In some embodiments an included CDR is substantially identical to a reference CDR in that 1-5 amino acids within the included CDR are deleted, added, or substituted as compared with the reference CDR but the included CDR has an amino acid sequence that is otherwise identical to the reference CDR. In some embodiments, an antibody agent is or comprises a polypeptide whose amino acid sequence includes structural elements recognized by those skilled in the art as an immunoglobulin variable domain. In some embodiments, an antibody agent is a polypeptide protein having a binding domain which is homologous or largely homologous to an immunoglobulin-binding domain.

[0050] *Antibody polypeptide:* As used herein, the terms "antibody polypeptide" or "antibody", or "antigen-binding fragment thereof", which may be used interchangeably, refer to polypeptide(s) capable of binding to an epitope. In some embodiments, an antibody polypeptide is a full-length antibody, and in some embodiments, is less than full length but includes at least one binding site (comprising at least one, and preferably at least two sequences with structure of antibody "variable regions"). In some embodiments, the term "antibody polypeptide"

encompasses any protein having a binding domain which is homologous or largely homologous to an immunoglobulin-binding domain. In particular embodiments, "antibody polypeptides" encompasses polypeptides having a binding domain that shows at least 99% identity with an immunoglobulin binding domain. In some embodiments, "antibody polypeptide" is any protein having a binding domain that shows at least 70%, 80%, 85%, 90%, or 95% identity with an immuglobulin binding domain, for example a reference immunoglobulin binding domain. An included "antibody polypeptide" may have an amino acid sequence identical to that of an antibody that is found in a natural source. Antibody polypeptides in accordance with the present invention may be prepared by any available means including, for example, isolation from a natural source or antibody library, recombinant production in or with a host system, chemical synthesis, etc., or combinations thereof. An antibody polypeptide may be monoclonal or polyclonal. An antibody polypeptide may be a member of any immunoglobulin class, including any of the human classes: IgG, IgM, IgA, IgD, and IgE. In certain embodiments, an antibody may be a member of the IgG immunoglobulin class. As used herein, the terms "antibody polypeptide" or "characteristic portion of an antibody" are used interchangeably and refer to any derivative of an antibody that possesses the ability to bind to an epitope of interest. In certain embodiments, the "antibody polypeptide" is an antibody fragment that retains at least a significant portion of the full-length antibody's specific binding ability. Examples of antibody fragments include, but are not limited to, Fab, Fab', $F(ab')_2$, scFv, Fv, dsFv diabody, and Fd fragments. Alternatively or additionally, an antibody fragment may comprise multiple chains that are linked together, for example, by disulfide linkages. In some embodiments, an antibody polypeptide may be a human antibody. In some embodiments, the antibody polypeptides may be a humanized. Humanized antibody polypeptides include may be chimeric immunoglobulins, immunoglobulin chains or antibody polypeptides (such as Fv, Fab, Fab', F(ab')2 or other antigen-binding subsequences of antibodies) that contain minimal sequence derived from non-human immunoglobulin. In general, humanized antibodies are human immunoglobulins (recipient antibody) in which residues from a complementary-determining region (CDR) of the recipient are replaced by residues from a CDR of a non-human species (donor antibody) such as mouse, rat or rabbit having the desired specificity, affinity, and capacity. In particular embodiments,

antibody polyeptides for use in accordance with the present invention bind to particular epitopes of on immune checkpoint molecules.

[0051] *Antigen*: An "antigen" is a molecule or entity to which an antibody binds. In some embodiments, an antigen is or comprises a polypeptide or portion thereof. In some embodiments, an antigen is a portion of an infectious agent that is recognized by antibodies. In some embodiments, an antigen is an agent that elicits an immune response; and/or (ii) an agent that is bound by a T cell receptor (e.g., when presented by an MHC molecule) or to an antibody (e.g., produced by a B cell) when exposed or administered to an organism. In some embodiments, an antigen elicits a humoral response (e.g., including production of antigen-specific antibodies) in an organism; alternatively or additionally, in some embodiments, an antigen elicits a cellular response (e.g., involving T-cells whose receptors specifically interact with the antigen) in an organism. It will be appreciated by those skilled in the art that a particular antigen may elicit an immune response in one or several members of a target organism (e.g., mice, rabbits, primates, humans), but not in all members of the target organism species. In some embodiments, an antigen elicits an immune response in at least about 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% of the members of a target organism species. In some embodiments, an antigen binds to an antibody and/or T cell receptor, and may or may not induce a particular physiological response in an organism. In some embodiments, for example, an antigen may bind to an antibody and/or to a T cell receptor *in vitro*, whether or not such an interaction occurs *in vivo*. In general, an antigen may be or include any chemical entity such as, for example, a small molecule, a nucleic acid, a polypeptide, a carbohydrate, a lipid, a polymer [in some embodiments other than a biologic polymer (e.g., other than a nucleic acid or amino acid polymer)] etc. In some embodiments, an antigen is or comprises a polypeptide. In some embodiments, an antigen is or comprises a glycan. Those of ordinary skill in the art will appreciate that, in general, an antigen may be provided in isolated or pure form, or alternatively may be provided in crude form (e.g., together with other materials, for example in an extract such as a cellular extract or other relatively crude preparation of an antigen-containing source). In some embodiments, antigens utilized in accordance with the present invention are provided in a crude form. In some embodiments, an antigen is or comprises a recombinant antigen.

[0052] *Approximately*: As used herein, the term "approximately" or "about," as applied to one or more values of interest, refers to a value that is similar to a stated reference value. In certain embodiments, the term "approximately" or "about" refers to a range of values that fall within 25%, 20%, 19%, 18%, 17%, 16%, 15%, 14%, 13%, 12%, 11%, 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or less in either direction (greater than or less than) of the stated reference value unless otherwise stated or otherwise evident from the context (except where such number would exceed 100% of a possible value).

[0053] *"Blockade"*: The term "blockade" as used herein, refers to an entity or event whose presence or level correlates with a reduction in level and/or activity of an indicated target. Thus, for example, "a PD-1 blockade" is an agent or event whose presence correlates with reduction in level and/or activity of PD-1. In some such embodiments, a relevant activity of PD-1 may be or comprise interaction with one of more of its ligands (e.g., PD-L1 and/or PD-L2) and/or a downstream effect thereof. In some embodiments, a PD-1 blockade may be achieved by administration of an agent, such as an antibody agent, that targets PD-1 and/or a PD-1 ligand (e.g., PD-L1 and/or PD-L2) and/or a complex thereof. In some particular embodiments, a PD-1 blockade may be achieved through administration of an antibody agent that binds to PD-1. In some embodiments, a PD-1 blockade may be achieved through administration of one or more of nivolumab, pembrolizumab, atezolizumab, avelumab, and/or durvalumab. Analogously, a "CTL4-blockade is an agent or event whose presence correlates with reduction in level and/or activity of CTLA-4. In some such embodiments, a relevant activity of CTLA-4 may be or comprise interaction with one of more of its ligands (e.g., CD80 and/or CD86) and/or a downstream effect thereof. In some embodiments, a CTLA-4 blockade may be achieved by administration of an agent, such as an antibody agent, that targets CTLA-4 ligand (e.g., CD80 and/or CD86) and/or a complex thereof. In some particular embodiments, a CTLA-4 blockade may be achieved through administration of an antibody agent that binds to CTLA-4. In some embodiments, a CTLA-4 blockade may be achieved through administration of one or more of ipilimumab and/or tremelimumab.

[0054] *Combination therapy*: The term "combination therapy", as used herein, refers to those situations in which two or more different pharmaceutical agents are administered in overlapping regimens so that the subject is simultaneously exposed to both agents. When used in

combination therapy, two or more different agents may be administered simultaneously or separately. This administration in combination can include simultaneous administration of the two or more agents in the same dosage form, simultaneous administration in separate dosage forms, and separate administration. That is, two or more agents can be formulated together in the same dosage form and administered simultaneously. Alternatively, two or more agents can be simultaneously administered, wherein the agents are present in separate formulations. In another alternative, a first agent can be administered just followed by one or more additional agents. In the separate administration protocol, two or more agents may be administered a few minutes apart, or a few hours apart, or a few days apart.

[0055] *Comparable*: The term "comparable" is used herein to describe two (or more) sets of conditions, circumstances, individuals, or populations that are sufficiently similar to one another to permit comparison of results obtained or phenomena observed. In some embodiments, comparable sets of conditions, circumstances, individuals, or populations are characterized by a plurality of substantially identical features and one or a small number of varied features. Those of ordinary skill in the art will appreciate that sets of circumstances, individuals, or populations are comparable to one another when characterized by a sufficient number and type of substantially identical features to warrant a reasonable conclusion that differences in results obtained or phenomena observed under or with different sets of circumstances, individuals, or populations are caused by or indicative of the variation in those features that are varied. Those skilled in the art will appreciate that relative language used herein (e.g., enhanced, activated, reduced, inhibited, etc) will typically refer to comparisons made under comparable conditions.

[0056] *Consensus sequence:* As used herein, the term "consensus sequence" refers to a core sequence that elicits or drives a physiological phenomenon (e.g., an immune response). It is to be understood by those of skill in the art that a a cancer cell that shares a "consensus sequence" with an antigen of an infectious agent shares a portion of amino acid sequence that affects the binding affinity of the antigen to an MHC molecule (either directly or allosterically), and/or facilitates recognition by T cell receptors. In some embodiments, a consensus sequence is a tetrapeptide. In some embodiments, a consensus sequence is a nonapeptide. In some

embodiments, a consensus sequence is betwene four and nine amino acids in length. In some embodiments, a consesnsus sequence is greater than nine amino acids in length.

[0057] *Diagnostic information*: As used herein, diagnostic information or information for use in diagnosis is any information that is useful in determining whether a patient has a disease or condition and/or in classifying the disease or condition into a phenotypic category or any category having significance with regard to prognosis of the disease or condition, or likely response to treatment (either treatment in general or any particular treatment) of the disease or condition. Similarly, diagnosis refers to providing any type of diagnostic information, including, but not limited to, whether a subject is likely to have a disease or condition (such as cancer), state, staging or characteristic of the disease or condition as manifested in the subject, information related to the nature or classification of a tumor, information related to prognosis and/or information useful in selecting an appropriate treatment. Selection of treatment may include the choice of a particular therapeutic (e.g., chemotherapeutic) agent or other treatment modality such as surgery, radiation, etc., a choice about whether to withhold or deliver therapy, a choice relating to dosing regimen (e.g., frequency or level of one or more doses of a particular therapeutic agent or combination of therapeutic agents), etc.

[0058] *Dosing regimen:* A "dosing regimen" (or "therapeutic regimen"), as that term is used herein, is a set of unit doses (typically more than one) that are administered individually to a subject, typically separated by periods of time. In some embodiments, a given therapeutic agent has a recommended dosing regimen, which may involve one or more doses. In some embodiments, a dosing regimen comprises a plurality of doses each of which are separated from one another by a time period of the same length; in some embodiments, a dosing regimen comprises a plurality of doses and at least two different time periods separating individual doses. In some embodiments, a dosing regimen is or has been correlated with a desired therapeutic outcome, when administered across a population of patients.

[0059] *Durable clinical benefit:* As used herein, the term "durable clinical benefit" (DCB), has its art-understood meaning, referring to a clinical benefit that lasts for a relevant period of time. In some embodiments, such a clinical benefit is or comprises reduction in tumor size, increase in progression free survival, increase in overall survival, decrease in overall tumor

burden, decrease in the symptoms caused by tumor growth such as pain, organ failure, bleeding, damage to the skeletal system, and other related sequelae of metastatic cancer and combinations thereof. In some embodiments, the relevant period of time is at least 1 month, 2 months, 3 months, 4 months, 5 months, 6 months, 7 months, 8 months, 9 months, 10 months, 11 months, 1 year, 2 years, 3 years, 4 years, 5 years, or longer. In some particular embodiments, the relevant period of time is 6 months.

[0060] *Exome:* As used herein, the term "exome" is used in accordance with its art-understood meaning referring to the set of exon sequences that are found in a particular genome.

[0061] *Favorable response*: As used herein, the term "favorable response" refers to a reduction in frequency and/or intensity of one or more symptoms, reduction in tumor burden, full or partial remission, or other improvement in disease pathophysiology. Symptoms are reduced when one or more symptoms of a particular disease, disorder or condition is reduced in magnitude (e.g., intensity, severity, etc.) and/or frequency. For purposes of clarity, a delay in the onset of a particular symptom is considered one form of reducing the frequency of that symptom. Many cancer patients with smaller tumors have no symptoms. It is not intended that the present invention be limited only to cases where the symptoms are eliminated. The present invention specifically contemplates treatment such that one or more symptoms is/are reduced (and the condition of the subject is thereby "improved"), albeit not completely eliminated. In some embodiments, a favorable response is established when a particular therapeutic regimen shows a statistically significant effect when administered across a relevant population; demonstration of a particular result in a specific individual may not be required. Thus, in some embodiments, a particular therapeutic regimen is determined to have a favorable response when its administration is correlated with a relevant desired effect.

[0062] *Homology*: As used herein, the term "homology" refers to the overall relatedness between polymeric molecules, e.g., between nucleic acid molecules (e.g., DNA molecules and/or RNA molecules) and/or between polypeptide molecules. In some embodiments, polymeric molecules are considered to be "homologous" to one another if their sequences are at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or 99% identical. In some embodiments, polymeric molecules are considered to be "homologous" to one

another if their sequences are at least 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or 99% similar.

[0063] *Identity*: As used herein, the term "identity" refers to the overall relatedness between polymeric molecules, e.g., between nucleic acid molecules (e.g., DNA molecules and/or RNA molecules) and/or between polypeptide molecules. Calculation of the percent identity of two nucleic acid sequences, for example, can be performed by aligning the two sequences for optimal comparison purposes (e.g., gaps can be introduced in one or both of a first and a second nucleic acid sequences for optimal alignment and non-identical sequences can be disregarded for comparison purposes). In certain embodiments, the length of a sequence aligned for comparison purposes is at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, or substantially 100% of the length of the reference sequence. The nucleotides at corresponding nucleotide positions are then compared. When a position in the first sequence is occupied by the same nucleotide as the corresponding position in the second sequence, then the molecules are identical at that position. The percent identity between the two sequences is a function of the number of identical positions shared by the sequences, taking into account the number of gaps, and the length of each gap, which needs to be introduced for optimal alignment of the two sequences. The comparison of sequences and determination of percent identity between two sequences can be accomplished using a mathematical algorithm. For example, the percent identity between two nucleotide sequences can be determined using the algorithm of Meyers and Miller (CABIOS, 1989, 4: 11-17), which has been incorporated into the ALIGN program (version 2.0) using a PAM120 weight residue table, a gap length penalty of 12 and a gap penalty of 4. The percent identity between two nucleotide sequences can, alternatively, be determined using the GAP program in the GCG software package using an NWSgapdna.CMP matrix.

[0064] *Immune checkpoint modulator*: As used herein, the term "immune checkpoint modulator" refers to an agent that interacts directly or indirectly with an immune checkpoint. In some embodiments, an immune checkpoint modulator increases an immune effector response (e.g., cytotoxic T cell response), for example by stimulating a positive signal for T cell activation. In some embodiments, an immune checkpoint modulator increases an immune effector response (e.g., cytotoxic T cell response), for example by inhibiting a negative signal for

T cell activation (e.g. disinhibition). In some embodiments, an immune checkpoint modulator interferes with a signal for T cell anergy. In some embodiments, an immune checkpoint modulator reduces, removes, or prevents immune tolerance to one or more antigens.

[0065] *Long Term Benefit*: In general, the term "long term benefit" refers to a desirable clinical outcome, e.g., observed after administration of a particular treatment or therapy of interest, that is maintained for a clinically relevant period of time. To give but one example, in some embodiments, a long term benefit of cancer therapy is or comprises (1) no evidence of disease ("NED", for example upon radiographic assessment) and/or (2) stable or decreased volume of diseases. In some embodiments, a clinically relevant period of time is at least 1 month, at least 2 months, at least 3 months, at least 4 months, at least 5 months or more. In some embodiments, a clinically relevant period of time is at least six months. In some embodiments, a clinically relevant period of time is at least 1 year.

[0066] *Marker*: A marker, as used herein, refers to an agent whose presence or level is a characteristic of a particular tumor or metastatic disease thereof. For example, in some embodiments, the term refers to a gene expression product that is characteristic of a particular tumor, tumor subclass, stage of tumor, etc. Alternatively or additionally, in some embodiments, a presence or level of a particular marker correlates with activity (or activity level) of a particular signaling pathway, for example that may be characteristic of a particular class of tumors. The statistical significance of the presence or absence of a marker may vary depending upon the particular marker. In some embodiments, detection of a marker is highly specific in that it reflects a high probability that the tumor is of a particular subclass. Such specificity may come at the cost of sensitivity (i.e., a negative result may occur even if the tumor is a tumor that would be expected to express the marker). Conversely, markers with a high degree of sensitivity may be less specific that those with lower sensitivity. According to the present invention a useful marker need not distinguish tumors of a particular subclass with 100% accuracy.

[0067] *Modulator*: The term "modulator" is used to refer to an entity whose presence in a system in which an activity of interest is observed correlates with a change in level and/or nature of that activity as compared with that observed under otherwise comparable conditions when the modulator is absent. In some embodiments, a modulator is an activator, in that activity

is increased in its presence as compared with that observed under otherwise comparable conditions when the modulator is absent. In some embodiments, a modulator is an inhibitor, in that activity is reduced in its presence as compared with otherwise comparable conditions when the modulator is absent. In some embodiments, a modulator interacts directly with a target entity whose activity is of interest. In some embodiments, a modulator interacts indirectly (i.e., directly with an intermediate agent that interacts with the target entity) with a target entity whose activity is of interest. In some embodiments, a modulator affects level of a target entity of interest; alternatively or additionally, in some embodiments, a modulator affects activity of a target entity of interest without affecting level of the target entity. In some embodiments, a modulator affects both level and activity of a target entity of interest, so that an observed difference in activity is not entirely explained by or commensurate with an observed difference in level.

[0068] *Mutation:* As used herein, the term "mutation" refers to permanent change in the DNA sequence that makes up a gene. In some embodiments, mutations range in size from a single DNA building block (DNA base) to a large segment of a chromosome. In some embodiments, mutations can include missense mutations, frameshift mutations, duplications, insertions, nonsense mutation, deletions and repeat expansions. In some embodiments, a missense mutation is a change in one DNA base pair that results in the substitution of one amino acid for another in the protein made by a gene. In some embodiments, a nonsense mutation is also a change in one DNA base pair. Instead of substituting one amino acid for another, however, the altered DNA sequence prematurely signals the cell to stop building a protein. In some embodiments, an insertion changes the number of DNA bases in a gene by adding a piece of DNA. In some embodiments, a deletion changes the number of DNA bases by removing a piece of DNA. In some embodiments, small deletions may remove one or a few base pairs within a gene, while larger deletions can remove an entire gene or several neighboring genes. In some embodiments, a duplication consists of a piece of DNA that is abnormally copied one or more times. In some embodiments, frameshift mutations occur when the addition or loss of DNA bases changes a gene's reading frame. A reading frame consists of groups of 3 bases that each code for one amino acid. In some embodiments, a frameshift mutation shifts the grouping of these bases and changes the code for amino acids. In some embodiments, insertions, deletions, and duplications can all be frameshift mutations. In some embodiments, a repeat expansion is

another type of mutation. In some embodiments, nucleotide repeats are short DNA sequences that are repeated a number of times in a row. For example, a trinucleotide repeat is made up of 3-base-pair sequences, and a tetranucleotide repeat is made up of 4-base-pair sequences. In some embodiments, a repeat expansion is a mutation that increases the number of times that the short DNA sequence is repeated.

[0069] "*Mutational Load*": The term "mutational load" is used herein to refer to the number of mutations detected in a sample (e.g., a tumor sample) at a given point in time. Those skilled in the art will appreciate that "mutational load" may also be referred to as "mutational burden". In some embodiments, mutations included in an assessment of mutational load may be neoantigen mutations (i.e., mutations that give rise to neoantigens). In some embodiments, a sample in which mutational load is assessed is from a single tumor. In some embodiments, a sample is pooled from multiple tumors, either from a single individual subject, or from a plurality of subjects.

[0070] *Neoepitope*: A "neoepitope" is understood in the art to refer to an epitope that emerges or develops in a subject after exposure to or occurrence of a particular event (e.g., development or progression of a particular disease, disorder or condition, e.g., infection, cancer, stage of cancer, etc). As used herein, a neoepitope is one whose presence and/or level is correlated with exposure to or occurrence of the event. In some embodiments, a neoepitope is one that triggers an immune response against cells that express it (e.g., at a relevant level). In some embodiments, a neopepitope is one that triggers an immune response that kills or otherwise destroys cells that express it (e.g., at a relevant level). In some embodiments, a relevant event that triggers a neoepitope is or comprises somatic mutation in a cell. In some embodiments, a neoepitope is not expressed in non-cancer cells to a level and/or in a manner that triggers and/or supports an immune response (e.g., an immune response sufficient to target cancer cells expressing the neoepitope). In some embodiments, a neoepitope is a neoantigen.

[0071] *No Benefit*: As used herein, the phrase "no benefit" is used to refer to absence of detectable clinical benefit (e.g., in response to administration of a particular therapy or treatment of interest). In some embodiments, absence of clinical benefit refers to absence of statistically significant change in any particular symptom or characteristic of a particular disease, disorder, or

condition. In some embodiments, absence of clinical benefit refers to a change in one or more symptoms or characteristics of a disease, disorder, or condition, that lasts for only a short period of time such as, for example, less than about 6 months, less than about 5 months, less than about 4 months, less than about 3 months, less than about 2 months, less than about 1 month, or less. In some embodiments, no benefit refers to no durable benefit.

[0072] *Objective Response:* As used herein, the phrase "objective response" refers to size reduction of a cancerous mass by a defined amount. In some embodiments, the cancerous mass is a tumor. In some embodiments, confirmed objective response is response confirmed at least four (4) weeks after treatment.

[0073] *Objective Response Rate*: As used herein, the term "objective response rate" ("ORR") has its art-understood meaning referring to the proportion of patients with tumor size reduction of a predefined amount and for a minimum time period. In some embodiments, response duration usually measured from the time of initial response until documented tumor progression. In some embodiments, ORR involves the sum of partial responses plus complete responses.

[0074] *Patient*: As used herein, the term "patient" or "subject" refers to any organism to which a provided composition is or may be administered, e.g., for experimental, diagnostic, prophylactic, cosmetic, and/or therapeutic purposes. Typical patients include animals (e.g., mammals such as mice, rats, rabbits, non-human primates, and/or humans). In some embodiments, a patient is a human. In some embodiments, a patient is suffering from or susceptible to one or more disorders or conditions. In some embodiments, a patient displays one or more symptoms of a disorder or condition. In some embodiments, a patient has been diagnosed with one or more disorders or conditions. In some embodiments, the disorder or condition is or includes cancer, or presence of one or more tumors. In some embodiments, the disorder or condition is metastatic cancer.

[0075] *Polypeptide*: As used herein, a "polypeptide", generally speaking, is a string of at least two amino acids attached to one another by a peptide bond. In some embodiments, a polypeptide may include at least 3-5 amino acids, each of which is attached to others by way of at least one peptide bond. Those of ordinary skill in the art will appreciate that polypeptides

sometimes include "non-natural" amino acids or other entities that nonetheless are capable of integrating into a polypeptide chain, optionally.

[0076] *Prognostic and predictive information*: As used herein, the terms prognostic and predictive information are used interchangeably to refer to any information that may be used to indicate any aspect of the course of a disease or condition either in the absence or presence of treatment. Such information may include, but is not limited to, the average life expectancy of a patient, the likelihood that a patient will survive for a given amount of time (e.g., 6 months, 1 year, 5 years, etc.), the likelihood that a patient will be cured of a disease, the likelihood that a patient's disease will respond to a particular therapy (wherein response may be defined in any of a variety of ways). Prognostic and predictive information are included within the broad category of diagnostic information.

[0077] *Progression Free Survival*: As used herein, the term "progression free survival" (PFS) has its art-understood meaning relating to the length of time during and after the treatment of a disease, such as cancer, that a patient lives with the disease but it does not get worse. In some embodiments, measuring the progression-free survival is utilized as an assessment of how well a new treatment works. In some embodiments, PFS is determined in a randomized clinical trial; in some such embodiments, PFS refers to time from randomization until objective tumor progression and/or death.

[0078] *Protein*: As used herein, the term "protein" refers to a polypeptide (i.e., a string of at least two amino acids linked to one another by peptide bonds). Proteins may include moieties other than amino acids (e.g., may be glycoproteins, proteoglycans, etc.) and/or may be otherwise processed or modified. Those of ordinary skill in the art will appreciate that a "protein" can be a complete polypeptide chain as produced by a cell (with or without a signal sequence), or can be a characteristic portion thereof. Those of ordinary skill will appreciate that a protein can sometimes include more than one polypeptide chain, for example linked by one or more disulfide bonds or associated by other means. Polypeptides may contain L-amino acids, D-amino acids, or both and may contain any of a variety of amino acid modifications or analogs known in the art. Useful modifications include, e.g., terminal acetylation, amidation, methylation, etc. In some embodiments, proteins may comprise natural amino acids, non-natural

amino acids, synthetic amino acids, and combinations thereof. The term "peptide" is generally used to refer to a polypeptide having a length of less than about 100 amino acids, less than about 50 amino acids, less than 20 amino acids, or less than 10 amino acids.

[0079] *Reference*: Those of skill in the art will appreciate that, in many embodiments described herein, a determined value or characteristic of interest is compared with an appropriate reference. In some embodiments, a reference value or characteristic is one determined for a comparable cohort, individual, population, or sample. In some embodiments, a reference value or characteristic is tested and/or determined substantially simultaneously with the testing or determination of the characteristic or value of interest. In some embodiments, a reference characteristic or value is or comprises a historical reference, optionally embodied in a tangible medium. Typically, as would be understood by those skilled in the art, a reference value or characteristic is determined under conditions comparable to those utilized to determine or analyze the characteristic or value of interest.

[0080] *Response*: As used herein, the term "response" may refer to an alteration in a subject's condition that occurs as a result of or correlates with treatment. In some embodiments, a response is or comprises a beneficial response. In some embodiments, a beneficial response may include stabilization of the condition (e.g., prevention or delay of deterioration expected or typically observed to occur absent the treatment), amelioration (e.g., reduction in frequency and/or intensity) of one or more symptoms of the condition, and/or improvement in the prospects for cure of the condition, etc. In some embodiments, "response" may refer to response of an organism, an organ, a tissue, a cell, or a cell component or in vitro system. In some embodiments, a response is or comprises a clinical response. In some embodiments, presence, extent, and/or nature of response may be measured and/or characterized according to particular criteria; in some embodiments, such criteria may include clinical criteria and/or objective criteria. In some embodiments, techniques for assessing response may include, but are not limited to, clinical examination, positron emission tomography, chest X-ray CT scan, MRI, ultrasound, endoscopy, laparoscopy, presence or level of a particular marker in a sample, , cytology, and/or histology. Where a response of interest is or comprises response of a tumor to therapy, those of ordinary skill will be aware of a variety of established techniques for assessing such response, including, for example, for determining tumor burden, tumor size, tumor stage,

etc. For example, certain technologies for assessing response of solid tumors to treatment are discussed in Therasse et. al., "New guidelines to evaluate the response to treatment in solid tumors", European Organization for Research and Treatment of Cancer, National Cancer Institute of the United States, National Cancer Institute of Canada, *J. Natl. Cancer Inst.*, 2000, 92(3):205-216. Those of ordinary skill in the art will be aware of, and/or will appreciate in light of the present disclosure, strategies for determining particular response criteria for individual tumors, tumor types, patient populations or cohorts, etc, as well as for determining appropriate references therefor..

[0081] *Sample:* As used herein, the term "sample" typically refers to a biological sample obtained or derived from a source of interest, as described herein. In some embodiments, a source of interest comprises an organism, such as an animal or human. In some embodiments, a biological sample is or comprises biological tissue or fluid. In some embodiments, a biological sample may be or comprise bone marrow; blood; blood cells; ascites; tissue or fine needle biopsy samples; cell-containing body fluids; free floating nucleic acids; sputum; saliva; urine; cerebrospinal fluid, peritoneal fluid; pleural fluid; feces; lymph; gynecological fluids; skin swabs; vaginal swabs; oral swabs; nasal swabs; washings or lavages such as a ductal lavages or broncheoalveolar lavages; aspirates; scrapings; bone marrow specimens; tissue biopsy specimens; surgical specimens; feces, other body fluids, secretions, and/or excretions; and/or cells therefrom, *etc.* In some embodiments, a biological sample is or comprises cells obtained from an individual. In some embodiments, obtained cells are or include cells from an individual from whom the sample is obtained. In some embodiments, a sample is a "primary sample" obtained directly from a source of interest by any appropriate means. For example, in some embodiments, a primary biological sample is obtained by methods selected from the group consisting of biopsy (*e.g.*, fine needle aspiration or tissue biopsy), surgery, collection of body fluid (*e.g.,* blood, lymph, feces *etc.*), *etc.* In some embodiments, as will be clear from context, the term "sample" refers to a preparation that is obtained by processing (e.g., by removing one or more components of and/or by adding one or more agents to) a primary sample. For example, filtering using a semi-permeable membrane. Such a "processed sample" may comprise, for example nucleic acids or proteins extracted from a sample or obtained by subjecting a primary

sample to techniques such as amplification or reverse transcription of mRNA, isolation and/or purification of certain components, *etc.*

[0082] *Specific:* The term "specific", when used herein with reference to an agent having an activity, is understood by those skilled in the art to mean that the agent discriminates between potential target entities or states. For example, an in some embodiments, an agent is said to bind "specifically" to its target if it binds preferentially with that target in the presence of one or more competing alternative targets. In many embodiments, specific interaction is dependent upon the presence of a particular structural feature of the target entity (e.g., an epitope, a cleft, a binding site). It is to be understood that specificity need not be absolute. In some embodiments, specificity may be evaluated relative to that of the binding agent for one or more other potential target entities (e.g., competitors). In some embodiments, specificity is evaluated relative to that of a reference specific binding agent. In some embodiments specificity is evaluated relative to that of a reference non-specific binding agent. In some embodiments, the agent or entity does not detectably bind to the competing alternative target under conditions of binding to its target entity. In some embodiments, binding agent binds with higher on-rate, lower off-rate, increased affinity, decreased dissociation, and/or increased stability to its target entity as compared with the competing alternative target(s).

[0083] *Specific binding*: As used herein, the terms "specific binding" or "specific for" or "specific to" refer to an interaction (typically non-covalent) between a target entity (e.g., a target protein or polypeptide) and a binding agent (e.g., an antibody, such as a provided antibody). As will be understood by those of ordinary skill, an interaction is considered to be "specific" if it is favored in the presence of alternative interactions. In many embodiments, an interaction is typically dependent upon the presence of a particular structural feature of the target molecule such as an antigenic determinant or epitope recognized by the binding molecule. For example, if an antibody is specific for epitope A, the presence of a polypeptide containing epitope A or the presence of free unlabeled A in a reaction containing both free labeled A and the antibody thereto, will reduce the amount of labeled A that binds to the antibody. It is to be understood that specificity need not be absolute. For example, it is well known in the art that numerous antibodies cross-react with other epitopes in addition to those present in the target molecule. Such cross-reactivity may be acceptable depending upon the application for which the antibody

is to be used. In particular embodiments, an antibody specific for receptor tyrosine kinases has less than 10% cross-reactivity with receptor tyrosine kinase bound to protease inhibitors (e.g., ACT). One of ordinary skill in the art will be able to select antibodies having a sufficient degree of specificity to perform appropriately in any given application (e.g., for detection of a target molecule, for therapeutic purposes, etc.). Specificity may be evaluated in the context of additional factors such as the affinity of the binding molecule for the target molecule versus the affinity of the binding molecule for other targets (e.g., competitors). If a binding molecule exhibits a high affinity for a target molecule that it is desired to detect and low affinity for non-

[0084] *Stage of cancer*: As used herein, the term "stage of cancer" refers to a qualitative or quantitative assessment of the level of advancement of a cancer. Criteria used to determine the stage of a cancer include, but are not limited to, the size of the tumor and the extent of metastases (e.g., localized or distant).

[0085] *Subject*: As used herein, the term "subject" or "patient" refers to any organism upon which embodiments of the invention may be used or administered, e.g., for experimental, diagnostic, prophylactic, and/or therapeutic purposes. Typical subjects include animals (e.g., mammals such as mice, rats, rabbits, non-human primates, and humans; insects; worms; etc.).

[0086] *Substantially*: As used herein, the term "substantially" refers to the qualitative condition of exhibiting total or near-total extent or degree of a characteristic or property of interest. One of ordinary skill in the biological arts will understand that biological and chemical phenomena rarely, if ever, go to completion and/or proceed to completeness or achieve or avoid an absolute result. The term "substantially" is therefore used herein to capture the potential lack of completeness inherent in many biological and chemical phenomena.

[0087] *Suffering from*: An individual who is "suffering from" a disease, disorder, or condition (e.g., a cancer) has been diagnosed with and/or exhibits one or more symptoms of the disease, disorder, or condition. In some embodiments, an individual who is suffering from cancer has cancer, but does not display any symptoms of cancer and/or has not been diagnosed with a cancer.

[0088] *Susceptible to*: An individual who is "susceptible to" a disease, disorder, or condition (e.g., cancer) is at risk for developing the disease, disorder, or condition. In some

embodiments, an individual who is susceptible to a disease, disorder, or condition does not display any symptoms of the disease, disorder, or condition. In some embodiments, an individual who is susceptible to a disease, disorder, or condition has not been diagnosed with the disease, disorder, and/or condition. In some embodiments, an individual who is susceptible to a disease, disorder, or condition is an individual who displays conditions associated with development of the disease, disorder, or condition. In some embodiments, a risk of developing a disease, disorder, and/or condition is a population-based risk.

[0089] *Target cell or target tissue*: As used herein, the terms "target cell" or "target tissue" refer to any cell, tissue, or organism that is affected by a condition described herein and to be treated, or any cell, tissue, or organism in which a protein involved in a condition described herein is expressed. In some embodiments, target cells, target tissues, or target organisms include those cells, tissues, or organisms in which there is a detectable amount of immune checkpoint signaling and/or activity. In some embodiments, target cells, target tissues, or target organisms include those cells, tissues or organisms that display a disease-associated pathology, symptom, or feature.

[0090] *Therapeutic regimen*: As used herein, the term "therapeutic regimen" refers to any method used to partially or completely alleviate, ameliorate, relieve, inhibit, prevent, delay onset of, reduce severity of and/or reduce incidence of one or more symptoms or features of a particular disease, disorder, and/or condition. It may include a treatment or series of treatments designed to achieve a particular effect, e.g., reduction or elimination of a detrimental condition or disease such as cancer. The treatment may include administration of one or more compounds either simultaneously, sequentially or at different times, for the same or different amounts of time. Alternatively, or additionally, the treatment may include exposure to radiation, chemotherapeutic agents, hormone therapy, or surgery. In addition, a "treatment regimen" may include genetic methods such as gene therapy, gene ablation or other methods known to reduce expression of a particular gene or translation of a gene-derived mRNA.

[0091] *Therapeutic agent*: As used herein, the phrase "therapeutic agent" refers to any agent that, when administered to a subject, has a therapeutic effect and/or elicits a desired biological and/or pharmacological effect.

[0092] *Therapeutically effective amount*: As used herein, the term "therapeutically effective amount" refers to an amount of an agent (e.g., an immune checkpoint modulator) that confers a therapeutic effect on the treated subject, at a reasonable benefit/risk ratio applicable to any medical treatment. The therapeutic effect may be objective (i.e., measurable by some test or marker) or subjective (i.e., subject gives an indication of or feels an effect). In particular, the "therapeutically effective amount" refers to an amount of a therapeutic agent or composition effective to treat, ameliorate, or prevent a desired disease or condition, or to exhibit a detectable therapeutic or preventative effect, such as by ameliorating symptoms associated with the disease, preventing or delaying the onset of the disease, and/or also lessening the severity or frequency of symptoms of the disease. A therapeutically effective amount is commonly administered in a dosing regimen that may comprise multiple unit doses. For any particular therapeutic agent, a therapeutically effective amount (and/or an appropriate unit dose within an effective dosing regimen) may vary, for example, depending on route of administration, on combination with other pharmaceutical agents. Also, the specific therapeutically effective amount (and/or unit dose) for any particular patient may depend upon a variety of factors including the disorder being treated and the severity of the disorder; the activity of the specific pharmaceutical agent employed; the specific composition employed; the age, body weight, general health, sex and diet of the subject; the time of administration, route of administration, and/or rate of excretion or metabolism of the specific fusion protein employed; the duration of the treatment; and like factors as is well known in the medical arts.

[0093] *Treatment*: As used herein, the term "treatment" (also "treat" or "treating") refers to any administration of a substance (e.g., provided compositions) that partially or completely alleviates, ameliorates, relieves, inhibits, delays onset of, reduces severity of, and/or reduces incidence of one or more symptoms, features, and/or causes of a particular disease, disorder, and/or condition (e.g., cancer). Such treatment may be of a subject who does not exhibit signs of the relevant disease, disorder and/or condition and/or of a subject who exhibits only early signs of the disease, disorder, and/or condition. Alternatively or additionally, such treatment may be of a subject who exhibits one or more established signs of the relevant disease, disorder and/or condition. In some embodiments, treatment may be of a subject who has been diagnosed as suffering from the relevant disease, disorder, and/or condition. In some embodiments, treatment

may be of a subject known to have one or more susceptibility factors that are statistically correlated with increased risk of development of the relevant disease, disorder, and/or condition.

[0094] *Wild-type*: As used herein, the term "wild-type" has its art-understood meaning that refers to an entity having a structure and/or activity as found in nature in a "normal" (as contrasted with mutant, diseased, altered, etc.) state or context. Those of ordinary skill in the art will appreciate that wild-type genes and polypeptides often exist in multiple different forms (e.g., alleles).

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

Cancers

[0095] In some embodiments, the present disclosure relates to treatment of cancer. Certain exemplary cancers that may, in some embodiments, be treated in accordance with the present disclosure include, for example, adrenocortical carcinoma, astrocytoma, basal cell carcinoma, carcinoid, cardiac, cholangiocarcinoma, chordoma, chronic myeloproliferative neoplasms, craniopharyngioma, ductal carcinoma *in situ*, ependymoma, intraocular melanoma, gastrointestinal carcinoid tumor, gastrointestinal stromal tumor (GIST), gestational trophoblastic disease, glioma, histiocytosis, leukemia (*e.g.,* acute lymphoblastic leukemia (ALL), acute myeloid leukemia (AML), chronic lymphocytic leukemia (CLL), chronic myelogenous leukemia (CML), hairy cell leukemia, myelogenous leukemia, and myeloid leukemia), lymphoma (*e.g.,* Burkitt lymphoma (non-Hodgkin lymphoma), cutaneous T-cell lymphoma, Hodgkin lymphoma, mycosis fungoides, Sezary syndrome, AIDS-related lymphoma, follicular lymphoma, diffuse large B-cell lymphoma), melanoma, merkel cell carcinoma, mesothelioma, myeloma (*e.g.,* multiple myeloma), myelodysplastic syndrome, papillomatosis, paraganglioma, pheochromacytoma, pleuropulmonary blastoma, retinoblastoma, sarcoma (*e.g.,* Ewing sarcoma, Kaposi sarcoma, osteosarcoma, rhabdomyosarcoma, uterine sarcoma, vascular sarcoma), Wilms' tumor, and/or cancer of the adrenal cortex, anus, appendix, bile duct, bladder, bone, brain, breast, bronchus, central nervous system, cervix, colon, endometrium, esophagus, eye, fallopian tube, gall bladder, gastrointestinal tract, germ cell, head and neck, heart, intestine, kidney (*e.g.,* Wilms' tumor), larynx, liver, lung (*e.g.,* non-small cell lung cancer, small cell lung cancer), mouth, nasal

cavity, oral cavity, ovary, pancreas, rectum, skin, stomach, testes, throat, thyroid, penis, pharynx, peritoneum, pituitary, prostate, rectum, salivary gland, ureter, urethra, uterus, vagina, or vulva.

[0096] In some embodiments, a cancer may involve one or more tumors. In some embodiments, a tumor comprises a solid tumor. In some embodiments, solid tumors include but are not limited to tumors of the bladder, breast, central nervous system, cervix, colon, esophagus, endometrium, head and neck, kidney, liver, lung, ovary, pancreas, skin, stomach, uterus, or upper respiratory tract.

[0097] In some embodiments, a cancer is selected from the group consisting of bladder cancer, bone cancer, breast cancer, cancer of unknown primary, esophagogastric cancer, gastrointestinal cancer, glioma, head and neck cancer, hepatobiliary cancer, melanoma, mesothelioma, non-hodgkin lymphoma, non-small cell lung cancer, pancreatic cancer, prostate cancer, renal cell carcinoma, skin cancer (non-melanoma), small cell lung cancer, soft tissue sarcoma, thyroid cancer, and combinations thereof.

[0098] In some embodiments, a cancer is selected from the group consisting of bladder cancer, breast cancer, esophagogastric cancer, glioma, head and neck cancer, melanoma, non-small cell lung cancer, renal cell carcinoma, and combinations thereof.

[0099] In some embodiments, a cancer that may be treated in accordance with the present disclosure is one that has been exposed to immunotherapy as described herein.

[0100] In some embodiments, a cancer that may be treated in accordance with the present disclosure is one that has been exposed to immunotherapy, which in some embodiments may be or include therapy with one or more immune checkpoint inhibitor modulators.

[0101] In some embodiments, a cancer that may be treated in accordance with the present disclosure is one characterized by high tumor mutational load (i.e., tumor mutational load above a relevant threshold) as described herein. Alternatively or additionally, a cancer that may be treated in accordance with the present disclosure is one characterized by neoantigens.

[0102] In some embodiments, a cancer that may be treated in accordance with the present disclosure is characterized by both prior exposure to immunotherapy comprising immune

checkpoint modulators and high tumor mutational load; in some such embodiments, the cancer shows higher tumor mutational load than was present prior to its exposure to the immunotherapy.

Immunotherapy

[0103] In some embodiments, the present disclosure relates to administration of immunotherapy to a subject. In some embodiments, immunotherapy is or comprises immune checkpoint modulation therapy. In some embodiments, immunotherapy involves administration of one or more immunomodulatory agents; in some embodiments an immunomodulatory agent is or comprises an immune checkpoint modulator. In some embodiments, an immune checkpoint modulator is an agent (e.g., an antibody agent) that targets (i.e., specifically interacts with) an immune checkpoint target. In some embodiments, an immune checkpoint target is or comprises one or more of CTLA-4, PD-1, PD-L1, GITR, OX40, LAG-3, KIR, TIM-3, CD28, CD40, and CD137; in some embodiments, immune checkpoint modulator therapy is or comprises administration of an antibody agent that targets one or more such immune checkpoint targets.

[0104] In some embodiments, immune checkpoint refers to inhibitory pathways of an immune system that are responsible for maintaining self-tolerance and modulating duration and amplitude of physiological immune responses. Certain cancer cells thrive by taking advantage of immune checkpoint pathways as a major mechanism of immune resistance, particularly with respect to T cells that are specific for tumor antigens. For example, certain cancer cells may overexpress one or more immune checkpoint proteins responsible for inhibiting a cytotoxic T cell response. Thus, among other things, immune checkpoint modulators may be administered to overcome inhibitory signals and permit and/or augment an immune attack against cancer cells. Immune checkpoint modulators may facilitate immune cell responses against cancer cells by decreasing, inhibiting, or abrogating signaling by negative immune response regulators (e.g. CTLA-4), or may stimulate or enhance signaling of positive regulators of immune response (e.g. CD28).

[0105] Advances in understanding of molecular mechanisms of T cell activation and inhibition and immune homeostasis have allowed for rational development of immunologically targeted therapies for cancer. The best known of these are immune checkpoint modulator monoclonal antibodies that block CTLA-4 and PD-1 pathways, representing critical inhibitory

checkpoints that restrain T cells from full and persistent activation and proliferation under normal physiologic conditions. Blockade of CTLA-4 and/or PD-1 pathways can result in durable regressions for patients with a widening spectrum of malignancies. In some embodiments, an immunotherapy is or comprises administration of one or more of PD-1 or PD-L1 blockade therapies. In some embodiments, an immunotherapy is or comprises administration of one or more of CTLA-4 blockade therapies. In some embodiments, an immunotherapy can include any of ipilumimab and tremelimumab which target CTLA-4; pembrolizumab, nivolumab, avelumab, durvalumab, and atezoluzumab, which target PD-1; or combinations thereof.

[0106] Teachings of the present disclosure, among other things, predict responsiveness to immune checkpoint modulators, and particularly to therapeutic modalities or regimens targeting immune checkpoint regulators. The present disclosure, among other things, demonstrates that tumor mutational load threshold correlates with responsiveness to immune checkpoint modulators. In some embodiments, the present disclosure demonstrates that tumor mutational load threshold correlates with an increased likelihood of clinical efficacy from immune checkpoint regulators for those cancers responsive to immunotherapy (e.g., to PD-1 blockade and/or to CTLA-4 blockade). In some embodiments, immunotherapy (e.g. immune checkpoint modulator therapy) involves administration of an agent that acts as a blockade of cytotoxic T-lymphocyte-associated protein 4 (CTLA-4). In certain embodiments, immunotherapy involves treatment with an agent that interferes with an interaction involving CTLA-4 (e.g., with CD80 or CD86). In some embodiments, immunotherapy involves administration of one or more of tremelimumab and/or ipilimumab. In some embodiments, immunotherapy (e.g. immune checkpoint modulator therapy) involves administration of an agent (e.g. antibody agent) that acts as a blockade of programmed cell death 1 (PD-1). In certain embodiments, immunotherapy involves treatment with an agent that interferes with an interaction involving PD-1 (e.g., with PD-L1). In some embodiments, immunotherapy involves administration of an agent (e.g. antibody agent) that specifically interacts with PD-1 or with PD-L1. In some embodiments, immunotherapy (e.g. immune checkpoint modulator therapy) involves administration of one or more of nivolumab, pembrolizumab, atezolizumab, avelumab, and/or durvalumab.

CTLA-4

[0107] CTLA-4 is a member of the immunoglobulin superfamily that is expressed by activated T cells and transmits an inhibitory signal to T cells. CTLA-4 is structurally similar to T cell co-stimulatory protein, CD28, and both molecules bind to CD80 and CD86 on antigen-presenting cells.[18] CTLA-4 binds CD80 and CD86 with greater affinity than CD28, thus enabling it to outcompete CD28 for its ligands.[18] CTLA-4 transmits an inhibitory signal to T cells, whereas CD28 transmits a stimulatory signal. T cell activation through T cell receptor and CD28 leads to increased expression of CTLA-4.

[0108] The mechanism by which CTLA-4 acts in T cells remains somewhat elusive. Biochemical evidence suggests that CTLA-4 recruits a phosphatase to a T cell receptor, thus attenuating the signal. It has also been suggested that CTLA-4 may function *in vivo* by capturing and removing CD80 and CD86 from membranes of antigen-presenting cells, thus making these antigens unavailable for triggering of CD28.

[0109] CTLA-4 protein contains an extracellular V domain, a transmembrane domain, and a cytoplasmic tail. CTLA-4 has an intracellular domain that is similar to that of CD28, in that it has no intrinsic catalytic activity and contains one YVKM motif able to bind PI3K, PP2A and SHP-2, as well as one proline-rich motif able to bind SH3-containing proteins. One role of CTLA-4 in inhibiting T cell responses seems to directly involve SHP-2 and PP2A dephosphorylation of T cell receptor-proximal signaling proteins, such as CD3 and LAT. CTLA-4 can also affect signaling indirectly, via competition with CD28 for CD80 and/or CD86 binding.

[0110] The first clinical evidence that modulation of T cell activation could result in effective anti-cancer therapy came from development of CTLA-4 blockade antibody ipilimumab.[18] In some embodiments, ipilimumab is a human IgG1 antibody with specificity for CTLA-4. In some embodiments, another CTLA-4 blockade therapy, tremelimumab, is a human IgG2 antibody.

PD-1

[0111] PD-1 is expressed on T cells, B cells, and certain myeloid cells; however, its role is best characterized in T cells. PD-1 expression on T cells is induced by antigen stimulation. Unlike CTLA-4, which limits early T-cell activation, PD-1 mainly exerts its inhibitory effect on T cells in the periphery where T cells encounter PD-1 ligands. Two ligands of PD-1 have been

identified so far, PD-L1 and PD-L2, which are expressed by a large range of cell types, including tumor cells, monocyte-derived myeloid dendritic cells, epithelial cells, T cells, and B cells.[18] In cancer, tumor cells and myeloid cells are thought to be main cell types mediating T-cell suppression through PD-1 ligation. It is still unclear whether effects of PD-L1 and PD-L2 on PD-1 downstream signaling are dependent on cell type that expresses a given ligand. Moreover, there are differences between PD-L1- versus PD-L2-induced effects, which remain to be fully elucidated.

[0112] Several mechanisms of PD-1-mediated T cell suppression have been proposed.[18] One mechanism suggests that PD-1 ligation inhibits T cell activation only upon T cell receptor engagement. PD-1 has an intracellular "immunoreceptor tyrosine-based inhibition motif" or (ITIM) and an immunoreceptor tyrosine-based switch motif. It has been shown that PD-1 ligation leads to recruitment of phosphatases called "src homology 2 domain-containing tyrosine phosphatases," or SHP-1 and SHP-2, to immunoreceptor tyrosine-based switch motif. Moreover, PD-1 ligation has been shown to interfere with signaling molecules, such as phosphatidylinositol-4,5-bisphosphate 3-kinase and Ras, which are important for T-cell proliferation, cytokine secretion, and metabolism. Analysis of human immunodeficiency virus (HIV)-specific T cells has also demonstrated PD-1-dependent basic leucine zipper transcription factor upregulation, which inhibits T cell function. Ligation of PD-1 has also been shown to induce metabolic alterations in T cells. Metabolic reprogramming of T cells from glycolysis to lipolysis is a consequence of PD-1-mediated impairment of T-cell effector function. Furthermore, PD-1-induced defects in mitochondrial respiration and glycolysis leads to impaired T-cell effector function that could be reversed by a mammalian target of rapamycin inhibition. Since most of the identified mechanisms of PD-1-mediated T-cell suppression are based on *in vitro* or *ex vivo* experiments, it remains to be demonstrated that these same mechanisms are responsible for T-cell exhaustion *in vivo*.

[0113] PD-1 is a type I membrane protein of 288 amino acids and is a member of the extended CD28/CTLA-4 family of T cell regulators.[19] PD-1 protein structure includes an extracellular IgV domain followed by a transmembrane region and an intracellular tail, which contains two phosphorylation sites located in an immunoreceptor tyrosine-based inhibitory motif (ITIM) and an immunoreceptor tyrosine-based switch motif, which suggests that PD-1

negatively regulates T cell receptor signals. This is consistent with binding of SHP-1 and SHP-2 phosphatases to PD-1 cytoplasmic tail upon ligand binding. In addition, PD-1 ligation up-regulates E3-ubiquitin ligases CBL-b and c-CBL that trigger T cell receptor down-modulation. PD-1 is expressed on the surface of activated T cells, B cells, and macrophages, suggesting that compared to CTLA-4, PD-1 more broadly negatively regulates immune responses.

CTLA-4 and PD-1 in Combination

[0114] Although monotherapies with CTLA-4- or PD-1-blocking antibodies have significantly prolonged survival of some patients with certain cancers, there are cases where some patients do not respond to therapy. A previous study has shown that combined treatment with ipilimumab (CTLA-4 blockade) and nivolumab (PD-1 blockade) induced better responses than either treatment alone.[18,20] In some embodiments, immunotherapy, in accordance with the present disclosure, comprises both PD-1 blockade therapy and CTLA-4 blockade therapy. In certain embodiments, immunotherapy (e.g. immune checkpoint modulator therapy) involves treatment with an agent (e.g. antibody agent) that interferes with an interaction involving CTLA-4 and/or PD-1. In some embodiments, immunotherapy (e.g. immune checkpoint modulator therapy) involves administration of an agent (e.g. antibody agent) that specifically interacts with one or more of CTLA-4, CD80, CD86, PD-1 or PD-L1. In some embodiments, such therapy involves administration of one or more of atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, and/or tremelimumab.

Tumor Mutational Load

[0115] Among other things, the present disclosure demonstrates a that tumor mutational load can predict clinical efficacy of immunotherapy treatment for certain cancers. The present disclosure establishes, among other things, that in certain cases, individuals with higher tumor mutational loads are more likely to respond positively to immunotherapy than individuals with significantly lower tumor mutational loads. The present disclosure, among other things, establishes that, in certain cases, individuals with higher tumor mutational loads and who have already received immunotherapy, are more likely to respond positively to immunotherapy, than individuals with significantly lower tumor mutational loads.

[0116] In some embodiments, tumor mutational load comprises a number of somatic mutations within a region of a tumor genome. In some embodiments, somatic mutations comprise DNA alterations in non-germline cells and commonly occur in cancer cells. In some embodiments, a somatic mutation results in a neoantigen or neoepitope. It has been discovered that certain somatic mutations in cancer cells result in expression of neoepitopes, that in some embodiments transition a stretch of amino acids from being recognized as "self" to "non-self". A cancer cell harboring a "non-self" antigen is typically more likely to elicit an immune response against a cancer cell. The identification of multiple mutations in a cancer sample as described herein can be useful for determining which cancer patients are likely to respond favorably to immunotherapy (e.g. continued and/or extended or modified immunotherapy); in some embodiments, such identification can be useful for determining which cancer patients are likely to respond, in particular, to treatment with an immune checkpoint modulator and/or otherwise to PD-1 and/or CTLA-4 blockade.

[0117] The present disclosure, among other things, demonstrates that, for certain cancers, patients with high numbers of somatic mutations, or a high tumor mutational load, are more likely to benefit from treatment with immune checkpoint modulators than those patients with lower tumor mutational loads. In some embodiments, patients with a high tumor mutational load respond better to PD-1 (programmed cell death 1) blockade than those patients with a significantly lower tumor mutational load. In some embodiments, individuals with a high tumor mutational load respond better to treatment with anti-PD-1 antibodies than those individuals with a low tumor mutational load. In some embodiments, individuals with a high tumor mutational load respond better to treatment with CTLA-4 blockade than those individuals with a low tumor mutational load. In some embodiments, individuals with a high tumor mutational load respond better to treatment with CTLA-4 antibodies than those individuals with a low tumor mutational load.

Tumor Mutational Load Threshold

[0118] The present disclosure, among other things, encompasses an insight that meaningful limits can be imposed on mutational analysis of cancer cells and, moreover, that use of such limits surprisingly defines and/or provides tumor mutational load thresholds that

effectively predict responsiveness to treatment (e.g., continued and/or extended or modified immunotherapy). In some embodiments, a tumor mutational load threshold as described herein correlates with and/or predicts response to immunotherapy (e.g., immune checkpoint modulator therapy, e.g. PD-1 blockade or CTLA-4 blockade).

[0119] Moreover, the present disclosure, among other things, encompasses the discovery that a tumor mutational load threshold that predicts likelihood of responsiveness to cancer immunotherapy (and/or to a specific immunomodulatory agent and/or regimen) can be defined for tumors that have already received prior immunotherapy. In some embodiments, the number of mutations in a given tumor correlates with and/or is predictive of positive response to immunotherapy. Moreover, the present disclosure demonstrates that tumor mutational load level relative to a threshold, can be detected and effectively utilized to predict tumor responsiveness for a wide variety of cancers.

[0120] In some embodiments, as described herein, the present disclosure provides technologies for defining tumor mutational load thresholds that predict responsiveness to immunotherapy (e.g. continued and/or extended or modified), and particularly to immune checkpoint modulator therapy. In some embodiments, the present disclosure describes and/or establishes effective use of such thresholds in predicting therapeutic responsiveness.

[0121] The present disclosure demonstrates that a mutational landscape and/or tumor mutational load threshold of a particular tumor can predict the likelihood of clinical benefit from immunotherapy (e.g., PD-1 blockade or CTLA-4 blockade). The disclosure also teaches that a tumor mutational load threshold can predict likelihood of positive response to immunotherapy with immune checkpoint modulators. Furthermore, the nature of the somatic mutations present can predict response to immunotherapy with immune checkpoint modulators.

[0122] In some embodiments, tumor mutational load level relative to a threshold, can be determined and/or detected using targeted gene panel technologies (*e.g.,* assessed with next-generation sequencing), and do not necessarily require whole exome sequencing.

[0123] Thus, among other things, the present disclosure establishes that relevant thresholds for these cancers may be, for example:

Cancer Type	Threshold
Bladder Cancer	Within a range of about 7 to about 27; in some embodiments about 17.
Breast Cancer	Within a range of about 1 to about 14; in some embodiments about 4.
Esophagogastric Cancer	Within a range of about 1 to about 21; in some embodiments about 11.
Glioma	Within a range of about 1 to about 15; in some embodiments about 5.
Head and Neck Cancer	Within a range of about 1 to about 18; in some embodiments about 8.
Melanoma	Within a range of about 1 to about 21; in some embodiments about 11.
Non-Small Cell Lung Cancer	Within a range of about 1 to about 29; in some embodiments about 18.
Renal Cell Carcinoma	Within a range of about 1 to about 12; in some embodiments about 2.

Detection of Tumor Mutational Load and/or Neoepitopes

[0124] Cancers may be screened to detect mutations and/or neoepitopes (e.g., to detect tumor mutational load and/or neoepitope load and/or neoantigen identity, and/or neopitope nature, level, and/or frequency) as described herein using any of a variety of known technologies. In some embodiments, particular mutations or neoepitopes, or expression thereof, is/are detected at the nucleic acid level (e.g., in DNA or RNA). One of skill in the art would recognize that mutations or neoepitopes, or expression thereof, can be detected in a sample comprising DNA or RNA from cancer cells. Further, one of skill in the art would understand that a sample comprising DNA or RNA from cancer cells can include but is not limited to circulating tumor DNA (ctDNA), cell free DNA (cfDNA), cells, tissues, or organs. In some embodiments, mutations or neopeitopes, or expression thereof, is detected at the protein level (e.g., in a sample comprising polypeptides from cancer cells, which sample may be or comprise polypeptide complexes or other higher order structures including but not limited to cells, tissues, or organs).

[0125] In some particular embodiments, detection involves nucleic acid sequencing. In some embodiments, detection involves whole exome sequencing. In some embodiments, detection involves an immunoassay. In some embodiments, detection involves use of a microarray. In some embodiments, detection involves massively parallel exome sequencing. In some embodiments, detection involves genome sequencing. In some embodiments, detection involves RNA sequencing. In some embodiments, detection involves standard DNA or RNA sequencing. In some embodiments, detection involves mass spectrometry.

[0126] In some embodiments, detection involves next generation sequencing (DNA and/or RNA). In some embodiments, detection involves genome sequencing, genome resequencing, targeted sequencing panels, transcriptome profiling (RNA-Seq), DNA-protein interactions (ChIP-sequencing), and/or epigenome characterization. In some embodiments, re-sequencing of a patient's genome may be utilized, for example to detect genomic variations.

[0127] In some embodiments, detection involves using a technique such as ELISA, Western Transfer, immunoassay, mass spectrometry, microarray analysis, etc.

[0128] In some embodiments, detection involves next generation sequencing (DNA and/or RNA). In some embodiments, detection involves next generation sequencing of targeted gene panels (e.g. MSK-IMPACT or FoundationOne ®). In some embodiments, detection

involves genomic profiling. In some embodiments, detection involves genomic profiling using Integrated Mutation Profiling of Actionable Cancer Targets (MSK-IMPACT).[8,17] MSK-IMPACT is a comprehensive molecular profiling assay that involves hybridization capture and deep sequencing of all exons and selected introns of multiple oncogenes and tumor-suppressor genes, allowing for detection of point mutations, small and large insertions or deletions, and rearrangements. MSK-IMPACT also captures intergenic and intronic single-nucleotide polymorphisms (e.g., tiling probes), interspersed across a genome, aiding in accurate assessment of genome-wide copy number. In some embodiments, probes may target a megabase.

[0129] In some embodiments, detection may involve sequencing of exon and/or intron sequences from at least 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1000 or more genes (e.g., oncogenes and/or tumor-suppressor genes). For example, literature reports indicate that MSK-IMPACT has been used to achieve deep sequencing of all exons and selected introns of 468 oncogenes and tumor-suppressor genes.

[0130] Alternatively or additionally, in some embodiments, detection may involve sequencing of intergenic and/or intronic single-nucleotide polymorphisms. For example, literature reports indicate that MSK-IMPACT has been used to achieve deep sequencing of >1000 intergenic and intronic single-nucleotide polymorphisms.

[0131] In some embodiments, administering immunotherapy to a subject who has received prior immunotherapy displays a tumor mutational load above a threshold that has been correlated with a statistically significant probability of responding to immunotherapy.

[0132] In some embodiments, a method of administering immunotherapy to a subject comprises a further step of measuring tumor mutational load level relative to a threshold in the subject, which measuring step is performed at a time selected from the group consisting of prior to the administering, during the administering, after the administering, and combinations thereof.

[0133] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described herein.

Human Leukocyte Antigen

[0134] Prior to the present disclosure, there has been little understanding of how host genetics impact response to cancer immunotherapy. One factor that has been repeatedly associated with modulating the immune response during bacterial or viral infection, inflammatory conditions, and autoimmune diseases, is HLA class I genotype (*21-29*). The human leukocyte antigen (HLA) complex is a gene complex encoding the major histocompatibility complex (MHC) proteins. The major histocompatibility complex (MHC) class I coding region in humans is central to the immune response. Each HLA class I molecule binds specific peptides derived from intracellular proteins that have been processed and transported into the endoplasmic reticulum by the TAP proteins, where they are bound to the MHC class I molecules for presentation on the cell surface (30).

[0135] MHC molecules are extremely polymorphic, and over a thousand allelic variants have already been described at the class I A and B loci. Most of the polymorphism is located in the peptide-binding region, and as a result each variant is believed to bind a unique repertoire of peptide ligands. Despite this polymorphism, HLA class I molecules can be clustered into groups, designated as supertypes (a.k.a. superfamilies), representing sets of molecules that share largely overlapping peptide binding specificity. Exemplary supertypes include but are not limited to A02, A24, A03, B07, B27, B44, Each supertype can be described by a supermotif that reflects the broad main anchor motif recognized by molecules within the corresponding supertype. For example, molecules of the A02-supertype share specificity for peptides with aliphatic hydrophobic residues in position 2 and at the C-terminus, while A03-supertype molecules recognize peptides with small or aliphatic residues in position 2 and basic residues at the C-terminus.

[0136] Typically, in the case of human leukocyte antigen (HLA) class I, the main binding energy is provided by the interaction of residues in position 2 and the C-terminus of the peptide with the B and F binding pockets of the MHC molecule, respectively although side chains throughout the ligand can have a positive or negative influence on binding capacity. Once pathogen or tumor-derived epitopes are presented on the cell surface, CD8+ T-cells must be able to recognize them to subsequently elicit an immune response and eliminate cells bearing those

same epitopes (31, 32). Some tumor cells have reduced ability to present epitopes on the surface due to genetic alterations resulting in loss of heterozygosity (LOH) in the HLA locus. LOH is a gross chromosomal event that results in loss of an entire gene and surrounding chromosomal region. The anti-tumor activity of immune checkpoint treatment has been shown to depend on CD8+ T cell, MHC class I-dependent immune activity (33-35).

[0137] Among other things, the present disclosure demonstrates that HLA class I genotype can influence clinical efficacy of immunotherapy treatment for certain cancers. The present disclosure establishes, among other things, that heterozygosity at one or more HLA class I loci (e.g., A, B, or C) can influence clinical efficacy of immunotherapy treatment. In some embodiments, heterozygosity at all three HLA class I loci (i.e., maximum heterozygosity) can influence clinical efficacy of immunotherapy treatment.

[0138] The present disclosure establishes, among other things, that in certain cases, individuals with heterozygosity at one or more HLA class I loci (e.g., A, B, or C) are more likely to respond positively to immunotherapy. In some embodiments, individuals with heterozygosity at all three HLA class I loci (i.e., maximum heterozygosity) are more likely to respond positively to immunotherapy.

[0139] In some embodiments, the present disclosure establishes that individuals with particular HLA class I superfamily alleles are more likely to respond positively to immunotherapy. In some embodiments, individuals with HLA class I B44 allele are more likely to respond positively to immunotherapy. In some embodiments, individuals with HLA class I B62 allele are more likely to respond positively to immunotherapy.

[0140] Further, the present disclosure establishes, among other things, that in certain cases, individuals with heterozygosity at one or more HLA class I loci (e.g., A, B, or C) and higher tumor mutational loads as described herein are more likely to respond positively to immunotherapy than individuals with significantly lower tumor mutational loads and/or no or less heterozygosity at HLA class I loci. In some embodiments, individuals with heterozygosity at all three HLA class I loci and higher tumor mutational loads as described herein are more likely to respond positively to immunotherapy than individuals with significantly lower tumor mutational loads and/or no or less heterozygosity at HLA class I loci.

[0141] In some embodiments, a subject's HLA class I genotype can be determined sequencing. Sequencing can be performed by methods known in the art. In some embodiments, for example, HLA class I genotype can be determined by exome sequencing. In some embodiments, a subject's HLA class I genotype can be determined using a clinically validated HLA typing assay.

Treatment

[0142] In some embodiments, the invention relates to treatment of tumors that display a tumor mutational load above a relevant threshold. In some embodiments, such tumors have previously received immunotherapy. In some embodiments, such immunotherapy is an immune checkpoint modulator.

Administration of Immune Checkpoint Modulators

[0143] In accordance with certain methods of the invention, an immunomodulatory agent (e.g. immune checkpoint modulator) is and/or has been administered to an individual. In some embodiments, treatment with an immunomodulatory agent (e.g.immune checkpoint modulator) is utilized as a sole therapy. In some embodiments, treatment with an immunomodulatory agent (e.g. immune checkpoint modulator) is used in combination with one or more other therapies.

[0144] Those of ordinary skill in the art will appreciate that appropriate formulations, indications, and dosing regimens are typically analyzed and approved by government regulatory authorities such as the Food and Drug Administration in the United States. For example, Examples 4 and 5 present certain FDA-approved dosing information for PD-1 and CTLA-4 blockade regimens, respectively. In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulator) is administered in accordance with the present invention according to such an approved protocol. However, the present disclosure, among other things, provides certain technologies for identifying, characterizing, and/or selecting particular patients to whom an immunomodulatory agent (e.g.immune checkpoint modulator) may be desirably administered. In some embodiments, insights provided by the present disclosure permit dosing of a given an immunomodulatory agent (e.g. immune checkpoint modulator) with greater frequency and/or greater individual doses (e.g., due to reduced susceptibility to and/or incidence or intensity of undesirable effects) relative to that recommended or approved based on

population studies that include both individuals identified as described herein (e.g., expressing neoepitopes or having a tumor mutational load above the threshold) and other individuals. In some embodiments, insights provided by the present disclosure permit dosing of a given an immunomodulatory agent (e.g. immune checkpoint modulator) with reduced frequency and/or reduced individual doses (e.g., due to increased responsiveness) relative to that recommended or approved based on population studies that include both individuals identified as described herein (e.g., expressing neoepitopes or having a tumor mutational load above the threshold) and other individuals.

[0145] In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulator) is administered in a pharmaceutical composition that also comprises a physiologically acceptable carrier or excipient. In some embodiments, a pharmaceutical composition is sterile. In many embodiments, a pharmaceutical composition is formulated for a particular mode of administration.

[0146] In some embodiments, suitable pharmaceutically acceptable carriers include but are not limited to water, salt solutions (e.g., NaCl), saline, buffered saline, alcohols, glycerol, ethanol, gum arabic, vegetable oils, benzyl alcohols, polyethylene glycols, gelatin, carbohydrates such as lactose, amylose or starch, sugars such as mannitol, sucrose, or others, dextrose, magnesium stearate, talc, silicic acid, viscous paraffin, perfume oil, fatty acid esters, hydroxymethylcellulose, polyvinyl pyrrolidone, etc., as well as combinations thereof. In some embodiments, a pharmaceutical preparation can, if desired, comprise one or more auxiliary agents (e.g., lubricants, preservatives, stabilizers, wetting agents, emulsifiers, salts for influencing osmotic pressure, buffers, coloring, flavoring and/or aromatic substances and the like) which do not deleteriously react with the active compounds or interference with their activity. In some embodiments, a water-soluble carrier suitable for intravenous administration is used.

[0147] In some embodiments, a pharmaceutical composition or medicament, if desired, can contain an amount (typically a minor amount) of wetting or emulsifying agents, and/or of pH buffering agents. In some embodiments, a pharmaceutical composition can be a liquid solution, suspension, emulsion, tablet, pill, capsule, sustained release formulation, or powder. In some

embodiments, a pharmaceutical composition can be formulated as a suppository, with traditional binders and carriers such as triglycerides. In some embodiments, oral formulation can include standard carriers such as pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, polyvinyl pyrrolidone, sodium saccharine, cellulose, magnesium carbonate, etc.

[0148] In some embodiments, a pharmaceutical composition can be formulated in accordance with routine procedures as a pharmaceutical composition adapted for administration to human beings. For example, in some embodiments, a composition for intravenous administration typically is a solution in sterile isotonic aqueous buffer. In some embodiments, where necessary, a composition may also include a solubilizing agent and a local anesthetic to ease pain at the site of the injection. In some embodiments, generally, ingredients are supplied either separately or mixed together in unit dosage form, for example, as a dry lyophilized powder or water free concentrate in a hermetically sealed container such as an ampule or sachet indicating the quantity of active agent. In some embodiments, where a composition is to be administered by infusion, it can be dispensed with an infusion bottle containing sterile pharmaceutical grade water, saline or dextrose/water. In some embodiments, where a composition is administered by injection, an ampule of sterile water for injection or saline can be provided so that the ingredients may be mixed prior to administration.

[0149] In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulator) can be formulated in a neutral form; in some embodiments it may be formulated in a salt form. In some embodiments, pharmaceutically acceptable salts include those formed with free amino groups such as those derived from hydrochloric, phosphoric, acetic, oxalic, tartaric acids, etc., and those formed with free carboxyl groups such as those derived from sodium, potassium, ammonium, calcium, ferric hydroxides, isopropylamine, triethylamine, 2-ethylamino ethanol, histidine, procaine, etc.

[0150] Pharmaceutical compositions for use in accordance with the present invention may be administered by any appropriate route. In some embodiments, a pharmaceutical composition is administered intravenously. In some embodiments, a pharmaceutical composition is administered subcutaneously. In some embodiments, a pharmaceutical composition is administered by direct administration to a target tissue, such as heart or muscle

(e.g., intramuscular), or nervous system (e.g., direct injection into the brain; intraventricularly; intrathecally). Alternatively or additionally, in some embodiments, a pharmaceutical composition is administered parenterally, transdermally, or transmucosally (e.g., orally or nasally). More than one route can be used concurrently, if desired.

[0151] In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulator (or a composition or medicament containing an immune checkpoint modulator)), can be administered alone, or in conjunction with other immunomodulatory agents. The term, "in conjunction with," indicates that a first immune checkpoint modulator is administered prior to, at about the same time as, or following another immune checkpoint modulator. In some embodiments, a first immunomodulatory agent (e.g. immune checkpoint modulator) can be mixed into a composition containing one or more different immunomodulatory agents (e.g. immune checkpoint modulators), and thereby administered contemporaneously; alternatively, in some embodiments, the agent can be administered contemporaneously, without mixing (e.g., by "piggybacking" delivery of the agent on the intravenous line by which the immunomodulatory agent (e.g. immune checkpoint modulator) is also administered, or vice versa). In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulator) can be administered separately (e.g., not admixed), but within a short time frame (e.g., within 24 hours) of administration of another immunomodulatory agent (e.g. immune checkpoint modulator).

[0152] In some embodiments, subjects treated with an immunomodulatory agent (e.g. immune checkpoint modulator) are administered one or more immunosuppressants. In some embodiments, one or more immunosuppressants are administered to decrease, inhibit, or prevent an undesired autoimmune response (e.g., enterocolitis, hepatitis, dermatitis (including toxic epidermal necrolysis), neuropathy, and/or endocrinopathy), for example, hypothyroidism. In some embodiments, exemplary immunosuppressants include steroids, antibodies, immunoglobulin fusion proteins, and the like. In some embodiments, an immunosuppressant inhibits B cell activity (e.g. rituximab). In some embodiments, an immunosuppressant is a decoy polypeptide antigen.

[0153] In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulators (or a composition or medicament containing immune checkpoint modulators)) are

administered in a therapeutically effective amount (e.g., a dosage amount and/or according to a dosage regimen that has been shown, when administered to a relevant population, to be sufficient to treat cancer, such as by ameliorating symptoms associated with the cancer, preventing or delaying the onset of the cancer, and/or also lessening the severity or frequency of symptoms of cancer). In some embodiments, long term clinical benefit is observed after treatment with an immunomodulatory agent (e.g. immune checkpoint modulators), including, for example, PD-1 blockade such as pembrolizumab, CTLA-4 blockade such as ipilimumab, and/or other agents. Those of ordinary skill in the art will appreciate that a dose which will be therapeutically effective for the treatment of cancer in a given patient may depend, at least to some extent, on the nature and extent of cancer, and can be determined by standard clinical techniques. In some embodiments, one or more *in vitro* or *in vivo* assays may optionally be employed to help identify optimal dosage ranges. In some embodiments, a particular dose to be employed in the treatment of a given individual may depend on the route of administration, the extent of cancer, and/or one or more other factors deemed relevant in the judgment of a practitioner in light of patient's circumstances. In some embodiments, effective doses may be extrapolated from dose-response curves derived from *in vitro* or animal model test systems (e.g., as described by the U.S. Department of Health and Human Services, Food and Drug Administration, and Center for Drug Evaluation and Research in "Guidance for Industry: Estimating Maximum Safe Starting Dose in Initial Clinical Trials for Therapeutics in Adult Healthy Volunteers", Pharmacology and Toxicology, July 2005).

[0154] In some embodiments, a therapeutically effective amount of an immunomodulatory agent (e.g. immune checkpoint modulator) can be, for example, more than about 0.01 mg/kg, more than about 0.05 mg/kg, more than about 0.1 mg/kg, more than about 0.5 mg/kg, more than about 1.0 mg/kg, more than about 1.5 mg/kg, more than about 2.0 mg/kg, more than about 2.5 mg/kg, more than about 5.0 mg/kg, more than about 7.5 mg/kg, more than about 10 mg/kg, more than about 12.5 mg/kg, more than about 15 mg/kg, more than about 17.5 mg/kg, more than about 20 mg/kg, more than about 22.5 mg/kg, or more than about 25 mg/kg body weight. In some embodiments, a therapeutically effective amount can be about 0.01-25 mg/kg, about 0.01-20 mg/kg, about 0.01-15 mg/kg, about 0.01-10 mg/kg, about 0.01-7.5 mg/kg, about 0.01-5 mg/kg, about 0.01-4 mg/kg, about 0.01-3 mg/kg, about 0.01-2 mg/kg, about 0.01-

1.5 mg/kg, about 0.01-1.0 mg/kg, about 0.01-0.5 mg/kg, about 0.01-0.1 mg/kg, about 1-20 mg/kg, about 4-20 mg/kg, about 5-15 mg/kg, about 5-10 mg/kg body weight. In some embodiments, a therapeutically effective amount is about 0.01 mg/kg, about 0.05 mg/kg, about 0.1 mg/kg, about 0.2 mg/kg, about 0.3 mg/kg, about 0.4 mg/kg, about 0.5 mg/kg, about 0.6 mg/kg, about 0.7 mg/kg, about 0.8 mg/kg, about 0.9 mg/kg, about 1.0 mg/kg, about 1.1 mg/kg, about 1.2 mg/kg, about 1.3 mg/kg about 1.4 mg/kg, about 1.5 mg/kg, about 1.6 mg/kg, about 1.7 mg/kg, about 1.8 mg/kg, about 1.9 mg/kg, about 2.0 mg/kg, about 2.5 mg/kg, about 3.0 mg/kg, about 4.0 mg/kg, about 5.0 mg/kg, about 6.0 mg/kg, about 7.0 mg/kg, about 8.0 mg/kg, about 9.0 mg/kg, about 10.0 mg/kg, about 11.0 mg/kg, about 12.0 mg/kg, about 13.0 mg/kg, about 14.0 mg/kg, about 15.0 mg/kg, about 16.0 mg/kg, about 17.0 mg/kg, about 18.0 mg/kg, about 19.0 mg/kg, about 20.0 mg/kg, body weight, or more. In some embodiments, the therapeutically effective amount is no greater than about 30 mg/kg, no greater than about 20 mg/kg, no greater than about 15 mg/kg, no greater than about 10 mg/kg, no greater than about 7.5 mg/kg, no greater than about 5 mg/kg, no greater than about 4 mg/kg, no greater than about 3 mg/kg, no greater than about 2 mg/kg, or no greater than about 1 mg/kg body weight or less.

[0155] In some embodiments, the administered dose for a particular individual is varied (e.g., increased or decreased) over time, depending on the needs of the individual.

[0156] In some embodiments, a loading dose (e.g., an initial higher dose) of a therapeutic composition may be given at the beginning of a course of treatment, followed by administration of a decreased maintenance dose (e.g., a subsequent lower dose) of the therapeutic composition. Without wishing to be bound by any theories, it is contemplated that a loading dose may clear out an initial and, in some cases massive, accumulation of undesirable materials (e.g., fatty materials and/or tumor cells, etc) in tissues (e.g., in the liver), and maintenance dosing may delay, reduce, or prevent buildup of fatty materials after initial clearance.

[0157] In some embodiments, it will be appreciated that a loading dose and maintenance dose amounts, intervals, and duration of treatment may be determined by any available method, such as those exemplified herein and those known in the art. In some embodiments, a loading dose amount is about 0.01-1 mg/kg, about 0.01-5 mg/kg, about 0.01-10 mg/kg, about 0.1-10 mg/kg, about 0.1-20 mg/kg, about 0.1-25 mg/kg, about 0.1-30 mg/kg, about 0.1-5 mg/kg, about

0.1-2 mg/kg, about 0.1-1 mg/kg, or about 0.1-0.5 mg/kg body weight. In some embodiments, a maintenance dose amount is about 0-10 mg/kg, about 0-5 mg/kg, about 0-2 mg/kg, about 0-1 mg/kg, about 0-0.5 mg/kg, about 0-0.4 mg/kg, about 0-0.3 mg/kg, about 0-0.2 mg/kg, about 0-0.1 mg/kg body weight. In some embodiments, a loading dose is administered to an individual at regular intervals for a given period of time (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more months) and/or a given number of doses (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30 or more doses), followed by maintenance dosing. In some embodiments, a maintenance dose ranges from 0 – 2 mg/kg, about 0-1.5 mg/kg, about 0-1.0 mg/kg, about 0-0.75 mg/kg, about 0-0.5 mg/kg, about 0-0.4 mg/kg, about 0-0.3 mg/kg, about 0-0.2 mg/kg, or about 0-0.1 mg/kg body weight. In some embodiments, a maintenance dose is about 0.01, 0.02, 0.04, 0.06, 0.08, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.4, 1.6, 1.8, or 2.0 mg/kg body weight. In some embodiments, maintenance dosing is administered for 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 or more months. In some embodiments, maintenance dosing is administered for 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or more years. In some embodiments, maintenance dosing is administered indefinitely (e.g., for life time).

[0158] In some embodiments, a therapeutically effective amount of an immunomodulatory agent (e.g. an immune checkpoint modulator) may be administered as a one-time dose or administered at intervals, depending on the nature and extent of the cancer, and on an ongoing basis. Administration at an "interval," as used herein indicates that the therapeutically effective amount is administered periodically (as distinguished from a one-time dose). In some embodiments, an interval can be determined by standard clinical techniques. In some embodiments, an immunomodulatory agent (e.g. immune checkpoint modulator) is administered bimonthly, monthly, twice monthly, triweekly, biweekly, weekly, twice weekly, thrice weekly, or daily. In some embodiments, the administration interval for a single individual need not be a fixed interval, but can be varied over time, depending on the needs and rate of recovery of the individual.

[0159] As used herein, those of skill in the art are familiar with certain terms commonly used to describe dosing regimens. For example, the term "bimonthly" has its art understood meaning, referring to administration once per two months (i.e., once every two months); the term "monthly" means administration once per month; the term "triweekly" means

administration once per three weeks (i.e., once every three weeks); the term "biweekly" means administration once per two weeks (i.e., once every two weeks); the term "weekly" means administration once per week; and the term "daily" means administration once per day.

[0160] The invention, among other things, additionally pertains to a pharmaceutical composition comprising an immunomodulatory agent (e.g. immune checkpoint modulator), as described herein; in some embodiments in a container (e.g., a vial, bottle, bag for intravenous administration, syringe, etc.) with a label containing instructions for administration of the composition for treatment of cancer.

Combination Therapy

[0161] In some embodiments, an immunomodulatory agent can be used in combination with another therapeutic agent to treat diseases such as cancer. In some embodiments, an immunomodulatory agent, or a pharmaceutical composition comprising immunotherapy as described herein can optionally contain, and/or be administered in combination with, one or more additional therapeutic agents, such as a cancer therapeutic agent, *e.g.*, a chemotherapeutic agent or a biological agent. An additional agent can be, for example, a therapeutic agent that is art-recognized as being useful to treat the disease or condition being treated by the immunomodulatory agent, e.g., an anti-cancer agent, or an agent that ameliorates a symptom associated with the disease or condition being treated. The additional agent also can be an agent that imparts a beneficial attribute to the therapeutic composition (*e.g.*, an agent that affects the viscosity of the composition). For example, in some embodiments, immunotherapy is administered to a subject who has received, is receiving, and/or will receive therapy with another therapeutic agent or modality (*e.g.*, with a chemotherapeutic agent, surgery, radiation, or a combination thereof).

[0162] Some embodiments of combination therapy modalities provided by the present disclosure provide, for example, administration of an immunomodulatory agent and additional agent(s) in a single pharmaceutical formulation. Some embodiments provide administration of an immunomodulatory agent and administration of an additional therapeutic agent in separate pharmaceutical formulations.

[0163] Examples of chemotherapeutic agents that can be used in combination with an immunomodulatory agent described herein include platinum compounds (*e.g.*, cisplatin, carboplatin, and oxaliplatin), alkylating agents (*e.g.*, cyclophosphamide, ifosfamide, chlorambucil, nitrogen mustard, thiotepa, melphalan, busulfan, procarbazine, streptozocin, temozolomide, dacarbazine, and bendamustine), antitumor antibiotics (*e.g.*, daunorubicin, doxorubicin, idarubicin, epirubicin, mitoxantrone, bleomycin, mytomycin C, plicamycin, and dactinomycin), taxanes (*e.g.*, paclitaxel and docetaxel), antimetabolites (*e.g.*, 5-fluorouracil, cytarabine, premetrexed, thioguanine, floxuridine, capecitabine, and methotrexate), nucleoside analogues (*e.g.*, fludarabine, clofarabine, cladribine, pentostatin, and nelarabine), topoisomerase inhibitors (*e.g.*, topotecan and irinotecan), hypomethylating agents (*e.g.*, azacitidine and decitabine), proteosome inhibitors (*e.g.*, bortezomib), epipodophyllotoxins (*e.g.*, etoposide and teniposide), DNA synthesis inhibitors (*e.g.*, hydroxyurea), vinca alkaloids (*e.g.*, vicristine, vindesine, vinorelbine, and vinblastine), tyrosine kinase inhibitors (*e.g.*, imatinib, dasatinib, nilotinib, sorafenib, and sunitinib), nitrosoureas (*e.g.*, carmustine, fotemustine, and lomustine), hexamethylmelamine, mitotane, angiogenesis inhibitors (*e.g.*, thalidomide and lenalidomide), steroids (*e.g.*, prednisone, dexamethasone, and prednisolone), hormonal agents (*e.g.,* tamoxifen, raloxifene, leuprolide, bicaluatmide, granisetron, and flutamide), aromatase inhibitors (*e.g.*, letrozole and anastrozole), arsenic trioxide, tretinoin, nonselective cyclooxygenase inhibitors (*e.g.*, nonsteroidal anti-inflammatory agents, salicylates, aspirin, piroxicam, ibuprofen, indomethacin, naprosyn, diclofenac, tolmetin, ketoprofen, nabumetone, and oxaprozin), selective cyclooxygenase-2 (COX-2) inhibitors, or any combination thereof.

[0164] Examples of biological agents that can be used in the compositions and methods described herein include monoclonal antibodies (*e.g.*, rituximab, cetuximab, panetumumab, tositumomab, trastuzumab, alemtuzumab, gemtuzumab ozogamicin, bevacizumab, catumaxomab, denosumab, obinutuzumab, ofatumumab, ramucirumab, pertuzumab, ipilimumab, nivolumab, nimotuzumab, lambrolizumab, pidilizumab, siltuximab, BMS-936559, RG7446/MPDL3280A, MEDI4736, tremelimumab, or others known in the art), enzymes (*e.g.*, L-asparaginase), cytokines (*e.g.*, interferons and interleukins), growth factors (*e.g.*, colony stimulating factors and erythropoietin), cancer vaccines, gene therapy vectors, or any combination thereof.

[0165] In some embodiments, an immunomodulatory agent is administered to a subject in need thereof in combination with another agent for the treatment of cancer, either in the same or in different pharmaceutical compositions. In some embodiments, the additional agent is an anticancer agent. In some embodiments, the additional agent affects (*e.g.*, inhibits) histone modifications, such as histone acetylation or histone methylation. In certain embodiments, an additional anticancer agent is selected from the group consisting of chemotherapeutics (such as 2CdA, 5-FU, 6-Mercaptopurine, 6-TG, Abraxane™, Accutane®, Actinomycin-D, Adriamycin®, Alimta®, all-trans retinoic acid, amethopterin, Ara-C, Azacitadine, BCNU, Blenoxane®, Camptosar®, CeeNU®, Clofarabine, Clolar™, Cytoxan®, daunorubicin hydrochloride, DaunoXome®, Dacogen®, DIC, Doxil®, Ellence®, Eloxatin®, Emcyt®, etoposide phosphate, Fludara®, FUDR®, Gemzar®, Gleevec®, hexamethylmelamine, Hycamtin®, Hydrea®, Idamycin®, Ifex®, ixabepilone, Ixempra®, L-asparaginase, Leukeran®, liposomal Ara-C, L-PAM, Lysodren, Matulane®, mithracin, Mitomycin-C, Myleran®, Navelbine®, Neutrexin®, nilotinib, Nipent®, Nitrogen Mustard, Novantrone®, Oncaspar®, Panretin®, Paraplatin®, Platinol®, prolifeprospan 20 with carmustine implant, Sandostatin®, Targretin®, Tasigna®, Taxotere®, Temodar®, TESPA, Trisenox®, Valstar®, Velban®, Vidaza™, vincristine sulfate, VM 26, Xeloda® and Zanosar®); biologics (such as Alpha Interferon, Bacillus Calmette-Guerin, Bexxar®, Campath®, Ergamisol®, Erlotinib, Herceptin®, Interleukin-2, Iressa®, lenalidomide, Mylotarg®, Ontak®, Pegasys®, Revlimid®, Rituxan®, Tarceva™, Thalomid®, Velcade® and Zevalin™); small molecules (such as Tykerb®); corticosteroids (such as dexamethasone sodium phosphate, DeltaSone® and Delta-Cortef®); hormonal therapies (such as Arimidex®, Aromasin®, Casodex®, Cytadren®, Eligard®, Eulexin®, Evista®, Faslodex®, Femara®, Halotestin®, Megace®, Nilandron®, Nolvadex®, Plenaxis™ and Zoladex®); and radiopharmaceuticals (such as Iodotope®, Metastron®, Phosphocol® and Samarium SM-153).

[0166] The additional agents that can be used in combination with immunotherapy as set forth above are for illustrative purposes and not intended to be limiting. The combinations embraced by this disclosure, include, without limitation, one or more immunomodulatory agent(s) as provided herein or otherwise known in the art, and at least one additional agent selected from the lists above or otherwise provided herein. Immunomodulatory agents can also

be used in combination with one or with more than one additional agent, *e.g.*, with two, three, four, five, or six, or more, additional agents.

[0167] In some embodiments, treatment methods described herein are performed on subjects for which other treatments of the medical condition have failed or have had less success in treatment through other means, e.g., in subjects having a cancer refractory to standard-of-care treatment. Additionally, the treatment methods described herein can be performed in conjunction with one or more additional treatments of the medical condition, e.g., in addition to or in combination with standard-of-care treatment. For instance, the method can comprise administering a cancer regimen, *e.g.*, nonmyeloablative chemotherapy, surgery, hormone therapy, and/or radiation, prior to, substantially simultaneously with, or after the administration of an immunomodulatory agent described herein, or composition thereof. In certain embodiments, a subject to which an immunomodulatory agent described herein is administered can also be treated with antibiotics and/or one or more additional pharmaceutical agents.

EXEMPLIFICATION

Example 1. Pan-cancer Analysis of Tumor Mutational Load Threshold and Survival after Immunotherapy with Immune Checkpoint Modulators

[0168] This example illustrates the association between tumor mutational load, as measured by a targeted sequencing panel, and overall survival after treatment with immune checkpoint modulators (ICM).

[0169] In prior studies, the data on tumor mutational load were primarily based on whole exome sequencing, which is typically not broadly performed as part of routine clinical care. Currently, the most widely used precision oncology platforms utilize next-generation sequencing of targeted gene panels. An association between higher tumor mutational load and clinical benefit from ICM were observed in melanoma patients treated with CTLA4 blockade,[3,4] as well as non-small cell lung cancer (NSCLC), melanoma, and bladder cancer patients treated with PD-1/PD-L1 inhibitors.[5-7] Importantly, it remains unknown how broadly tumor mutational load predicts clinical benefit across different human cancers.

[0170] At Memorial Sloan Kettering Cancer Center, over 15,000 patients have undergone genomic profiling using an assay termed "Integrated Mutation Profiling of Actionable Cancer Targets" (MSK-IMPACT), which identifies somatic exonic mutations in a pre-defined subset of 341, 410 or in its most updated version, 468 cancer-related genes, using both tumor-derived and matched germline normal DNA.[8,17]

[0171] Specifically, MSK-IMPACT was used to analyze a cohort of 1534 patients treated at Memorial Sloan Kettering Cancer Center (MSKCC) who previously received at least one dose of an ICM (Figure 1). Patients who previously received atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab as monotherapy or in combination were included in the study. In total, 130 patients received anti-CTLA-4 immunotherapy, 1166 anti-PD-1 or PD-L1 immunotherapy, and 228 received both anti-CTLA-4 and anti-PD-1 or PD-L1 immunotherapy. The total number of somatic mutations was calculated for all patient samples in the cohort and normalized to the total number of megabases in the exons sequenced. Tumor mutational load, as measured by targeted next-generation sequencing (NGS) panels, including MSK-IMPACT, has been previously validated as a means to estimate total tumor mutational load of tumors by multiple investigators.[9,10,11] Overall survival (OS) was measured from the date of first ICM treatment to time of death or last follow-up. Median followup was 11 months with 984 (64%) patients alive at last followup.

[0172] The largest number of patients had tumors with histologies for which use of an ICM is FDA approved: 351 patients with non-small cell lung cancer (NSCLC), 323 with melanoma, 155 with renal cell carcinoma (RCC), 127 with bladder cancer and 78 with head and neck squamous cell cancer (Table 1). Patients with other tumor types such as breast cancer, glioma and gastrointestinal cancers were also included in the study. Multivariable analysis of all patients using Cox proportional-hazards regression demonstrated that the normalized number of somatic, exonic non-synonymous mutations discovered using MSK-IMPACT, or tumor mutational load relative to a threshold, was significantly associated with overall survival (as a continuous variable: HR=0.987, p=.001; binary cutoff: HR 0.524, $p=5.0x10^{-5}$), adjusting for cancer type, age, and drug class of ICM (Table 2). In the table, the term "cutoff" is used to signify tumor mutational load threshold, as used herein. As one of skill in the art will appreciate, a hazard ratio (HR) in survival analysis is the ratio of the hazard rates corresponding to

conditions described by two levels of an explanatory variable. For example, in a drug study, if a treated population survives at twice the rate per unit time as a control population, the hazard ratio would be 0.5, indicating higher hazard of death from no treatment.

Table 1: Hazard ratios of OS for normalized tumor mutational load threshold across histologies tested

Histology	HR	CIlo	CIhi	pvalue	N	Thresh old	Med OS<	Med OS>
Pan Cancer	0.44	0.32	0.60	$3.00x10^{-8}$	1551	17.55	20	NA
Bladder Cancer	0.48	0.23	0.98	0.038	127	16.73	10	NA
Breast Cancer	0.35	0.13	0.91	0.025	46	3.51	4	NA
Cancer of Unknown Primary	4.71	0.42	52.75	0.166	29	25.58	9	1
Esophagogastric Cancer	0.34	0.1	1.13	0.065	53	10.82	4	NA
Glioma	1.93	1.01	3.71	0.043	117	4.46	NA	12
Head and Neck Cancer	0.36	0.14	0.93	0.028	78	7.87	8	NA
Hepatobiliary Cancer	0.43	0.07	2.65	0.352	23	1.12	5	NA
Melanoma	0.35	0.21	0.57	$1.11x10^{-5}$	323	11.15	29	NA
Non-Small Cell Lung Cancer	0.23	0.10	0.57	$4.69x10^{-4}$	351	17.84	12	NA
Pancreatic Cancer	0			0.084	23	9.84	3	NA
Prostate Cancer	4.55	0.75	27.44	0.07	23	32.34	NA	20
Renal Cell Carcinoma	0.43	0.19	0.98	0.038	155	1.76	32	NA
Skin Cancer, Non-Melanoma	1.86	0.57	6.1	0.3	30	4.46	NA	15
Drug Class								
Combination	0.54	0.25	1.18	0.115	238	17.55	32	NA
CTLA4	0.29	0.12	0.68	0.003	130	17.55	34	NA
PD-1/PD-L1	0.49	0.35	0.70	$6.89x10^{-5}$	1166	17.55	13	NA

*Other rare and miscellaneous cancers are included in the overall analysis but limited numbers (<20) did not allow analysis individually.

Table 2: Multivariate analysis of factors associated with overall survival.

	HR	95% CI	P value

Normalized Mutation Count			
Continuous	0.987	0.979-0.995	.001
Binary (>17.55)	0.524	0.384-0.716	5.0×10^{-5}
Cancer Type			
Melanoma (reference)			
NSCLC	1.803	1.329-2.444	1.5×10^{-4}
Not Melanoma/NSCLC	1.445	1.101-1.898	.008
Age	1.003	0.997-1.010	0.340
Drug Class			
PD-1/PD-L1 (reference)			
CTLA4	0.619	0.441-0.866	.005
Combo	0.701	0.541-0.908	.007

[0173] In pan-cancer analysis, a higher number of somatic mutations, or high tumor mutational load, was associated with proportionally improved overall survival (Figure 2). As expected, distribution of tumor mutational load varied across diverse histologies.[12] More importantly, optimal tumor mutational load thresholds were identified that predict overall survival after ICM therapy for each cancer subtype using maximum chi-squared analysis (Figures 4A and 5A-B).[13] A significant association or strong trend was observed with increased tumor mutational load and improved overall survival from immunotherapy treatment across many histologies, concordant with the number of patients in the subgroup (Figures 6A-H and 7). Importantly, in patients who did not receive ICM therapy (n=9196), there was no association between higher tumor mutational load and improved overall survival (Figures 3B and 4B).

[0174] A significant association with improved overall survival and higher tumor mutational load was observed with CTLA-4 and PD-1/PD-L1 blockade targeted therapy while a

similar non-significant trend was observed with combination therapy. It is intriguing that combination therapy appears to lessen the significance of tumor mutational load on outcome. This relationship suggests that abrogating multiple immune checkpoints may enable the immune system to target a broader set of potential neoantigens more effectively, increasing the likelihood of establishing an effective anti-tumor response.

[0175] Glioma was an outlier in the study (Figure 4A), as increased tumor mutational load, or a high tumor mutational load threshold was associated with a trend towards poorer overall survival. This is in contrast to reports of dramatic responses to immune checkpoint modulators in patients with glioblastoma associated with childhood biallelic mismatch repair deficiency.[14] This discrepancy may reflect the fact that mismatch repair is very rare in GBM and tumor mutational load in these patients may reflect prior exposure to the alkylating agent temozolomide, which has been shown to promote the expansion of subclonal mutations that have been suggested to be less immunogenic.[15] It should be noted, as anticipated from a large pan-cancer analysis, that the patients included were heterogeneous, with some having been heavily pre-treated whereas others were treated with a variety of combination therapies.

[0176] These findings are confirmed by additional analysis of a larger cohort in the MSK-IMPACT study. The cohort included 1662 patients whose tumors were profiled by next generation sequencing and who received at least one dose of ICI therapy, representing a variety of cancer types with sufficient number of patients for analysis (Fig 13). Patients who received atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab as monotherapy or in combination were included in the study. The vast majority of patients (1446, 94% of tumors excluding glioma) had stage IV or metastatic disease. A small number of patients had locally recurrent disease (n=10), or were melanoma patients with regionally advanced unresectable disease (stage III, n= 89 (Table 3). In total, 146 received anti-CTLA4, 1447 received anti-PD1 or PD-L1, and 189 received both. A large number of patients had cancers for which ICI is FDA-approved, including 350 NSCLCs, 321 melanomas, 151 renal cell carcinomas (RCC), 214 bladder cancers and 138 head and neck squamous cell cancers (Table 4). To calculatetumor mutational burden (TMB), the total number of somatic non-synonymous mutations was normalized to the total number of megabases sequenced. OS was measured from the date of first ICI treatment to time of death or last follow-up. The median

followup was 19 months (range 0-80, with 830 [50%] patients alive and censored at last followup.

Table 3: Patient Clinical Characteristics

	N (%)
Gender	
Male	1034 (62)
Female	628 (38)
Cancer Type	
See Figure 1	
Cancer Disease State	
Metastatic	1446 (87)
Unresectable locally recurrent	10 (0.7)
Melanoma stage III	89 (6)
Glioma	117 (7)
Drug Class	
CTLA4 targeted	146 (9)
PD-1/PD-L1 targeted	1256 (76)
Combination of above	260 (16)
Year of ICI start	
2011-2012	26 (2)
2013-2014	189 (11)
2015-2017	1447 (87)
	Median (range)
Age	62 (4-93)
Tumor Mutational Burden	5.9(0-210)

Table 4: Multivariable analysis of TMB association with removal of Melanoma and NSCLC patients

	HR	95% CI	P value
Normalized Mutation Count			
Continuous	0.982	0.974-0.990	$1.7x10^{-5}$

Cancer Type			
Bladder Cancer (reference)			
Glioma	1.25	0.91-1.72	0.17
Esophagogastric Cancer	1.28	0.91-1.79	0.16
Renal Cell Carcinoma	0.41	0.29-0.58	$5.1x10^{-7}$
Head and Neck Cancer	1.20	0.88-1.64	0.24
Other	1.17	0.87-1.57	0.30
Age	0.993	0.986-1.00	0.05
Drug Class			
PD-1/PD-L1 (reference)			
CTLA4	1.41	0.85-2.34	0.18
Combo	0.78	0.57-1.06	0.11
Year of ICI start			0.02

[0177] TMB subgroups were defined by percentiles within each histology. This approach was used because the median and range of mutational load has been shown to vary across tumor types[13]; therefore, a universal cutoff for "high TMB" would be enriched for tumor types with higher mutation load. Across the entire cohort, stratifying tumors by TMB decile within histology revealed that a higher number of mutations was associated with improved OS. This significant association, stratified by histology, was seen across a variety of cutpoints chosen to define the high TMB group (ranging from top 10-50%; Figs. 14A, 15, 16). A clear trend

toward decreasing hazard ratio (HR) of death with increasing TMB cutoff was observed across cancer types demonstrating increasing benefit from ICI with higher TMB (Figs.14B, 16).[13]

[0178] To confirm that these results were present across multiple cancer types, two additional analyses were performed. First, a multivariable analysis across the entire cohort using Cox proportional-hazards regression demonstrated that the tumor mutation burden was significantly associated with OS both as a continuous variable (HR=0.985, $p=3.4x10^{-7}$) and with a binary cutoff (top 20% of each histology, HR 0.61 $p=1.3x10^{-7}$), adjusting for cancer type, age, drug class of ICI, and year of ICI start (Table 5). Furthermore, this association remained significant with removal of melanoma and NSCLC patients from the cohort (Table 4), indicating that this effect was not solely driven by these histologies.

Table 5: Multivariable analysis of factors associated with overall survival.

	HR	**95% CI**	**P value**
Normalized Mutation Count			
Continuous	0.985	0.979-0.991	$3.4x10^{-7}$
Binary (Top 20% of each histology)	0.61	0.508-0.733	$1.3x10^{-7}$
Cancer Type			
Melanoma (reference)			
NSCLC	2.08	1.61-2.68	$1.9x10^{-8}$
Not Melanoma/NSCLC	1.52	1.21-1.92	$3.7x10^{-4}$
Age	0.995	0.990-1.004	0.07
Drug Class			
PD-1/PD-L1 (reference)			
CTLA4	1.18	0.846-1.66	0.32

Combo	0.67	0.534-0.844	$6.6x10^{-4}$
Year of ICI start			$2.3X10^{-8}$

[0179] A stratified analysis within each cancer type was also performed, by selecting the higher mutation load quintile (top 20%) in each histology as the TMB-high group. Using this approach, a similar association of longer OS with higher TMB (top 20% within each histology) across multiple cancer types was observed (Figs. 17, 18). Although the effect for some individual cancers did not reach statistical significance, possibly due to smaller sample size, the numerical trend of better OS (HR<1) was observed in nearly all cancer types, with glioma the clearest exception. Taken together, these data indicate that the association between TMB and improved survival after ICI is likely to be present in the majority of cancer histologies.

[0180] Consistent with varying distributions of TMB across histologies, the TMB cutoff associated with the top 20% of each cancer type varied markedly (Figs 17, 19). Importantly, this suggests that there is not likely to be a universal number defining high TMB that is predictive of clinical benefit to ICI across all cancer types, and that the optimal cutpoint is likely to vary for different cancers.

[0181] A similar numerical trend was observed for longer OS with TMB measured as a continuous variable, across many histologies, concordant with the number of patients in the subgroup (Fig. 20). Consistent with the differences in OS, similar associations between TMB and rates of clinical benefit to ICI, or progression free survival, was observed in patients with cancer types for which response data was available – NSCLC, melanoma, esophagogastric, head and neck, and renal cell cancer (Figs. 21-22). [72-74]

[0182] To investigate the possibility that the observed survival differences among patients with higher TMB tumors could simply be attributable to a general prognostic benefit of high mutational load, unrelated to ICI, the outcomes of 5371 patients with metastatic cancers who did not receive ICI, and whose tumors were sequenced with MSK-IMPACT was measured.

In these patients, there was no association between higher TMB and improved OS (HR 1.12, p=0.11). This lack of prognostic benefit was also observed within each histology (Figs. 17, 23).

[0183] Of note, the TMB cutpoint for the top 20% of colorectal cancer patients was high (52.2/MB), potentially consistent with many MSI-high colorectal tumors receiving ICI treatment. To evaluate the possibility that the ICI-treated cohort of patients might be enriched for patients with higher TMB – if, for example, clinicians were more likely to triage higher TMB patients to ICI therapy –the survival analyses was repeated, instead calculating the top 20% of TMB among all (both ICI and non-ICI treated) patients. The TMB cutpoints in other cancer types were not changed with this calculation, and the associations with survival in each cancer type remained very similar, in both the ICI and non-ICI treated cohorts (Figs. 24, 25).

[0184] Distinct from the other cancer types, there was no association between higher TMB and improved survival in patients with glioma; in fact, the trend was toward poorer survival. Although there have been case reports of dramatic responses to ICI in patients with glioblastoma associated with childhood biallelic mismatch repair deficiency[14], mismatch repair is very rare in GBM, and higher TMB in many glioma patients may reflect prior exposure to the alkylating agent temozolomide, which can promote the expansion of less immunogenic subclonal mutations.[15] Alternatively, anti-tumor immune responses in the CNS may be distinct and less dependent on TMB.

[0185] As would be expected in a large multi-cancer analysis of tumors sequenced as part of clinical care, the patients included were heterogeneous, with some having been heavily pre-treated whereas others were treated with a variety of combination therapies. The timing of MSK-IMPACT testing relative to ICI start was also variable. Nevertheless, the finding of a significant association with OS in a heterogeneous cohort underscores the robustness of TMB as a predictive biomarker, suggesting it is likely to be clinically meaningful.

[0186] The variable threshold of TMB across histologies can likely be attributed to distinct tumor microenvironments as well as the numerous other factors shows to independently predict response to ICI including clonality, immune infiltration, immune cell exclusion, HLA genotype and alterations, expression levels of checkpoint molecules, as well as others.[15,75-78] Our data overall suggest that TMB is associated with increasing OS in a dose-dependent fashion. The

pan-cancer nature of this biomarker likely reflects fundamental mechanisms by which ICI functions. Our data are also consistent with the hypothesis that higher mutation load is associated with a higher number of tumor neoantigens presented on MHC molecules that facilitate immune recognition as foreign and the development of an anti-tumor immune response.[79,80]

[0187] This finding is in line with the observation that patients with hypermutated tumors as a result of defective mismatch repair have high response rates to pembrolizumab, a finding that had led to the FDA's tissue/site-agnostic approval of this agent for microsatellite instability-high or mismatch repair deficient tumors[65]. Mutational load can predict survival across diverse types of human cancers and is relevant in patients treated with either anti-CTLA4 or anti-PD1 therapies. Second, previous studies on the association between mutational load and survival after ICI had examined small cohorts and therefore, the effects of TMB on clinical benefit could not be quantified in a precise manner. This study presents genomic data from the largest cohort of patients treated with ICI to date and demonstrates the continuous association between higher TMB and superior OS. Capturing as little as 3% of the coding exome using targeted panels such as MSK IMPACT appears to provide a sufficient estimation of total tumor mutational load to confer predictive value for patients in whom ICI treatment is being considered. Finally, the mutational number defining TMB high appears to vary across cancer types, and there is unlikely to be a universal number that defines the likelihood of benefit from ICI across all histologies.

Example 2: Patient Population Selection Criteria for Example 1

[0188] The present example describes the criteria in which a patient was selected for analysis in predicting overall survival based on tumor mutational load threshold.

[0189] After receiving institutional review board approval from the Memorial Sloan Kettering Cancer Center, institutional pharmacy records were used to identify patients who received at least one dose of an immune checkpoint modulator (e.g. tezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab) and then cross-referenced with patients who had MSK-IMPACT testing done in the context of routine clinical care. Importantly, concurrent sequencing of germline DNA from peripheral blood is performed for all samples to identify somatic tumor mutations. Patients enrolled in ongoing clinical trials

for which publication of outcomes data was prohibited were removed. Other preceding or concurrent non-ICM treatments were not recorded or accounted for in the analysis. The timing of tissue pathology on which MSK-IMPACT was performed relative to ICM administration is also heterogeneous with a small portion of patients with testing after ICM administration.

[0190] For analysis of patients who did not receive ICM, all patients for whom MSK-IMPACT data was available across all histologies were included. Overall survival analysis was performed from the start of first chemotherapy.

[0191] This study addresses several fundamentally important questions in immune-oncology. First, it had previously been unclear how broadly tumor mutational load thresholds predicted for clinical benefit from immune checkpoint modulators across human cancers. Our study suggests that tumor mutational load threshold can predict survival across many diverse types of human cancers, in patients treated with both CTLA-4 blockade or PD-1 blockade therapies. Second, previous studies on the association between tumor mutational load and survival after ICM therapy had examined smaller cohorts and therefore, the effects of tumor mutational load on clinical benefit could not be quantified in a precise manner. This study presents genomic data from the largest cohort of patients treated with ICM to date (over 1500 patients) and also expands upon and validates earlier data from smaller studies. Lastly, the MSK-IMPACT targeted panel captures approximately 3% of the coding exome and our data indicate that this profiling strategy provides sufficient representation of total tumor mutational load to have predictive value in patients treated with ICM. Taken together, these data collectively indicate that tumor mutational load and tumor mutational load threshold is a predictive biomarker for ICM response across multiple human cancer types and could potentially have value in concert with PD-L1 immunohistochemistry.[16] The pan-cancer nature of this biomarker likely reflects fundamental mechanisms by which ICM functions. Our data is thus consistent with the theory that higher tumor mutation load is presumed to be associated with a higher number of tumor neoantigens presented on MHC molecules that facilitate immune recognition as foreign and development of an anti-tumor immune response.

Example 3: Calculation of Tumor Mutational Load Threshold for Example 1

[0192] The present example describes how tumor mutational load is calculated from collected patient data.

[0193] The total number of somatic mutations, or tumor mutational load, identified was normalized to the exonic coverage of the respective MSK-IMPACT panel in megabases. Overall survival analysis on ICM therapy patients was performed from the date of first infusion of any ICM. For patients who received multiple courses of ICM, the first treatment was used for analysis. Patients were censored at the date of last attended appointment. For non-ICM patients, the date of first dose of any chemotherapy was used for overall survival analysis.

[0194] Survival analysis was performed using Kaplan Meier with log-rank p values reported. Multivariable analysis was performed using Cox proportional hazard regression. These data analysis methods are known to one of skill in the art. Optimal tumor mutational load cutoffs, or tumor mutational load thresholds as used herein, were determined by maximum chi-squared analysis as known to one of skill in the art, as the distribution of tumor mutational load varied significantly by histology. Statistical analysis was performed in R using the survival package.

Example 4 HLA class I Genotype Influences Survival with Immune Checkpoint Modulators

Materials and Methods

Study Design and Description of Patient Sets

[0195] For the analyses presented in this study, we used two different sets of cancer patients who were treated with immune checkpoint inhibitors. For cohort 1, we obtained exome sequencing data and clinical data from 371 patients who were treated with anti-CTLA-4 or anti-PD-1 therapy. Two patients did not have overall survival data and they were not included in the analyses. Out of the 369 patients with complete clinical data, 269 patients had advanced melanoma and 100 patients had advanced non-small cell lung cancer (NSCLC). The melanoma data are from four previously reported studies (*3, 4, 7, 36*). The NSCLC data are from patients with metastatic disease treated mainly with anti-PD-1 monotherapy. The patients are from a prospective trial that we reported previously (*5*) and from NewYork-Presbyterian /Columbia

University Medical Center. Exome sequencing data were not available for 67 patients with NSCLC. All patients were treated under institutional review approved prospective protocols. For cohort 2, we obtained independent next-generation sequencing data using a targeted gene panel (MSK-IMPACT) and clinical data from 1,166 patients representing different cancer types on an institutional IRB-approved research protocol (NCT01775072). These patients were treated with anti-CTLA-4, or PD-1/PD-L1 blockade, or a combination of both drugs at the Memorial Sloan Kettering Cancer Center (*32*). Clinical characteristics of patient cohorts are provided in Appendix 1. For analysis of germline variants, original sequencing files and relevant clinical data were anonymized by a third party without investigator access to the original patient identification according the protocol design. Additional details regarding these tumors can be found in the original publications (*3-5, 7,11, 36).* The results published here are in part based on data generated by TCGA pilot project established by the National Cancer Institute and National Human Genome Research Institute. Information about TCGA and the investigators and institutions that constitute the TCGA research network can be found at cancergenome.nih.gov/. The TCGA exome data for the patients with melanoma was obtained from the Cancer Genome Atlas (TCGA) (N = 378).

Overall Survival and Clinical Response Data

[0196] The clinical endpoint used in these analyses was overall survival, defined as the length of time from treatment start to time to event (survival or censor). All clinical data were obtained from the original studies (*3-5, 7,11, 36*). Clinical data for the TCGA patients with melanoma were accessed through the TCGA data portal.

HLA Class I Genotyping Data

[0197] We performed high-resolution HLA class I genotyping from germline normal DNA exome sequencing data directly or using a clinically validated HLA typing assay (LabCorp). Patient exome data or targeted gene panels were obtained and the well-validated tool Polysolver was used to identify HLA class I alleles with default parameter settings (*38*). It has previously been shown that Polysolver is highly accurate compared to serology or PCR-based

methods (*37, 38*). For quality assurance, a subset of these patients (N = 22) was molecularly HLA typed at a CLIA-certified center (New York Blood Center) and typed using Polysolver. The overall concordance between Polysolver and the molecular typing was 96%. Concordance is defined as [(6 – number of allele mismatches between Polysolver and molecular typing) / 6] x 100. Furthermore, HLA class I homozygosity detected by Polysolver was confirmed by two additional computational tools, OptiType and HLA-SOAP (*39,40*). For the 67 patients with NSCLC with no available exome sequencing data, HLA class I molecular typing was done at LabCorp. For quality assurance of MSK-IMPACT (CLIA-certified hybridization-capture based assay) captures HLA class I (*8,11, 41*), we compared HLA class I typing by Polysolver between 37 samples that we sequenced with MSK-IMPACT and whole exome. The MSK-IMPACT panel successfully captured HLA-A, -B, and -C. To make sure that HLA class I genes have adequate coverage in MSK-IMPACT bam files, we also applied bedtools multicov tool (//bedtools.readthedocs.io/en/latest/content/tools/multicov.html), which reports the count of alignments from multiple position-sorted and indexed BAM files that overlap with targets intervals in a BED format. Only high quality reads were counted and only samples with sufficient coverage were used. The overall concordance of class I typing between the MSK-IMPACT samples and their matched WES samples was 96%.

Statistical Analysis

[0198] We performed survival analyses using the Kaplan-Meier estimator. The log-rank test was used to determine statistical significance of the survival distributions between patients with a specific genotyping and patients without it. We computed hazard ratios using univariate or multivariable Cox regression. To stratify patients into two groups, with high and low tumor mutational load, we used cutoffs calculated by the R function maxstat.test (//cran.r-project.org/web/packages/maxstat/vignettes/maxstat.pdf). In Fig. 8F, Fig. 8G, Fig. 9G, and Fig. 9H we used a range of cutoffs across the quartiles of the distribution of the number of somatic mutations of the specific cohort analyzed. The cutoffs were used to stratify patients into two groups, high or low tumor mutational load, and to generate the box plot showing the distribution of hazard ratios resulting from the survival analyses using the multiple cutoffs. In Figure 8F, we used the range [80, 542]. For Figure 8G, we used [5, 65]. For Figure 9G, we used the range [108,

569]. And for Figure 9H, we used [5, 25]. Comparison of number of somatic mutations between HLA class I homozygotes and heterozygotes groups was performed with the Wilcoxon-rank sum test. All statistical analysis was performed in the R Statistical Computing environment version 3.3.1 (www.r-project.org).

Mutational Analysis Pipeline

[0199] For cohort 1, whole-exome sequencing for all data sets was previously completed (*3-5, 36*). Analysis was performed as described by DePristo et al. (*42, 43*) As previously described (*42*), paired-end reads in FASTQ format were aligned to the reference human genome GRCh37 using the Burrows–Wheeler aligner (BWA; v0.7.10) (*44*). Local realignment was performed using the Genome Analysis Toolkit (GATK 3.2.2) (*45*). Duplicate reads were removed using Picard version 1.119. To identify somatic single nucleotide variants (SNVs), we used a pipeline that integrates mutation calls from four different mutation callers: MuTect 1.1.4, Strelka 1.0.3, SomaticSniper 1.0.4, and Varscan 2.3.7 (*46-49*). Insertions and deletions were determined using Strelka 1.0.3 with default settings (*42,43*). SNVs with an allele read count of less than 4 or with corresponding normal coverage of less than 7 reads were filtered out. For cohort 2, relative mutational load was determined using MSK-IMPACT consistent with targeted panels as a validated method to determine relative mutational load (8, *11, 41, 50*).

Loss of Heterozygosity of HLA Class I Analysis

[0200] Copy number variation analysis was performed using FACETS 0.5.6 (*51*) to determine allele specific copy number. Segments within the chromosome 6p locus were identified containing the HLA-A, HLA-B and HLA-C loci. Loss of heterozygosity (LOH) was defined as a minor allele copy number estimate of 0 for any of the HLA loci using the expectation-maximization model.

HLA Class I Structural Analysis and Molecular Dynamics Simulations

[0201] The neoantigen structure within the pHLA complex presented in PDB 1M6O was mutated to conform to the desired B44 motif (F3I, P4G, A6V, F9Y) using the VMD Mutator plugin. All images were rendered using the VMD 1.9.2 software package (*52*).

[0202] Molecular dynamics (MD) simulations of isolated HLA class I alleles and HLA-peptide complexes were initiated from configurations drawn from crystal structures at the highest available resolutions: HLA-B*15:01 (PDB ID: 1XR9); HLA-B*07:02 (PDB ID: 5EO0); and HLA-B*53:01 (PDB ID: 1A1M). To generate isolated HLA configurations, atoms corresponding to bound peptides were removed. After the addition of hydrogen atom and disulfide bond patches, each system was solvated in TIP3P water molecules and brought to a physiological concentration (150 mM) of Na^+ and Cl^- ions. Following similar protocols used in our previous studies (*53-55*), the resulting protein-water systems were minimized for 25000 steps by steepest descent, and then equilibrated with and without harmonic protein restraints in separate 5 ns simulations. Configurations taken from the ends of equilibration runs were used to seed production simulations, which were extended to 500 ns in duration for HLA-B*15:01 and 300 ns in length for HLA-B*07:02 and HLA-B*53:01. In all equilibration and production runs, temperature and pressure were constrained at 310 K and 1 atm using a Langevin thermostat and Parrinello-Rahman barostat, respectively. All MD simulations were conducted with the NAMD 2.11 simulation package (*56*). Inter-residue separations and residue-position root mean square fluctuations (RMSFs) were computed using standard utilities included in the GROMACS 5.1 software suite (*57*). Simulation snapshots were generated with VMD (*52*).

Results

[0203] We performed survival and genetic association analyses to address two hypotheses: (i) heterozygosity at HLA class I genes confers a selective advantage on survival with the administration of immune checkpoint inhibitors in cancer patients, and (ii) individual HLA class I germline alleles vary in their influence on survival after ICM therapy.

[0204] To examine these hypotheses, we scrutinized two sets of cancer patients (henceforth called cohort 1 and cohort 2) who were treated with ICM therapy. Cohort 1 was comprised of 369 patients who were treated with anti-CTLA-4 or anti-PD-1 drugs, for which exome sequencing data and clinical data were obtained. Out of these 369 patients, 269 patients

had advanced melanoma, previously reported by Snyder et al. (*3*), Van Allen et al. (*4*), Hugo et al. (*7*), and Riaz et al. (*36*), and 100 patients had advanced non-small cell lung cancer (NSCLC) (*5*) (Appendix 1). The patients with NSCLC were treated mainly with anti-PD-1 monotherapy. Cohort 2 was comprised of 1,166 patients representing different cancer types including melanoma and NSCLC (Appendix 1), whose tumors were subjected to targeted next-generation sequencing (MSK-IMPACT) (*11*). These patients were treated with drugs targeting CTLA-4, PD-1/PD-L1, or a combination of both, at the Memorial Sloan Kettering Cancer Center (*11*). For all patients in both cohorts, we performed high-resolution HLA class I genotyping from normal DNA using DNA sequencing data or a clinically validated HLA typing assay (LabCorp). HLA typing from sequencing data was done using Polysolver, which has been extensively validated (*33, 34*). For quality assurance, a subset of these patients (N = 22) were HLA typed using a CLIA-certified assay (at the New York Blood Center) and typed using Polysolver (*38*). As expected and previously shown, the overall concordance between Polysolver and the HLA-typing assay was very high (96%).

[0205] MHC class I molecules are extremely polymorphic with most of the polymorphism located in the peptide-binding region; each variant binds a select repertoire of peptide ligands. As such, a person who is homozygous in at least one HLA class I locus would be predicted to present a smaller, less diverse repertoire of tumor-derived peptides that are recognized by cytotoxic T lymphocytes (CTLs) compared to a person who is heterozygous at each class I locus (*32*). We thus reasoned that, greater diversity (heterozygosity) in the repertoire of antigen-presenting HLA class I molecules would be associated with better survival following ICM treatment. Conversely, less diversity (homozygosity) at these class I genes would be associated with poorer survival. We tested this hypothesis by examining HLA zygosity at each of the HLA class I genes (HLA-A, -B, and -C) in cohort 1 and cohort 2, independently. For this analysis, we employed a Cox proportional hazard regression model to examine the probability of overall survival. The results showed a statistically significant association between HLA class I homozygosity and reduced survival in the 369 patients from cohort 1 treated with ICM therapy (Fig. 8A). The association was apparent when at least one HLA class I locus was homozygous (cohort 1; $P = 0.036$, HR = 1.40, 95% CI 1.02 – 1.9; Fig. 8A). We validated this finding in the independent cohort of 1,166 patients treated with ICM therapy (cohort 2; $P = 0.028$, HR = 1.31,

95% CI 1.03 – 1.70; Fig. 8B). The number of somatic mutations in tumors was not statistically different between homozygotes and heterozygotes patients in either cohort 1 (Wilcoxon rank-sum test $P = 0.09$; fig. 11A) or cohort 2 (Wilcoxon rank-sum test $P = 0.7$; fig. 11B). Furthermore, the association of homozygosity with reduced survival remained significant in multivariable Cox regression modeling when including mutation load, tumor stage, age, and drug class in cohort 1 ($P = 0.02$, HR = 1.50, 95% CI 1.07 – 2.10) (Table 4) and in cohort 2 ($P = 0.028$, HR = 1.31, 95% CI 1.03 – 1.67) (table 5).

Table 4. Multivariable survival analysis incorporating homozygosity for at least one HLA class I locus, mutation burden (as a continuous variable), age, tumor stage, and drug class from cohort 1

Covariate	HR	95% CI	P value
Homozygosity for at least one HLA-I locus	1.50	1.07 – 2.10	0.02
Mutation load (Continuous)	1.00	0.98 – 0.99	0.004
Age	1.00	0.99 – 1.01	0.96
Stage M0 (reference)			
Stage M1a	2.30	0.75 – 6.70	0.15
Stage M1b	2.70	0.91 – 7.77	0.08
Stage M1c	4.06	1.49 – 11.08	0.006
Drug class: CTLA-4 (reference)			
Drug class: PD-1	0.64	0.47 – 0.87	0.004

Table 5. Multivariable survival analysis incorporating homozygosity for at least one HLA class I locus, mutation burden (as a continuous variable), age, tumor stage, and drug class from cohort 2

Covariate	HR	95% CI	P value
Homozygosity for at least one HLA-I locus	1.31	1.03 – 1.67	0.028
Mutation load (Continuous)	0.99	0.98 – 0.99	0.003
Age group < 30 (reference)			

Age group > 71	0.94	0.44 – 2.02	0.88
Age group 31-50	0.90	0.44 – 1.84	0.78
Age group 50-60	0.77	0.37 –1.59	0.47
Age group 61-70	0.76	0.36 – 1.61	0.48
Drug class: Combo (reference)			
Drug class: CTLA-4	0.52	0.28 – 0.96	0.036
Drug class: PD-1/PDL-1	1.53	1.12 – 2.08	0.007

[0206] The generation of HLA class I-restricted T-cell responses has been shown to be important in the clinical response of cancer patients treated with immunotherapies (*3, 5, 34, 35*). These results suggest that by limiting the number of HLA class I-restricted tumor-derived epitopes that can be presented to T cells, HLA homozygosity may impair a patient's survival after ICM therapy perhaps by decreasing the chance that antigens needed for anti-tumor immunity will be presented. Interestingly, these data are consistent with the association of rapid progression to AIDS of HIV-infected patients having HLA class I homozygosity (*22, 25*), and with the association of HLA class II with persistent hepatitis B virus infection (*58*).

[0207] We next examined all 1,535 patients from cohort 1 and 2 together, to determine whether the effect of homozygosity may be due to a single class I locus, or a combination of different loci. This analysis revealed that homozygosity at one HLA class I locus (A, or B, or C) was associated with significant reduction of overall survival ($P = 0.003$, HR = 1.38, 95% CI 1.11 – 1.70; Fig. 8C). Interestingly, the effect of homozygosity on survival due to specific HLA class I locus seemed mostly associated with HLA-B ($P = 0.052$, HR = 1.66, 95% CI 0.93 – 2.94; Fig. 8C) and HLA-C ($P = 0.004$, HR = 1.60, 95% CI 1.16 – 2.21; Fig. 8C). Of note, the number of patients available likely limited the interpretability of analyses involving combinations of loci (HLA-A and -B, etc.).

[0208] Without wishing to be bound by any particular theory, there are two possible explanations for the significant association of homozygosity at the HLA-B locus with decreased survival. First, HLA-B is expressed at higher levels on the cell surface than HLA-A and HLA-C,

and HLA-B alleles bind to greater diversity of peptides (*59,60*). Amino acids that bind to the B pocket of HLA-A alleles are broadly hydrophobic residues. In contrast, the B pocket of HLA-B alleles can accommodate a greater variety of residues (proline, positively and negatively charged residues, and histidine and glutamine) (*60*). The principal source of HLA-B diversity arises from intralocus recombination events within exon 3, primarily affecting the F, C, and D pockets (*60*) and the HLA-B locus is dominant in determining clinical outcomes in infectious diseases such as HIV and malaria (*21-28*). Similarly, heterozygosity at HLA-C loci may enable greater peptide ligand diversity. Although HLA-C also has the ability to present peptides to cytotoxic $CD8^+$ T cells, antigen-presenting cells (APCs) express higher levels of HLA-C on the cell surface than other cell types (*61*). Because HLA-C molecules bind to inhibitory killer cell immunoglobulin-like receptors (KIRs) that are up regulated upon acquisition of effector functions (*62*), heterozygous HLA-C locus may more effectively limit CTL lysis of cross-presenting APCs. This may, therefore, facilitate continuous priming of naïve CTLs during treatment with ICM therapy (*63*).

[0209] Previous reports have shown that the total number of somatic coding mutations in a cancer genome correlates with response to ICM therapy (*6, 3-5, 65*). An explanation for this observation is that the number of neopeptides presented by the tumor increases with the number of somatic mutations, which in turn also increases the probability that $CD8^+$ T cells recognize a neoepitope following ICM therapy (*64*). Therefore, we assessed the effect of zygosity at the HLA class I loci in combination with mutation burden. This analysis revealed that HLA class I homozygosity and low mutation burden were strongly associated with decreased survival compared to patients who were heterozygous at each class I locus and whose tumors had high mutation burden. This effect was seen in both in cohort 1 ($P = 0.003$, HR = 2.03, 95% CI 1.27 – 3.30; Fig. 8D) and in cohort 2 ($P < 0.0001$, HR = 2.98, 95% CI 1.84 – 4.82; Fig. 8E). Notably, the combined effect of HLA class I heterozygosity and mutation load on survival was greater compared with mutation load alone in both cohort 1 and cohort 2 (Fig. 8, F and G).

[0210] Previous work has reported the presence of loss of heterozygosity (LOH) of HLA class I genes in cancer (*66*). We therefore examined whether LOH of HLA class I in the tumor may have a similar effect on survival outcome after ICM therapy as in the case of germline HLA class I homozygosity. We analyzed all tumor exomes from cohort 1 and identified 32 patients

who were heterozygous at all HLA class I loci, but had LOH in at least one HLA class I locus in their tumors (Appendix 1). We found that patients with LOH of HLA class I were associated with reduced survival compared to patients who were heterozygous at each HLA class I locus and without LOH ($P = 0.05$, HR = 1.60, 95% CI 1.03 – 2.43; Fig. 8H). Consistent with the above results, the effect of LOH of HLA class I on survival was enhanced in patients whose tumors contained low mutation load compared to patients who were heterozygous at all HLA class I loci, without LOH, and whose tumors had high mutation burden ($P = 0.0006$, HR = 3.68, 95% CI 1.64 – 8.23; Fig. 8I). Taken together, these results indicate that patient-specific diversity of antigen-presenting HLA class I molecules and mutation burden in the tumor may both impact the number of immunogenic neoantigens that are presented on the cell surface, which in turn, influences response to ICM therapy. Furthermore, the demonstration of a significant survival advantage to HLA class I heterozygosity in patients treated with ICM therapy both at the germline and somatic level highlights its importance in the dynamic anti-tumor immune response and its evasion.

[0211] To investigate the clinical relevance of individual HLA class I alleles after anti-PD-1 or anti-CTLA-4 therapy, we examined the effects of HLA class I supertypes on overall survival after ICM treatment. Individual HLA class I alleles are classified into twelve discrete supertypes (or superfamilies) (*67,68*). HLA alleles within the same supertype are expected to present similar peptides and this classification is supported by strong evidence for shared-presentation of peptide-binding motifs by different HLA class I molecules (*25, 67, 68*). Importantly, these supertypes together cover most HLA-A and HLA-B alleles found in distinct populations (*67, 68*).

[0212] To assess the effect of HLA supertype on survival, we focused on melanoma patients, as we had enough patients in the two patient sets for meaningful analysis given HLA allelic diversity. Based on the biological definition of supertypes, we classified the 27 HLA-A alleles present in the patients with melanoma into six A supertypes, and the 50 HLA-B alleles into six B supertypes (Appendix 1 and Fig. 9A). We determined whether each HLA superfamily was associated with survival following ICM treatment. Strikingly, this analysis identified two supertypes, both B supertypes, associated with survival outcome in patients with advanced melanoma treated with anti-CTLA-4. Patients with B44 superfamily alleles had significantly

better overall survival (P = 0.01, HR = 0.61, 95% CI 0.42 – 0.89) (Table 3) and patients with B62 alleles had significantly decreased survival (P = 0.0007, HR = 2.29, 95% CI 1.40 – 3.7) (Table 3). In these patients, the B44 supertype was present at a prevalence of 45%; the B62 supertype, 15% (Fig. 9A). We did not find any supertype significantly associated with overall survival in patients with NSCLC, likely due to the limited sample size.

Table 3. HLA supertype association with overall survival in patients with melanoma from cohort 1 treated with ICM and influence of specific alleles on the associations

HLA class I supertype	**Frequency**	**HR**	**P value**
A24	0.29	0.67 (0.44 - 1.03)	0.07
A01	0.59	0.87 (0.60 - 1.27)	0.47
A03	0.52	1.39 (0.96 - 2.03)	0.08
A02	0.5	1.13 (0.76 - 1.63)	0.53
B58	0.09	0.98 (0.51 - 1.88)	0.96
B62	0.15	2.29 (1.40 - 3.74)	0.0007
B27	0.29	1.09 (0.73 - 1.63)	0.67
B44	0.45	0.61 (0.42 - 0.89)	0.009
B07	0.54	1.35 (0.92 - 1.97)	0.12
B08	0.2	0.85 (0.52 - 1.39)	0.51
A01A03	0.04	1.20 (0.49 - 2.94)	0.69
A01A24	0.09	0.89 (0.43 - 1.83)	0.76
Alleles influencing the significant associations			
B44s, B*18:01, B*44:02, B*44:03, B*44:05, B*50:01	0.34	0.5 (0.32 - 0.76)	0.001
B62s, B*15:01	0.13	2.21 (1.33 - 3.7)	0.002

[0213] We then examined whether these supertype associations were influenced by the presence of specific component HLA class I alleles. The B44 association was influenced by HLA-B*18:01, HLA-B*44:02, HLA-B*44:03, HLA-B*44:05, and HLA-B*50:01 (P = 0.001, HR = 0.49, 95% CI 0.32 – 0.76; Fig. 9C) (Table 3). And, the B62 association was significantly driven by HLA-B*15:01 (P = 0.002, HR = 2.21, 95% CI 1.33 –3.7; Fig. 10A) (Table 3). Both of these B44 and B62 supertype allele associations remained statistically significant (P = 0.01 and P = 0.02, respectively) after a conservative Bonferroni correction for multiple comparisons.

[0214] In the independent set of patients, cohort 2, melanoma patients treated with anti-PD-1 or anti-CTLA-4 who had the B44 supertype alleles had significantly better overall survival ($P = 0.05$, HR = 0.32, 95% CI 0.09 – 1.1; Fig. 9, B and D). The association of the B44s with increased survival remained significant in multivariable analysis when including mutation load, tumor stage, age, and drug class (anti-CTLA-4 or anti-PD-1) in both cohort 1 (table 6) and in cohort 2 (table 7). Furthermore, the effect of B44s on extended survival was enhanced when somatic mutational load in the tumor was also considered. Patients with melanoma possessing B44s and whose tumors also contained high mutation burden had significantly prolonged survival compared to patients who did not carry B44s and having tumors that contained low mutation load in cohort 1 ($P < 0.0001$, HR = 0.23, 95% CI 0.13 – 0.41; Fig. 9E) and in cohort 2 ($P = 0.023$, HR = 0.13, 95% CI 0.02 – 1.07; Fig. 9F). The combined effect of the B44s and mutation load was greater than simply considering mutation burden alone in both cohort 1 and cohort 2 (Fig. 9, G and H). We note that, in general, outcomes of melanoma patients in cohort 2 tended to be better than in cohort 1 because patients who received ICM therapy and were accrued to our protocol for MSK-IMPACT testing tended to have lived longer. Yet, despite this trend, we still observed a significant effect from the B44 superfamily alleles. Notably, the B44 supertype did not associate with overall survival in patients with melanoma from The Cancer Genome Atlas (TCGA), suggesting that the presence of B44 is predictive of response to ICM therapy and is not prognostic (Fig. 9I).

Table 6. Multivariable survival analysis incorporating presence of B44s, mutation burden (as a continuous variable), age, tumor stage, and drug class from patients with melanoma from cohort 1

Covariate	HR	95% CI	P value
HLA-B44(+)	0.54	0.34 – 0.84	0.013
Mutation load (Continuous)	1.00	0.98 – 0.99	0.007
Age	1.00	0.99 – 1.01	0.5
Stage M0 (reference)			
Stage M1a	1.91	0.62 – 5.87	0.26
Stage M1b	2.14	0.73 – 6.25	0.16
Stage M1c	3.53	1.30 – 9.64	0.01
Drug class:			

CTLA-4 (reference)			
Drug class: PD-1	0.73	0.52 – 1.02	0.07

Table 7. Multivariable survival analysis incorporating presence of B44s, mutation burden (as a continuous variable), age, and drug class from patients with melanoma from cohort 2

Covariate	HR	95% CI	P value
HLA-B44(+)	0.27	0.07 – 0.95	0.04
Mutation load (continuous variable)	0.99	0.97 – 1.01	0.4
Age group < 30 (reference)			
Age group > 71	0	0 –	1.00
Age group 31-50	0.25	0.06 – 1.01	0.05
Age group 50-60	0.7	0.17 – 2.97	0.63
Age group 61-70	0.64	0.12 – 3.46	0.60
Drug class: CTLA-4 (reference)			
Drug class: PD-1/PDL-1	4.36	1.35 – 14.10	0.01

[0215] Members of the B44 supertype share a preference for peptides with negatively charged residues at anchor position P2 (Glu) near the N-terminus and polar residues at the C-terminus (*69*) (Fig. 9J). A number of previously identified immunogenic antigens expressed by melanomas are HLA-B44 restricted (Fig. 9J and table 8), including the testis antigen MAGEA3 epitope, which has been shown to be restricted to HLA-B*44:03 and HLA-B*18:01 (both members of B44), and an immunogenic clonal neoantigen (FAM3C: T***E***SPFEQHI) identified in a melanoma patient who derived a long-term response to CTLA-4 blockade from cohort 1 (table 8) (*3, 15*). Additionally, an association of B44 with spontaneous immune response in NY-ESO-1 expressing tumors has been recently reported (*70*). Taken together, these data suggest that the B44s may facilitate presentation of tumor-derived antigens that are recognized by CD8+ T cells, which in turn contribute to the improved survival outcome following ICM therapy.

Table 8. Some experimentally identified immunogenic HLA-B44 restricted neoantigens expressed by melanomas reported in the literature

Gene	WT Peptide	Neoantigen	HLA-B44 allele	WT score	Neoantigen score	Reference
MAGE3	--	MEVDPIGHLY	B*44:03	--	0.01	(*67, 68*)
MAGE3	--	MEVDPIGHLY	B*18:01	--	0.10	(*67, 68*)
TYR	--	SEIWRDIDF	B*44:03	--	0.25	(*69*)
FAM3C	TKSPFEQHI	TXSPFEQHI	B*44:02	16	0.6	(*10*)
MUM1	EEKLSVVLF	EEKLXVVLF	B*44:02	0.09	0.1	(*70*)
MUM2	SELFRSRLDSY	SELFRSXLDSY	B*44:02	0.7	2.5	(*71*)
OS9	KELEGILLP	KELEGILLX	B*44:03	2.5	0.6	(*72*)

The WT score and the neoantigen score refer to the binding strengths of the wild type pepetide and its mutated peptide, respectively, predicted by NetMHC version 4.0 (*73*).

[0216] In contrast, the B62 association with poor survival driven by the HLA-B*15:01 allele was intriguing (Fig. 10A) (Table 3). In an exploratory analysis, we sought to determine whether any molecular features in the HLA-B*15:01 allele are associated with its effect on survival following immunotherapy. Out of all the HLA-B alleles that were available for three-dimensional structural analysis (N = 119; Appendix 2), we identified three alleles at their highest resolutions, HLA-B*15:01 (PDB ID: 1XR9); HLA-B*07:02 (PDB ID: 5EO0); and HLA-B*53:01 (PDB ID: 1A1M), as possessing a structural bridge in the peptide-binding grooves at positions 62, 66, and 163. The bridge in HLA-B*15:01 apparently sequesters bound-peptide residue positions P2 and P3 (Fig. 10, B and C).

[0217] The poor survival associated with the HLA-B*15:01 allele may not reflect simple failure to present peptides, because significant peptide presentation has been reported for this allele (*71*). We thus postulated that this specific structural feature may modulate the effective T cell recognition of neoepitopes presented on the HLA-B*15:01 molecule. To evaluate the validity of this hypothesis, we conducted molecular dynamics (MD) simulations on these three HLA class I molecules following similar protocols used in previous studies (*53-55*).

[0218] In the case of HLA-B*07:02 and HLA-B*53:01, molecular dynamics simulations demonstrated that the bound peptide expands the respective HLA binding cleft, effectively

breaking the bridge (fig. 12, A to D). Conversely, in the HLA-B*15:01 molecule, the bridge was largely maintained with the peptide present, and the bridging residues were also made much less flexible (Fig. 10, D and E). Fig. 10D shows MD simulation snapshots of both the isolated HLA B*15:01 and its complex with a 9-mer UBCH6 peptide, each over the course of 500 ns of dynamics. In both cases, the bridging residues (Arg62, Ile66, and Leu163) separated somewhat when their crystal coordinates were relaxed, and bridging residue positions fluctuated as the trajectories proceeded. However, the general bridge configuration seen in the crystal structure was conserved in our simulated conformational ensembles (Fig. 10, D and E). As Fig. 10E illustrates, the occupation of the peptide-binding groove in HLA-B*15:01 had the effect of arresting bridging residue dynamics. While the mean bridge separation remained nearly constant (~6Å) in both systems of HLA B*15:01 (Fig. 10E), the fluctuations in this distance were less dramatic in the peptide-bound complex. The residue-position root mean square fluctuations (RMSFs) indicate that each of the bridging residues was more rigid with the presence of peptide (Fig. 10E). Altogether, these unique structural and dynamical elements of the HLA-B*15:01 molecule may impair the total strength of the interaction for effective antigen recognition between the HLA-B*15:01-neoepitope complex and T-cell receptor. However, further experimental work will be necessary to test this hypothesis.

[0219] Thus, results presented here show that HLA class I genes influence survival outcome with ICM therapy. Our data indicate that patient-specific HLA class I genotype and somatic alterations, in combination or in the alternative, in tumors impact clinical outcomes following ICM therapy. Both can be considered during the design of future clinical trials and/or recommended therapeutic dosing . The observation that the B44 superfamily is associated with extended overall survival may provide an opportunity for the development of therapeutic vaccines that potentially target immunodominant HLA-B44-restricted neoantigens expressed by melanomas. Additionally, our findings suggest that HLA class I homozygosity and LOH of HLA class I represent a genetic barrier that can be considered to enhance immunotherapeutic efficacy.

Example 5: Exemplary Dosing Regimens for Approved PD-1 Immune Checkpoint Modulators

The present Example sets forth certain dosing regimens that have been approved by the United States Food and Drug Administration for the indicated immune checkpoint modulator agents. **Atezolizumab (TECENTRIQ™)**

[0220] ----------INDICATIONS AND USAGE----------

[0221] TECENTRIQ is a programmed death-ligand 1 (PD-L1) blocking antibody indicated for the treatment of patients with locally advanced or metastatic urothelial carcinoma who:

[0222] Have disease progression during or following platinum-containing chemotherapy;

[0223] Have disease progression within 12 months of neoadjuvant or adjuvant treatment with platinum-containing chemotherapy.

[0224] This indication is approved under accelerated approval based on tumor response rate and duration of response. Continued approval for this indication may be contingent upon verification and description of clinical benefit in confirmatory trials.

[0225] ----------DOSAGE AND ADMINISTRATION----------

[0226] Administer 1200 mg as an intravenous infusion over 60 minutes every 3 weeks.

[0227] Dilute prior to intravenous infusion.

[0228] ----------DOSAGE FORMS AND STRENGTHS----------

[0229] Injection: 1200 mg/20 mL (60 mg/mL) solution in a single-dose vial.

[0230] ----------CONTRAINDICATIONS----------

[0231] None.

[0232] ----------WARNINGS AND PRECAUTIONS----------

[0233] Immune-Related Pneumonitis: Withhold for moderate and permanently discontinue for severe or life-threatening pneumonitis. (5.1)

[0234] Immune-Related Hepatitis: Monitor for changes in liver function. Withhold for moderate and permanently discontinue for severe or life- threatening transaminase or total bilirubin elevation.

[0235] Immune-Related Colitis: Withhold for moderate or severe, and permanently discontinue for life-threatening colitis.

[0236] Immune-Related Endocrinopathies:

[0237] Hypophysitis: Withhold for moderate or severe and permanently discontinue for life-threatening hypophysitis.

[0238] Thyroid Disorders: Monitor for changes in thyroid function. Withhold for symptomatic thyroid disease.

[0239] Adrenal Insufficiency: Withhold for symptomatic adrenal insufficiency.

[0240] Type 1 Diabetes Mellitus: Withhold for ≥ Grade 3 hyperglycemia.

[0241] Immune-Related Myasthenic Syndrome/Myasthenia Gravis, Guillain- Barré or Meningoencephalitis: Permanently discontinue for any grade.

[0242] Ocular Inflammatory Toxicity: Withhold for moderate and permanently discontinue for severe ocular inflammatory toxicity.

[0243] Immune-Related Pancreatitis: Withhold for moderate or severe, and permanently discontinue for life-threatening pancreatitis, or any grade of recurring pancreatitis.

[0244] Infection: Withhold for severe or life-threatening infection.

[0245] Infusion Reaction: Interrupt or slow the rate of infusion for mild or moderate infusion reactions and discontinue for severe or life- threatening infusion reactions.

[0246] Embryo-Fetal Toxicity: TECENTRIQ can cause fetal harm. Advise females of reproductive potential of the potential risk to a fetus and use of effective contraception.

Avelumab (BAVENCIO®)

[0247] ----------INDICATIONS AND USAGE----------

[0248] BAVENCIO is a programmed death ligand-1 (PD-L1) blocking antibody indicated for the treatment of adults and pediatric patients 12 years and older with metastatic Merkel cell carcinoma (MCC).

[0249] This indication is approved under accelerated approval. Continued approval for this indication may be contingent upon verification and description of clinical benefit in confirmatory trials.

[0250] ----------DOSAGE AND ADMINISTRATION----------

[0251] Administer 10 mg/kg as an intravenous infusion over 60 minutes every 2 weeks.

[0252] Premedicate with acetaminophen and an antihistamine for the first 4 infusions and subsequently as needed.

[0253] ----------DOSAGE FORMS AND STRENGTHS----------

[0254] Injection: 200 mg/10 mL (20 mg/mL) solution in single-dose vial.

[0255] ----------CONTRAINDICATIONS----------

[0256] None. (4)

[0257] ----------WARNINGS AND PRECAUTIONS----------

[0258] Immune-mediated pneumonitis: Withhold for moderate pneumonitis; permanently discontinue for severe, life-threatening or recurrent moderate pneumonitis.

[0259] Immune-mediated hepatitis: Monitor for changes in liver function. Withhold for moderate hepatitis; permanently discontinue for severe or life- threatening hepatitis.

[0260] Immune-mediated colitis: Withhold for moderate or severe colitis; permanently discontinue for life-threatening or recurrent severe colitis.

[0261] Immune-mediated endocrinopathies: Withhold for severe or life-threatening endocrinopathies.

[0262] Immune-mediated nephritis and renal dysfunction: Withhold for moderate or severe nephritis and renal dysfunction; permanently discontinue for life- threatening nephritis or renal dysfunction.

[0263] Infusion-related reactions: Interrupt or slow the rate of infusion for mild or moderate infusion-related reactions. Stop the infusion and permanently discontinue BAVENCIO for severe or life-threatening infusion-related reactions.

[0264] Embryo-fetal toxicity: BAVENCIO can cause fetal harm. Advise of potential risk to a fetus and use of effective contraception.

Durvalumab (IMFINZI™)

[0265] ----------INDICATIONS AND USAGE----------

[0266] IMFINZI is a programmed death-ligand 1 (PD-L1) blocking antibody indicated for the treatment of patients with:

[0267] Locally advanced or metastatic urothelial carcinoma who:

[0268] have disease progression during or following platinum-containing chemotherapy.

[0269] have disease progression within 12 months of neoadjuvant or adjuvant treatment with platinum-containing chemotherapy.

[0270] This indication is approved under accelerated approval based on tumor response rate and duration of response. Continued approval for this indication may be contingent upon verification and description of clinical benefit in confirmatory trials.

[0271] ----------DOSAGE AND ADMINISTRATION----------

[0272] Administer 10 mg/kg as an intravenous infusion over 60 minutes every 2 weeks.

[0273] Premedicate with acetaminophen and an antihistamine for the first 4 infusions and subsequently as needed.

[0274] ----------DOSAGE FORMS AND STRENGTHS----------

[0275] Administer 10 mg/kg as an intravenous infusion over 60 minutes every 2 weeks and dilute prior to intravenous infusion.

[0276] ----------CONTRAINDICATIONS----------

[0277] None.

[0278] ----------WARNINGS AND PRECAUTIONS----------

[0279] Immune-Mediated Pneumonitis: Withhold for moderate and permanently discontinue for severe or life-threatening pneumonitis.

[0280] Immune-Mediated Hepatitis: Monitor for changes in liver function.

[0281] Withhold for moderate and permanently discontinue for severe or life-threatening transaminase or total bilirubin elevation.

[0282] Immune-Mediated Colitis: Withhold for moderate and permanently discontinue for severe or life-threatening colitis.

[0283] Immune-Mediated Endocrinopathies: Adrenal Insufficiency, Hypophysitis, or Type 1 Diabetes Mellitus: Withhold for moderate, severe or life-threatening.

[0284] Immune-Mediated Nephritis: Monitor for changes in renal function. Withhold for moderate and permanently discontinue for severe or life-threatening nephritis.

[0285] Infection: Withhold for severe or life-threatening infection.

[0286] Infusion-Related Reactions: Interrupt infusion or slow the rate of infusion for mild or moderate and permanently discontinue for severe or life-threatening infusion-related reactions.

[0287] Embryo-Fetal Toxicity: Can cause fetal harm. Advise females of reproductive potential of the potential risk to a fetus and use of effective contraception.

Nivolumab (OPDIVO®)

[0288] ----------INDICATIONS AND USAGE----------

[0289] OPDIVO is a human programmed death receptor-1 (PD-1) blocking antibody indicated for the treatment of patients with unresectable or metastatic melanoma and disease progression following ipilimumab and, if BRAF V600 mutation positive, a BRAF inhibitor.

[0290] This indication is approved under accelerated approval based on tumor response rate and durability of response. Continued approval for this indication may be contingent upon verification and description of clinical benefit in the confirmatory trials. (1, 14)

[0291] ----------DOSAGE AND ADMINISTRATION----------

[0292] Administer 3 mg/kg as an intravenous infusion over 60 minutes every 2 weeks.

[0293] ----------DOSAGE FORMS AND STRENGTHS----------

[0294] Injection: 40 mg/4 mL and 100 mg/10 mL solution in a single-use vial.

[0295] ----------CONTRAINDICATIONS----------

[0296] None.

[0297] ----------WARNINGS AND PRECAUTIONS----------

[0298] Immune-mediated adverse reactions: Administer corticosteroids based on the severity of the reaction

[0299] Immune-mediated pneumonitis: Withhold for moderate and permanently discontinue for severe or life-threatening pneumonitis.

[0300] Immune-mediated colitis: Withhold for moderate or severe and permanently discontinue for life-threatening colitis.

[0301] Immune-mediated hepatitis: Monitor for changes in liver function. Withhold for moderate and permanently discontinue for severe or life-threatening transaminase or total bilirubin elevation.

[0302] Immune-mediated nephritis and renal dysfunction: Monitor for changes in renal function. Withhold for moderate and permanently discontinue for severe or life-threatening serum creatinine elevation.

[0303] Immune-mediated hypothyroidism and hyperthyroidism: Monitor for changes in thyroid function. Initiate thyroid hormone replacement as needed.

[0304] Embryofetal toxicity: Can cause fetal harm. Advise of potential risk to a fetus and use of effective contraception.

Pembrolizumab (KEYTRUDA®)

[0305] ----------INDICATIONS AND USAGE ----------

[0306] KEYTRUDA is a human programmed death receptor-1 (PD-1)-blocking antibody indicated for the treatment of patients with unresectable or metastatic melanoma and disease progression following ipilimumab and, if BRAF V600 mutation positive, a BRAF inhibitor.

[0307] This indication is approved under accelerated approval based on tumor response rate and durability of response. An improvement in survival or disease-related symptoms has not yet been established. Continued approval for this indication may be contingent upon verification and description of clinical benefit in the confirmatory trials.

[0308] ---------- DOSAGE AND ADMINISTRATION ----------

[0309] Administer 2 mg/kg as an intravenous infusion over 30 minutes every 3 weeks.

[0310] Reconstitute and dilute prior to intravenous infusion.

[0311] ----------DOSAGE FORMS AND STRENGTHS ----------

[0312] For injection: 50 mg, lyophilized powder in single-use vial for reconstitution.

[0313] ---------- CONTRAINDICATIONS----------

[0314] None.

[0315] ---------- WARNINGS AND PRECAUTIONS ----------

[0316] Immune-mediated adverse reactions: Administer corticosteroids based on the severity of the reaction.

[0317] Immune-mediated pneumonitis: Withhold for moderate, and permanently discontinue for severe or life-threatening pneumonitis.

[0318] Immune-mediated colitis: Withhold for moderate or severe, and permanently discontinue for life-threatening colitis.

[0319] Immune-mediated hepatitis: Monitor for changes in hepatic function. Based on severity of liver enzyme elevations, withhold or discontinue.

[0320] Immune-mediated hypophysitis: Withhold for moderate, withhold or discontinue for severe, and permanently discontinue for life-threatening hypophysitis.

[0321] Immune-mediated nephritis: Monitor for changes in renal function. Withhold for moderate, and permanently discontinue for severe or life-threatening nephritis.

[0322] Immune-mediated hyperthyroidism and hypothyroidism: Monitor for changes in thyroid function. Withhold for severe and permanently discontinue for life-threatening hyperthyroidism.

[0323] Embryofetal Toxicity: KEYTRUDA may cause fetal harm. Advise females of reproductive potential of the potential risk to a fetus.

Example 6: Exemplary Dosing Regimens for Approved CTLA-4 Immune Checkpoint Modulators

The present Example sets forth certain dosing regimens that have been approved by the United States Food and Drug Administration for the indicated immune checkpoint modulator agents.

Ipilimumab (YERVOY™)

[0324] ----------INDICATIONS AND USAGE----------

[0325] YERVOY is a human cytotoxic T-lymphocyte antigen 4 (CTLA-4)-blocking antibody indicated for:

[0326] Treatment of unresectable or metastatic melanoma.

[0327] Adjuvant treatment of patients with cutaneous melanoma with pathologic involvement of regional lymph nodes of more than 1 mm who have undergone complete resection, including total lymphadenectomy.

[0328] ----------DOSAGE AND ADMINISTRATION----------

[0329] Unresectable or metastatic melanoma: 3mg/kg administered intravenously over 90 minutes every 3 weeks for a total of 4 doses.

[0330] Adjuvant melanoma: 10 mg/kg administered intravenously over 90 minutes every 3 weeks for 4 does, followed by 10 mg/kg every 12 weeks for up to 3 years or until documented disease recurrence or unacceptable toxicity.

[0331] Permanently discontinue for severe adverse reactions.

[0332] ----------DOSAGE FORMS AND STRENGTHS----------

[0333] Injection: 50 mg/10 mL (5 mg/mL)

[0334] Injection: 200 mg/40 mL (5 mg/mL)

[0335] ----------CONTRAINDICATIONS----------

[0336] None.

[0337] ----------WARNINGS AND PRECAUTIONS----------

[0338] Immune-mediated adverse reactions: Permanently discontinue for severe reactions. Withhold dose for moderate immune-mediated adverse reactions until return to baseline, improvement to mild severity, or complete resolution, and patient is receiving less than 7.5 mg prednisone or equivalent per day. Administer systemic high-dose corticosteroids for severe, persistent, or recurring immune-mediated reactions.

[0339] Immune-mediated hepatitis: Evaluate liver function tests before each dose of YERVOY.

[0340] Immune-mediated endocrinopathies: Monitor clinical chemistries, ACTH level, and thyroid function tests prior to each dose. Evaluate at each visit for signs and symptoms of endocrinopathy. Institute hormone replacement therapy as needed.

[0341] Embryo-fetal toxicity: Can cause fetal harm. Advise of potential risk to a fetus and use of effective contraception.

Tremelimumab

[0342] ----------INDICATIONS AND USAGE----------

[0343] Tremelimumab is a human cytotoxic T-lymphocyte antigen 4 (CTLA-4)-blocking antibody, still in clinical trials for the following:

[0344] Treatment of Head and Neck Cancer, HR+/HER2 Breast Cancer, Malignant Mesothelioma, Melanoma, Metastatic Renal Cell Carcinoma, Unresectable Malignant Melanoma, Urothelial Cancer, NSCLC, etc.

[0345] ----------DOSAGE AND ADMINISTRATION----------

[0346] In combination with one or more other drugs, Tremelimumab is given via IV over one hour on day 29 of the dosing cycle, which repeats once a month three of the treatment regimen. Doses range from 6 mg/kg to 15 mg/kg. Alternatively, in combination with one or

more other drugs or given alone, Tremelimumab is given via IV every 90 days for four cycles at a concentration of 15 mg/kg; or IV infusions every 3 weeks for 12 weeks for four cycles with an additional dose administered at week 16.

Appendix 1 Cohort 1

Sample	OS_Months	OS_Event	Drug Class	Stage #	Stage	Age	Gender	MutCnt	Cancer Type	Reference	HLA Class I Alleles	HLA Class I Supertypes	Homozygous (1=Yes; 0=No)	LOH (1=Yes; 0=No)
CR0035	67.53638479	0	CTLA-4	M1b	Stage 4	74	M	2852	Melanoma	Snyder et al. 2014	A0201,A3101,B3502,B3906,C0702,C0401	A02,A31,B07,B27,UNK,UNK	0	0
CR0A995	25.51752464	0	CTLA-4	M0	Stage 3	45	F	21102	Melanoma	Snyder et al. 2014	A0201,A3201,B2705,B1501,C0701,C0702	A02,A01,B07,B44,UNK,UNK	0	0
CR0B670	44.4308043	0	CTLA-4	M0	Stage 3	76	F	1620	Melanoma	Snyder et al. 2014	A2402,A2601,B1801,B4403,C1601,C1203	A24,A01,B44,B44,UNK,UNK	0	0
CR1598	53.88621476	0	CTLA-4	M1c	Stage 4	54	F	838	Melanoma	Snyder et al. 2014	A3301,A2601,B3801,B3501,C1203,C0401	A03,A01,B27,B07,UNK,UNK	0	0
CR22940	51.22604828	0	CTLA-4	M1c	Stage 4	71	M	394	Melanoma	Snyder et al. 2014	A0201,A0201,B4101,B5001,C0701,C0602	A02,A02,B44,B44,UNK,UNK	0	0
CR3685	31.97931677	0	CTLA-4	M1b	Stage 4	76	M	1441	Melanoma	Snyder et al. 2014	A0206,A6801,B1402,B1801,C0701,C0802	A02,A68,B14,B18,UNK,UNK	0	0
CR4866	64.35087166	0	CTLA-4	M1b	Stage 4	63	M	2570	Melanoma	Snyder et al. 2014	A0101,A0201,B4001,B4601,C0701,C0304	A01,A02,B44,B44,UNK,UNK	0	0
CR6126	22.81565788	0	CTLA-4	M1b	Stage 4	66	F	962	Melanoma	Snyder et al. 2014	A0101,A3201,B5101,B4402,C0501,C1502	A01,A01,B07,B44,UNK,UNK	0	0
CR8161	31.3214286	1	CTLA-4	M1b	Stage 4	81	M	1690	Melanoma	Snyder et al. 2014	A0201,A0201,B1501,B5701,C0802,C1203	A02,A02,B44,B58,UNK,UNK	1	0
CR7623	64.84439925	0	CTLA-4	M1c	Stage 4	62	M	1903	Melanoma	Snyder et al. 2014	A0201,A6801,B3501,B5101,C0602,C0401	A02,A68,B07,B07,UNK,UNK	0	0
CR8306	63.56123752	0	CTLA-4	M1c	Stage 4	65	M	11393	Melanoma	Snyder et al. 2014	A2402,A2402,B3502,B4402,C0704,C0401	A24,A24,B07,B44,UNK,UNK	1	0
CR8569	62.83614457	0	CTLA-4	M1c	Stage 4	70	M	11208	Melanoma	Snyder et al. 2014	A2601,A2601,B4403,B7302,C0702,C0401	A26,A01,B44,B27,UNK,UNK	0	1
CR8762	28.21725092	0	CTLA-4	M1c	Stage 4	49	M	543	Melanoma	Snyder et al. 2014	A0101,A2301,B0702,B4402,C0702,C0501	A01,A23,B07,B44,UNK,UNK	0	0
CR8762472	26.41364456	0	CTLA-4	M1c	Stage 4	71	M	627	Melanoma	Snyder et al. 2014	A3002,A2301,B1501,B1501,C0501,C0303	A02,A23,B44,B62,UNK,UNK	0	0
CR9A1e1	66.49649458	0	CTLA-4	M1c	Stage 4	46	F	1117	Melanoma	Snyder et al. 2014	A6802,A6206,B4601,B1501,C0501,C0303	A02,A62,B44,B15,UNK,UNK	0	0
LS50167	32.42217962	0	CTLA-4	M1c	Stage 4	33	M	3368	Melanoma	Snyder et al. 2014	A0301,A0101,B0801,B0702,C0701,C0702	A03,A01,B08,B07,UNK,UNK	0	0
LS12057	40.12745077	0	CTLA-4	M1c	Stage 4	56	F	1171	Melanoma	Snyder et al. 2014	A1101,A2402,B3501,B5101,C0702,C0401	A03,A24,B07,B07,UNK,UNK	0	0
LS03484	34.82382256	0	CTLA-4	M1c	Stage 4	74	M	1403	Melanoma	Snyder et al. 2014	A2601,A1101,B4403,B4501,C0501,C0401	A26,A01,B44,B44,UNK,UNK	0	0
LS04691	67.65985713	0	CTLA-4	M1c	Stage 4	62	M	393	Melanoma	Snyder et al. 2014	A0101,A2402,B3503,B4402,C0501,C0401	A01,A24,B07,B44,UNK,UNK	0	0
LS04744	25.21725092	0	CTLA-4	M1c	Stage 4	52	M	11124	Melanoma	Snyder et al. 2014	A2402,A0201,B0702,B3501,C0702,C1203	A24,A02,B07,B07,UNK,UNK	0	0
LS06819	40.8276269	0	CTLA-4	M1c	Stage 4	55	M	216	Melanoma	Snyder et al. 2014	A0101,A2402,B4001,B4402,C0501,C1601	A01,A01,B44,B44,UNK,UNK	0	0
LS0NR1120	55.23778751	0	CTLA-4	M1a	Stage 4	60	M	5537	Melanoma	Snyder et al. 2014	A0301,A0201,B0801,B0801,C0702,C0701	A03,A02,B08,B08,UNK,UNK	1	0
LS0NR1660	32.42217962	0	CTLA-4	M1c	Stage 4	71	F	125	Melanoma	Snyder et al. 2014	A0201,A2601,B3501,B3501,C0701,C0401	A02,A01,B07,B44,UNK,UNK	0	0
LS0NR9066	31.22135616	1	CTLA-4	M1c	Stage 4	43	M	151	Melanoma	Snyder et al. 2014	A3001,A2601,B4501,B1501,C0702,C1203	A03,A01,B44,B15,UNK,UNK	0	0
LS0NR9288	50.03422213	0	CTLA-4	M1c	Stage 4	62	F	12277	Melanoma	Snyder et al. 2014	A3201,A2902,B4501,B4402,C0602,C0501	A01,A01,B44,B44,UNK,UNK	0	0
NR1087	16.55228685	1	CTLA-4	M1c	Stage 4	66	M	80	Melanoma	Snyder et al. 2014	A6901,A3402,B1503,B1503,C0210,C0210	A03,A03,B27,B27,UNK,UNK	1	0
NR2137	9.90673861	0	CTLA-4	M1c	Stage 4	52	M	1535	Melanoma	Snyder et al. 2014	A0101,A0201,B0702,B3901,C0702,C0702	A01,A02,B07,B27,UNK,UNK	0	0
NR3196	12.9333229	1	CTLA-4	M1b	Stage 4	68	F	8	Melanoma	Snyder et al. 2014	A6801,A3201,B4402,B1401,C0704,C0802	A03,A01,B44,B27,UNK,UNK	0	0
NR3849	6.185363122	1	CTLA-4	M1c	Stage 4	50	M	365	Melanoma	Snyder et al. 2014	A1101,A0301,B0702,B0702,C0702,C0702	A03,A03,B07,B07,UNK,UNK	1	0
NR4016	3.305225536	1	CTLA-4	M1c	Stage 4	55	M	1646	Melanoma	Snyder et al. 2014	A0201,A2601,B3501,B3501,C0701,C0401	A02,A01,B07,B44,UNK,UNK	0	0
NR4045	20.41336435	1	CTLA-4	M1c	Stage 4	42	M	451	Melanoma	Snyder et al. 2014	A0201,A2601,B0702,B1801,C0702,C1203	A02,A01,B07,B44,UNK,UNK	0	0
NR4083	2.701845302	1	CTLA-4	M1c	Stage 4	54	M	4444	Melanoma	Snyder et al. 2014	A0101,A3101,B2705,B3701,C0602,C0202	A01,A03,B27,B44,UNK,UNK	0	0
NR4631	6.004127338	1	CTLA-4	M1c	Stage 4	56	M	11485	Melanoma	Snyder et al. 2014	A0101,A2301,B4201,B0702,C0702,C0702	A01,A03,B07,B07,UNK,UNK	0	0
NR4810	4.903308597	1	CTLA-4	M1c	Stage 4	48	F	3958	Melanoma	Snyder et al. 2014	A0201,A3301,B1402,B1501,C0202,C0802	A02,A03,B27,B44,UNK,UNK	0	0
NR4949	6.356447514	1	CTLA-4	M1c	Stage 4	79	F	5713	Melanoma	Snyder et al. 2014	A0201,A2301,B4402,B2705,C0501,C0102	A02,A23,B44,B27,UNK,UNK	0	1
NR4978	8.494169495	1	CTLA-4	M1c	Stage 4	58	F	56	Melanoma	Snyder et al. 2014	A2402,A2301,B4501,B4501,C0702,C0303	A24,A23,B44,B44,UNK,UNK	0	NA
NR6688	15.01028834	1	CTLA-4	M1c	Stage 4	46	F	6	Melanoma	Snyder et al. 2014	A0301,A1101,B4001,B3501,C0701,C0401	A03,A03,B08,B07,UNK,UNK	0	0
NR6721	9.6095774	1	CTLA-4	M1a	Stage 4	64	M	128	Melanoma	Snyder et al. 2014	A0201,A1101,B5501,B5101,C0102,C0303	A02,A03,B07,B07,UNK,UNK	0	0
NR8842	9.8967208851	1	CTLA-4	M1c	Stage 4	84	M	3	Melanoma	Snyder et al. 2014	A2402,A0201,B1501,B5501,C0303,C0401	A24,A02,B62,B07,UNK,UNK	0	0
NR8915	14.81013889	1	CTLA-4	M1b	Stage 4	67	F	1698	Melanoma	Snyder et al. 2014	A6901,A0201,B2705,B5101,C0102,C0202	A69,A02,B27,B07,UNK,UNK	0	0
NR9314	12.13981147	1	CTLA-4	M1a	Stage 4	77	M	323	Melanoma	Snyder et al. 2014	A0201,A0301,B1402,B0702,C0702,C0802	A02,A03,B27,B07,UNK,UNK	1	0
NR9445	2.501771139	1	CTLA-4	M1c	Stage 4	50	M	2867	Melanoma	Snyder et al. 2014	A0201,A2601,B2705,B2705,C0202,C0602	A02,A01,B58,B27,UNK,UNK	0	0
NR9449	7.200405805	1	CTLA-4	M1c	Stage 4	64	F	205	Melanoma	Snyder et al. 2014	A6901,A0201,B4501,B5701,C0502,C0501	A69,A02,B44,B57,UNK,UNK	0	0
NR9921	32.42217962	1	CTLA-4	M1b	Stage 4	74	M	1081	Melanoma	Snyder et al. 2014	A2402,A0201,B5701,B4402,C0702,C0501	A24,A02,B07,B44,UNK,UNK	0	0
NR9705	14.4098576	1	CTLA-4	M1c	Stage 4	63	F	37	Melanoma	Snyder et al. 2014	A0101,A2402,B4901,B1501,C0701,C0303	A01,A24,B49,B62,UNK,UNK	0	0
NR9765	26.01711391	1	CTLA-4	M1b	Stage 4	58	F	11748	Melanoma	Snyder et al. 2014	A0101,A0301,B0702,B1817,C0702,C0702	A01,A03,B07,B18,UNK,UNK	0	0
PR03803	54.82476902	1	CTLA-4	M0	Stage 3	60	M	289	Melanoma	Snyder et al. 2014	A2201,A0201,B5201,B4402,C0701,C0202	A23,A02,B44,B44,UNK,UNK	0	0
PR1217	16.71285212	1	CTLA-4	M1c	Stage 4	66	M	1081	Melanoma	Snyder et al. 2014	A0301,A0201,B4501,B3901,C0304,C0401	A03,A02,B44,B07,UNK,UNK	0	0
PR4035	50.29436472	0	CTLA-4	M1c	Stage 4	78	M	1825	Melanoma	Snyder et al. 2014	A0101,A0201,B3901,B3906,C1203,C0602	A01,A02,B27,B27,UNK,UNK	0	0
PR4046	25.91731627	0	CTLA-4	M1a	Stage 4	44	M	139	Melanoma	Snyder et al. 2014	A2201,A0205,B1501,B4601,C0701,C0303	A22,A02,B62,UNK,UNK,UNK	0	0
PR4077	72.74976724	0	CTLA-4	M1c	Stage 4	75	M	17411	Melanoma	Snyder et al. 2014	A0101,A0101,B0801,B5701,C0701,C0602	A01,A01,B08,B58,UNK,UNK	1	0
PR4091	72.43956187	0	CTLA-4	M1a	Stage 4	65	F	277	Melanoma	Snyder et al. 2014	A0101,A0201,B2705,B4402,C0602,C0501	A01,A02,B44,B44,UNK,UNK	0	0
PR4092	72.8496357	0	CTLA-4	M1a	Stage 4	67	F	12967	Melanoma	Snyder et al. 2014	A2402,A2601,B3501,B4901,C0701,C1203	A24,A01,B07,B49,UNK,UNK	0	0
PR4096	23.72035368	0	CTLA-4	M1c	Stage 4	45	F	2537	Melanoma	Snyder et al. 2014	A6201,A0201,B4001,B4402,C0702,C0602	A68,A02,B44,B44,UNK,UNK	0	0
SD1494	10.1658954	1	CTLA-4	M1c	Stage 4	70	M	3915	Melanoma	Snyder et al. 2014	A0101,A2902,B4403,B0801,C0701,C1601	A01,A29,B44,B08,UNK,UNK	0	0
SD2051	47.27618107	0	CTLA-4	M1b	Stage 4	39	F	38	Melanoma	Snyder et al. 2014	A2901,A2301,B5301,C0401,C0401	A29,A23,B53,B53,UNK,UNK	1	0
SD3056	13.95216503	1	CTLA-4	M1c	Stage 4	55	M	256	Melanoma	Snyder et al. 2014	A0201,A3301,B1402,B3901,C0802,C1203	A02,A33,B27,B27,UNK,UNK	0	0
SD3934	19.8052659	1	CTLA-4	M1c	Stage 4	52	M	156	Melanoma	Snyder et al. 2014	A2402,A2402,B3502,B3502,C0401,C0401	A24,A24,B07,B07,UNK,UNK	1	0
SD5336	83.4524151	0	CTLA-4	M1c	Stage 4	53	M	1448	Melanoma	Snyder et al. 2014	A3001,A3301,B1302,B1402,C0502,C0602	A03,A33,B13,B27,UNK,UNK	0	0
SD5464	8.712223278	1	CTLA-4	M1c	Stage 4	63	F	824	Melanoma	Snyder et al. 2014	A6802,A2402,B3501,B1402,C0403,C0602	A68,A24,B07,B27,UNK,UNK	0	0
SD7357	24.50991894	1	CTLA-4	M1c	Stage 4	60	F	11149	Melanoma	Snyder et al. 2014	A2402,A0201,B4501,B1801,C0303,C0303	A24,A02,B44,B18,UNK,UNK	0	0
Pat02	53.8547746	1	CTLA-4	M1c	Stage 4	42	F	2313	Melanoma	Van Allen et al. 2015	A0201,A2601,B0702,B4001,C0702,C0702	A02,A01,B07,B44,UNK,UNK	0	0
Pat03	3.28767	1	CTLA-4	M1c	Stage 4	61	F	372	Melanoma	Van Allen et al. 2015	A2301,A2601,B5701,B4901,C0501,C0401	A23,A01,B57,B49,UNK,UNK	0	1
Pat04	32.44936029	0	CTLA-4	M1b	Stage 4	71	M	3336	Melanoma	Van Allen et al. 2015	A0101,A0201,B1501,B4405,C0702,C0501	A01,A02,B62,B44,UNK,UNK	0	0
Pat06	3.23931487	1	CTLA-4	M1c	Stage 4	33	M	174	Melanoma	Van Allen et al. 2015	A1101,A0201,B2705,B5501,C0303,C0202	A03,A02,B27,B07,UNK,UNK	0	0
Pat07	34.5305535	0	CTLA-4	M1c	Stage 3	36	M	148	Melanoma	Van Allen et al. 2015	A0101,A0101,B2702,B0801,C0702,C0701	A01,A01,B27,B08,UNK,UNK	1	0
Pat08	4.6927795	1	CTLA-4	M1c	Stage 4	73	M	2665	Melanoma	Van Allen et al. 2015	A6801,A2901,B3501,C0303,C0401	A68,A29,B35,UNK,UNK,UNK	0	0
Pat100	11.3356712	1	CTLA-4	M1c	Stage 4	70	M	5516	Melanoma	Van Allen et al. 2015	A0301,A2201,B4001,B4403,C1601,C0304	A03,A22,B44,B44,UNK,UNK	0	0
Pat101	9.46568456	1	CTLA-4	M1c	Stage 4	75	M	80	Melanoma	Van Allen et al. 2015	A0301,A2902,B2702,B4403,C0702,C1601	A03,A01,A24,B07,B44,UNK,UNK	1	1

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P7360	1.3726502	0	PD-1	Mixe	Stage 4	148.6	M	NA	Non-Small Cell Lu	Rizvi_CUMC	A02:02,A2:02,B8:21,B8703,Cw3:02,Cw7:01	A02,B44,B58,UNK,UNK	1	NA
P7361	2.20227389	0	CTLA-4 + PD-	Mixe	Stage 4	176.6	M	NA	Non-Small Cell Lu	Rizvi_CUMC	A03:02,A2:601,B1:501,B3501,Cw4:01,Cw7:04	A03,A31,B62,B07,UNK,UNK	0	NA
P7362	8.1962693	0	PD-1	Mixe	Stage 4	174.1	M	NA	Non-Small Cell Lu	Rizvi_CUMC	A1:101,A2:02,B35:01,B5801,Cw4:01,Cw7:01	A03,A31,A24,B07,B58,UNK,UNK	0	NA
P7363	6.6525856	0	PD-1	Mixe	Stage 4	176.5	M	NA	Non-Small Cell Lu	Rizvi_CUMC	A02:01,A2:602,B35:03,B58:02,Cw4:01,Cw7:01	A02,A31,A24,B07,B58,UNK,UNK	0	NA
P7364	2.9917797	0	PD-1	Mixe	Stage 4	188	F	NA	Non-Small Cell Lu	Rizvi_CUMC	A02:05,A2:301,B41:01,B50:01,Cw2:02,Cw7:01	A02,A03,B44,B44,UNK,UNK	0	NA
P7365	4.2896293	0	CTLA-4 + PD-	Mixe	Stage 4	75.1	M	NA	Non-Small Cell Lu	Rizvi_CUMC	A02:01,A1:101,B1:301,B4001,Cw3:04,Cw7:02	A02,A03,UNK,B44,UNK,UNK	0	NA
P7366	NA	1	PD-1	Mixe	Stage 4	80.9	F	NA	Non-Small Cell Lu	Rizvi_CUMC	NA	UNK		NA

Appendix 1 Cohort 2

Sample	Age Group	OS_Months	OS_Event	IMPACT468Unt	Drug Class	Cancer Type	Reference	HLA Class I Alleles	HLA Class I Supertypes	Homozygous (Yes=1; else=0)
DB0302257	31-50	1	0	7.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A3301,B1402,B1502,C0302,C0602	A01,A03,A03,B27,UNK,UNK,UNK,UNK	0
EP8372868	<30	0	0	4.39	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201,A0201,B0702,B1517,C0701,C0702	A01,A02,B07,B58,UNK,UNK	0
BV3791185	>71	3	1	1.76	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A3303,B5201,B5901,C0302,C1202	A03,A03,B52,B58,UNK,UNK	0
NB536458	31-50	2	0	20.19	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3401,A3303,B1525,B5501,C0302,C0403	UNK,A03,B62,B58,UNK,UNK	0
RX9004694	31-50	2	0	60.66	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B5501,B4002,C0102,C0401	A24,A02,B57,B07,UNK,UNK	0
AN2933177	61-70	1	0	1.76	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A3101,B0702,B3901,C1203,C0702	A01,A03,B07,B27,UNK,UNK	0
AA3633618	31-50	4	0	7.02	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2601,B4001,B5501,C0304,C0706	A03,A01,B44,B58,UNK,UNK	0
NC8658467	50-60	1	0	10.53	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2402,A0201,B0702,B3908,C0702,C0702	A24,A02,B07,B27,UNK,UNK	1
KW7877528	>71	2	0	2.63	PD-1/PDL-1	Glioma	MSK-IMPACT	A2601,A6901,B6701,B5501,C0102,C1203	A01,A02,B07,B07,UNK,UNK	0
AW8820770	<30	2	0	2.63	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0206,A0205,B4601,B5501,C0305,C0602	A02,A02,B27,B44,UNK,UNK	0
HE1750946	61-70	2	0	4.39	PD-1/PDL-1	Glioma	MSK-IMPACT	A2402,A2402,B3901,B1517,C1203,C0701	A24,A24,B27,B58,UNK,UNK	1
HK6373659	50-60	6	1	8.78	Combo	Esophagogastric Cancer	MSK-IMPACT	A1101,A0101,B0801,B5501,C0303,C0701	A03,A01,B58,B07,UNK,UNK	0
WU2845568	50-60	5	0	2.63	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3002,A6801,B4001,B4402,C0304,C0706	A01,A03,B44,B44,UNK,UNK	0
WV2482884	31-50	6	0	0.88	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2902,B0702,B4403,C1601,C0702	A03,A01,A24,B07,B44,UNK,UNK	0
QT7221351	31-50	0	0	44.76	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A0301,A0201,B0702,B5501,C0102,C0702	A03,A02,B07,B07,UNK,UNK	0
WF5615011	61-70	2	0	7.02	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B0702,B0702,C0702,C0702	A03,A02,B07,B07,UNK,UNK	1
RL5625554	50-60	9	0	8.78	PD-1/PDL-1	Gastrointestinal Neuroendocrine Tumor	MSK-IMPACT	A1101,A2402,B3501,B5101,C1502,C0401	A03,A24,B07,B07,UNK,UNK	0
GL5866205	>71	5	0	4.39	PD-1/PDL-1	Glioma	MSK-IMPACT	A0205,A3301,B1402,B3801,C0802,C0706	A02,A03,B27,B58,UNK,UNK	0
DC9190051	31-50	6	0	2.63	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A0301,A2601,B0702,B6701,C1203,C0702	A03,A01,B07,B07,UNK,UNK	0
AC7502831	31-50	2	0	7.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3201,A0201,B3801,B1401,C0802,C1203	A01,A02,B27,B27,UNK,UNK	0
RL0368636	31-50	7	0	35.09	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B3501,B4901,C0401,C0701	A03,A02,B07,UNK,UNK,UNK	0
PW5293575	31-50	5	0	0	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0101,A3303,B2801,B1801,C1203,C0701	A01,A03,B58,B44,UNK,UNK	0
BP9853860	50-60	46	0	7.9	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B0702,B1501,C0401,C0702	A03,A02,B07,B62,UNK,UNK	0
ZK4348939	>71	6	0	7.02	PD-1/PDL-1	Melanoma	MSK-IMPACT	A6802,A0201,B1501,B4402,C0303,C0501	A03,A02,B62,B44,UNK,UNK	0
RJ4011736	31-50	3	0	3.51	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2403,A2402,B3502,B1801,C1203,C0401	A24,A24,B07,B44,UNK,UNK	0
ZL3388826	61-70	3	1	0	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A3201,A0201,B0702,B3501,C0401,C0601	A01,A02,B07,B07,UNK,UNK	1
PT3881136	50-60	0	0	3.51	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A2402,A0201,B1501,B4002,C0304,C1701	A24,A02,B62,B44,UNK,UNK	0
YH8652293	31-50	3	0	0.88	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A6801,B1501,B3503,C0303,C0401	A24,A03,B62,B07,UNK,UNK	0
PJ7928599	31-50	53	0	66.71	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0101,A0201,B0702,B5701,C0602,C0702	A01,A02,B07,B58,UNK,UNK	0
CS1875743	31-50	2	0	10.53	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A6901,B5501,B1801,C0102,C0501	A01,A02,B07,B44,UNK,UNK	0
LT1366554	61-70	3	0	2.63	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A0207,B4601,B1527,C0102,C0401	A03,A02,B62,UNK,UNK,UNK	0
WH-9281128	31-50	2	0	7.02	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B0702,B0801,C0701,C0702	A01,A02,B07,B08,UNK,UNK	0
K5686411	50-60	1	0	52.66	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A2902,B5701,B5801,C0602,C0706	A01,A01,A24,B44,B58,UNK,UNK,UNK	0
IH0092321	50-60	2	0	10.53	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A7401,A2301,B1503,B4501,C0210,C0602	A03,A24,B27,B44,UNK,UNK	0
HT2775463	50-60	5	0	2.63	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A2402,B0702,B5701,C0602,C0702	A24,A24,B07,B58,UNK,UNK	1
AQ3867934	31-50	1	0	7.02	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B0702,B3501,C0401,C0702	A03,A02,B07,B07,UNK,UNK	0
VK4253375	31-50	0	0	1.76	PD-1/PDL-1	Melanoma	MSK-IMPACT	A1101,A0201,B0702,B4402,C0501,C0702	A03,A02,B07,B44,UNK,UNK	0
EH8145563	31-50	2	0	68.34	Combo	Melanoma	MSK-IMPACT	A0101,A2402,B5501,B5801,C0102,C0706	A01,A24,B07,B58,UNK,UNK	0
DS0069834	31-50	0	0	12.28	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A2301,A6901,B3502,B5501,C0401,C0706	A24,A02,B07,B58,UNK,UNK	0
QT7135615	50-60	4	0	5.27	PD-1/PDL-1	Glioma	MSK-IMPACT	A3301,A0201,B4402,B5201,C1202,C0501	A01,A02,B44,B62,UNK,UNK	0
IK8652613	>71	4	0	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B0702,B1302,C0602,C0702	A01,A02,B07,UNK,UNK,UNK	0
CD3889551	50-60	1	0	20.19	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3303,B0702,B1801,C1505,C1203	A01,A03,B07,B44,UNK,UNK	0
CD1118417	50-60	0	0	11.41	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A0101,B5701,B3701,C0802,C0602	A03,A01,B58,B44,UNK,UNK	1
LS1677396	>71	1	0	8.78	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0301,A0201,B0702,B5702,C0702,C0702	A03,A01,B07,B07,UNK,UNK	1
EL4492261	50-60	0	1	4.39	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A1101,B5502,B3503,C0102,C1203	A03,A03,B07,B07,UNK,UNK	1
BD2415560	31-50	1	0	36.86	Combo	Cancer of Unknown Primary	MSK-IMPACT	A2301,A6801,B5501,B4403,C0303,C0401	A24,A03,B07,B44,UNK,UNK	0
WU0852117	31-50	1	1	8.78	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2902,A6802,B1402,B1402,C0802,C0802	A01A24,A02,B27,B27,UNK,UNK	1
YF9996519	50-60	0	0	21.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0205,B1501,B4901,C0303,C0701	A02,A02,B62,UNK,UNK,UNK	0
JL0960305	>71	4	0	2.63	Combo	Melanoma	MSK-IMPACT	A0101,A0201,B4001,B3701,C0304,C0602	A01,A02,B44,B44,UNK,UNK	0
YA8517025	50-60	13	0	3.51	Combo	Bladder Cancer	MSK-IMPACT	A1101,A0201,B1509,B3501,C0401,C0704	A03,A02,B27,B07,UNK,UNK	0
WE6021111	31-50	2	0	28.09	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A6802,B6801,B1402,C0802,C0701	A01,A02,B62,B27,UNK,UNK	0
DL2460387	50-60	2	0	57.99	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A2402,B6801,B3502,C0401,C0701	A01,A24,B62,B07,UNK,UNK	0
SE9498395	50-60	3	0	22.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B1501,B4402,C0304,C0501	A02,A02,B62,B44,UNK,UNK	0
VK1102917	31-50	1	1	8.78	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2902,B0801,B4403,C1601,C0701	A01,A01,A29,B08,B44,UNK,UNK,UNK	0
EX3158834	31-50	9	0	0	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A2301,A6802,B1402,B4901,C0701,C0802	A24,A02,B27,UNK,UNK,UNK	0
EI5961875	31-50	7	0	6.14	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A0201,B0801,B3501,C0401,C0701	A01,A02,B08,B07,UNK,UNK	0
GJ5496646	31-50	22	0	5.27	Combo	Bladder Cancer	MSK-IMPACT	A6601,A2601,B3801,B3508,C0401,C1203	A03,A01,B27,B07,UNK,UNK	0
YL9459822	61-70	0	0	1.76	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A2402,A0201,B3501,B1502,C1402,C0602	A24,A02,B07,UNK,UNK,UNK	0
TJ9586009	31-50	0	0	9.65	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0101,B3801,B3901,C1203,C1203	A03,A01,B27,B27,UNK,UNK	1
PL0203321	31-50	1	0	17.55	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B1501,B5501,C0303,C0706	A02,A02,B62,B58,UNK,UNK	0
OP3960628	61-70	5	0	1.76	Combo	Melanoma	MSK-IMPACT	A1101,A3101,B2801,B3501,C1203,C0401	A03,A03,B27,B07,UNK,UNK	0
UN8072129	31-50	1	0	6.14	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2601,A2601,B0705,B3901,C1505,C1203	A01A24,A01,B07,B27,UNK,UNK	0
ZV1029948	31-50	3	0	1.76	CTLA4	Melanoma	MSK-IMPACT	A0103,A6801,B7301,B3501,C1505,C0301	A01,A03,B27,B07,UNK,UNK	0
HV8923240	31-50	4	0	6.14	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2301,B1501,B4901,C0303,C0701	A24,A24,B62,UNK,UNK,UNK	0
IB1743085	50-60	10	0	5.27	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A2601,B1801,B4102,C1203,C1701	A24,A01,B44,B44,UNK,UNK	0

NA845383	31-50	16	0	4.39	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601,A2601,B3501,B3501,C1203,C1203	A01,A01,B27,B27,UNK,UNK	1	
AE290128	>71	5	0	2.63	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0201,B4402,B4101,B5101,C0202,C0602	A03,A01,B44,B07,UNK,UNK	0	
HG0780627	31-50	3	0	14.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B0702,B4402,B5501,C0702	A03,A02,B07,B44,UNK,UNK	0	
PH640297	50-60	4	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3303,A3402,B1510,B5101,C0804,C1601	A03,A03,B27,B07,UNK,UNK	0	
FD411530	31-50	12	0	7.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2901,B0705,B5501,C0102,C1505	A03,A01,A24,B07,B07,UNK,UNK	0	
R1929197	50-60	5	0	2.63	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2902,B5401,B5201,C1202,C0602	A03,A01,A24,B44,B62,UNK,UNK	0	
G52134640	31-50	0	0	14.04	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A3303,B4601,B4403,C0103,C0706	A03,A03,B62,B44,UNK,UNK	0	
YZ3388736	61-70	3	0	11.41	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B3906,B5701,C0602,C0702	A01,A02,B27,B58,UNK,UNK	0	
PH804519	31-50	3	0	17.55	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B0702,B5201,C1202,C0702	A03,A02,B07,B62,UNK,UNK	0	
MD7748114	61-70	3	0	1.76	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0302,A0201,B0702,B4402,C0501,C0702	A03,A02,B07,B44,UNK,UNK	0	
YD6623028	31-50	6	0	2.63	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3002,A0201,B1801,B4801,C0501,C0701	A01,A02,B44,UNK,UNK,UNK	0	
CV5172854	61-70	4	0	1.76	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B0702,B4402,C0501,C1202	A03,A02,B07,B44,UNK,UNK	0	
GM1553633	31-50	14	0	9.65	Combo	Bladder Cancer	MSK-IMPACT	A0201,A3301,B1402,B1801,C0802,C1703	A02,A03,B27,B44,UNK,UNK	0	
DC9395401	31-50	2	0	1.76	Combo	Melanoma	MSK-IMPACT	A6601,A2601,B3501,B3501,C1203,C1203	A03,A01,B27,B27,UNK,UNK	1	
ED2336873	31-50	1	1	14.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0101,B0801,B1402,C0802,C0701	A03,A01,B58,B27,UNK,UNK	0	
LQ4991699	31-50	3	0	10.53	Combo	Small Cell Lung Cancer	MSK-IMPACT	A2601,A0201,B0801,B1801,C0702,C0701	A01,A02,B58,B44,UNK,UNK	0	
RH1381187	31-50	0	0	24.58	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2403,A0201,B3501,B1518,C1203,C0704	A24,A02,B27,B27,UNK,UNK	0	
JE884424	50-60	4	0	5.27	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2501,B3901,B5301,C0602,C0401	A01,A24,B27,B07,UNK,UNK	0	
HN0394410	61-70	1	0	4.39	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A1101,A0201,B0702,B3801,C0701,C0702	A03,A02,B07,B07,UNK,UNK	0	
LH2295562	31-50	3	0	3.51	Combo	Cancer of Unknown Primary	MSK-IMPACT	A2402,A3301,B1402,B3502,C0802,C0401	A24,A03,B27,B07,UNK,UNK	0	
WA1185194	31-50	8	0	2.63	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A2301,A2901,B5705,B4403,C1505,C0401	A24,A01,A24,B57,B44,UNK,UNK	0	
ES3877661	31-50	1	0	29.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601,A0206,B5101,B5801,C0102,C0706	A01,A02,B07,B58,UNK,UNK	0	
AE162231	>71	4	0	30.72	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0101,B0702,B1501,C0304,C0702	A03,A01,B07,B62,UNK,UNK	0	
AH329297	31-50	1	0	23.7	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2402,A2402,B3901,B1801,C0501,C1203	A24,A24,B27,B44,UNK,UNK	1	
VR1175191	31-50	3	0	12.28	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A0101,B0801,B1302,C0802,C0701	A01403,A01,B58,UNK,UNK,UNK	0	
YA3082248	<50	0	0	3.51	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0101,A0101,B4402,B5701,C0202,C0802	A01,A01,B44,B58,UNK,UNK	0	
RC2768619	>71	4	0	30.72	Combo	Melanoma	MSK-IMPACT	A3201,A3201,B1501,B3501,C0303,C0801	A01,A01,B62,B07,UNK,UNK	1	
RT4866956	61-70	4	0	5.14	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0301,B0702,B3501,C0401,C0702	A03,A03,B07,B07,UNK,UNK	1	
S8246044	50-60	0	1	23.7	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0201,A0201,B5701,B3501,C0802,C0401	A02,A02,B58,B07,UNK,UNK	1	
TC9930720	31-50	3	0	6.14	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A3301,B1402,B7702,C0802,C0202	A03,A03,B27,B27,UNK,UNK	0	
YF8205618	31-50	4	1	8.78	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6301,A3601,B5701,B1801,C0802,C0701	A03,A01,A03,B58,B44,UNK,UNK	0	
IN5737123	31-50	4	0	28.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B3801,B3901,C1203,C0706	A01,A01,B27,B58,UNK,UNK	1	
TG7668862	31-50	3	0	0.88	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0101,A0201,B0901,B0702,C0303,C0701	A01,A02,B08,B07,UNK,UNK	0	
CV4369015	61-70	0	0	8.78	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A6602,A3303,B5801,B5301,C0404,C0706	A03,A03,B58,B07,UNK,UNK	0	
UA2036372	61-70	3	0	24.58	Combo	Melanoma	MSK-IMPACT	A0301,A0201,B0801,B4402,C0501,C0701	A03,A02,B08,B44,UNK,UNK	0	
QX8553757	31-50	0	0	5.27	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3201,A0201,B5501,B5101,C0102,C1402	A01,A02,B07,B07,UNK,UNK	0	
PJ9858909	50-60	0	0	11.41	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A1101,B3501,B5101,C1502,C0401	A03,A03,B07,B07,UNK,UNK	0	
KA3077633	50-60	0	0	2.63	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0205,A2601,B3501,B3501,C0802,C0401	A02,A01,B07,B44,UNK,UNK	0	
UX8348810	>71	1	0	0.88	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0301,A0201,B5703,B5801,C0706,C1801	A03,A02,B58,B58,UNK,UNK	0	
YD4980937	31-50	2	0	5.27	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B3801,B3501,C1203,C0401	A03,A01,B27,B07,UNK,UNK	0	
GZ5537792	31-50	0	0	16.31	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A2402,B3501,B1302,C0802,C0401	A01403,A24,B07,UNK,UNK,UNK	0	
MF1805507	31-50	2	0	10.53	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0101,B0702,B2702,C0702,C0702	A03,A01,B07,B07,UNK,UNK	1	
PQ5993968	31-50	6	0	4.39	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B0801,B1518,C1402,C0701	A01,A02,B08,B58,UNK,UNK	0	
LE953613	61-70	9	0	3.51	CTLA4	Breast Cancer	MSK-IMPACT	A1101,A0201,B1803,B3503,C0401,C0701	A03,A02,B44,B07,UNK,UNK	0	
LS2446634	31-50	6	0	6.14	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B4402,B1501,C0401,C0501	A02,A02,B44,B62,UNK,UNK	1	
EW6664244	31-50	9	0	14.04	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A3101,B0702,B1801,C0701,C0702	A02,A03,B07,B44,UNK,UNK	0	
NK7726633	50-60	2	0	21.07	Combo	Melanoma	MSK-IMPACT	A0301,A3002,B5604,B3501,C0102,C0401	A03,A01,B07,B07,UNK,UNK	0	
HP971166	31-50	0	0	2.63	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A2402,B4402,B3501,C0202,C0401	A03,A24,B44,B07,UNK,UNK	0	
WD007764	31-50	9	0	3.51	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A0201,B4402,B5101,C1502,C0501	A03,A02,B44,B07,UNK,UNK	0	
CE7570061	31-50	1	0	13.17	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B0801,B2705,C0202,C0701	A01,A01,B08,B27,UNK,UNK	0	
GD0260783	61-70	9	0	13.17	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402,A3101,B0702,B3501,C0401,C0702	A24,A03,B07,B07,UNK,UNK	0	
RA9111363	50-60	0	0	1.76	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0301,A1101,B5701,B5301,C0401,C0602	A03,A03,B58,B07,UNK,UNK	0	
CV3242207	>71	1	0	0.88	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0301,A0101,B0702,B5701,C0602,C0702	A03,A01,B07,B58,UNK,UNK	0	
RV6539854	31-50	2	1	51.79	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A2402,B0801,B1801,C1203,C0701	A01,A24,B08,B44,UNK,UNK	0	
MM5027191	50-60	2	0	2.63	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0101,A0101,B5801,B3501,C0701,C0701	A01,A01,B58,B58,UNK,UNK	1	
TY6852273	61-70	0	0	8.14	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2301,A3301,B4201,B7801,C1601,C1701	A24,A03,B07,B07,UNK,UNK	0	
CF668249	>71	0	0	3.51	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A1101,B0702,B3501,C0401,C0702	A03,A03,B07,B07,UNK,UNK	0	
HB514859	31-50	5	0	1.76	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2201,B5701,B5101,C1402,C0602	A24,A01,B58,B07,UNK,UNK	0	
RY8226164	31-50	1	0	2.63	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2402,A2201,B5701,B5101,C1402,C0602	A24,A01,B58,B07,UNK,UNK	0	
GK0889158	31-50	5	1	24.58	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B1501,B1501,C0303,C0701	A02,A02,B44,B07,UNK,UNK	1	
RF0986631	61-70	4	0	4.39	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B0702,B5001,C0701,C0702	A03,A01,B07,B08,UNK,UNK	0	
BX3622244	31-50	2	0	23.7	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0101,B0702,B5001,C0701,C0702	A03,A01,B07,B08,UNK,UNK	0	
HT8869944	31-50	4	0	5.27	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A6801,B4402,B5101,C1602,C0801	A02,A02,B44,B07,UNK,UNK	0	
OF3230000	31-50	0	0	8.78	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2301,A2902,B4701,B4801,C0701,C1701	A24,A24,B44,UNK,UNK,UNK	0	
UC5659608	>71	3	0	7.9	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A3601,A0201,B4201,B3501,C1601,C1701	A01403,A02,B07,B07,UNK,UNK	0	
SY2741110	31-50	7	0	0.88	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2402,B2705,B5101,C0102,C0202	A03,A24,B27,B07,UNK,UNK	0	

KE015183	>71	0	0	16.68	Combo	Cancer of Unknown Primary	MSK-IMPACT	A2402,A0201,B4001,B4001,B4001,C03304,C03304	A24,A02,B44,B44,B44,UNK,UNK	1
IY1C14457	50-60	5	0	0	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0205,A3301,B1402,B5301,B5301,C03502,C03502	A02,A03,B27,B44,UNK,UNK	0
OA2419643	31-50	14	0	46.82	Combo	Breast Cancer	MSK-IMPACT	A6301,A0101,B0801,B0801,B0801,C07001,C07001	A03,A01,B08,B08,UNK,UNK	1
GY2237003	31-50	1	0	23.7	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A2601,B0801,B1503,C12103,C07001	A01,A01,B08,B27,UNK,UNK	0
QM8339384	31-50	2	0	18.43	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A3301,B1401,B1517,C08202,C07001	A24,A03,B27,B58,UNK,UNK	0
BF8119643	31-50	1	0	5.27	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A6802,A3201,B2702,B4402,C03202,C05001	A02,A01,B27,B44,UNK,UNK	0
KV6791102	50-60	8	0	35.11	Combo	Melanoma	MSK-IMPACT	A0302,A0201,B0801,B0801,B0801,C07001,C07001	A03,A02,B38,B08,UNK,UNK	1
WW5331877	31-50	7	0	14.04	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A0201,B1801,B3501,C04001,C07001	A03,A02,B44,B07,UNK,UNK	0
HI5045569	31-50	4	0	42.73	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B4403,B3503,C14001,C04001	A02,A02,B44,B07,UNK,UNK	1
QW3864103	<30	0	0	1.76	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B0801,B4402,C05001,C07001	A01,A02,B08,B44,UNK,UNK	0
UB6628857	50-60	0	1	7.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0205,A0201,B4006,B5301,C1502,C03602	A02,A02,B44,B44,UNK,UNK	0
ND7C14383	50-60	4	0	26.33	Combo	Melanoma	MSK-IMPACT	A6301,A0101,B5801,B1402,C03503,C08002	A03,A01,B07,B27,UNK,UNK	0
ND8919479	61-70	5	0	8.14	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B4002,B4402,C03202,C07704	A01,A02,B44,B44,UNK,UNK	0
IH1998687	50-60	2	0	79.87	Combo	Melanoma	MSK-IMPACT	A3201,A0201,B4402,B4402,C05001,C07001	A01,A02,B44,B44,UNK,UNK	1
MX7477377	50-60	3	0	21.07	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2402,B3801,B3502,C12103,C04001	A03,A24,B27,B07,UNK,UNK	0
EJ3462170	31-50	1	0	4.39	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A1101,A2402,B3501,B4402,C04001,C05001	A03,A24,B07,B44,UNK,UNK	0
RR2251424	50-60	1	1	5.27	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B1801,B1501,C05202,C07001	A03,A02,B44,B44,UNK,UNK	1
AY1135758	50-60	2	0	8.78	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0201,A0201,B0702,B0702,C03904,C07002	A02,A02,B07,B07,UNK,UNK	1
YD4252234	61-70	1	1	4.39	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6802,A3201,B1503,B7801,C03304,C16001	A02,A01,B27,B07,UNK,UNK	0
TQ0967716	<30	2	0	5.27	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2402,B0801,B2702,C02202,C07001	A01,A24,B38,B27,UNK,UNK	0
NE7822283	61-70	2	0	19.31	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A2902,B1402,B1501,C03304,C08002	A03,A01,A24,B27,B62,UNK,UNK	0
KN7988858	50-60	3	0	0.88	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A2901,A2601,B3801,B2701,C12103,C07701	A01,A24,A01,B27,B58,UNK,UNK	0
IR8592253	50-60	3	0	9.65	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0101,B3502,B5703,C04001,C04602	A01,A01,B07,B58,UNK,UNK	1
YH998041	31-50	24	0	31.6	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A2601,B5702,B4402,C02501,C07102	A03,A01,B57,B44,UNK,UNK	0
VT3977227	31-50	3	1	8.14	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A6801,B0801,B4402,C03501,C07701	A03,A03,B08,B44,UNK,UNK	0
J8989906	31-50	6	0	15.8	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2601,A6801,B3501,B5701,C12103,C07001	A01,A03,B27,B58,UNK,UNK	0
QR5467332	31-50	3	0	15.8	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A2601,A2601,B2705,B1501,C02202,C12103	A01,A01,B27,B44,UNK,UNK	1
UR5374486	61-70	2	0	5.27	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0101,B4001,B3501,C03503,C04001	A03,A01,B57,B07,UNK,UNK	0
LM2271756	50-60	0	0	4.39	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A0205,B4101,B1501,C03304,C07001	A02,A02,B44,B62,UNK,UNK	0
VA9335608	<30	1	0	5.27	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B3801,B3801,C17203,C07001	A01,A01,B38,B27,UNK,UNK	0
MC3435627	61-70	4	0	5.27	Combo	Melanoma	MSK-IMPACT	A2901,A2601,B2705,B3801,C01505,C17203	A01,A01,B27,B27,UNK,UNK	0
BC6811957	50-60	4	0	2.63	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B2702,B4402,C05001,C07001	A02,A02,B07,B44,UNK,UNK	1
MS3033862	61-70	9	0	3.51	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0201,A0201,B2702,B4402,C05001,C05001	A02,A02,B07,B44,UNK,UNK	1
Z7851796	50-60	7	1	5.27	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2601,A0201,B2705,B4403,C03102,C04001	A01,A02,B27,B44,UNK,UNK	0
DE743483	31-50	0	0	2.63	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2207,B2705,B3801,C03102,C03002	A03,A02,B27,B58,UNK,UNK	0
XC6960573	50-60	1	0	7.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B5501,B4405,C03303,C02202	A03,A02,B07,B44,UNK,UNK	0
LI826221	31-50	1	0	5.27	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B4102,B4405,C02202,C17701	A02,A02,B44,B44,UNK,UNK	1
SK0411077	31-50	2	0	4.39	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B4101,B1801,C07701,C17701	A02,A02,B44,B44,UNK,UNK	1
BU0122611	31-50	3	0	3.51	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3201,A0201,B1401,B5201,C12202,C08002	A01,A02,B27,B62,UNK,UNK	0
JK3986172	50-60	10	0	2.63	PD-1/PDL-1	Glioma	MSK-IMPACT	A3001,A3201,B3502,B1502,C08602,C04001	A01/A02,A01,B07,UNK,UNK,UNK	0
LM6150385	31-50	3	0	21.07	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A0201,B4403,B5108,C03501,C07001	A03,A02,B44,B07,UNK,UNK	0
GG5338274	31-50	0	0	6.14	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A0201,B5701,B3503,C03602,C03001	A01,A02,B58,B07,UNK,UNK	0
CK7596849	>71	1	0	13.17	Combo	Melanoma	MSK-IMPACT	A0201,A3303,B3501,B5101,C11502,C04001	A02,A03,B07,B07,UNK,UNK	0
PR3463356	61-70	1	1	14.04	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0302,A0201,B2705,B4402,C18004,C02202	A03,A02,B27,B44,UNK,UNK	0
TG3772084	31-50	6	1	1.76	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B1501,B4501,C05001,C17701	A03,A02,B44,B44,UNK,UNK	0
WB5443363	31-50	1	0	0.87	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0101,B5801,B2801,C07701,C07701	A01,A01,B58,B08,UNK,UNK	1
HU0113383	31-50	0	0	0.88	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0201,B1501,B5201,C15202,C02202	A01,A02,B52,B62,UNK,UNK	0
QZ3964186	50-60	0	0	1.76	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A0201,B4001,B1501,C03304,C04001	A02,A02,B44,B62,UNK,UNK	1
BS3957817	31-50	2	0	100.06	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3009,A0201,B1501,B3502,C03303,C04001	A01,A02,B62,B07,UNK,UNK	0
KZ5858653	61-70	11	1	1.97	Combo	Breast Cancer	MSK-IMPACT	A0206,A3303,B4801,B3801,C03902,C04001	A02,A03,B27,B58,UNK,UNK	0
GB3918563	31-50	12	0	26.56	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2601,B3502,B3801,C04001,C12103	A24,A01,B07,B27,UNK,UNK	0
WW6668436	61-70	5	1	1.97	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A2402,A2601,B0702,B3801,C12103,C07702	A24,A01,B07,B27,UNK,UNK	0
VK8455636	50-60	2	1	1.97	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A3004,A2301,B3701,B4101,C03602,C17701	A01,A24,B44,B44,UNK,UNK	0
KS1367792	50-60	18	0	2.95	CTLA4	Melanoma	MSK-IMPACT	A2402,A6802,B3503,B5701,C03602,C07701	A24,A03,B58,B07,UNK,UNK	0
RT5767755	50-60	9	0	3.94	CTLA4	Breast Cancer	MSK-IMPACT	A2402,A6802,B0702,B5201,C12202,C07002	A24,A02,B07,B62,UNK,UNK	0
AI7196687	50-60	34	1	0	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A1101,A3201,B4001,B5201,C03504,C12202	A03,A01,B44,B62,UNK,UNK	0
EP8529689	31-50	7	0	25.58	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A1101,B0702,B4403,C04001,C07002	A03,A03,B07,B44,UNK,UNK	0
DE2177728	31-50	9	0	1.97	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A6801,B5701,B4001,C03504,C03602	A01,A03,B58,B44,UNK,UNK	0
EM1407795	61-70	13	1	4.92	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2601,A0201,B5801,B5301,C12103,C12103	A01,A02,B27,B44,UNK,UNK	1
EE593601	>71	9	0	3.94	Combo	Colorectal Cancer	MSK-IMPACT	A0301,A0101,B0702,B5701,C04602,C07002	A03,A01,B07,B58,UNK,UNK	0
FJ772993	31-50	10	0	5.9	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A3002,A0201,B3501,B5301,C04001,C04001	A01,A02,B07,B07,UNK,UNK	1
FL7000226	31-50	5	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2902,A3101,B5703,B4403,C18001,C07706	A01/A24,A03,B58,B44,UNK,UNK	0
NT2593292	50-60	2	1	2.95	Combo	Pancreatic Cancer	MSK-IMPACT	A0301,A2601,B3801,B1801,C12103,C12103	A03,A01,B27,B44,UNK,UNK	1
GW3622077	61-70	4	0	2.95	PD-1/PDL-1	Gastrointestinal Stromal Tumor	MSK-IMPACT	A0101,A0101,B0801,B0801,C07701,C07701	A01,A01,B08,B08,UNK,UNK	1
QS3311947	<30	0	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A3002,B3801,B5801,C03502,C12103	A01,A01,B27,B58,UNK,UNK	1
AH7611270	31-50	9	1	9.84	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A0101,B2702,B3801,C07701,C07702	A03,A01,B27,B08,UNK,UNK	0

FB523718	50-60	3	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0200,A0201,B1501,B5101,C03303,C01601	A02,A02,B52,B07,UNK,UNK	1		
AJ637519	31-50	2	0	43.29	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0101,A0201,B4501,B5201,C1202,C0701	A01,A01,UNK,B52,UNK,UNK	0	
TP646859	60-69	7	0	5.74	CTLA4	Soft Tissue Sarcoma	MSK-IMPACT	A0301,A0201,B0702,B5201,C01202,C07702	A03,A02,B07,B521,UNK,UNK	0	
BF585566	31-50	3	0	8.85	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6802,A2601,B1402,B3901,C03802,C12203	A02,A01,B27,B57,UNK,UNK	0	
IK8057715	31-50	22	0	7.87	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2601,A0201,B0705,B67701,C1505,C12203	A01,A02,B07,B07,UNK,UNK	0	
EI1318743	50-60	15	1	9.84	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A1101,A0101,B1517,B5101,C1802,C0701	A03,A01,B58,B07,UNK,UNK	0	
FW8603799	50-60	54	0	9.68	CTLA4	Melanoma	MSK-IMPACT	A0101,A2402,B0702,B5501,C03303,C07202	A01,A24,B07,B07,UNK,UNK	0	
GW9448612	31-50	6	0	7.87	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B1517,B1501,C0501,C07201	A01,A02,B58,B44,UNK,UNK	0	
PZ8232250	31-50	3	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A3101,B0702,B3508,C0401,C07702	A03,A03,B07,B07,UNK,UNK	0	
ZJ847811	31-50	9	0	0	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0101,A2601,B5701,B3901,C1203,C01602	A01,A01,B58,B27,UNK,UNK	0	
EW3981128	31-50	2	1	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3201,A0201,B0702,B4402,C0202,C07702	A01,A02,B07,B44,UNK,UNK	0	
FG4083328	31-50	5	1	6.89	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A3001,A0101,B0801,B1801,C0701,C07501	A01403,A01,B08,B44,UNK,UNK	1	
PD3648224	50-60	2	1	2.95	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0301,A0301,B0702,B1501,C03804,C07702	A03,A03,B07,B52,UNK,UNK	1	
IS8726618	50-60	7	0	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0101,B5501,B1517,C0102,C07201	A01,A01,B07,B58,UNK,UNK	1	
LR1743370	50-60	19	0	8.85	Combo	Melanoma	MSK-IMPACT	A3002,A2402,B1402,B1508,C0102,C08602	A01,A24,B27,B07,UNK,UNK	0	
PW7748629	61-70	54	0	4.92	CTLA4	Melanoma	MSK-IMPACT	A6801,A0201,B5701,B4402,C0501,C08602	A03,A02,B58,B44,UNK,UNK	0	
JW7238525	31-50	41	0	2.95	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B1501,B5502,C03303,C08602	A03,A02,B52,B58,UNK,UNK	0	
NB4721516	31-50	12	1	8.85	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B0702,B6701,C1205,C07002	A03,A02,B07,B07,UNK,UNK	0	
XB7766857	31-50	8	0	5.9	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B2705,B3801,C0102,C12303	A02,A02,B27,B27,UNK,UNK	1	
YV3968614	60-69	17	0	6.89	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402,A3301,B1402,B0801,C0802,C07718	A24,A03,B27,B08,UNK,UNK	0	
QR8522407	50-60	17	0	18.69	Combo	Melanoma	MSK-IMPACT	A1101,A0201,B0702,B1801,C0702,C07701	A03,A02,B07,B44,UNK,UNK	0	
RF9413394	50-60	30	0	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A2601,B0801,B1801,C0701,C07701	A02,A01,B08,B44,UNK,UNK	1	
SP5982255	31-50	6	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A3303,B4001,B5901,C03802,C07202	A24,A03,B44,B58,UNK,UNK	0	
SS1128035	31-50	4	0	8.85	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2402,A2601,B1501,B3501,C0305,C12203	A24,A01,B52,B27,UNK,UNK	0	
WN3672967	31-50	15	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3101,A3301,B1402,B3801,C0802,C12203	A03,A03,B27,B27,UNK,UNK	0	
YG1152378	50-60	3	0	11.81	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0301,A2601,B0702,B1801,C12203,C07202	A03,A01,B07,B44,UNK,UNK	0	
WY0938864	61-70	2	1	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B1501,B3501,C0401,C04001	A01,A02,B62,B07,UNK,UNK	1	
BC8311776	61-70	2	0	22.63	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A6801,B3701,B4402,C0602,C07704	A01,A03,B44,B44,UNK,UNK	0	
C9784271	31-50	5	1	9	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0101,A2402,B3502,B5501,C03303,C04001	A01,A24,B07,B07,UNK,UNK	0	
D3658632	50-60	4	0	7.87	Combo	Melanoma	MSK-IMPACT	A0301,A2402,B0702,B3508,C0401,C07702	A03,A24,B07,B07,UNK,UNK	0	
HC2231191	31-50	11	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6301,A3303,B4901,B3501,C0602,C07501	A03,A03,UNK,B07,UNK,UNK	0	
HC2231191	61-70	7	0	2.95	CTLA4	Prostate Cancer	MSK-IMPACT	A0101,A0101,B0801,B5701,C0701,C07701	A01,A01,B08,B08,UNK,UNK	1	
VR4065657	31-50	19	0	4.92	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B0801,B3508,C0401,C07701	A02,A02,B08,B07,UNK,UNK	1	
XU0013435	50-60	6	0	23.61	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A2402,B1801,B1302,C0602,C07701	A01403,A24,B44,UNK,UNK,UNK	0	
YA2705966	31-50	40	0	6.89	Combo	Melanoma	MSK-IMPACT	A0301,A2902,B0702,B4801,C0803,C07702	A03,A02,B57,B27,UNK,UNK	0	
KQ2222690	50-60	15	0	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A2301,B5501,B4901,C1203,C07701	A24,A23,B57,UNK,UNK,UNK	0	
RR1916649	31-50	3	1	5.9	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A3001,A3201,B5501,B1302,C03504,C06602	A01403,A01,B07,B07,UNK,UNK	1	
ZJ250921	50-60	1	1	0.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A3001,B5801,B5101,C0102,C04001	A03,A01,A03,B57,B07,UNK,UNK	0	
DH0269388	61-70	1	1	6.89	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B4405,B1302,C0202,C06602	A02,A02,B44,UNK,UNK,UNK	1	
GS4620214	31-50	36	0	3.94	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B2705,B3801,C0102,C12203	A03,A02,B27,B27,UNK,UNK	0	
IL4440982	31-50	0	1	2.95	PD-1/PDL-1	Thyroid Cancer	MSK-IMPACT	A0301,A2402,B0702,B4001,C03804,C07702	A03,A24,B07,B44,UNK,UNK	0	
RA2663407	61-70	5	0	24.59	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A6801,A6601,B4001,B4405,C0305,C06202	A03,A03,B44,B44,UNK,UNK	0	
RP0702224	>71	5	0	2.95	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2902,A0201,B4402,B4403,C1601,C05001	A01424,A02,B44,B44,UNK,UNK	0	
TF4881143	50-60	3	1	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B0702,B0702,C0702,C07202	A03,A02,B07,B07,UNK,UNK	1	
TF7355669	31-50	42	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	0.3001,A0201,B4403,B1302,C05602,C16202	A01403,A02,B44,UNK,UNK,UNK	1	
UK9771155	31-50	2	0	20.69	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B5801,B5701,C0202,C07201	A01,A02,B58,B58,UNK,UNK	0	
WO1200157	<30	28	0	48.21	CTLA4	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0201,A2601,B3701,B1501,C03602,C07704	A02,A01,B44,B62,UNK,UNK	0	
BR3741139	60-69	0	1	19.68	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0101,A6801,B4001,B1801,C03804,C12203	A01,A03,B44,B44,UNK,UNK	0	
ED3611455	>71	2	0	1.97	Combo	Cancer of Unknown Primary	MSK-IMPACT	A2902,A6802,B4501,B5802,C0602,C07201	A01424,A02,UNK,B58,UNK,UNK	0	
GZ3235586	50-60	3	1	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2402,B0702,B1801,C0102,C07702	A01,A24,B07,B44,UNK,UNK	0	
HC0127075	31-50	1	1	14.76	Combo	Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B0801,B4402,C0501,C07701	A01,A02,B08,B44,UNK,UNK	0	
QT2564684	50-60	11	0	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A6802,B3503,B3501,C0401,C04001	A24,A02,B07,B07,UNK,UNK	1	
QV5272200	31-50	7	0	10.82	CTLA4	Melanoma	MSK-IMPACT	A3002,A3301,B1402,B3801,C0802,C12303	A01,A03,B27,B27,UNK,UNK	0	
TH5864442	>71	11	1	3.94	PD-1/PDL-1	Bone Cancer	MSK-IMPACT	A0101,A2402,B0801,B3801,C0701,C07701	A01,A24,B08,B58,UNK,UNK	1	
ZP8201505	>71	18	1	25.58	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2902,B5101,B4403,C1502,C16201	A03,A01424,B57,B44,UNK,UNK	0	
IN5221880	<30	4	0	4.92	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0301,A0201,B0702,B3508,C07702,C07702	A03,A02,B07,B27,UNK,UNK	1	
JP2452257	>71	11	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0101,B0702,B3801,C0705,C07201	A03,A01,B07,B58,UNK,UNK	0	
JX5347724	>71	8	1	6.89	PD-1/PDL-1	Bone Cancer	MSK-IMPACT	A0301,A0301,B0702,B4801,C0701,C07202	A03,A03,B07,UNK,UNK,UNK	1	
MF5356839	31-50	6	0	8.85	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B0801,B3501,C0701,C07702	A02,A02,B08,B27,UNK,UNK	1	
NK4794215	31-50	18	0	0.82	Combo	Melanoma	MSK-IMPACT	A3001,A0206,B2705,B3508,C03903,C04001	A01A03,A02,B27,B07,UNK,UNK	0	
QE7998634	60-69	5	1	1.97	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0301,B1501,B3901,C1203,C03303	A03,A03,B62,B27,UNK,UNK	1	
OM5310967	31-50	2	1	1.87	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2402,B1402,B5801,C0802,C07706	A03,A24,B27,B58,UNK,UNK	0	
XX3634415	>71	3	0	5.9	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B0801,B1402,C0802,C01701	A01,A02,B08,B27,UNK,UNK	0	
HK3759614	60-69	4	0	13.77	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A2902,B5701,B1501,C03303,C09602	A01,A24,B44,B62,UNK,UNK	0	
IF3248640	>71	21	1	4.92	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0301,A3101,B0702,B5101,C1402,C07702	A03,A03,B07,B07,UNK,UNK	0	
KB7243373	50-60	0	1	10.98	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A1101,A3201,B5501,B3501,C03903,C02202	A03,A01,B07,B07,UNK,UNK	0	

CU108820	61-70	3	1	35.42	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2402,B2702,B5101,C03303,C03602	A03,A24,B38,B07,UNK,UNK	0
RT756250	<30	15	0	0.98	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3101,A3303,B4403,B4506,C03501,C03706	A03,A03,B44,B44,UNK,UNK	0
TX8897700	61-70	2	1	0.98	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6802,A6901,B0801,B3508,C04101,C07101	A03,A68,B08,B07,UNK,UNK	0
WI8413869	50-60	12	0	44.27	Combo	Melanoma	MSK-IMPACT	A0301,A3101,B0702,B4501,C03804,C07102	A03,A03,B07,B44,UNK,UNK	0
ZP4182201	50-60	7	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A1101,B1302,B5101,C03102,C06602	A01,A03,A03,UNK,B07,UNK,UNK	0
ZU0021130	>71	2	1	4.92	Combo	Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B0705,B4402,C04001,C05801	A03,A02,B07,B44,UNK,UNK	0
DA1792245	50-60	8	0	8.86	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0201,B4901,B5701,C06602,C07001	A01,A02,UNK,B58,UNK,UNK	0
EZ2682112	<30	1	1	1.97	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A6802,A0201,B1517,B1801,C07001,C07101	A03,A02,B58,B44,UNK,UNK	1
KT7815225	<30	1	1	3.94	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201,A0201,B5801,B1801,C03102,C03501	A02,A02,B07,B44,UNK,UNK	1
NU0344867	50-60	3	1	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A3201,B5701,B3501,C04001,C06602	A03,A01,B58,B07,UNK,UNK	0
RR682184	31-50	0	0	3.94	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0201,A0201,B5702,B4502,C03202,C03702	A02,A02,B07,B44,UNK,UNK	1
TX0937727	50-60	3	0	4.92	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402,A2301,B4402,B4801,B1801,C03504,C17201	A24,A24,B44,B44,UNK,UNK	0
UB5584651	31-50	11	0	6.89	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2402,B0801,B1801,C03303,C07101	A01,A24,B58,B44,UNK,UNK	0
YW9357743	61-70	1	1	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0207,B4601,B1502,C03102,C06801	A03,A02,B62,B62,UNK,UNK	0
YA6880084	61-70	16	0	36.4	Combo	Melanoma	MSK-IMPACT	A3004,A2902,B0702,B5201,C03602,C07102	A01,A01,A24,B07,B44,UNK,UNK	0
CC6329903	31-50	2	0	7.87	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A6802,B1402,B1302,C03602,C06602	A02,A02,B27,UNK,UNK,UNK	0
GV5280013	>71	7	1	3.94	Combo	Melanoma	MSK-IMPACT	A0301,A2902,B0702,B4403,C1601,C07102	A03,A01,A24,B07,B44,UNK,UNK	1
PX3661152	>71	2	1	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A2402,A2601,B4901,B5301,C04001,C07101	A24,A01,UNK,B07,UNK,UNK	0
JJ9499181	31-50	7	0	7.87	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2402,B0801,B1501,C03303,C07701	A01,A24,B58,B62,UNK,UNK	0
CR8686451	31-50	6	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A7401,B0801,B5601,C03102,C03706	A01,A03,B58,B07,UNK,UNK	0
RV8112068	>71	12	1	3.94	Combo	Melanoma	MSK-IMPACT	A0301,A0206,B1501,B4402,C03303,C03501	A03,A02,B62,B44,UNK,UNK	0
TW7287733	50-60	7	0	1.97	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A2402,B3906,B4403,C03602,C07102	A01,A24,B27,B44,UNK,UNK	0
AZ3567907	50-60	6	0	47.22	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A2601,B3501,B4902,C02102,C12103	A03,A01,B27,B44,UNK,UNK	0
FF3927752	61-70	3	0	4.92	CTLA4	Breast Cancer	MSK-IMPACT	A1101,A0201,B3503,B3501,C03401,C04001	A03,A02,B57,B07,UNK,UNK	1
FO9886647	>71	9	0	13.77	Combo	Melanoma	MSK-IMPACT	A0301,A2402,B5101,B5101,C03102,C07102	A03,A24,B07,B07,UNK,UNK	1
TS8939271	61-70	55	0	15.74	CTLA4	Melanoma	MSK-IMPACT	A0301,A0101,B0702,B4402,C0501,C07102	A03,A01,B07,B44,UNK,UNK	0
UK5338610	31-50	7	1	1.97	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0301,A3301,B0702,B1402,C03602,C07102	A03,A03,B07,B27,UNK,UNK	0
UQ7484037	31-50	1	0	0	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A0101,B0801,B0801,C03701,C03701	A01,A01,B08,B08,UNK,UNK	1
ZP2484675	50-60	35	1	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2402,B5502,B5201,C1202,C04001	A03,A24,B07,B62,UNK,UNK	0
KR2598040	50-60	6	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2403,B0801,B3502,C03401,C03701	A01,A24,B08,B07,UNK,UNK	0
LS2710625	50-60	7	0	8.69	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A2402,A3303,B4001,B3901,C03502,C03702	A24,A03,B44,B58,UNK,UNK	0
NB2769869	61-70	5	0	1.97	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A0207,A3303,B4002,B3901,C03303,C03602	A02,A03,B44,B58,UNK,UNK	0
PD5718253	31-50	4	0	43.21	Combo	Melanoma	MSK-IMPACT	A2902,A0201,B0702,B5101,C1601,C07102	A01A24,A02,B07,B07,UNK,UNK	0
RR3557724	31-50	2	1	27.69	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2402,A3101,B4001,B1801,C03504,C07701	A24,A03,B44,B44,UNK,UNK	0
UQ7539092	50-60	34	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A3201,B0801,B5101,C15102,C03702	A03,A01,B38,B07,UNK,UNK	0
YI8769805	31-50	3	1	0.98	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A2902,B1402,B5101,C1402,C03602	A03,A01,A24,B27,B07,UNK,UNK	0
EH0626438	61-70	5	0	34.49	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0101,B0801,B6701,C03602,C07701	A01,A01,B08,B58,UNK,UNK	1
HB1171494	>71	55	1	2.79	CTLA4	Melanoma	MSK-IMPACT	A0101,A2402,B3502,B1302,C03602,C04001	A01,A24,B07,UNK,UNK,UNK	0
HY4207730	31-50	1	1	1.97	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A0101,A1101,B2705,B1508,C03102,C0102	A01,A03,B27,B07,UNK,UNK	1
SM1086076	>71	18	0	5.9	Combo	Melanoma	MSK-IMPACT	A0201,A0201,B4403,B1801,C07106,C07101	A02,A02,B44,B44,UNK,UNK	1
XJ3020231	>71	4	1	0.98	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A2902,A6802,B3501,B1302,C16104,C17102	A01A24,A02,B62,UNK,UNK,UNK	0
XJ5364453	61-70	10	0	1.97	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301,A0201,B3601,B5501,C04001,C12103	A24,A02,B27,B44,UNK,UNK	0
EL0021996	31-50	1	1	29.51	Combo	Melanoma	MSK-IMPACT	A2902,A0201,B1801,B5108,C12103,C16102	A01A24,A02,B44,B07,UNK,UNK	0
CN0597789	61-70	22	0	5.9	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0101,B0702,B0901,C07701,C07702	A01,A01,B07,B08,UNK,UNK	1
EO2364437	31-50	7	0	8.85	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B4201,B6702,C07101,C03702	A01,A02,B07,B07,UNK,UNK	0
ME1752350	31-50	1	1	4.92	PD-1/PDL-1	Prostate Cancer	MSK-IMPACT	A0301,A0201,B1801,B3503,C04001,C07701	A03,A02,B44,B07,UNK,UNK	0
MX2600877	61-70	13	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A2601,B4101,B3801,C1203,C17101	A24,A01,B44,B27,UNK,UNK	0
TQ0021548	>71	17	0	7.87	Combo	Melanoma	MSK-IMPACT	A1101,A0101,B0801,B4403,C16101,C07101	A03,A01,B38,B44,UNK,UNK	0
VC2436648	>71	8	0	2.95	CTLA4	Melanoma	MSK-IMPACT	A1101,A1101,B5502,B5101,C03102,C1402	A03,A03,B07,B07,UNK,UNK	1
YD7776923	31-50	2	0	5.9	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B4006,B1501,C15102,C03804	A02,A02,B44,B62,UNK,UNK	1
YT1818084	50-60	2	1	7.87	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A0201,B1402,B1501,C03804,C03602	A01,A02,B27,B62,UNK,UNK	0
ZK9350604	31-50	11	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A3101,E1402,B4501,C04502,C07001	A03,A03,B27,UNK,UNK,UNK	0
ZM4362683	>71	4	0	0	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A0201,A0201,B0801,B6102,C04001,C07701	A02,A02,B08,B07,UNK,UNK	1
ZN6894436	50-60	12	1	0	Combo	Anal Cancer	MSK-IMPACT	A0201,A0201,B4402,B4402,C05601,C05601	A02,A02,B44,B44,UNK,UNK	1
AK3987732	31-50	3	1	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B3901,B3502,C1203,C03602	A01,A01,B27,B07,UNK,UNK	0
DM2477664	>71	7	0	0.98	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0101,B0702,B0801,C07701,C03702	A03,A01,B07,B08,UNK,UNK	0
EB9811648	61-70	1	0	0	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A1101,A2402,B4006,B3901,C03801,C03702	A03,A24,B44,B27,UNK,UNK	0
LH5442209	>71	2	1	30.5	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A3201,B5701,B4402,C05501,C03602	A01,A01,B58,B44,UNK,UNK	0
LQ6536676	31-50	10	0	1.97	Combo	Melanoma	MSK-IMPACT	A1101,A0101,B1801,B5701,C02505,C03602	A03,A01,B62,B58,UNK,UNK	0
PV7118637	>71	6	0	0	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0301,A0301,B4002,B5101,C15102,C04001	A03,A03,B44,B07,UNK,UNK	1
QQ2073602	31-50	11	0	15.74	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A0201,B4101,B1302,C06502,C17101	A01A03,A02,B44,UNK,UNK,UNK	0
SH7664427	>71	4	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2402,B3906,B4402,C1604,C07702	A01,A24,B27,B44,UNK,UNK	0
ZC5143121	>71	7	1	8.86	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A3201,B0702,B1401,C03602,C07702	A24,A01,B07,B27,UNK,UNK	0
BZ8535679	50-60	24	0	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A3201,B0801,B4101,C07701,C17101	A01,A01,B08,B44,UNK,UNK	0
DC8133628	>71	3	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A3201,B1901,B5701,C03504,C09602	A01,A01,B62,B58,UNK,UNK	0
EJ3735989	31-50	32	1	5.9	Combo	Melanoma	MSK-IMPACT	A1101,A1101,B5101,B3501,C03401,C04001	A03,A03,B07,B07,UNK,UNK	1

CA0255672	>71	67	0	47.22	CTLA4	Melanoma	MSK-IMPACT	A1101,A0101,B0801,B1801,C0701,C0701	A03,A01,B08,B44,UNK,UNK	1
IN9603775	50-60	5	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A2601,B2705,B5101,C0202,C1602	A02,A01,B27,B07,UNK,UNK	0
MW215777	61-70	1	1	5.9	PD-1/PDL-1	Anal Cancer	MSK-IMPACT	A3001,A3001,B8101,B8301,C0602,C0401	A01,A01,A03,B07,B58,UNK,UNK	0
SM3534636	31-50	5	0	9.84	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0101,B0801,B4501,C0304,C0701	A03,A01,B08,B44,UNK,UNK	0
TP561311	50-60	8	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A2601,B3801,B4402,C1203,C0501	A02,A01,B27,B44,UNK,UNK	0
VX262680	61-70	1	0	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0217,A3201,B5101,B5101,C1802,C1802	A02,A01,B07,B07,UNK,UNK	1
YZ3798670	>71	18	0	6.89	PD-1/PDL-1	Glioma	MSK-IMPACT	A3001,A0101,B3502,B1302,C0401,C0602	A01,A03,A01,B07,UNK,UNK	0
AQ2347293	31-50	3	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A3201,B4402,B3501,C0202,C0401	A03,A01,B44,B07,UNK,UNK	0
BR4041154	50-60	0	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2902,A6802,B1510,B4403,C0304,C1601	A01,A24,A02,B27,B44,UNK,UNK	0
DU5212291	61-70	9	0	0.98	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A3201,B8701,B5501,C0102,C1203	A03,A01,B07,B07,UNK,UNK	0
EZ372684	>71	7	1	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A3201,B5501,B4002,C0202,C1203	A03,A01,B27,B44,UNK,UNK	0
HO3144881	31-50	1	1	10.82	Combo	Melanoma	MSK-IMPACT	A1101,A0201,B1501,B4403,C0303,C0304	A03,A02,B62,B44,UNK,UNK	0
JC3258672	31-50	17	0	45.25	Combo	Melanoma	MSK-IMPACT	A0301,A1101,B0702,B4403,C1601,C0702	A03,A03,B07,B44,UNK,UNK	0
NE7221159	<50	0	0	153.31	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2902,A2601,B4403,B1501,C1501,C1205	A01,A24,A01,B44,B44,UNK,UNK	0
DU3978339	31-50	25	0	2.95	CTLA4	Prostate Cancer	MSK-IMPACT	A0201,A0201,B1501,B4201,C0304,C0401	A02,A02,B62,B44,UNK,UNK	1
TF7744146	61-70	9	0	53.12	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B3508,B1801,C0401,C1203	A24,A02,B07,B44,UNK,UNK	0
YE4546657	50-60	2	0	40.54	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A3101,B4402,B4901,C0501,C0701	A24,A03,B44,UNK,UNK,UNK	0
XE8648688	31-50	20	0	0	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2601,B3901,B5701,C1205,C0602	A01,A01,B27,B58,UNK,UNK	0
ZE1129370	31-50	7	0	2.79	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A0101,A0205,B3801,B3502,C0401,C1203	A01,A02,B27,B07,UNK,UNK	0
ZE2213131	>71	3	0	3.94	Combo	Bone Cancer	MSK-IMPACT	A1101,A0203,B1512,B1301,C0304,C0409	A03,A02,B62,B44,UNK,UNK	0
DB7983112	61-70	11	0	60.01	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2402,A3201,B5702,B4403,C0304,C0702	A24,A01,B07,B44,UNK,UNK	0
NL3274689	50-60	3	0	4.92	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2301,A0201,B0702,B5801,C0718,C0702	A24,A02,B07,B58,UNK,UNK	0
NW9600639	50-60	13	0	1.97	CTLA4	Gastrointestinal Stromal Tumor	MSK-IMPACT	A0301,A0201,B1501,B1501,C0303,C0501	A03,A02,B62,B44,UNK,UNK	0
QW6837720	50-60	5	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A6801,B1302,B3501,C0401,C0602	A01,A03,A03,UNK,B07,UNK,UNK	0
PX9476710	31-50	9	1	4.92	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0301,A3002,B0702,B4403,C1601,C0702	A03,A01,B07,B44,UNK,UNK	0
QH6922221	31-50	0	1	8.86	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2403,A0201,B5801,B4501,C0102,C0102	A24,A02,B07,B62,UNK,UNK	1
TJ5728227	>71	20	0	6.89	Combo	Renal Cell Carcinoma	MSK-IMPACT	A3201,A2601,B1801,B5101,C1502,C1203	A01,A01,B44,B07,UNK,UNK	0
UW5955663	61-70	1	0	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A2301,A2902,B4403,B4901,C1601,C0701	A24,A01,A24,B44,UNK,UNK	0
KN0808112	50-60	5	0	0.98	CTLA4	Melanoma	MSK-IMPACT	A0101,A6802,B1402,B5701,C0802,C0602	A01,A02,B27,B44,UNK,UNK	0
CW2407992	50-60	37	0	2.95	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2402,B4001,B1501,C2401,C0702	A03,A24,B44,B62,UNK,UNK	0
DR9733373	50-60	26	0	4.78	Combo	Melanoma	MSK-IMPACT	A2402,A2402,B3502,B4901,C0401,C0701	A24,A24,B27,UNK,UNK,UNK	1
NI4981165	31-50	6	0	0.98	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A0201,B0801,B6901,C0701,C0701	A01,A02,B58,B58,UNK,UNK	1
NU5832995	61-70	5	0	53.12	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A1101,A2402,B1505,B3501,C0305,C0401	A03,A24,B62,B07,UNK,UNK	0
PJ1733983	>71	12	0	2.95	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B5201,B1501,C0505,C1202	A24,A02,B62,B62,UNK,UNK	0
PV8437659	50-60	0	0	1.71	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0301,A2601,B3801,B3901,C1203,C1203	A03,A01,B27,B27,UNK,UNK	1
PX8568045	50-60	6	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A3601,B1302,B5101,C1402,C0602	A03,A01,A03,UNK,B07,UNK,UNK	0
RC9318605	>71	17	0	3.94	PD-1/PDL-1	Bone Cancer	MSK-IMPACT	A0201,A0201,B4901,B1501,C0505,C0701	A02,A02,UNK,B62,UNK,UNK	1
SC5513340	31-50	4	1	11.81	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2403,A2402,B1801,B1801,C1203,C0701	A24,A24,B44,B44,UNK,UNK	1
TH0389044	>71	2	0	0.98	PD-1/PDL-1	Bone Cancer	MSK-IMPACT	A3002,A0201,B6101,B4501,C1601,C0801	A01,A02,B07,B44,UNK,UNK	0
TP1306607	50-60	1	0	0.98	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0101,A0101,B0801,B3501,C0401,C0701	A01,A01,B58,B07,UNK,UNK	1
YC0026126	31-50	12	1	21.64	Combo	Melanoma	MSK-IMPACT	A0301,A0101,B0702,B0801,C0701,C0702	A03,A01,B07,B08,UNK,UNK	0
WK9719939	>71	11	0	0.98	PD-1/PDL-1	Hodgkin Lymphoma	MSK-IMPACT	A0101,A0101,B0801,B0801,C0701,C0701	A01,A01,B08,B08,UNK,UNK	1
YV5038688	50-60	19	0	1.97	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0302,B2705,B4402,C0102,C0704	A03,A03,B27,B44,UNK,UNK	0
BA6536244	31-50	25	0	3.94	Combo	Renal Cell Carcinoma	MSK-IMPACT	A2402,A0201,B1517,B3503,C0401,C0701	A24,A02,B58,B07,UNK,UNK	0
BM2565386	31-50	13	1	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2301,B4101,B5301,C0602,C1701	A24,A23,B44,B44,UNK,UNK	1
BT3949803	50-60	15	0	1.97	Combo	Melanomas	MSK-IMPACT	A3002,A0205,B3701,B1801,C0201,C0602	A01,A02,B44,B44,UNK,UNK	0
CQ2651110	61-70	5	0	1.97	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A3201,B0702,B2701,C0602,C0702	A02,A01,B07,B58,UNK,UNK	0
DU8939576	50-60	1	1	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B1517,B3502,C0401,C0701	A01,A01,B58,B07,UNK,UNK	0
EK3206634	61-70	10	1	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601,A0201,B0702,B4501,C0601,C0702	A01,A02,B07,B27,UNK,UNK	0
EV8546604	61-70	5	1	3.94	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A0101,B0702,B0801,C0701,C0702	A03,A01,B07,B08,UNK,UNK	0
GX3462946	31-50	5	0	7.87	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A2402,B1501,B5101,C1502,C0304	A03,A24,B62,B07,UNK,UNK	0
KH1915548	61-70	11	1	4.92	Combo	Head and Neck Cancer	MSK-IMPACT	A2402,A2902,B4403,B5701,C1601,C0602	A24,A01,A24,B44,B58,UNK,UNK	0
KX9501095	31-50	0	0	11.8	PD-1/PDL-1	Melanoma	MSK-IMPACT	A1101,A0201,B0801,B1402,C0802,C0701	A03,A02,B58,B27,UNK,UNK	0
CQ3946625	61-70	56	0	8.69	CTLA4	Melanoma	MSK-IMPACT	A0101,A2402,B0801,B1801,C1203,C0701	A01,A24,B58,B44,UNK,UNK	0
PE0027950	61-70	1	0	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A0205,B5501,B1501,C0602,C0501	A02,A02,B44,B44,UNK,UNK	0
PX5787748	50-60	5	0	7.87	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A3601,B0702,B3801,C0701,C0702	A24,A01,B07,B08,UNK,UNK	0
RC9459846	31-50	4	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A3201,B5801,B4901,C1203,C0701	A03,A01,B27,UNK,UNK,UNK	0
SP02 1117	61-70	16	0	0.98	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0301,A3002,B5701,B1801,C0501,C0602	A03,A01,B58,B44,UNK,UNK	0
TE8351191	50-60	10	0	10.82	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0301,A2902,B0702,B4403,C1601,C0702	A03,A01,A24,B07,B44,UNK,UNK	0
VZ6861197	50-60	26	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A3201,B4001,B3501,C0303,C0304	A24,A01,B44,B07,UNK,UNK	0
XV9560799	31-50	6	0	6.89	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A2601,B4402,B3801,C0501,C1203	A02,A01,B44,B27,UNK,UNK	0
ZE1822555	31-50	21	0	17.71	CTLA4	Melanoma	MSK-IMPACT	A1101,A0201,B5101,B4402,C1402,C1502	A03,A02,B07,B44,UNK,UNK	0
AR8432502	31-50	2	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B0801,B1501,C0305,C0701	A01,A02,B58,B62,UNK,UNK	0
DT5772035	50-60	4	0	57.08	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A0201,B1302,B5101,C0401,C0602	A02,A02,UNK,B07,UNK,UNK	1
FL1158594	50-60	18	0	0.98	Combo	Melanoma	MSK-IMPACT	A2601,A2601,B3801,B3801,C1203,C1203	A01,A01,B27,B27,UNK,UNK	1
CA0263392	31-50	11	0	9.68	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3001,A0201,B1302,B5102,C0401,C0602	A01A03,A02,UNK,B07,UNK,UNK	0

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EL3411780	31-50	5	0	36.4	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3301,A4201,B4701,B1501,C0401,C0602	A01,A02,UNK,B44,UNK,UNK	0
RM3341407	31-50	13	1	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0203,B4001,B5102,C0102,C0304	A03,A02,B44,B07,UNK,UNK	0
MT9286683	31-50	11	0	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A6201,A0201,B4101,B1801,C1701,C0701	A02,A02,B44,B44,UNK,UNK	1
PA3269028	61-70	0	1	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3301,B1402,B3502,C0802,C0401	A01,A03,B27,B07,UNK,UNK	0
PW5579102	31-50	1	0	2.95	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0101,A2402,B3901,B5701,C1203,C0602	A01,A24,B27,B58,UNK,UNK	0
RF3269353	61-70	4	0	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2902,A2206,B4403,B3802,C1601,C0702	A01,A24,A02,B44,B27,UNK,UNK	0
SL2338618	31-50	10	0	0.98	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3004,A2402,B0702,B5201,C0802,C0702	A01,A24,B07,B44,UNK,UNK	0
SM7117841	61-70	12	0	52.14	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B0702,B5701,C0602,C0702	A01,A02,B07,B58,UNK,UNK	0
TA6220796	50-60	4	0	1.97	PD-1/PDL-1	Sex Cord Stromal Tumor	MSK-IMPACT	A0101,A3101,B0801,B4001,C0304,C0701	A01,A03,B08,B44,UNK,UNK	0
YY2342463	50-60	41	0	7.87	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A0101,B0801,B3501,C0401,C0701	A03,A01,B08,B07,UNK,UNK	0
WG8528822	50-60	0	1	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B1402,B1501,C0202,C0701	A03,A02,B27,B44,UNK,UNK	0
YY9421117	31-50	17	0	8.85	PD-1/PDL-1	Melanoma	MSK-IMPACT	A1101,A0101,B5701,B5201,C1202,C0602	A03,A01,B58,B62,UNK,UNK	0
Z_8220780	31-50	4	1	14.76	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A0201,B3901,B3501,C0401,C0401	A01,A02,B27,B07,UNK,UNK	1
AI853614	31-50	6	0	10.82	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A1101,A3201,B1501,B5001,C0305,C0302	A03,A01,B62,B58,UNK,UNK	0
CD4555638	61-70	32	0	14.76	CTLA4	Melanoma	MSK-IMPACT	A2402,A0201,B1501,B4403,C0305,C1601	A24,A02,B62,B44,UNK,UNK	0
CG2003297	31-50	1	0	5.9	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A2402,A0201,B1402,B4405,C0802,C0202	A24,A02,B27,B44,UNK,UNK	0
DM4867441	50-60	0	1	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A3303,B0702,B4403,C0706,C0702	A24,A03,B07,B44,UNK,UNK	0
EP3931793	31-50	10	1	2.95	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A2402,E0901,B1501,C1205,C0702	A03,A24,B62,B44,UNK,UNK	0
PC2853273	50-60	31	0	1.97	Combo	Renal Cell Carcinoma	MSK-IMPACT	A3004,A0101,B4101,B1517,C1701,C0701	A01,A01,B44,B58,UNK,UNK	0
IB7586171	31-50	11	0	2.95	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2402,A0201,B4403,B1501,C0309,C1601	A24,A02,B44,B62,UNK,UNK	0
KU2554411	31-50	10	0	3.94	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A1101,A2601,B5501,B1402,C0102,C0802	A03,A01,B07,B27,UNK,UNK	0
CK8668849	>71	13	0	8.85	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2402,B5701,B3502,C0802,C0401	A01,A24,B58,B07,UNK,UNK	0
RL1392281	31-50	13	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6801,A3201,B2705,B4901,C0102,C0304	A03,A01,B07,B44,UNK,UNK	0
YB4J00702	61-70	0	1	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A2301,A6802,B4403,B4402,C0401,C0401	A24,A02,B44,B44,UNK,UNK	1
Y8539485	>71	3	1	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A1102,A6802,B3802,B5301,C0401,C0702	A03,A02,UNK,B07,UNK,UNK	0
YD0038871	50-60	1	1	27.55	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3201,A2601,B0702,B4402,C0501,C0702	A01,A01,B07,B44,UNK,UNK	0
YH2351278	>71	7	0	6.89	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0101,A0201,E0801,B1501,C0303,C0701	A01,A02,B62,B62,UNK,UNK	0
AD8755088	50-60	0	1	24.59	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2301,A2402,B4403,B3502,C0401,C0401	A24,A24,B44,B07,UNK,UNK	1
BG4155363	61-70	5	0	13.69	PD-1/PDL-1	Prostate Cancer	MSK-IMPACT	A0101,A2301,B5701,B4901,C0602,C0701	A01,A24,B58,UNK,UNK,UNK	0
EZ7074402	50-60	9	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A3101,B1501,B5701,C0305,C0602	A02,A03,B62,B58,UNK,UNK	0
BY6656262	50-60	25	1	4.92	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2301,A6801,B4901,B5101,C1602,C0701	A24,A03,UNK,B07,UNK,UNK	0
CU2411212	50-60	7	0	11.81	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A1101,A3301,B1402,B4402,C0501,C0802	A03,A03,B27,B44,UNK,UNK	0
DG1116801	31-50	1	1	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2601,A2601,B0702,B3501,C0401,C0702	A01,A01,B07,B07,UNK,UNK	1
FH0363673	61-70	16	1	25.79	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0201,B4001,B4201,C0304,C0504	A02,A02,B44,B44,UNK,UNK	1
FQ5913229	31-50	12	0	0.98	PD-1/PDL-1	Thyroid Cancer	MSK-IMPACT	A0101,A2902,B0801,B4403,C1601,C0701	A01,A01,A24,B58,B44,UNK,UNK	0
GZ8942098	31-50	4	1	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A2601,B1501,B1501,C1203,C0701	A02,A01,B44,B44,UNK,UNK	1
JQ5538820	31-50	5	0	11.81	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2902,B4402,B6801,C0501,C0706	A01,A01,A24,B44,B58,UNK,UNK	0
KT2271657	31-50	7	0	11.81	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A3004,A0201,B1801,B4403,C0706,C0701	A01,A02,B44,B44,UNK,UNK	0
LE928694	>71	9	0	13.77	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A3002,A2301,B1402,B4403,C0802,C0401	A01,A23,B27,B44,UNK,UNK	0
CZ3767159	61-70	1	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0101,B3503,B3501,C0401,C0401	A03,A01,B07,B07,UNK,UNK	1
PW9935997	31-50	7	1	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A6901,B8501,B7801,C0102,C0706	A01,A03,A02,B07,B58,UNK,UNK	0
QK3513000	50-60	3	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A0201,B2702,B1501,C0202,C0501	A01,A02,B27,B44,UNK,UNK	0
ZK0945596	>71	9	1	0.98	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A0201,B1402,B5701,C0802,C0602	A01,A02,B27,B58,UNK,UNK	0
CC7023072	31-50	4	0	20.65	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A1101,A0201,B3501,B3501,C0303,C0401	A03,A02,B07,B07,UNK,UNK	1
CH7363773	31-50	3	1	6.89	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A0101,A0201,B1501,B1302,C0602,C0701	A01,A02,B44,UNK,UNK,UNK	0
EL2471113	31-50	4	0	5.9	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B4001,B3501,C0304,C0401	A03,A02,B44,B07,UNK,UNK	0
EP9462324	61-70	10	0	1.97	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0201,A0201,B1501,B6101,C1602,C0304	A02,A02,B62,B07,UNK,UNK	1
FU9469944	31-50	0	1	12.79	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2402,B5701,B3508,C1205,C0602	A03,A24,B58,B07,UNK,UNK	0
FT5582287	31-50	30	0	17.71	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A0101,B1801,B5801,C0701,C0706	A03,A01,B44,B58,UNK,UNK	0
HE3688595	>71	3	0	4.92	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0201,A0205,B4402,B1517,C0501,C0701	A02,A02,B44,B58,UNK,UNK	0
HJ7786699	>71	1	1	1.97	Combo	Esophagogastric Cancer	MSK-IMPACT	A0101,A0201,B0702,B1501,C0304,C0702	A01,A02,B07,B62,UNK,UNK	0
HM5244270	31-50	11	0	0	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0301,A2501,B3502,B3503,C0602,C0401	A03,A24,B07,B07,UNK,UNK	0
IQ9142766	31-50	7	0	20.66	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0201,A0205,B0702,B2705,C1602,C0702	A02,A02,B07,B27,UNK,UNK	0
JU4423803	31-50	4	0	15.74	PD-1/PDL-1	Melanoma	MSK-IMPACT	A1101,A2601,B3801,B4001,C0304,C1203	A03,A01,B27,B44,UNK,UNK	0
JI5397107	61-70	10	0	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A0201,B1801,B1302,C0602,C0701	A01,A03,A02,B44,UNK,UNK	0
KG9564615	50-60	26	1	0.98	Combo	Melanoma	MSK-IMPACT	A0101,A0201,B0801,B1801,C0701,C0701	A01,A02,B58,B44,UNK,UNK	1
KI1398482	31-50	1	0	3.94	Combo	Soft Tissue Sarcoma	MSK-IMPACT	A0101,A0201,B1402,B1302,C0602,C0706	A01,A02,B27,UNK,UNK,UNK	0
KZ4777043	31-50	19	0	0.84	Combo	Renal Cell Carcinoma	MSK-IMPACT	A2902,A2601,B1402,B1801,C1203,C0602	A01,A24,A01,B27,B44,UNK,UNK	0
NP9451180	61-70	17	0	3.94	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0101,B0702,B2701,C0602,C0702	A03,A01,B07,B44,UNK,UNK	0
RB4198564	50-60	33	0	5.9	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2601,A6801,B3701,B3503,C0401,C0602	A01,A03,B44,B07,UNK,UNK	0
OW7625404	50-60	30	0	13.77	CTLA4	Melanoma	MSK-IMPACT	A0301,A2402,B3501,B3503,C0401,C0401	A03,A24,B07,B07,UNK,UNK	1
PB7707126	31-50	40	0	33.45	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0201,B1501,B2503,C0304,C0401	A03,A02,B62,B07,UNK,UNK	0
TY5398981	>71	15	0	2.95	Combo	Cancer of Unknown Primary	MSK-IMPACT	A2601,A0205,B0705,B3501,C1606,C0602	A01,A24,A02,B07,B44,UNK,UNK	0
UZ8183372	31-50	0	1	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	B0277,A0201,B4402,B5101,C0501,C1502	A02,A02,B44,B07,UNK,UNK	0
WX0237661	31-50	25	0	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A0201,B0801,B1501,C0305,C0701	A24,A02,B08,B62,UNK,UNK	0
XS8239351	31-50	0	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6801,A0201,B1503,B1518,C0210,C0704	A23,A02,B27,B27,UNK,UNK	0

Y13351061	31-50	2	1	12.79	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0200,A2601,B0702,B3501,C1602,C0702	A02,A01,B07,B07,UNK,UNK	0		
ZG0386634	50-60	5	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B0702,B1501,C0501,C0702	A03,A02,B07,B44,UNK,UNK	0		
DJ2411021	61-70	7	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B0702,B3701,C0602,C0702	A03,A02,B07,B44,UNK,UNK	1		
DL2894586	61-70	2	0	3.77	PD-1/PDL-1	Salivary Gland Cancer	MSK-IMPACT	A2402,A0201,B0801,B3906,C0702,C0701	A24,A02,B08,B27,UNK,UNK	0		
EF2762650	31-50	17	0	89.52	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0302,A2402,B4601,B3501,C0103,C0401	A03,A24,B62,B07,UNK,UNK	0		
FJ2115060	31-50	6	0	3.94	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A3301,B1402,B3502,C0401,C0602	A01,A33,B27,B07,UNK,UNK	0		
FR3970048	31-50	1	1	8.85	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A1101,B5101,B3501,C0401,C1602	A01,A03,B07,B07,UNK,UNK	0		
GN2750852	50-60	39	1	6.89	CTLA4	Melanoma	MSK-IMPACT	A0101,A0201,B2705,B5701,C0102,C0602	A01,A02,B27,B58,UNK,UNK	0		
HG1736225	31-50	3	1	1.97	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A0301,A2402,B5701,B3501,C0602,C0401	A03,A24,B58,B07,UNK,UNK	0		
HH80178905	31-50	11	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0101,B3801,B3502,C1203,C0401	A03,A01,B27,B07,UNK,UNK	0		
IB0278541	31-50	20	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A6801,A0201,B2705,B3501,C0102,C0401	A03,A02,B27,B07,UNK,UNK	0		
IK2372268	61-70	1	0	4.92	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A0101,B0702,B0801,C0701,C0702	A03,A01,B07,B08,UNK,UNK	0		
IZ8823155	31-50	20	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0101,B0702,B0702,C0702,C0702	A03,A01,B07,B07,UNK,UNK	1		
JM9177596	50-60	5	0	3.94	Combo	Melanoma	MSK-IMPACT	A2603,A0205,B4101,B3501,C1205,C0701	A02,A02,B44,B27,UNK,UNK	0		
KC2683122	61-70	6	0	6.89	PD-1/PDL-1	Thyroid Cancer	MSK-IMPACT	A2402,A2402,B1302,B5101,C0102,C0602	A24,A24,UNK,B07,UNK,UNK	1		
KG9851106	31-50	37	0	2.95	CTLA4	Melanoma	MSK-IMPACT	A3401,A0207,B4601,B4002,C0102,C1502	UNK,A02,B62,B44,UNK,UNK	0		
L13259268	31-50	3	0	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A0201,B0801,B1501,C0303,C0701	A01,A02,B08,B62,UNK,UNK	0		
MP5108830	31-50	4	0	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A0201,B5501,B1501,C0305,C0701	A03,A02,B07,B44,UNK,UNK	0		
MW7076385	>71	0	1	0.98	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A1101,A2403,B0702,B3502,C0401,C0702	A03,A24,B07,B07,UNK,UNK	0		
MY5353343	31-50	2	1	3.94	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A2601,A6901,B6701,B5501,C0305,C1203	A01,A02,B07,B07,UNK,UNK	0		
RH8603784	61-70	2	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A6901,B4002,B3501,C0202,C1203	A02,A69,B40,B27,UNK,UNK	0		
RK1686881	31-50	9	1	8.85	Combo	Melanoma	MSK-IMPACT	A0301,A2402,B3503,B5101,C0102,C0401	A03,A24,B07,B07,UNK,UNK	0		
SI8576715	50-60	4	1	19.68	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3901,A2402,B1801,B1302,C0602,C0478	A01,A03,A24,B44,UNK,UNK,UNK	0		
UJ8398828	31-50	14	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601,A0201,B1401,B0801,C1203,C0701	A01,A02,B27,B08,UNK,UNK	0		
UT1948883	61-70	25	0	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B1801,B1801,C0701,C0701	A02,A02,B44,B44,UNK,UNK	1		
VU2365547	31-50	6	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3601,A0201,B3501,B3501,C0401,C0304	A01,A02,B07,B07,UNK,UNK	0		
YE3351113	50-60	7	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B0801,B0801,C0701,C0701	A02,A02,B08,B08,UNK,UNK	1		
ZT6995305	>71	35	0	14.76	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0201,A2601,B2705,B3801,C0202,C1203	A02,A01,B27,B27,UNK,UNK	0		
BG6557112	61-70	9	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A7401,A3303,B1503,B1503,C0210,C0210	A23,A33,B27,B27,UNK,UNK	1		
C8366827	31-50	9	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A6801,B4402,B5501,C0302,C0501	A01,A02,B44,B58,UNK,UNK	0		
D7569466	31-50	11	1	1.97	PD-1/PDL-1	Melanoma	MSK-IMPACT	A6901,A7401,B3910,B4403,C1505,C0401	A69,A74,B39,B44,UNK,UNK	0		
FD2668208	50-60	18	0	3.94	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A0201,B3501,B1902,C0401,C0602	A01,A02,B07,UNK,UNK,UNK	0		
GD54956503	61-70	3	1	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B4402,B4405,C0501,C0202	A24,A02,B44,B44,UNK,UNK	0		
IV9890629	61-70	3	1	0.98	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6901,A0207,B4002,B4402,C0304,C0501	A69,A02,B44,B44,UNK,UNK	0		
KF2714581	>71	10	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A2402,B3502,B3502,C0102,C0401	A24,A24,B35,B07,UNK,UNK	1		
LA7746581	>71	13	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A0101,B2705,B1501,C0303,C0202	A03,A01,B27,B62,UNK,UNK	0		
M1578443	31-50	2	0	0.98	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A6801,B3701,B6101,C1402,C0602	A01,A03,B44,B07,UNK,UNK	0		
MT8101843	31-50	4	1	5.74	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0101,B3801,B3701,C0602,C0701	A03,A01,B38,B44,UNK,UNK	0		
NP6949656	61-70	8	1	17.71	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2601,B3801,B5201,C1203,C1202	A03,A01,B27,B62,UNK,UNK	0		
NY6082269	31-50	7	0	0.98	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B4403,B4901,C1601,C0701	A24,A02,B44,UNK,UNK,UNK	0		
OE7040083	>71	8	0	0	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0101,A0201,B3902,B0801,C0702,C0701	A01,A02,B27,B08,UNK,UNK	0		
QN4594966	31-50	22	0	5.9	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0201,A0201,B5701,B1501,C0602,C0202	A02,A02,B58,B44,UNK,UNK	1		
PL3752255	50-60	4	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2402,B0702,B5701,C0602,C0702	A01,A24,B07,B58,UNK,UNK	0		
QF4863479	61-70	3	1	3.94	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A2402,A0201,B2705,B3501,C1801,C0702	A24,A02,B27,B07,UNK,UNK	0		
QC0131046	50-60	6	0	64.93	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B0801,B4901,C0701,C0701	A01,A02,B08,UNK,UNK,UNK	1		
QZZ1146810	31-50	8	1	19.68	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A2301,B3701,B4403,C0401,C0602	A03,A23,B44,B44,UNK,UNK	0		
RS4588156	50-60	7	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3101,A0201,B1301,B5102,C1502,C0801	A03,A02,UNK,B51,UNK,UNK	0		
TY6485092	31-50	0	0	8.85	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2601,B1801,B4403,C1601,C1203	A03,A01,B44,B44,UNK,UNK	0		
UW6356468	31-50	0	1	8.85	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A0205,B4001,B5101,C0304,C0602	A02,A02,B44,B44,UNK,UNK	0		
VT3851111	31-50	15	0	0.98	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0201,A6802,B1402,B4402,C0802,C0501	A02,A02,B27,B44,UNK,UNK	0		
WB9370014	50-60	6	0	4.92	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3002,A3201,B4101,B1501,C0501,C1701	A30,A32,B41,B44,UNK,UNK	0		
WM1423226	31-50	7	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2403,B3801,B3501,C0401,C1203	A03,A24,B27,B07,UNK,UNK	0		
XC7443652	31-50	9	1	16.72	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0301,A0201,B1402,B4402,C0801,C0802	A03,A02,B27,B44,UNK,UNK	0		
YA6033885	31-50	15	1	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A2601,B2705,B4403,C0401,C0202	A03,A01,B27,B44,UNK,UNK	0		
ZF3744437	61-70	11	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A2403,B3503,B5101,C0102,C0401	A03,A24,B35,B07,UNK,UNK	0		
AJ5881468	61-70	11	0	1.97	Combo	Melanoma	MSK-IMPACT	A0101,A2402,B0801,B1801,C0704,C0701	A01,A24,B08,B44,UNK,UNK	0		
CJ5412524	>71	7	0	26.56	Combo	Melanoma	MSK-IMPACT	A3201,A0201,B5501,B4501,C0802,C0602	A32,A02,B55,B44,UNK,UNK	1		
DR8901278	31-50	8	1	3.94	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2301,A0201,B4403,B3501,C0401,C0401	A23,A02,B44,B07,UNK,UNK	1		
EI4320052	61-70	11	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0205,A6802,B1801,B3502,C0801,C0602	A02,A02,B44,B58,UNK,UNK	0		
FA4577911	61-70	8	1	6	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A0201,A2601,B1801,B4402,C1203,C0501	A02,A01,B44,B44,UNK,UNK	0		
FV0688094	31-50	7	0	4.92	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A6801,B1402,B4403,C0602,C0401	A24,A03,B27,B44,UNK,UNK	0		
GY6751187	50-60	6	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A3303,B4201,B4403,C1701,C0706	A03,A33,B42,B44,UNK,UNK	0		
HD4329382	50-60	10	0	2.46	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B0702,B4402,C0501,C0702	A24,A02,B07,B44,UNK,UNK	0		
MR2833955	50-60	15	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B4402,B5101,C1402,C0501	A24,A02,B44,B07,UNK,UNK	0		
NH8366630	50-60	1	1	90.67	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402,A2301,B4403,B1302,C0401,C0602	A24,A23,B44,UNK,UNK,UNK	0		
PS1172801	50-60	3	1	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B4101,B4002,C0202,C1701	A03,A02,B44,B44,UNK,UNK	0		

GZ3305828	>71	15	0	3.94	CTLA4	Breast Cancer	MSK-IMPACT	A2301;A3402;B1503;B1302;C0804;C0210	A24,A03,B27,B07,UNK,UNK,UNK	0
RM6606755	50-60	2	0	9.84	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A3101;A0206;B5201;B3503;C1702;C0401	A03,A02,B62,B07,UNK,UNK	0
SF6685454	60-69	5	0	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A6901;A0101;B3502;B4402;C0401;C0704	A03,A01,B27,B44,UNK,UNK	0
SL3767922	31-50	0	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A0201;B4402;C0304;C0501	A03,A02,B44,B44,UNK,UNK	0
TP9431425	61-70	2	0	3.94	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0101;A0201;B0801;B1501;C0701;C0701	A01,A02,B08,B44,UNK,UNK	1
TU2961192	>71	2	1	4.92	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0205;A2402;B3701;B5301;C0802;C0802	A02,A24,B44,B44,UNK,UNK	1
WL7617475	50-60	9	0	12.79	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2402;A0201;B5501;B4801;C0102;C0701	A24,A02,B07,B07,UNK,UNK	0
WM3P70639	61-70	7	0	32.47	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A2301;B0702;B5501;C0102;C0702	A01,A24,B07,B07,UNK,UNK	0
WQ3553852	61-70	16	0	0.98	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101;A0201;B0702;B2705;C0202;C0702	A01,A02,B07,B27,UNK,UNK	0
XH115119	31-50	5	0	25.58	CTLA4	Melanoma	MSK-IMPACT	A3301;A2601;B1402;B3901;C0802;C1203	A03,A01,B27,B27,UNK,UNK	0
YC6211057	31-50	6	0	0.98	Combo	Melanoma	MSK-IMPACT	A1101;A2301;B4403;B4601;C1601;C0701	A03,A24,B44,B44,UNK,UNK,UNK	0
AN9597365	31-50	11	0	209.55	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2902;A0201;B4403;B4501;C1601;C1601	A01;A24,A02,B44,B44,UNK,UNK,UNK	1
AC0855857	31-50	3	0	2.95	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3001;A0201;B4402;B1302;C0802;C0501	A01;A03,A07,B44,B44,UNK,UNK,UNK	0
BA3210622	50-60	9	0	0.98	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101;A3101;B3502;B1501;C0401;C0701	A01;A03,B07,B44,UNK,UNK	0
BD5574032	31-50	13	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A2601;B0801;B1302;C0701;C0701	A01,A01,B08,UNK,UNK,UNK	1
BZ2775325	50-59	7	0	5.9	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201;A0201;B0702;B1401;C0802;C0702	A02,A02,B07,B27,UNK,UNK	1
C4091968	61-70	0	0	4.92	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0101;A0101;B5701;B1801;C0602;C0701	A01,A01,B44,B08,UNK,UNK	1
EX155661	31-50	10	0	8.85	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A0201;B5101;B3501;C0102;C0401	A03,A02,B07,B07,UNK,UNK	0
GP9685505	31-50	4	0	1.97	CTLA4	Breast Cancer	MSK-IMPACT	A0301;A0201;B1402;B3501;C0401;C0802	A03,A02,B27,B07,UNK,UNK	0
IP8405936	<30	13	0	16.72	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2301;A6802;B1801;B3501;C0401;C0701	A24,A02,B44,B07,UNK,UNK	0
IN5909938	61-70	0	1	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101;A0101;B1402;B1501;C1203;C0802	A01,A01,B27,B44,UNK,UNK	1
KF6205757	31-50	6	1	1.97	CTLA4	Breast Cancer	MSK-IMPACT	A0301;A0101;B0801;B1501;C0704;C0701	A03,A01,B08,B62,UNK,UNK	0
GL4766933	50-60	9	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A6601;B1402;B1302;C0802;C0602	A03,A03,B27,UNK,UNK,UNK	0
CP5718972	>71	3	0	6.89	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402;A3101;B2705;B3502;C0102;C0401	A24,A03,B27,B07,UNK,UNK	0
CR0994114	31-50	2	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A0201;B3501;B5101;C0401;C0202	A03,A02,B07,B07,UNK,UNK	0
GP9685505	31-50	4	0	1.97	CTLA4	Breast Cancer	MSK-IMPACT	A0301;A0201;B1402;B3501;C0401;C0802	A03,A02,B27,B07,UNK,UNK	0
GS2526841	50-60	10	1	6.89	Combo	Melanoma	MSK-IMPACT	A3004;A2301;B4403;B3901;C0706;C0706	A01;A24;B44;B58,UNK,UNK	1
GW7812135	31-50	15	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A0101;B0702;B0801;C0701;C0702	A03;A01;B07;B08;UNK,UNK	0
PN2231718	>71	7	0	2.95	PD-1/PDL-1	N/A	MSK-IMPACT	A3001;A0207;B4801;B1302;C0102;C0602	A01;A03,A02,B62,UNK,UNK,UNK	0
S2972004	50-60	2	1	11.81	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A3101;B0702;B0702;C0702;C0702	A03,A03,B07,B07,UNK,UNK	1
TH0389073	61-70	1	0	4.92	PD-1/PDL-1	Gastrointestinal Neuroendocrine Tumor	MSK-IMPACT	A0101;A2601;B4002;B5101;C1502;C0202	A01,A01,B44,B07,UNK,UNK	0
VR2453262	>71	14	0	11.81	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A3201;A0201;B2705;B3501;C1203;C0202	A01,A02,B27,B27,UNK,UNK	0
XM9411141	31-50	4	0	17.71	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601;A2501;B1801;B1901;C1203;C1203	A01,A01,B44,B44,UNK,UNK	1
XQ8316699	61-70	3	0	6.89	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402;A2402;B3906;B3502;C0401;C0702	A24,A24,B27,B07,UNK,UNK	1
XS9315703	61-70	2	1	0	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A2402;A3401;B1502;B1501;C0801;C0702	A24,UNK,B62,B62,UNK,UNK	0
XT1498820	50-59	12	0	8.85	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101;A0101;B1402;B5701;C0802;C0602	A01,A01,B27,B58,UNK,UNK	1
XV7538523	61-70	1	0	0	PD-1/PDL-1	Hodgkin Lymphoma	MSK-IMPACT	A0301;A0101;B0702;B5701;C0602;C0702	A03,A01,B07,B44,UNK,UNK	0
YT0036827	31-50	22	0	66.9	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0101;A2608;B0702;B1801;C0701;C0702	A01,A01,B07,B44,UNK,UNK	0
YW0265555	31-50	2	1	17.71	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2901;A0201;B2702;B1517;C0701;C0702	A01;A24,A02,B27,B58,UNK,UNK	0
YQ5111961	31-50	2	1	13.77	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6801;A6601;B2702;B1501;C0202;C1203	A03,A03,B27,B44,UNK,UNK	0
Z7339428	50-60	32	0	7.87	CTLA4	Melanoma	MSK-IMPACT	A1101;A2901;B0705;B4001;C1505;C0702	A03;A01;A24,B07,B44,UNK,UNK	0
EN3128934	31-50	12	0	46.34	Combo	Melanoma	MSK-IMPACT	A3201;A0201;B4402;B1801;C0501;C0706	A01,A02,B44,B58,UNK,UNK	0
FN1985636	61-70	14	1	4.92	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A3201;A0201;B0702;B1501;C0303;C0702	A01,A02,B07,B62,UNK,UNK	0
HH2559934	50-60	0	0	6.89	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0101;A0201;B0801;B4402;C0704;C0701	A01,A02,B08,B44,UNK,UNK	0
IC5060184	31-50	10	0	3.94	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301;A0201;B1402;B4101;C1701;C0802	A03,A02,B27,B44,UNK,UNK	0
LB4425555	50-60	1	0	2.95	PD-1/PDL-1	Anal Cancer	MSK-IMPACT	A1101;A3301;B1402;B3701;C0602;C0802	A03,A03,B27,B44,UNK,UNK	0
LF9222776	50-60	5	0	1.97	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201;A3101;B1501;B4402;C0102;C0501	A02,A03,B62,B44,UNK,UNK	0
LI7308609	31-50	5	1	1.81	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A6801;B0801;B4402;C0704;C0701	A01,A03,B08,B44,UNK,UNK	0
MA2899596	>71	4	1	9.84	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0201;A0201;B5501;B3501;C0401;C0602	A02,A02,B44,B07,UNK,UNK	0
ME7184412	<30	10	0	35.42	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201;A0201;B1401;B4402;C0802;C0501	A02,A02,B27,B44,UNK,UNK	1
MR7559177	>71	8	0	7.87	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A6601;A0205;B4403;B4102;C1601;C1701	A03,A02,B44,B44,UNK,UNK	0
NY6653367	31-50	14	0	24.59	Combo	Bladder Cancer	MSK-IMPACT	A0101;A2402;B0801;B4403;C1601;C0701	A01,A24,B08,B44,UNK,UNK	0
OP4818847	61-70	5	0	3.94	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402;A2902;B1501;B3501;C0503;C0303	A24,A01;A24,B62,B07,UNK,UNK	1
TQ9805536	<30	10	0	61.98	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A2402;A6801;B4001;B3508;C0401;C0701	A24,A03,UNK,B07,UNK,UNK	0
UC1823832	31-50	8	0	6.89	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A3101;A2601;B5801;B1302;C1203;C0602	A03;A01,B27,UNK,UNK,UNK	0
UJU347700	>71	1	1	15.74	Combo	Melanoma	MSK-IMPACT	A0301;A0101;B4001;B4402;C0304;C0501	A03,A01,B44,B44,UNK,UNK	0
UW0877254	>71	9	1	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A6101;A0205;B4403;B5501;C0602;C0706	A01,A02,B44,B44,UNK,UNK	0
VF477197	31-50	16	0	8.85	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101;A0206;B4801;B3502;C0401;C0803	A01,A02,B27,B07,UNK,UNK	0
VL0969609	50-60	1	1	1.97	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101;A0101;B0801;B2705;C0202;C0701	A01,A01,B08,B27,UNK,UNK	0
VP3084462	31-50	2	1	1.81	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0101;A3201;B2705;B5701;C0102;C0602	A01,A01,B27,B58,UNK,UNK	0
WP2334176	61-70	16	0	1.97	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0201;A3402;B0801;B5701;C0602;C0701	A02,A03,B08,B58,UNK,UNK	0
XB162513	31-50	4	1	3.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601;A2601;B2705;B3901;C0102;C1203	A01,A01,B27,B27,UNK,UNK	0
XK7227674	31-50	5	1	47.22	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101;A0201;B0801;B4402;C0501;C0701	A01,A02,B08,B44,UNK,UNK	0
XW4883938	60-69	3	0	59.03	PD-1/PDL-1	Melanoma	MSK-IMPACT	A1101;A0205;B4101;B3501;C0401;C1701	A03,A02,B44,B07,UNK,UNK	0
ZL1119783	50-60	11	0	12.79	Combo	Bladder Cancer	MSK-IMPACT	A0101;A6801;B5801;B5201;C1203;C1202	A01;A03,B27,B62,UNK,UNK	0
ZV5683438	31-50	5	1	7.87	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A6802;A0201;B3906;B1402;C0802;C0702	A02,A02,B27,B27,UNK,UNK	0
BJ4773480	31-50	4	1	13.77	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A0301;B2702;B3801;C1203;C0702	A03,A03,B27,B27,UNK,UNK	1

BY3504416	50-60	0	1	23.61	CTLA4	Esophagogastric Cancer	MSK-IMPACT	A0101,A0101,B0801,B3508,C0401,C0718	A0101,A0101,B08,B07,UNK,UNK	1
DW6168325	31-50	18	0	17.71	Combo	Melanoma	MSK-IMPACT	A0201,A0201,B0702,B5101,C1402,C0702	A02,A02,B07,B07,UNK,UNK	1
DW8779977	<30	0	0	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B0702,B4402,C0501,C0702	A02,A02,B07,B44,UNK,UNK	1
EH5389523	50-60	3	0	0	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A2901,A3303,B4403,B2705,C1502,C0706	A0,A24,A03,B44,B27,UNK,UNK	0
FW5931458	31-50	2	0	18.69	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A6601,B4402,B3501,C0501,C1203	A03,A02,B44,B27,UNK,UNK	0
HA119260	61-70	7	1	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0201,B2702,B1801,C0202,C1203	A03,A02,B27,B44,UNK,UNK	0
MG4190964	50-60	5	0	11.81	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B3502,B3508,C0401,C0602	A01,A02,B07,B07,UNK,UNK	0
NP5687710	61-70	12	0	14.76	Combo	Melanoma	MSK-IMPACT	A0301,A3301,B1402,B1402,C0202,C0602	A03,A03,B27,B27,UNK,UNK	1
QD5106935	50-60	4	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0101,B0801,B3502,C0401,C0701	A01,A01,B08,B07,UNK,UNK	1
PC9833805	50-60	28	1	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2902,B0702,B1402,C0802,C0702	A01,A01,A24,B07,B27,UNK,UNK	0
PS7913389	31-50	6	0	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0201,B1402,B4402,C0501,C0602	A03,A02,B27,B44,UNK,UNK	0
PT9804698	50-60	13	0	34.48	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3301,A3301,B1402,B1402,C0902,C0802	A03,A03,B27,B27,UNK,UNK	1
QT1113706	50-60	23	1	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2301,B0801,B4403,C0401,C0701	A01,A24,B08,B44,UNK,UNK	0
QZ1867852	31-50	39	0	92.38	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A2301,B0702,B4801,C0702,C0701	A03,A23,B07,UNK,UNK,UNK	0
ST1162140	50-60	6	0	7.87	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A0101,B0702,B3501,C0701,C0702	A03,A01,B07,B08,UNK,UNK	0
TI7316664	50-60	11	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B4402,B5101,C0102,C0501	A03,A02,B44,B07,UNK,UNK	0
YB0778622	61-70	42	0	3.94	CTLA4	Melanoma	MSK-IMPACT	A0301,A0201,B0702,B1501,C0702,C0701	A03,A02,B07,B44,UNK,UNK	0
VE5987541	50-60	15	0	4.92	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0206,B4801,B0501,C0205,C0718	A01,A02,B27,B08,UNK,UNK	0
WJ1386194	50-60	7	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A6802,B1402,B5101,C3802,C0501	A03,A02,B27,B07,UNK,UNK	0
WX3782279	50-60	18	0	17.71	Combo	Melanoma	MSK-IMPACT	A0201,A3201,B4402,B4801,C0501,C0701	A24,A01,B44,UNK,UNK,UNK	0
XK1628854	31-50	12	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2902,B5702,B4403,C1601,C0702	A03,A01,A24,B07,B44,UNK,UNK	0
XY1867168	31-50	39	0	21.64	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3201,A6801,B2702,B4403,C2202,C0401	A01,A03,B27,B44,UNK,UNK	0
AJ8911935	31-50	6	1	11.81	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0101,B0801,B1501,C0501,C0701	A03,A01,B08,B44,UNK,UNK	0
AK0529383	61-70	4	0	6.89	PD-1/PDL-1	Glioma	MSK-IMPACT	A3201,A0205,B5001,B3508,C0304,C0602	A01,A02,B44,B07,UNK,UNK	0
BY2277443	61-70	13	0	0.98	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A0203,B5201,B1301,C0304,C1202	A03,A02,B62,UNK,UNK,UNK	0
CU7141354	50-60	20	0	1.97	Combo	Bladder Cancer	MSK-IMPACT	A1101,A3303,B4403,B5501,C0102,C0706	A03,A03,B44,B07,UNK,UNK	0
DC5857108	31-50	1	1	1.97	Combo	Soft Tissue Sarcoma	MSK-IMPACT	A0201,A3101,B3901,B3508,C0401,C0702	A02,A03,B27,B07,UNK,UNK	0
DT8074697	61-70	10	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0201,B5501,B3501,C1502,C0401	A01,A02,B52,B07,UNK,UNK	0
FG3923387	31-50	12	1	5.9	PD-1/PDL-1	Ampullary Carcinoma	MSK-IMPACT	A0201,A2601,B3701,B1501,C0602,C0701	A02,A01,B44,B44,UNK,UNK	0
HE5368457	31-50	2	0	7.87	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A2601,B3801,B3521,C1203,C0701	A03,A01,B27,UNK,UNK,UNK	0
IE5056811	31-50	0	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B5701,B1801,C1203,C0602	A01,A01,B58,B44,UNK,UNK	0
KD9566653	61-70	11	0	5.74	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A6801,B1801,B5101,C1502,C0701	A24,A03,B44,B07,UNK,UNK	0
LU2433185	31-50	1	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B4402,B3501,C0401,C0501	A03,A02,B44,B07,UNK,UNK	0
LW5947198	61-70	10	1	2.95	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3002,A2402,B1503,B4402,C0304,C0401	A01,A24,B27,B44,UNK,UNK	0
MG8283401	50-60	20	0	2.79	Combo	Melanoma	MSK-IMPACT	A6801,A3301,B1402,B4402,C0802,C0704	A03,A03,B27,B44,UNK,UNK	0
MQ9395328	31-50	0	0	5.9	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A2902,A0201,B4403,B1501,C1501,C0701	A01,A24,A02,B44,B44,UNK,UNK	0
NR8864603	>71	16	0	7.87	Combo	Melanoma	MSK-IMPACT	A2902,A2601,B4403,B4402,C1601,C0501	A01,A24,A01,B44,B44,UNK,UNK	0
OU048054	50-60	4	1	2.95	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A2301,B1402,B1510,C0304,C0802	A03,A24,B27,B27,UNK,UNK	0
OC0434430	50-60	0	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B0701,B1501,C0401,C0602	A01,A02,B44,B62,UNK,UNK	0
PX4425160	50-60	1	1	19.68	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3001,A0101,B2705,B2705,C0202,C0602	A01/A03,A01,B27,B27,UNK,UNK	1
RM2842272	50-60	10	1	6.89	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0201,B4403,B3503,C0401,C0401	A01,A02,B44,B07,UNK,UNK	1
SK4986637	61-70	12	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A0101,B5701,B5701,C0602,C0602	A01,A01,B58,B58,UNK,UNK	1
SN3781137	31-50	0	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2601,B0702,B5701,C1203,C0702	A03,A01,B07,B07,UNK,UNK	0
SQ3858495	31-50	7	1	6.89	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6801,A0205,B0702,B1509,C0702,C0704	A03,A02,B07,B27,UNK,UNK	0
TE3705578	50-60	10	0	66.91	Combo	Melanoma	MSK-IMPACT	A0301,A0101,B0801,B3501,C0401,C0701	A03,A01,B08,B07,UNK,UNK	0
YC0940281	31-50	3	0	1.97	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0301,A0201,B4402,B4402,C0501,C0704	A03,A02,B44,B44,UNK,UNK	1
TO5291127	>71	5	0	2.95	Combo	Melanoma	MSK-IMPACT	A2601,A0201,B0702,B3521,C0303,C0702	A01,A02,B07,B07,UNK,UNK	0
UB8931860	31-50	2	1	0.98	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2402,A0201,B0702,B1501,C0303,C0702	A24,A02,B07,B62,UNK,UNK	0
VR2847789	61-70	13	0	22.63	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A3303,B4006,B5801,C0304,C0303	A02,A03,B44,B58,UNK,UNK	0
VX0792278	61-70	8	1	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0207,B4601,B1302,C0102,C0602	A24,A02,B62,UNK,UNK,UNK	0
WY3806901	50-60	6	0	25.58	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0201,A2601,B0702,B3501,C0401,C0702	A02,A01,B07,B07,UNK,UNK	0
XE6626384	50-60	11	0	11.81	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B0801,B0702,C0701,C0702	A01,A01,B08,B07,UNK,UNK	0
YR5867743	31-50	0	1	3.94	Combo	Pancreatic Cancer	MSK-IMPACT	A0301,A2402,B1402,B1402,C0802,C0802	A03,A24,B27,B27,UNK,UNK	1
ZT7922273	31-50	0	0	9.84	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A2403,A0205,B5001,B3501,C0401,C0602	A24,A02,B44,B07,UNK,UNK	0
AA9192963	>71	3	0	0.98	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A3001,A2402,B3503,B1516,C1601,C1203	A01/A03,A24,B57,B58,UNK,UNK	0
BB1146083	61-70	2	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0101,B0801,B4402,C0501,C0701	A03,A01,B08,B44,UNK,UNK	0
EI5749344	31-50	3	1	0	PD-1/PDL-1	Glioma	MSK-IMPACT	A3201,A0201,B5801,B5101,C1402,C1203	A01,A02,B27,B07,UNK,UNK	0
FM9347739	50-60	17	0	6.89	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2301,A0201,B4001,B4801,C0304,C0701	A24,A02,B44,UNK,UNK,UNK	0
GR6955300	50-60	28	1	1.97	CTLA4	Melanoma	MSK-IMPACT	A0201,A3301,B4201,B7801,C1701,C1601	A02,A03,B57,B07,UNK,UNK	0
JR7757194	61-70	3	1	11.81	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2403,A0201,B1801,B3901,C0401,C1203	A24,A02,B44,B07,UNK,UNK	0
JN1744372	31-50	12	0	35.42	Combo	Melanoma	MSK-IMPACT	A3002,A2601,B2705,B1501,C0102,C0501	A01,A01,B27,B44,UNK,UNK	0
JR6538183	50-60	1	1	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B0801,B4402,C0501,C0701	A01,A02,B08,B44,UNK,UNK	0
US2858386	31-50	15	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B0801,B3501,C0401,C0701	A01,A02,B08,B07,UNK,UNK	0
KI6345346	50-60	0	0	48.21	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B4403,B5101,C0102,C0501	A24,A02,B44,B07,UNK,UNK	0
KI2795675	>71	17	0	44.27	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A2402,B0702,B1801,C1203,C0702	A03,A24,B07,B44,UNK,UNK	0
LL7739824	50-60	12	1	1.97	CTLA4	Melanoma	MSK-IMPACT	A0101,A2402,B5701,B3502,C0401,C0602	A01,A24,B58,B07,UNK,UNK	0

MSG2435949	50-60	6	0	10.82	Combo	Melanoma	MSK-IMPACT	A3001,A0201,B1801,B1302,C0602,C0701	A01,A03,A02,B44,UNK,UNK,UNK	0
MV7268910	31-50	4	1	7.87	Combo	Melanoma	MSK-IMPACT	A0101,A6802,B5801,B1402,B5801,C0602,C0701	A01,A02,B08,B27,UNK,UNK	0
NP0365656	31-50	5	0	31.48	Combo	Melanoma	MSK-IMPACT	A0101,A0101,B0801,B5701,C0602,C0701	A01,A01,B08,B58,UNK,UNK	1
CH8226253	31-50	1	0	9.84	Combo	Small Cell Lung Cancer	MSK-IMPACT	A0301,A2402,B0702,B3508,C0401,C0702	A03,A24,B07,B07,UNK,UNK	0
OT8941168	61-70	9	1	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A1101,B1301,B5101,C0304,C1402	A03,A03,UNK,B07,UNK,UNK	1
SF8380178	31-50	37	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A2601,B0702,B4403,C0602,C0702	A03,A01,B07,B44,UNK,UNK	0
TB2285316	31-50	39	0	48.21	CTLA4	Melanoma	MSK-IMPACT	A0101,A2402,B0801,B5701,C0602,C0701	A01,A24,B08,B58,UNK,UNK	0
TX0130149	31-50	14	0	1.97	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A3201,B5201,B5701,C1202,C1202	A03,A01,B52,B52,UNK,UNK	1
UN8559698	50-60	0	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3303,A0201,B0702,B1801,C1203,C0702	A03,A02,B07,B44,UNK,UNK	0
YV7765396	>71	5	0	0	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A1101,A3101,B5201,B5101,C1502,C1202	A03,A03,B52,B07,UNK,UNK	0
YH8165303	31-50	5	0	5.9	PD-1/PDL-1	Thymic Cancer	MSK-IMPACT	A2902,A6801,B1402,B2702,C0202,C0202	A01,A24,A03,B27,B27,UNK,UNK	0
ZZ3483896	50-60	7	0	10.82	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3001,A3201,B3801,B1302,C0602,C1203	A01,A03,A01,B27,B27,UNK,UNK	0
AI2881139	61-70	29	1	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A3101,B2705,B1501,C0102,C0303	A01,A03,B27,B62,UNK,UNK	0
AZ4436523	50-60	17	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A2601,A3301,B0702,B1402,C0602,C0702	A01,A03,B07,B27,UNK,UNK	0
CM3747200	50-60	8	0	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B0801,B4201,C0304,C0701	A03,A02,B08,B44,UNK,UNK	0
CT8498635	61-70	11	1	1.97	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0201,A0206,B2705,B1302,C0303,C0602	A02,A02,B27,UNK,UNK,UNK	0
EN8787757	31-50	7	0	10.82	CTLA4	Melanoma	MSK-IMPACT	A0101,A2402,B2705,B5101,C0102,C0202	A01,A24,B27,B07,UNK,UNK	0
EZ2853373	31-50	29	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2602,A0207,B1501,B1501,C0303,C0503	A01,A02,B62,B62,UNK,UNK	1
FQ0772342	31-50	2	0	3.94	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A0201,B4001,B5701,C0304,C0602	A01,A02,B44,B58,UNK,UNK	0
HH0366557	50-60	14	0	1.97	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A3303,B0702,B4901,C0701,C0702	A03,A03,B27,UNK,UNK,UNK	0
IG3439855	>71	0	0	0.98	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3303,B3701,B5101,C1602,C0602	A01,A03,B44,B07,UNK,UNK	0
KB5268348	61-70	4	0	7.87	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0206,A3303,B0702,B1518,C1402,C0702	A02,A03,B07,B58,UNK,UNK	0
NN8911113	50-60	5	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A6802,B1402,B5901,C0602,C0706	A01,A02,B27,B58,UNK,UNK	0
MI1350504	50-60	9	0	6.89	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0201,A0201,B3503,B3503,C0401,C0401	A02,A02,B57,B07,UNK,UNK	1
MJ0173310	50-60	2	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A2402,A2601,B4101,B1801,C1701,C1203	A24,A01,B44,B44,UNK,UNK	0
KD9122864	31-50	7	0	0.98	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A3001,A6801,B4001,B4501,C0304,C0304	A01A03,A03,B44,B44,UNK,UNK	1
MH2413829	50-60	7	0	11.81	CTLA4	Melanoma	MSK-IMPACT	A2601,A0201,B1402,B3801,C0802,C1203	A01,A02,B27,B27,UNK,UNK	0
CW5833083	31-50	4	0	36.4	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3001,A6802,B4201,B1801,C0501,C1701	A01A03,A03,B27,B44,UNK,UNK	0
QE0352353	31-50	2	0	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2601,B0702,B6701,C1203,C0702	A03,A01,B07,B07,UNK,UNK	0
R7706143	31-50	6	0	7.87	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0201,A0201,B4402,B4402,C0501,C0704	A02,A02,B44,B44,UNK,UNK	1
S8277387	50-60	10	0	3.77	Combo	Melanoma	MSK-IMPACT	A1101,A2601,B3801,B3503,C0401,C1703	A03,A01,B27,B07,UNK,UNK	0
UE6714470	61-70	85	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2402,B2702,B4402,C0501,C0702	A01,A24,B07,B44,UNK,UNK	0
VE8628668	31-50	13	0	9.84	Combo	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2901,B0705,B1402,C0602,C1505	A03,A01,A24,B07,B27,UNK,UNK	0
VI8756864	>71	1	1	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A2601,B4402,B4701,C1604,C0602	A03,A01,B44,UNK,UNK,UNK	0
VS6841361	50-60	9	1	3.94	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A2402,B4901,B5201,C1202,C0701	A03,A24,UNK,B62,UNK,UNK	0
WE8258446	31-50	11	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2301,B4403,B5502,C0401,C0401	A01,A23,B44,B07,UNK,UNK	1
WX1943523	50-60	4	1	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A6801,A0201,B0702,B3501,C0401,C0702	A03,A02,B07,B07,UNK,UNK	0
YU6412238	50-60	3	1	4.92	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A2402,A0201,B3801,B4402,C1203,C0501	A24,A02,B27,B44,UNK,UNK	0
AU6963996	50-60	3	1	0.98	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A0205,B4402,B3503,C0401,C0501	A24,A02,B44,B07,UNK,UNK	0
DQ3604796	31-50	8	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2402,B0801,B3502,C0401,C0701	A01,A24,B08,B07,UNK,UNK	0
EE8529574	61-70	13	1	2.95	CTLA4	Melanoma	MSK-IMPACT	A0201,A0201,B3701,B3801,C1203,C0602	A02,A02,B41,B27,UNK,UNK	1
EJ8752278	61-70	9	0	1.97	Combo	Melanoma	MSK-IMPACT	A0301,A2402,B2702,B1501,C0303,C0202	A03,A23,B27,B62,UNK,UNK	0
GC7692217	31-50	0	0	17.71	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2902,B4403,B5801,C1601,C0701	A01,A01,A24,B44,B07,UNK,UNK	0
JD4116542	>71	2	1	3.94	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A1101,A0101,B0801,B4501,C1502,C0701	A03,A01,B08,B07,UNK,UNK	0
KA6895526	31-50	6	0	12.79	Combo	Melanoma	MSK-IMPACT	A0302,A0201,B4402,B3502,C0501,C0301	A03,A02,B44,B07,UNK,UNK	0
MA04-7034	31-50	8	0	14.78	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A0301,B1402,B1302,C0602,C0602	A01A03,A03,B27,UNK,UNK,UNK	0
MX4958834	50-60	1	1	4.92	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A1101,A6802,B4403,B7301,C0401,C0401	A03,A07,B44,B07,UNK,UNK	1
CM8035229	31-50	9	0	15.74	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2601,B1801,B3508,C1203,C0401	A24,A01,B44,B07,UNK,UNK	0
DO4159868	>71	16	0	65.91	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0101,A2902,B4403,C1601,C1505	A01,A01,A24,B27,B44,UNK,UNK	0
PF9876543	31-50	2	0	12.79	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A6801,B1501,B4102,C1701,C0701	A01,A03,B52,B44,UNK,UNK	0
R1168392	31-50	4	0	74.77	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A2601,B3701,B3801,C1203,C0602	A01,A01,B44,B27,UNK,UNK	0
RX2431136	50-60	13	0	11.81	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2601,B0801,B5201,C0504,C0210	A03,A01,B08,B07,UNK,UNK	0
SC4175308	50-60	2	1	7.87	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0301,A2402,B3501,B3508,C0401,C0401	A03,A24,B07,B07,UNK,UNK	0
T1094057	31-50	5	0	11.81	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2601,B3801,B3801,C1203,C1203	A24,A01,B27,B27,UNK,UNK	1
VM7211050	31-50	7	0	20.66	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201,A0201,B0702,B1801,C0702,C0702	A02,A02,B07,B44,UNK,UNK	1
WV6835569	61-70	12	0	7.87	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2902,A6801,B1518,B4403,C1601,C0704	A01A24,A03,B27,B44,UNK,UNK	0
KC6532229	31-50	2	1	13.77	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301,A0201,B2705,B4901,C0102,C0701	A24,A02,B27,UNK,UNK,UNK	0
ZJ8096402	61-70	9	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2902,A3301,B1402,B4403,C0602,C1601	A01A24,A03,B27,B44,UNK,UNK	0
AP5946866	31-50	21	0	35.42	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B1801,B4402,C0303,C0501	A24,A02,B52,B44,UNK,UNK	0
BD0402728	50-60	14	0	7.87	Combo	N/A	MSK-IMPACT	A2402,A0201,B0702,B3901,C0702,C0702	A24,A02,B07,B27,UNK,UNK	1
CS0248658	50-60	1	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A0201,B3901,B4402,C0501,C1203	A02,A02,B27,B44,UNK,UNK	0
DK7568867	61-70	5	0	4.92	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0301,A0101,B0801,B2503,C0401,C0701	A03,A01,B08,B07,UNK,UNK	0
EQ3811337	31-50	4	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A2902,B0801,B4403,C1601,C0701	A01,A01,A24,B08,B44,UNK,UNK	0
GO6627209	31-50	0	0	10.82	Combo	Small Cell Lung Cancer	MSK-IMPACT	B0301,A2601,B1801,B3503,C1203,C0701	A03,A01,B44,B07,UNK,UNK	0
GU2361132	50-60	1	1	3.94	PD-1/PDL-1	Anal Cancer	MSK-IMPACT	A0301,A6802,B3701,B5301,C0401,C0602	A03,A02,B44,B07,UNK,UNK	0
KA118425	31-50	3	0	1.89	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A0201,B1402,B4001,C0102,C0802	A24,A02,B27,B44,UNK,UNK	0

MJ236116	31-50	22	1	5.9	CTLA4	Pancreatic Cancer	MSK-IMPACT	A0201;A0201;B0801;B1501;C0303;C0701	A02;A02;B08;B62;UNK;UNK	1
PC3499930	31-50	3	0	3.94	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A3001;A1101;B0702;B1302;C0602;C0702	A01;A03;A03;B07;UNK;UNK;UNK	0
PW869809	50-60	8	0	16.72	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A0201;B0801;B4403;C0401;C0701	A01;A02;B08;B44;UNK;UNK	0
QZ8954733	31-50	16	0	0	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0301;A2402;B0702;B5501;C0102;C1203	A03;A24;B07;B07;UNK;UNK	0
SM4920988	50-60	8	0	2.95	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0101;A0201;B0702;B4001;C0304;C0602	A01;A02;B58;B44;UNK;UNK	0
S19643388	31-50	12	1	80.52	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301;A0201;B0702;B1801;C0304;C0702	A03;A02;B07;B62;UNK;UNK	0
TD0890094	61-70	4	0	8.85	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402;A0201;B0705;B3701;C1505;C0602	A24;A02;B07;B44;UNK;UNK	0
VF7308164	31-50	11	0	8.85	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402;A6801;B5501;B3502;C0303;C0401	A24;A02;B07;B07;UNK;UNK	0
XW5509252	31-50	0	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A0201;B0801;B4101;C1701;C0701	A01;A02;B08;B44;UNK;UNK	0
BL451101	31-50	3	1	1.97	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A3001;A0301;B0702;B5703;C0701;C0702	A01;A03;A03;B07;B58;UNK;UNK	0
CP4378800	61-70	2	0	0.98	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3001;A0201;B0801;B3501;C1203;C0701	A01;A03;A02;B08;B27;UNK;UNK	0
DH0837227	>71	1	1	12.79	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0101;A0201;B5701;B5701;C0602;C0602	A01;A02;B58;B58;UNK;UNK	1
EY6179944	>71	3	0	65.91	PD-1/PDL-1	N/A	MSK-IMPACT	A0207;A3303;B4601;B4801;C0102;C0302	A02;A03;B52;B58;UNK;UNK	0
FOR188879	>71	22	0	68.87	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A1101;A0201;B1302;B3501;C0401;C0602	A03;A02;UNK;B07;UNK;UNK	0
IT8882206	61-70	15	0	8.85	Combo	Renal Cell Carcinoma	MSK-IMPACT	A1101;A6801;B1402;B3501;C0202;C0704	A03;A03;B27;B07;UNK;UNK	0
GC4143605	50-60	10	0	5.9	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301;A2402;B4001;B4402;C1701;C1604	A03;A24;B44;B44;UNK;UNK	0
JL0356420	50-60	5	1	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A3601;A1101;B0801;B5201;C1202;C0701	A01;A03;A01;B08;B62;UNK;UNK	0
KJ592397	50-60	14	0	4.92	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101;A0201;E0801;B4402;C0501;C0701	A01;A02;B08;B44;UNK;UNK	0
LE5083915	>71	12	1	23.61	Combo	Bladder Cancer	MSK-IMPACT	A2301;A2301;B4001;B1516;C1402;C1701	A24;A24;B07;B58;UNK;UNK	1
MA0869890	50-60	0	1	4.92	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3001;A2402;B0801;B3502;C0401;C0701	A01;A05;A24;B08;B07;UNK;UNK	0
NL203214	>71	9	0	10.82	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2402;A0201;B5701;B5101;C0102;C0602	A24;A02;B58;B07;UNK;UNK	0
RE7563358	<30	11	0	22.63	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101;A3101;B0801;B4701;C0602;C0701	A01;A03;B08;UNK;UNK;UNK	0
RY6313131	50-60	12	0	5.9	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201;A0201;B1401;B5101;C0602;C0202	A02;A02;B07;B07;UNK;UNK	1
SD9092013	31-50	0	1	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A6801;B0801;B3503;C0401;C0701	A01;A03;B08;B07;UNK;UNK	0
SH2712775	50-60	7	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101;A6801;B0705;B5101;C1402;C0702	A03;A03;B07;B07;UNK;UNK	0
TT7760421	31-50	0	0	10.82	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2601;A0205;B0801;B5501;C0602;C0702	A01;A02;B08;B44;UNK;UNK	0
TU9043433	61-70	6	1	5.9	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0101;A3301;B1402;B5701;C0802;C0602	A01;A03;B27;B58;UNK;UNK	0
UP2772365	31-50	8	1	16.72	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A0101;B0801;B3502;C0401;C0701	A01;A01;B08;B07;UNK;UNK	1
WS9839881	61-70	2	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402;A2601;B3801;B1801;C1203;C1203	A24;A01;B27;B44;UNK;UNK	1
XK4128776	61-70	11	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101;A2902;B4403;B4402;C1601;C0501	A01;A01;A24;B44;B44;UNK;UNK	0
YT6865462	50-60	25	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2901;A0201;B4002;B5108;C0202;C1602	A01;A24;A02;B44;B07;UNK;UNK	0
YX1936535	<30	19	0	38.37	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402;A0205;B3801;B5201;C0102;C1203	A24;A02;B27;B62;UNK;UNK	0
ZF2254339	50-60	2	0	1.97	PD-1/PDL-1	Anal Cancer	MSK-IMPACT	A2402;A3303;B4402;B3503;C0501;C1203	A24;A03;B44;B07;UNK;UNK	0
AN8017216	50-60	26	1	4.92	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0201;A0201;B1801;B1801;C0701;C0701	A02;A02;B44;B44;UNK;UNK	1
AP7B3434	31-50	6	0	3.94	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301;A3002;B0702;B5101;C1502;C0702	A03;A03;B07;B07;UNK;UNK	0
BE0998274	31-50	1	1	4.92	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A3301;A3301;B1402;B1402;C0602;C0602	A03;A03;B27;B27;UNK;UNK	1
CR1961193	50-60	2	1	2.95	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A3001;A2601;B1801;B1302;C1203;C0602	A01;A03;A01;B44;UNK;UNK	0
CM5512065	50-60	8	0	7.87	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301;A2902;B1510;B1302;C0304;C0602	A03;A01;A24;B27;UNK;UNK	0
HC2216759	61-70	26	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402;A0201;B4403;B3503;C1203;C1601	A24;A02;B44;B07;UNK;UNK	0
IO1699657	50-60	3	1	5.9	PD-1/PDL-1	N/A	MSK-IMPACT	A2301;A0201;B1503;B4403;C0210;C0708	A24;A02;B27;B44;UNK;UNK	0
MD5707774	50-60	8	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301;A0201;B1401;B4403;C0401;C0602	A24;A02;B27;B44;UNK;UNK	0
PJ7229478	31-50	8	0	13.29	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A6802;A0205;B5501;B5301;C0401;C0602	A02;A02;B44;B07;UNK;UNK	0
XF8707086	61-70	13	0	2.95	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0101;A6801;B3701;B4201;C0304;C0602	A01;A03;B44;B44;UNK;UNK	0
YL892257	31-50	27	0	33.45	CTLA4	Melanoma	MSK-IMPACT	A6801;A0201;B4001;B4701;C0304;C0602	A03;A02;B44;UNK;UNK;UNK	0
ZH5867728	31-50	12	1	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301;A2601;B5101;B1302;C1402;C0602	A03;A01;B07;UNK;UNK;UNK	0
ZW7258053	31-50	3	1	0.98	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002;A3201;B1801;B1801;C0303;C0501	A01;A01;B62;B44;UNK;UNK	0
BN1634008	31-50	2	1	5.9	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A1101;A1101;B4403;B5201;C1502;C1601	A03;A03;B44;B62;UNK;UNK	1
BV6562107	31-50	4	0	7.87	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101;A0201;B0801;B2705;C0202;C0701	A01;A02;B08;B27;UNK;UNK	0
EP8226139	31-50	0	1	12.79	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A3002;A3301;B1402;B3901;C0802;C1203	A01;A03;B27;B27;UNK;UNK	0
HC8777932	31-50	16	0	2.95	Combo	Bladder Cancer	MSK-IMPACT	A2402;A0203;B5502;B5801;C0102;C1203	A24;A02;B07;B07;UNK;UNK	0
HI7636916	61-70	0	1	1.97	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0301;A1101;B0702;B3502;C0401;C0702	A03;A03;B07;B07;UNK;UNK	0
IR0740431	50-60	3	1	0.98	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2403;A6801;E0801;B4801;C1203;C0701	A24;A03;B27;UNK;UNK;UNK	0
IV4871165	61-70	9	0	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201;A3201;B5501;B4402;C0303;C0501	A02;A01;B07;B44;UNK;UNK	0
JP3891116	31-50	42	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301;A6801;B4102;B4901;C1701;C0701	A24;A03;B44;UNK;UNK;UNK	0
KJ2338943	50-60	10	0	8.85	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2301;A0201;B4101;B5101;C1701;C1601	A24;A02;B44;B07;UNK;UNK	0
MB5993937	50-60	0	0	2.95	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2902;A0201;B0702;B4403;C0705;C1601	A01;A24;A02;B07;B44;UNK;UNK	0
MN1135641	61-70	18	0	8.85	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0201;A0201;B0702;B3901;C1203;C0702	A02;A02;B07;B27;UNK;UNK	1
QC8398655	50-60	11	1	12.79	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101;A0201;B4101;B5101;C1802;C1701	A01;A02;B44;B07;UNK;UNK	0
RI6456610	31-50	18	0	15.74	PD-1/PDL-1	N/A	MSK-IMPACT	A0101;A0201;B0801;B4501;C0304;C0701	A01;A02;B08;B44;UNK;UNK	0
TF1132355	31-50	3	1	1.97	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A1101;A3101;E0801;B4501;C1203;C0602	A03;A03;B27;B44;UNK;UNK	0
WF1584442	31-50	1	1	3.94	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A3002;A0201;B0702;B1801;C0501;C0702	A01;A02;B07;B44;UNK;UNK	0
WW9621784	31-50	12	0	5.9	PD-1/PDL-1	Melanoma	MSK-IMPACT	A6802;A0201;B4403;B1801;C0501;C0401	A02;A02;B44;B44;UNK;UNK	0
CA3994706	31-50	0	1	6.89	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A6801;A0201;B4402;B5701;C0602;C0708	A03;A02;B44;B58;UNK;UNK	0
DB7419328	31-50	0	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101;A0201;B6801;B1510;C0304;C0701	A01;A02;B68;B27;UNK;UNK	0
DT1062330	31-50	0	1	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101;A3301;B2705;B1402;C0202;C0802	A03;A03;B27;B27;UNK;UNK	0

FV1298697	31-50	9	0	19.68	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A0205,B3801,B1801,C0501,C1203	A01,A02,B27,B44,UNK,UNK	0
GI1764741	31-50	4	1	4.92	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0301,A0201,B0702,B0702,C0702,C0702	A03,A02,B07,B07,UNK,UNK	1
HR1650562	60-69	13	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2902,B1402,B4403,C0802,C1601	A03,A01,A24,B27,B44,UNK,UNK	0
IY582475	61-70	1	1	0	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0201,A3101,B5601,B5501,C0102,C0802	A02,A03,B07,B44,UNK,UNK	0
LR544436	31-50	5	0	13.77	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3001,A1101,B5201,B3501,C0401,C1202	A01,A03,A03,B62,B07,UNK,UNK	0
LZ59694	61-70	4	0	6.89	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A0201,B3702,B5701,C0802,C0602	A01,A02,B07,B58,UNK,UNK	1
NU555118	61-70	1	1	25.58	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A0301,A0201,B1801,B5701,C0602,C0701	A03,A02,B44,B58,UNK,UNK	0
NO5584430	50-60	2	1	4.92	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A0101,A0201,B4402,B4101,C0104,C1604	A01,A02,B44,B44,UNK,UNK	0
PO3999962	>71	1	1	11.81	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0202,A0201,B3508,B1801,C1601,C0401	A02,A02,B07,B44,UNK,UNK	0
GQ1229988	31-50	2	1	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A1101,B3501,B4801,C0401,C0701	A01,A03,B07,UNK,UNK,UNK	0
RA448371	31-50	7	1	24.59	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0201,A0201,B1507,B4402,C0303,C0501	A02,A02,B62,B44,UNK,UNK	1
LI1839273	31-50	14	0	6.89	PD-1/PDL-1	Cervical Cancer	MSK-IMPACT	A1101,A0101,B4402,B0801,C0501,C0701	A03,A01,B44,B08,UNK,UNK	1
UU457916	<30	24	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3301,A0201,B3501,B2801,C0401,C0706	A01,A03,B07,B58,UNK,UNK	0
VQ3447655	50-60	1	1	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A6802,B3502,B1501,C0501,C0401	A01,A02,B07,B44,UNK,UNK	0
YI6689458	31-50	9	0	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A2402,A2601,B3801,B3502,C0401,C1203	A24,A01,B27,B07,UNK,UNK	0
ZX3503297	61-70	25	0	1.97	Combo	Esophagogastric Cancer	MSK-IMPACT	A0201,A0201,B5101,B4501,C1502,C0602	A02,A02,B07,B44,UNK,UNK	1
AF4268478	61-70	11	0	3.94	Combo	Melanoma	MSK-IMPACT	A2403,A0201,B0705,B3501,C1505,C0401	A24,A02,B07,B07,UNK,UNK	0
AH2169625	61-70	19	0	2.95	Combo	Renal Cell Carcinoma	MSK-IMPACT	A1101,A0205,B5001,B3508,C0401,C0602	A03,A02,B44,B07,UNK,UNK	0
CB8857147	50-60	3	1	5.9	CTLA4	Breast Cancer	MSK-IMPACT	A1101,A2407,B3802,B3802,C0702,C0702	A03,UNK,UNK,UNK,UNK,UNK	1
DP8577913	31-50	8	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3401,A0201,B1502,B3505,C0401,C0801	UNK,A02,B62,B07,UNK,UNK	0
FF987914	>71	5	1	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A2601,B3806,B3801,C1203,C1203	A02,A01,B27,B27,UNK,UNK	1
CI2870894	>71	11	0	9.84	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A1101,A3303,B0705,B3801,C0302,C0702	A03,A03,B07,B58,UNK,UNK	0
HB207672	61-70	15	0	8.85	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0101,A0201,B2704,B3502,C0401,C0702	A01,A02,B07,B07,UNK,UNK	0
IK144116	>71	0	0	1.97	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A0301,A3001,B0702,B4201,C1701,C0702	A03,A01,A03,B07,B07,UNK,UNK	0
IL1126662	31-50	0	1	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A3201,B5201,B5101,C0102,C1202	A03,A01,B62,B07,UNK,UNK	0
KN1868588	>71	8	0	3.94	PD-1/PDL-1	Embryonal Tumor	MSK-IMPACT	A0201,A0205,B4101,B4502,C0202,C0701	A02,A02,B44,B44,UNK,UNK	0
LD8487761	>71	35	0	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2301,A0201,B1801,B5101,C1402,C0701	A01,A02,B44,B07,UNK,UNK	0
LJ2133345	61-70	17	0	5.9	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0301,A2601,B4001,B4403,C1403,C0304	A03,A01,B44,B44,UNK,UNK	0
LJ4134431	50-60	12	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0207,B6701,B5904,C0102,C0702	A03,A02,B07,B07,UNK,UNK	0
LQ937165	>71	9	0	47.22	Combo	Colorectal Cancer	MSK-IMPACT	A0101,A3101,B4101,B4301,C0304,C1701	A01,A03,B44,B44,UNK,UNK	0
LZ6964650	50-60	1	1	7.87	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A3001,A2601,B4403,B1302,C0401,C0602	A01,A03,A24,B44,UNK,UNK	0
OZ8126816	61-70	1	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0207,A0207,B4601,B4502,C0102,C0102	A02,A02,B62,B62,UNK,UNK	1
PQ4084463	61-70	6	1	11.81	Combo	Melanoma	MSK-IMPACT	A2402,A3101,B4402,B3901,C1604,C1205	A24,A03,B44,B27,UNK,UNK	0
PS7266658	31-50	3	0	6.89	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2301,A0201,B1801,B4801,C0701,C0701	A24,A02,B44,UNK,UNK,UNK	1
R8741231	31-50	18	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6801,A2901,B1518,B5301,C0602,C0704	A03,A01,A24,B27,B44,UNK,UNK	0
RD2498703	>71	5	1	51.16	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A0201,B0702,B5901,C0702,C0706	A01,A02,B07,B58,UNK,UNK	0
RV6981815	<30	11	1	24.59	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0201,B0801,B6801,C0718,C0706	A01,A02,B08,B58,UNK,UNK	0
RX2351147	31-50	2	0	4.92	CTLA4	Prostate Cancer	MSK-IMPACT	A0301,A0201,B1501,B3501,C0303,C0702	A03,A02,B62,B07,UNK,UNK	0
TW5650937	31-50	7	1	1.97	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2901,A6801,B4101,B4402,C1701,C0704	A01,A24,A03,B44,B44,UNK,UNK	0
VF6744691	50-60	3	0	4.92	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402,A2402,B1801,B1801,C0701,C0701	A24,A24,B44,B44,UNK,UNK	1
VT1380023	31-50	7	0	37.38	CTLA4	Melanoma	MSK-IMPACT	A0101,A2601,B0801,B3801,C1203,C0701	A01,A01,B58,B27,UNK,UNK	0
YH9617351	61-70	5	1	4.92	Combo	Head and Neck Cancer	MSK-IMPACT	A3002,A1101,B4403,B5301,C0401,C0706	A01,A03,B44,B07,UNK,UNK	0
ZK8102313	31-50	3	1	2.95	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2902,B1801,B5501,C1203,C0706	A24,A01,A24,B44,B58,UNK,UNK	0
ZQ1582110	50-60	15	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0205,A0206,B1501,B4801,C0303,C0706	A02,A02,B62,B58,UNK,UNK	0
BF6805839	31-50	15	0	19.68	CTLA4	Melanoma	MSK-IMPACT	A6601,A6801,B5501,B3502,C0303,C0301	A03,A02,B07,B07,UNK,UNK	0
DG1001147	31-50	8	0	23.61	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A2601,B4403,B5301,C1601,C0401	A01,A01,B44,B07,UNK,UNK	0
DR5708890	31-50	11	0	1.97	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A3101,A3303,B0702,B6701,C1503,C0702	A03,A03,B07,B07,UNK,UNK	0
EO8010001	50-60	5	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2902,A0201,B4403,B4003,C0304,C1601	A01A24,A02,B44,B44,UNK,UNK	0
FU924504	>71	0	1	8.85	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A6801,B3701,B4001,C0304,C0602	A01,A03,B44,B44,UNK,UNK	0
EY8653084	61-70	1	1	1.97	Combo	Melanoma	MSK-IMPACT	A0301,A3201,B0702,B4002,C0202,C0702	A03,A01,B07,B44,UNK,UNK	0
FC0677855	50-60	6	1	2.95	Combo	Pancreatic Cancer	MSK-IMPACT	A0201,A0201,B1501,B3501,C0102,C0401	A02,A02,B62,B07,UNK,UNK	1
GR1143855	31-50	7	1	13.77	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A2402,B3502,B1801,C0401,C0501	A01,A24,B07,B44,UNK,UNK	0
JD8698822	50-60	0	1	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A3001,B1801,B1801,C0210,C0210	A01A03,A01A03,B44,B44,UNK,UNK	1
JI9686544	31-50	0	0	3.94	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A2301,A3303,B5301,B3501,C0401,C0602	A24,A03,B07,B07,UNK,UNK	1
KM672281	31-50	32	0	8.85	CTLA4	Melanoma	MSK-IMPACT	A0201,A0201,B3801,B3503,C0401,C1203	A02,A02,B27,B07,UNK,UNK	1
MP4909889	31-50	5	0	20.66	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A0101,B4701,B5201,C1502,C0602	A01,A01,UNK,B62,UNK,UNK	1
NE455314	31-50	9	1	2.95	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0301,A0301,B0702,B0702,C0702,C0702	A03,A03,B07,B07,UNK,UNK	1
NO5901306	>71	10	1	1.97	Combo	Melanoma	MSK-IMPACT	A2402,A2601,B0702,B0702,C0202,C0702	A24,A01,B07,B27,UNK,UNK	0
NW7014435	61-70	12	1	4.92	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A0206,B4601,B4101,C0102,C0304	A03,A02,B62,B44,UNK,UNK	0
NY2944451	>71	0	1	6.89	Combo	Melanoma	MSK-IMPACT	A0201,A2601,B2705,B4402,C0102,C0501	A02,A01,B27,B44,UNK,UNK	0
QD5637077	31-50	2	1	0	PD-1/PDL-1	Mesothelioma	MSK-IMPACT	A0301,A0201,B0702,B5101,C1502,C0702	A03,A02,B07,B07,UNK,UNK	0
PQ0319402	31-50	2	0	0.98	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0301,A0101,B1402,B5701,C0802,C0602	A03,A01,B27,B58,UNK,UNK	0
QJ4326878	50-60	15	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A2402,B5601,B3502,C0303,C0401	A03,A24,B07,B07,UNK,UNK	0
TE7486331	>71	16	0	8.85	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A2402,A2601,B1402,B5201,C0802,C1202	A24,A01,B27,B62,UNK,UNK	0
YT6356343	31-50	22	0	3.94	Combo	Melanoma	MSK-IMPACT	A1101,A0101,B3801,B5701,C1203,C0602	A03,A01,B27,B58,UNK,UNK	0
BF3557001	31-50	13	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A2601,B1801,B4501,C1801,C1203	A02,A01,B44,B44,UNK,UNK	0

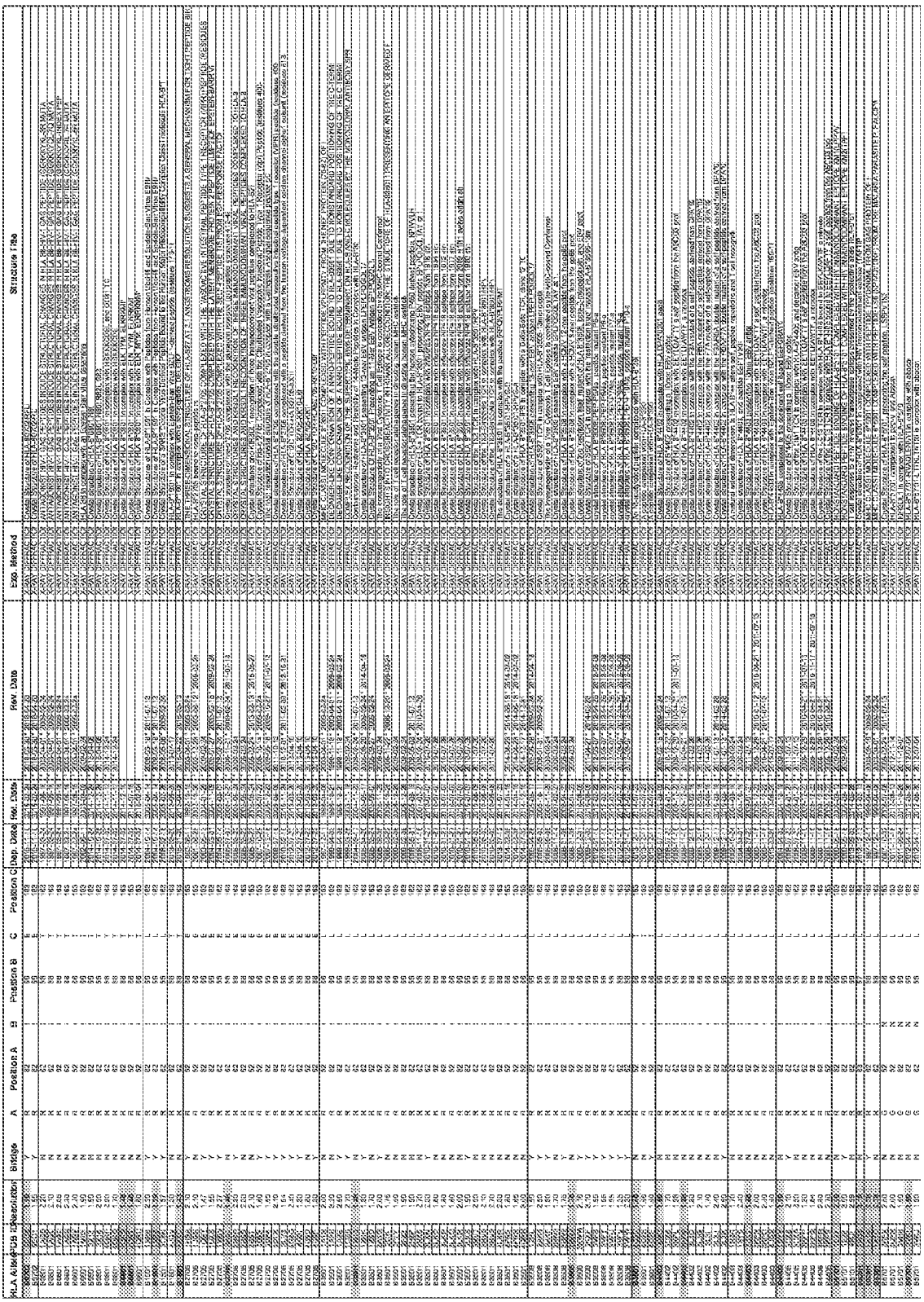
BQ621217	31-50	13	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0200,A3101,B0801,B1801,C0701,C0701	A02,A03,B08,B44,UNK,UNK	1
BW558321	50-60	11	0	4.92	Combo	Melanoma	MSK-IMPACT	A2301,A2601,B3801,B4501,C1703,C0701	A23,A01,B27,UNK,UNK,UNK	0
CW341651	31-50	9	0	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A3303,B4403,B3501,C0401,C0401	A02,A03,B44,B07,UNK,UNK	1
CZ808459	31-50	11	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A2601,A6801,B3801,B1902,C0802,C1203	A01,A03,B27,UNK,UNK,UNK	0
DH341617	>71	12	1	3.94	Combo	Melanoma	MSK-IMPACT	A0201,A0201,B4402,B5101,C0102,C0501	A02,A02,B44,B07,UNK,UNK	1
EP953249	61-70	5	0	23.61	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301,A3101,B4403,B3506,C0401,C0401	A23,A03,B44,B07,UNK,UNK	1
EJ708178	>71	3	1	0.98	CTLA4	Breast Cancer	MSK-IMPACT	A0301,A0201,B2705,B3503,C0102,C1203	A03,A02,B27,B07,UNK,UNK	0
EP098137	31-50	3	1	9.84	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0302,A0201,B5201,B1302,C0502,C1202	A03,A02,B62,UNK,UNK,UNK	0
HD143613	31-50	3	1	11.81	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A0201,B0702,B3503,C0401,C0702	A03,A02,B07,B07,UNK,UNK	0
HY936822	>71	0	1	33.45	Combo	Melanoma	MSK-IMPACT	A0101,A3201,B1801,B3502,C0401,C0701	A01,A01,B44,B07,UNK,UNK	0
IE795484	31-50	3	0	37.36	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0101,B0801,B2705,C0202,C0701	A03,A01,B08,B27,UNK,UNK	0
IJ483188	50-60	11	0	1.97	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A0201,A0201,B5801,B1501,C0304,C0303	A02,A02,B07,B62,UNK,UNK	1
IM831482	50-60	8	0	5.9	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3002,A0201,B4402,B3501,C0501,C0401	A01,A02,B44,B07,UNK,UNK	0
IM305672	61-70	1	1	9.84	Combo	Melanoma	MSK-IMPACT	A1101,A3101,B3503,B5101,C0202,C0401	A03,A03,B07,B07,UNK,UNK	0
IY740980	31-50	15	0	2.95	Combo	Renal Cell Carcinoma	MSK-IMPACT	A2402,A6801,B2705,B1801,C1502,C0701	A24,A03,B27,B44,UNK,UNK	0
LJ501075	61-70	11	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A6801,A0201,B1402,B4402,C0501,C0802	A03,A02,B27,B44,UNK,UNK	0
QA401786	31-50	15	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B0702,B4405,C0202,C0702	A02,A02,B07,B44,UNK,UNK	1
SE559393	31-50	2	0	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2501,B1402,B4801,C0802,C0701	A03,A24,B27,UNK,UNK,UNK	0
TX409749	50-60	8	1	8.85	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A2601,B1501,B4001,C0304,C0303	A03,A01,B52,B44,UNK,UNK	0
UA037737	61-70	0	1	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A3101,B0801,B5101,C0701,C0701	A03,A03,B08,B07,UNK,UNK	1
VU634628	31-50	10	0	1.97	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A0101,B5801,B0801,C0701,C0701	A01,A01,B58,B08,UNK,UNK	1
WF6235658	31-50	20	0	5.9	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A2601,A2601,B3801,B5101,C1502,C1203	A01,A01,B27,B07,UNK,UNK	1
XU469851	>71	17	0	0.98	PD-1/PDL-1	Bone Cancer	MSK-IMPACT	A6601,A0201,B4402,B4402,C1701,C0704	A03,A02,B44,B44,UNK,UNK	0
BR857502	31-50	12	1	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2402,B4402,B3801,C0304,C1203	A03,A24,B44,B27,UNK,UNK	0
DE436582	31-50	5	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A3001,B5001,B4501,C1601,C0701	A01/A03,A01/A03,B44,B44,UNK,UNK	1
DK783827	50-60	15	0	2.95	Combo	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2601,B2705,B1402,C0102,C0802	A03,A01,B27,B27,UNK,UNK	0
EB386647	<30	4	1	36.4	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A6801,B0801,B3701,C0602,C0701	A01,A03,B08,B44,UNK,UNK	0
EU139856	>71	2	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3101,A3101,B1508,B1508,C0102,C0102	A03,A03,B07,B07,UNK,UNK	1
HG213091	31-50	1	0	5.9	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A6801,A0201,B3502,B4402,C0401,C1502	A03,A02,B07,B44,UNK,UNK	0
HH290548	61-70	4	0	203.64	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A3001,A2402,B4702,B3501,C0305,C0304	A01/A03,A24,B44,B07,UNK,UNK	0
JF961036	31-50	1	0	50.17	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B4402,B4402,C0501,C1604	A24,A02,B44,B44,UNK,UNK	1
KF585579	31-50	3	0	5.9	CTLA4	Pancreatic Cancer	MSK-IMPACT	A6801,A6802,B1402,B2702,C0802,C0202	A03,A02,B27,B27,UNK,UNK	0
KQ267493	61-70	7	0	14.76	CTLA4	Soft Tissue Sarcoma	MSK-IMPACT	A2603,A2601,B3901,B3901,C1205,C1205	A01,A01,B27,B27,UNK,UNK	0
MB313963	50-60	0	0	5.9	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A3004,A2501,B4801,B4801,C0701,C0701	A01,A24,UNK,UNK,UNK,UNK	1
PV916704	>71	0	0	7.87	PD-1/PDL-1	Glioma	MSK-IMPACT	A2301,A0201,B1402,B4402,C0802,C0501	A24,A02,B27,B44,UNK,UNK	0
QM126917	31-50	2	1	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2402,B4402,B1501,C1504,C0701	A03,A24,B44,B44,UNK,UNK	0
QP194424	<30	5	1	62.36	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0201,A0201,B0702,B4402,C0501,C0702	A02,A02,B07,B44,UNK,UNK	1
RD412780	31-50	11	0	5.9	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3201,A3303,B2705,B1801,C1203,C1502	A01,A03,B27,B44,UNK,UNK	0
RK967996	>71	15	0	1.97	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A1101,A2402,B3906,B4506,C1502,C0702	A03,A24,B27,B44,UNK,UNK	0
TX456179	61-70	22	0	25.61	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A2301,A6802,B1510,B4801,C0504,C0701	A24,A02,B27,UNK,UNK,UNK	0
UC518723	31-50	0	0	3.69	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301,A0201,B4901,B4402,C1203,C1701	A24,A02,B27,B44,UNK,UNK	0
UW666903	50-60	18	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B5501,B5501,C0102,C0701	A03,A02,B07,B07,UNK,UNK	1
VE077996	61-70	0	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0207,B0705,B4801,C0102,C1505	A03,A02,B07,B65,UNK,UNK	0
VO581533	31-50	0	0	33.45	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3004,A0102,B810,B4403,C0804,C0706	A01,UNK,B07,B44,UNK,UNK	0
XA335416	50-60	25	0	1.97	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	03601,A3301,B1402,B3501,C0802,C1203	A01,A03,B27,B27,UNK,UNK	0
XF235060	>71	3	1	0	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0301,A2601,B4403,B5101,C0203,C1601	A03,A01,B44,B07,UNK,UNK	0
YI633805	31-50	8	0	1.97	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A2402,A3303,B4901,B3502,C0401,C0701	A24,A03,UNK,B07,UNK,UNK	0
YR519762	31-50	16	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3201,B0801,B2705,C0202,C0701	A01,A01,B08,B27,UNK,UNK	0
ZK526534	31-50	13	0	6.89	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A3201,B0702,B1801,C0501,C0702	A03,A01,B07,B44,UNK,UNK	0
DK273036	>71	8	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A6801,A0201,B3901,B2101,C1504,C0702	A03,A02,B27,B07,UNK,UNK	0
DM501870	>71	2	0	2.95	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A1101,B0702,B3503,C0401,C0702	A03,A03,B07,B07,UNK,UNK	0
GC396851	31-50	5	1	8.85	Combo	Head and Neck Cancer	MSK-IMPACT	A0101,A2402,B0702,B5101,C1502,C0702	A01,A24,B07,B07,UNK,UNK	0
IT581661	31-50	3	0	6.89	PD-1/PDL-1	Glioma	MSK-IMPACT	A6801,A0201,B0702,B4402,C0501,C0702	A03,A02,B07,B44,UNK,UNK	0
IV185293	31-50	8	0	2.95	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2902,B1517,B1402,C0802,C0701	A24,A01,A24,B35,B27,UNK,UNK	0
LJ345709	31-50	2	1	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3201,A3201,B4402,B4402,C0501,C0202	A01,A01,B44,B44,UNK,UNK	0
LQ821060	31-50	0	1	16.72	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B0801,B1517,C0701,C0718	A01,A01,B08,B58,UNK,UNK	0
NE821221	31-50	4	0	6.89	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A2402,B1801,B5101,C1402,C1203	A24,A24,B44,B07,UNK,UNK	1
PS842091	31-50	9	1	3.94	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A0205,B5001,B1801,C0602,C0602	A01,A02,B44,B44,UNK,UNK	1
RA928607	61-70	6	0	1.97	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2601,B0702,B5201,C1202,C0702	A03,A01,B07,B62,UNK,UNK	0
WC256663	31-50	2	0	3.94	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B2705,B4501,C0304,C0502	A24,A02,B27,B44,UNK,UNK	0
WL137245	61-70	47	0	11.81	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201,A0201,B4402,B4001,C0304,C0701	A02,A02,B44,B44,UNK,UNK	1
WM306865	50-60	32	1	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A3201,B3501,B2501,C0102,C0401	A24,A01,B07,B07,UNK,UNK	1
WP372878	61-70	8	0	15.74	Combo	Melanoma	MSK-IMPACT	A0301,A2601,B0702,B3501,C0401,C0702	A03,A01,B07,B07,UNK,UNK	0
YK675744	50-60	4	0	14.76	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	80301,A1101,B0702,B0702,C0702,C0702	A03,A03,B07,B07,UNK,UNK	1
YU626285	50-60	8	0	19.68	PD-1/PDL-1	Melanoma	MSK-IMPACT	A1101,A0201,B5501,B1801,C0305,C0701	A03,A02,B07,B44,UNK,UNK	0
ZK342685	31-50	7	1	8.85	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B3906,B3501,C0401,C0702	A24,A02,B27,B07,UNK,UNK	0

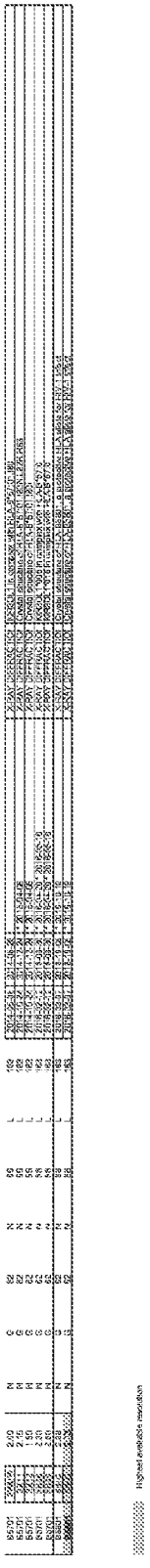
DS616246	50-60	20	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A0201,B1501,B4001,C0303,C0304	A24,A02,B62,B44,UNK,UNK	0
FI163501	50-60	15	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A1102,B0704,B4402,C1202,C0501	A03,A03,B27,B44,UNK,UNK	0
GG613373	31-50	7	1	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A1101,A2601,B3503,B4901,C1203,C0718	A03,A24,B07,UNK,UNK,UNK	0
GK382866	>71	16	0	PD-1/PDL-1	Bone Cancer	MSK-IMPACT	A0101,A0201,B0801,B1502,C0801,C0702	A01,A02,B08,B62,UNK,UNK	0
HA469182	31-50	25	0	CTLA4	Melanoma	MSK-IMPACT	A0301,A0206,B0702,B3501,C0303,C0702	A03,A02,B07,B07,UNK,UNK	0
KU935320	61-70	10	0	Combo	Melanoma	MSK-IMPACT	A3001,A3002,B1302,B3501,C0802,C0401	A01,A03,A01,UNK,B07,UNK,UNK	0
LM168179	50-60	1	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2902,A3301,B1402,B4403,C0802,C1601	A01,A24,A03,B27,B44,UNK,UNK	0
QD252630	>71	32	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B0702,B0702,C0702,C0702	A03,A02,B07,B07,UNK,UNK	1
CE555832	50-60	9	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3001,A3001,B1510,B1801,C0304,C0202	A01,A03,A01,A03,B27,B44,UNK,UNK	1
OF2470 65	31-50	14	0	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2402,A2402,B0702,B3503,C0401,C0702	A24,A24,B07,B07,UNK,UNK	1
CZ621986	50-60	12	0	Combo	Melanoma	MSK-IMPACT	A0301,A3002,B2705,B1501,C0102,C0501	A03,A01,B27,B44,UNK,UNK	0
RW388101	50-60	2	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B4402,B4002,C0501,C0202	A02,A02,B44,B44,UNK,UNK	1
SD689023	<30	17	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3101,B3801,B3503,C0401,C1903	A01,A03,B27,B07,UNK,UNK	0
WU141360	61-70	3	0	Combo	Melanoma	MSK-IMPACT	A0201,A0201,B0801,B1501,C0305,C0701	A02,A02,B08,B62,UNK,UNK	1
WY430099	50-60	3	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2601,B1801,B3502,C1203,C0401	A01,A01,B44,B07,UNK,UNK	0
KU923833	31-50	2	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A2402,B3502,B3501,C0401,C0401	A24,A24,B07,B07,UNK,UNK	1
XK856658	61-70	5	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A2301,B1501,B1801,C0303,C0501	A03,A24,B62,B44,UNK,UNK	0
YF634379	>71	2	0	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A1101,A6801,B1801,B5201,C1801,C0701	A03,A03,B44,B62,UNK,UNK	0
AY728752	>71	20	0	Combo	Melanoma	MSK-IMPACT	A0301,A3301,B4405,B5101,C0102,C0501	A03,A01,B44,B07,UNK,UNK	0
CH836399	50-60	12	0	CTLA4	Breast Cancer	MSK-IMPACT	A2301,A0201,B4403,B4501,C0401,C1601	A24,A02,B44,B44,UNK,UNK	0
DF452553	31-50	1	1	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A0101,B0801,B0801,C0701,C0701	A01,A01,B08,B08,UNK,UNK	1
DS822270	31-50	1	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A6601,B3801,B4102,C1102,C1701	A03,A03,B27,B44,UNK,UNK	0
GZ354793	61-70	17	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A7401,A7401,B0702,B1503,C0210,C0702	A03,A03,B07,B27,UNK,UNK	1
JC504331	>71	7	0	CTLA4	Breast Cancer	MSK-IMPACT	A0101,A0201,B0801,B4402,C0704,C0701	A01,A02,B08,B44,UNK,UNK	0
JD755987	50-60	5	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0101,B0801,B1302,C0602,C0701	A01,A01,B08,UNK,UNK,UNK	1
KI514256	50-60	0	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A3001,A2902,B3701,B1302,C0602,C0602	A03,A03,A01,02,B44,UNK,UNK,UNK	1
KL738735	50-60	14	0	CTLA4	Breast Cancer	MSK-IMPACT	A3601,A0201,B3501,B5301,C1601,C0401	A01,A02,B07,B07,UNK,UNK	0
KN186707	31-50	2	0	CTLA4	Breast Cancer	MSK-IMPACT	A0201,A0201,B0702,B5701,C0504,C0702	A02,A02,B07,B07,UNK,UNK	1
MI2289010	50-60	3	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A1101,B1801,B5201,C1202,C0701	A03,A03,B44,B62,UNK,UNK	0
RJ482568	50-60	33	0	Combo	Renal Cell Carcinoma	MSK-IMPACT	A2402,A0201,B5501,B3701,C0303,C0602	A24,A02,B07,B44,UNK,UNK	0
NU685569	61-70	8	1	Combo	Esophagogastric Cancer	MSK-IMPACT	A6301,A0201,B4403,B4402,C0401,C0704	A03,A02,B44,B44,UNK,UNK	0
QW538332	50-60	3	0	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A3101,B3801,B3901,C1203,C1203	A03,A03,B27,B27,UNK,UNK	1
FM135012	31-50	13	1	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A0301,B0702,B0702,C0702,C0702	A03,A03,B07,B07,UNK,UNK	1
PS208416	50-60	6	0	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A1101,B0702,B1801,C0304,C0504	A03,A03,B07,B62,UNK,UNK	1
PY496092	31-50	3	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0201,B3801,B5701,C0602,C0701	A03,A02,B58,B58,UNK,UNK	0
QD266127	>71	58	0	CTLA4	Melanoma	MSK-IMPACT	A0101,A0201,B4403,B4402,C1601,C0501	A01,A02,B44,B44,UNK,UNK	0
RT100686	50-60	1	0	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A1101,A2902,B5501,B4403,C0503,C1601	A03,A01,A24,B07,B44,UNK,UNK	0
RW567050	31-50	11	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0201,A6901,B3705,B5501,C1505,C0803	A02,A02,B07,B07,UNK,UNK	0
SQ788755	31-50	0	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0201,B3501,B5901,C0401,C0706	A03,A02,B07,B58,UNK,UNK	0
UD810304	50-60	2	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0101,B2705,B3503,C0202,C0401	A03,A01,B27,B07,UNK,UNK	0
UP636708	50-60	4	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B4402,B5101,C0501,C0602	A02,A02,B44,B07,UNK,UNK	1
WG9377 33	31-50	4	0	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A2601,A0201,B0801,B1501,C0303,C0701	A01,A02,B08,B62,UNK,UNK	0
WZ633302	31-50	1	1	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A2402,A0201,B1801,B5701,C0303,C0602	A24,A02,B62,B58,UNK,UNK	0
YG749543	50-60	29	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A3101,B4101,B3503,C0401,C1701	A03,A03,B44,B07,UNK,UNK	0
YD266016	61-70	14	0	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A2601,B1401,B1501,C0602,C1203	A02,A01,B27,B44,UNK,UNK	0
YQ853157	61-70	2	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0203,B1518,B1801,C0704,C0702	A03,A02,B27,B44,UNK,UNK	0
ZO253625	31-50	22	1	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0101,A0201,B5101,B5101,C1402,C0602	A01,A02,B07,B07,UNK,UNK	1
ZQ021549	50-60	51	0	CTLA4	Melanoma	MSK-IMPACT	A0301,A2601,B0702,B5101,C1402,C0702	A03,A01,B07,B07,UNK,UNK	0
CE91917 2	31-50	10	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2402,B5801,B5101,C0202,C0705	A03,A24,B58,B07,UNK,UNK	0
DD891488	61-70	5	1	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0101,A2402,B0702,B1517,C0701,C0702	A01,A24,B07,B58,UNK,UNK	0
EN709186	50-60	13	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B4403,B4801,C1601,C0701	A02,A02,B44,UNK,UNK,UNK	1
EB405485	31-50	1	1	Combo	Melanoma	MSK-IMPACT	A0101,A0201,B3901,B1517,C1203,C0701	A01,A02,B27,B58,UNK,UNK	0
HA824590	61-70	48	1	Combo	Melanoma	MSK-IMPACT	A0301,A6801,B0702,B4201,C1701,C0702	A03,A03,B07,B07,UNK,UNK	0
HU860149	50-60	1	0	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0101,A0201,B4403,B3501,C0802,C1601	A01,A02,B44,B62,UNK,UNK	0
HY288210	31-50	1	1	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B2705,B4402,C0202,C0703	A02,A02,B27,B44,UNK,UNK	1
IL267660	31-50	7	0	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0101,B5701,B3501,C0401,C0602	A03,A01,B58,B07,UNK,UNK	0
IL958694	50-60	5	0	PD-1/PDL-1	Melanoma	MSK-IMPACT	A3002,A0201,B1801,B5201,C0501,C1202	A01,A02,B44,B62,UNK,UNK	0
IU057564	31-50	31	0	Combo	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B0702,B4405,C0202,C0702	A03,A02,B07,B44,UNK,UNK	0
KE884708	>71	13	0	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A1101,A0201,B5401,B4001,C0304,C1602	A03,A02,B07,B44,UNK,UNK	0
LT668308	31-50	38	0	Combo	Non-Hodgkin Lymphoma	MSK-IMPACT	A2601,A6802,B4201,B3801,C1701,C1203	A01,A02,B07,B27,UNK,UNK	0
NN760931	61-70	1	1	Combo	Head and Neck Cancer	MSK-IMPACT	A2402,A0201,B1402,B4001,C0304,C0602	A24,A02,B27,B44,UNK,UNK	0
NV186145	61-70	1	1	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A0101,A2402,B1501,B2705,C0303,C0401	A01,A24,B62,B07,UNK,UNK	0
NW458478	<30	8	0	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0302,B0801,B1501,C0102,C0701	A03,A03,B08,B07,UNK,UNK	0
SQ342430	50-60	6	0	PD-1/PDL-1	Breast Cancer	MSK-IMPACT	A2301,A0201,B4402,B1801,C0501,C0501	A24,A02,B44,B44,UNK,UNK	1
SY601446	<30	3	1	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0302,A3303,B4402,B2601,C1604,C0302	A03,A03,B44,B58,UNK,UNK	0
WC509875	31-50	2	1	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A2601,B1517,B3901,C1203,C0701	A01,A01,B58,B27,UNK,UNK	0

KB540163	31-50	10	0	2.95	Combo	Melanoma	MSK-IMPACT	A3301,A0201,B4402,B3501,C0501,C0401	A01,A02,B44,B07,UNK,UNK	0
ZK695203	61-70	14	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A0101,A0201,B0702,B1501,C0702,C0701	A01,A02,B07,B44,UNK,UNK	0
BU258265	50-60	9	1	14.76	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6101,A2601,B3801,B5701,C1502,C1203	A01,A31,B27,B58,UNK,UNK	1
CS62G8630	61-70	10	0	45.25	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A2601,B3801,B1501,C1203,C0702	A02,A31,B27,B44,UNK,UNK	1
CY42231132	31-50	7	0	0.98	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A2403,A6206,B1525,B1525,C0403,C0702	A24,A62,B62,B62,UNK,UNK	1
FM8997744	50-60	9	0	69.85	Combo	Melanoma	MSK-IMPACT	A0201,A3101,B5701,B5801,C0102,C0702	A02,A03,B07,B07,UNK,UNK	0
IS8501001	>71	0	0	0	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A0201,A2601,B4402,B1801,C1203,C1701	A02,A31,B44,B44,UNK,UNK	0
JW2553371	31-50	2	1	4.92	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6901,A3201,B1302,B1501,C0303,C0602	A01,A03,A01,UNK,B62,UNK,UNK	0
KMA613117	61-70	11	0	50.17	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A0301,A0101,B0801,B5101,C1502,C0701	A03,A01,B58,B07,UNK,UNK	0
MW2283349	<30	1	1	8.85	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A6802,B1402,B3701,C0802,C0602	A01,A02,B27,B44,UNK,UNK	0
CD7704763	31-50	0	0	6.89	PD-1/PDL-1	Esophagogastric Cancer	MSK-IMPACT	A3303,A0205,B4403,B5201,C1202,C0706	A03,A02,B44,B62,UNK,UNK	0
OU370759	61-70	0	1	2.95	PD-1/PDL-1	Thyroid Cancer	MSK-IMPACT	A2301,A6601,B1503,B1503,C0210,C0210	A24,A03,B27,B27,UNK,UNK	1
GP857710	>71	0	0	0	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0201,A2601,B3801,B3501,C0401,C1703	A02,A01,B27,B07,UNK,UNK	0
RL045521	61-70	11	0	2.95	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A0302,A2601,B0801,B3501,C1203,C0701	A03,A01,B08,B27,UNK,UNK	0
UX8182612	50-60	22	0	2.95	Combo	Melanoma	MSK-IMPACT	A0301,A0101,B5101,B5201,C1502,C1202	A03,A01,B07,B62,UNK,UNK	0
WI153171	>71	3	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2601,A0205,B3801,B5201,C1203,C0602	A01,A02,B27,B44,UNK,UNK	0
XD2202884	50-60	8	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A0201,B0702,B4402,C0501,C0702	A24,A02,B07,B44,UNK,UNK	0
XJ239462	31-50	5	1	11.81	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A6901,B1402,B5501,C0102,C0602	A03,A02,B27,B07,UNK,UNK	0
XP592070	61-70	0	0	1.97	PD-1/PDL-1	Cancer of Unknown Primary	MSK-IMPACT	A1101,A2402,B0702,B3501,C0401,C0702	A03,A24,B07,B07,UNK,UNK	0
CU070821	31-50	46	0	0.98	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2402,A3303,B3501,B1801,C1203,C1203	A24,A03,B27,B44,UNK,UNK	1
CW2852274	50-60	15	0	7.87	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A6801,B2705,B1517,C0102,C0701	A02,A02,B27,B07,UNK,UNK	0
FL7118778	31-50	10	0	51.16	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0101,A3101,B5701,B4001,C0304,C0802	A01,A03,B58,B44,UNK,UNK	0
HL3413038	61-70	2	0	6.89	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A1101,B2801,B4901,C0701,C0701	A03,A03,B58,UNK,UNK,UNK	1
IL793595	50-60	2	0	8.85	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2301,A2301,B4901,B4801,C0701,C0701	A24,A24,UNK,UNK,UNK,UNK	1
IO7802267	>71	6	1	0.98	CTLA4	Breast Cancer	MSK-IMPACT	A1101,A0207,B4601,B3802,C0102,C0702	A03,A02,B62,UNK,UNK,UNK	0
IQ6533381	>71	8	0	2.95	PD-1/PDL-1	Glioma	MSK-IMPACT	A2902,A0201,B0801,B4501,C0602,C0701	A01,A24,A02,B08,B44,UNK,UNK	0
IT6802202	31-50	24	0	22.58	CTLA4	Melanoma	MSK-IMPACT	A0201,A0201,B2705,B3501,C0102,C0401	A02,A02,B27,B07,UNK,UNK	1
JT8965863	31-50	4	0	8.85	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A0301,A6802,B1518,B1402,C0802,C1601	A03,A02,B58,B27,UNK,UNK	1
JN7894460	>71	5	0	3.94	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0201,A0201,B4001,B4001,C0304,C0304	A02,A02,B44,B44,UNK,UNK	1
KM7510004	61-70	6	0	0.98	Combo	Melanoma	MSK-IMPACT	A1101,A2402,B4801,B3802,C0301,C0702	A03,A24,B27,UNK,UNK,UNK	0
RS9229876	50-60	0	1	3.77	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6301,A2402,B1402,B4801,C0802,C0701	A03,A24,B27,UNK,UNK,UNK	0
YQ6880189	31-50	1	1	56.08	Combo	Melanoma	MSK-IMPACT	A0301,A2402,B0702,B5101,C1602,C0702	A03,A24,B07,B07,UNK,UNK	0
ZM4952995	50-60	21	0	43.18	Combo	Melanoma	MSK-IMPACT	A0101,A0201,B0801,B2705,C0102,C0701	A01,A02,B08,B27,UNK,UNK	0
AJ8960534	31-50	6	0	1.97	Combo	Melanoma	MSK-IMPACT	A0201,A0201,B4402,B3801,C0505,C0501	A02,A02,B44,B07,UNK,UNK	1
DF3846622	50-60	2	0	1.97	PD-1/PDL-1	Adrenocortical Carcinoma	MSK-IMPACT	A0301,A0101,B0801,B3501,C0401,C0701	A03,A01,B08,B07,UNK,UNK	0
ES3857759	50-60	3	1	17.71	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6901,A6801,B5702,B4102,C1701,C0702	A03,A03,B07,B44,UNK,UNK	0
GF1776625	31-50	0	0	11.81	Combo	Melanoma	MSK-IMPACT	A1101,A0101,B4403,B3501,C0401,C0401	A03,A01,B44,B07,UNK,UNK	1
CG1117672	61-70	19	0	1.97	CTLA4	Prostate Cancer	MSK-IMPACT	A0301,A3402,B4001,B4901,C0304,C0701	A03,A03,B44,UNK,UNK,UNK	0
HM7004620	50-60	5	0	2.95	Combo	Renal Cell Carcinoma	MSK-IMPACT	A1101,A2402,B5502,B5201,C0401,C1202	A03,A24,B07,B62,UNK,UNK	0
LB6073353	31-50	1	1	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A3301,B4403,B1501,C0202,C0202	A03,A03,B44,B62,UNK,UNK	1
NM6699273	61-70	4	1	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0201,A0201,B4402,B1801,C0701,C0704	A02,A02,B44,B44,UNK,UNK	1
QR7743518	50-60	1	1	53.47	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A0301,B3501,B1501,C1203,C0401	A03,A03,B07,B44,UNK,UNK	1
QK7454450	61-70	0	1	0	PD-1/PDL-1	Prostate Cancer	MSK-IMPACT	A3303,A3101,B1402,B4001,C0304,C0802	A03,A03,B27,B44,UNK,UNK	0
QP894107	50-60	7	0	2.95	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0301,A2402,B2705,B5801,C0102,C0102	A03,A24,B27,B07,UNK,UNK	1
SH3883692	31-50	6	0	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A2902,B1501,B3501,C0401,C0701	A01,A01,A24,B44,B07,UNK,UNK	0
WM0513116	31-50	0	1	16.72	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A1101,A3301,B1801,B3503,C0802,C1203	A03,A03,B44,B07,UNK,UNK	0
XY3337478	31-50	1	1	8.85	PD-1/PDL-1	Small Cell Lung Cancer	MSK-IMPACT	A2301,A0201,B0801,B5101,C1402,C0701	A24,A02,B08,B07,UNK,UNK	0
YK1983564	31-50	46	0	1.97	CTLA4	Prostate Cancer	MSK-IMPACT	A2402,A3101,B3502,B3502,C0401,C0401	A24,A03,B07,B07,UNK,UNK	1
CG3383415	31-50	1	0	9.84	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A6601,A0201,B4403,B1501,C0802,C0704	A03,A02,B44,B44,UNK,UNK	0
CQ6378630	61-70	0	0	6.89	PD-1/PDL-1	Anal Cancer	MSK-IMPACT	A0301,A1101,B5501,B3501,C0903,C0401	A03,A03,B07,B07,UNK,UNK	0
EB7800441	31-50	3	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2902,A3101,B4403,B3502,C1601,C0401	A01,A24,A03,B44,B07,UNK,UNK	0
ES7209872	31-50	35	0	6.89	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2902,A0202,B4001,B4501,C0504,C0602	A01,A24,A02,B44,B44,UNK,UNK	0
FQ7811658	>71	21	0	5.9	Combo	Melanoma	MSK-IMPACT	A2402,A3201,B4002,B5701,C0202,C0602	A24,A01,B44,B58,UNK,UNK	0
JD5338617	61-70	15	0	5.74	Combo	Melanoma	MSK-IMPACT	A1101,A3303,B4402,B3501,C0302,C0501	A03,A03,B44,B58,UNK,UNK	0
KE5818649	61-70	9	0	53.12	CTLA4	Melanoma	MSK-IMPACT	A0301,A2902,B4403,B1801,C1601,C0701	A03,A01,A24,B44,B44,UNK,UNK	0
LL2045901	50-60	25	0	5.9	Combo	Renal Cell Carcinoma	MSK-IMPACT	A2402,A6901,B6501,B5101,C0303,C1602	A24,A02,B07,B07,UNK,UNK	0
MR0982286	31-50	3	1	2.79	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A6601,A6901,B5501,B1801,C0102,C1203	A03,A02,B07,B44,UNK,UNK	0
MZ9416567	31-50	22	0	15.74	Combo	Melanoma	MSK-IMPACT	A2601,A0205,B3801,B5501,C1203,C0602	A01,A02,B27,B44,UNK,UNK	0
NF3847722	31-50	7	0	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B4101,B4402,C0304,C1701	A24,A02,B44,B44,UNK,UNK	0
OY2298666	31-50	3	1	5.9	PD-1/PDL-1	Glioma	MSK-IMPACT	A2402,A2601,B1801,B4402,C1604,C1203	A24,A01,B44,B44,UNK,UNK	0
PA2367754	31-50	5	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A2601,B4002,B4501,C1601,C0202	A02,A01,B44,B44,UNK,UNK	0
PP2274205	31-50	3	0	59.05	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B4402,B1501,C0303,C0501	A24,A02,B44,B62,UNK,UNK	0
RH5483185	31-50	1	1	3.94	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3601,A3402,B4501,B3501,C0401,C0401	A01,A03,B07,B07,UNK,UNK	1
SH1221153	50-60	0	0	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A2902,B0801,B4403,C0602,C0702	A03,A24,B08,B44,UNK,UNK	0
SP2766683	31-50	10	1	7.87	PD-1/PDL-1	Glioma	MSK-IMPACT	A2902,A0201,B1501,B3501,C0304,C0401	A01,A24,A02,B62,B07,UNK,UNK	0
TA5831155	50-60	3	0	2.95	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A2601,B1518,B2705,C0102,C0704	A02,A01,B27,B27,UNK,UNK	0

AM575114	50-60	7	1	43.29	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0301,B0702,B3906,C0702,C0702	A03,A03,B07,B27,UNK,UNK	1		
CQ355649	50-60	7	1	3.94	PD-1/PDL-1	Pancreatic Cancer	MSK-IMPACT	A1101,A2402,B5401,B1501,C0303,C0102	A03,A24,B07,B62,UNK,UNK	0		
CF773826	31-50	0	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A1101,B1517,B3901,C1202,C0701	A03,A68,B39,B27,UNK,UNK	0		
IE2265086	50-60	25	0	8.85	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3101,B0801,B4001,C0304,C0701	A01,A03,B08,B44,UNK,UNK	0		
JU606221	50-60	20	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A2402,B1501,B1501,C0303,C0303	A03,A24,B07,B62,UNK,UNK	1		
NE982810	31-50	7	0	35.5	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0301,A0301,B0702,B0801,C0702,C0701	A03,A03,B07,B08,UNK,UNK	1		
CU264581	>71	23	1	0.98	Combo	Non-Small Cell Lung Cancer	MSK-IMPACT	A0302,A1101,B4101,B3503,C0401,C1701	A03,A03,B44,B07,UNK,UNK	0		
CN4654477	50-60	13	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A2301,B1701,B4801,C0802,C0701	A01,A24,B58,UNK,UNK,UNK	0		
RT6350006	61-70	9	1	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A1101,A2402,B1402,B5201,C0202,C1202	A03,A24,B27,B62,UNK,UNK	0		
SD0028427	50-60	0	0	12.79	Combo	Small Cell Lung Cancer	MSK-IMPACT	A2402,A3303,B4001,B3503,C1203,C0702	A24,A03,B44,B07,UNK,UNK	0		
SY259909	50-60	0	1	52.14	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0205,A3301,B5101,B5101,C1502,C1502	A02,A03,B07,B07,UNK,UNK	1		
TA865813	50-60	3	0	2.95	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0101,B0801,B1801,C0701,C0701	A03,A01,B08,B44,UNK,UNK	1		
YW0785579	31-50	5	0	25.58	PD-1/PDL-1	Melanoma	MSK-IMPACT	A0301,A0301,B0702,B0702,C0702,C0702	A03,A03,B07,B07,UNK,UNK	1		
ZU1116700	31-50	11	0	66.9	Combo	Melanoma	MSK-IMPACT	A0101,A2902,B0801,B4403,C0401,C0701	A01,A01,A24,B08,B44,UNK,UNK	0		
ZU9943390	31-50	2	1	0	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A0201,A3101,B0705,B3502,C1505,C0401	A02,A03,B07,B07,UNK,UNK	0		
BB8592688	31-50	28	0	55.09	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0201,A0201,B0801,B1801,C0701,C0701	A02,A02,B08,B44,UNK,UNK	1		
CN5184405	61-70	11	1	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0201,B4402,B5101,C0102,C0501	A03,A02,B44,B07,UNK,UNK	0		
CP5767210	61-70	19	0	24.59	Combo	Melanoma	MSK-IMPACT	A0101,A0101,B0801,B6501,C0718,C0718	A01,A01,B08,B08,UNK,UNK	1		
EA8436645	>71	4	1	0.98	PD-1/PDL-1	Glioma	MSK-IMPACT	A0202,A0206,B2705,B3501,C1601,C0202	A02,A02,B27,B07,UNK,UNK	0		
FA2698791	31-50	26	0	1.97	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0901,A2301,B4102,B1302,C0602,C1701	A01,A23,A24,B44,UNK,UNK,UNK	0		
HM2859985	50-60	10	1	4.92	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0101,A0201,B4403,B1501,C0303,C1601	A01,A02,B44,B62,UNK,UNK	0		
IO6301185	31-50	0	1	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A1101,A0101,B6701,B5101,C0401,C0602	A03,A01,B58,B07,UNK,UNK	0		
JF0719086	50-60	12	0	4.92	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0901,A0101,B2901,B4405,C0701,C0202	A01,A03,A01,B35,B44,UNK,UNK	0		
KA2519102	31-50	20	0	23.61	CTLA4	Melanoma	MSK-IMPACT	A0201,A0201,B5301,B5101,C0102,C0401	A02,A02,B07,B07,UNK,UNK	1		
LU597217	61-70	2	0	11.81	Combo	Melanoma	MSK-IMPACT	A0301,A2402,B3701,B3501,C0401,C0602	A03,A24,B44,B07,UNK,UNK	0		
KQ1487708	31-50	13	0	43.29	PD-1/PDL-1	Melanoma	MSK-IMPACT	A2402,A2402,B3901,B3502,C0401,C1203	A24,A24,B27,B07,UNK,UNK	1		
TH871342	61-70	0	0	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0201,A0205,B0702,B5301,C0602,C0702	A02,A02,B07,B44,UNK,UNK	0		
VY5683784	50-60	1	1	3.94	PD-1/PDL-1	Glioma	MSK-IMPACT	A0301,A0201,B0702,B1517,C0701,C0702	A03,A02,B07,B59,UNK,UNK	0		
KG2944852	31-50	3	1	5.9	Combo	Bladder Cancer	MSK-IMPACT	A0301,A0201,B1801,B3901,C1203,C0701	A03,A02,B44,B27,UNK,UNK	0		
AG1834588	50-60	8	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A0301,A0201,B1501,B3501,C0304,C0401	A03,A02,B62,B07,UNK,UNK	0		
CF6026093	50-60	35	0	10.82	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A3101,B1801,B3502,C0401,C0501	A01,A03,B44,B07,UNK,UNK	0		
DX8937247	31-50	7	1	4.92	Combo	Bladder Cancer	MSK-IMPACT	A0301,A0301,B4701,B5101,C1502,C0602	A03,A03,UNK,B07,UNK,UNK	1		
EU7255898	<50	6	0	0	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0201,A6801,B3501,B4402,C0401,C0704	A02,A02,B07,B44,UNK,UNK	0		
E7668077	>71	1	0	3.94	PD-1/PDL-1	Soft Tissue Sarcoma	MSK-IMPACT	A2402,A0201,B1402,B5301,C0802,C0602	A24,A02,B27,B44,UNK,UNK	0		
HR473373	31-50	0	1	7.87	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A0201,B0702,B4001,C0304,C0702	A24,A02,B07,B44,UNK,UNK	0		
KA2503532	31-50	6	1	14.76	PD-1/PDL-1	Bladder Cancer	MSK-IMPACT	A2601,A0205,B5001,B4901,C0602,C0701	A01,A02,B44,UNK,UNK,UNK	0		
EU572887	31-50	9	0	104.28	PD-1/PDL-1	Skin Cancer, Non-Melanoma	MSK-IMPACT	A0101,A2402,B0801,B1801,C0501,C0701	A01,A24,B08,B44,UNK,UNK	0		
NV5209595	>71	10	0	1.97	PD-1/PDL-1	Hepatobiliary Cancer	MSK-IMPACT	A0301,A1101,B0702,B4002,C0803,C0702	A03,A03,B07,B44,UNK,UNK	0		
PE0107187	50-60	4	1	12.79	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A2402,A2402,B1508,B4501,C0102,C0102	A24,A24,B07,B62,UNK,UNK	1		
QD1625636	31-50	8	0	5.9	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A0101,A3201,B0801,B5201,C1202,C0701	A01,A01,B08,B62,UNK,UNK	0		
UA8948121	>71	13	1	12.79	PD-1/PDL-1	Non-Hodgkin Lymphoma	MSK-IMPACT	A0801,A2601,B3502,B5101,C1602,C0401	A03,A01,B07,B07,UNK,UNK	0		
VY5690731	61-70	26	0	3.94	PD-1/PDL-1	Renal Cell Carcinoma	MSK-IMPACT	A2302,A2601,B3801,B3502,C0401,C1203	A24,A01,B27,B07,UNK,UNK	0		
YQ3886748	50-60	6	1	10.82	PD-1/PDL-1	Colorectal Cancer	MSK-IMPACT	A0301,A2402,B5501,B4701,C0102,C0602	A03,A24,B07,UNK,UNK,UNK	0		
ZD0390437	31-50	20	0	3.77	PD-1/PDL-1	Non-Small Cell Lung Cancer	MSK-IMPACT	A3002,A6802,B1402,B1503,C0210,C0802	A01,A02,B27,B27,UNK,UNK	0		
ZN0033598	>71	7	0	6.93	PD-1/PDL-1	Head and Neck Cancer	MSK-IMPACT	A3402,A6801,B3501,B5101,C0102,C1203	A24,A03,B27,B07,UNK,UNK	0		

Appendix 2





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EQUIVALENTS

[0347] It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims

CLAIMS

1. A method comprising steps of:
administering immunotherapy to a subject who has received prior immunotherapy and displays a tumor mutational load above a threshold that has been correlated with a statistically significant probability of responding to immunotherapy.

2. The method of claim 1, wherein the cancer is a solid type tumor.

3. The method of claim 1, wherein the cancer is selected from the group consisting of bladder cancer, breast cancer, esophagogastric cancer, glioma, head and neck cancer, melanoma, non-small cell lung cancer, renal cell carcinoma, and combinations thereof.

4. The method of claim 1, wherein the immunotherapy is or comprises administration of an immune checkpoint modulator.

5. The method of claim 1, wherein the immunotherapy is or comprises administration of an antibody agent.

6. The method of claim 1, wherein the immunotherapy is or comprises administration of a monoclonal antibody.

7. The method of claim 1, wherein the immunotherapy is or comprises administration of one or more of PD-1 or PD-L1 blockade therapies.

8. The method of claim 1, wherein the immunotherapy is or comprises administration of one or more of CTLA-4 blockade therapies.

9. The method of claim 1, wherein the immunotherapy is a combination of one or more of PD-1 blockade therapy and CTLA-4 blockade therapy.

10. The method of claim 1, wherein the immunotherapy is selected from the group comprising of atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab, and combinations therein.

11. The method of claim 1, wherein the displayed tumor mutational load is or was determined by use of a targeted sequence panel.

12. The method of claim 1, further comprising a step of:
measuring tumor mutational load in the subject, which measuring step is performed at a time selected from the group consisting of prior to the administering, during the administering, after the administering, and combinations thereof.

13. The method of claim 1, wherein the tumor mutational load is measured by next-generation sequencing.

14. The method of claim 1, wherein the tumor mutational load is measured by Mutation Profiling of Actionable Cancer Targets (MSK-IMPACT).

15. The method of claim 1, wherein the subject has a cancer included below and the tumor mutational load threshold after immune checkpoint modulator treatment is as set forth below:

Cancer Type	**Threshold**
Bladder Cancer	About 7 to about 27
Breast Cancer	About 1 to about 14
Esophagogastric Cancer	About 1 to about 21
Glioma	About 1 to about 15
Head and Neck Cancer	About 1 to about 18
Melanoma	About 1 to about 31
Non-Small Cell Lung Cancer	About 1 to about 29
Renal Cell Carcinoma	About 1 to about 12

16. The method of claim 1, wherein the subject has a cancer included below and the tumor mutational load threshold after immune checkpoint modulator treatment is as set forth below:

Cancer Type	Threshold
Bladder Cancer	about 16
Breast Cancer	about 4
Esophagogastric Cancer	about 11
Glioma	about 5
Head and Neck Cancer	about 8
Melanoma	about 11
Non-Small Cell Lung Cancer	about 18
Renal Cell Carcinoma	about 2

17. The method of claim 1, wherein the immunotherapy is or comprises therapy demonstrated to have a statistically significant probability of improving overall survival when administered to a population displaying the tumor mutational load above the threshold.

18. The method of claim 1, wherein the statistically significant probability of responding has been established by demonstration of a statistically significant improvement in overall survival.

19. A method comprising steps of:

administering immunotherapy to a subject who displays HLA class I supertype B44.

20. A method comprising steps of:

administering immunotherapy to a subject who displays HLA class I supertype B62.

21. A method comprising steps of:

administering immunotherapy to a subject who displays HLA class I heterozygosity.

22. The method of claim 21, wherein the subject displays heterozygosity at one or more HLA class I loci.

23. The method of claim 22, wherein the subject displays maximum heterozygosity at HLA class I loci.

24. The method of claim 21, wherein the HLA class I heterozygosity is determined by sequencing.

25. The method of claim 21, wherein the HLA class I heterozygosity is determined by an HLA typing assay.

26. The method of any one of claim 19-21, wherein the immunotherapy is or comprises administration of an immune checkpoint modulator.

27. The method of any one of claim 19-21, wherein the immunotherapy is or comprises administration of an antibody agent.

28. The method of any one of claim 19-21, wherein the immunotherapy is or comprises administration of a monoclonal antibody.

29. The method of any one of claim 19-21, wherein the immunotherapy is or comprises administration of one or more of PD-1 or PD-L1 blockade therapies.

30. The method of any one of claim 19-21, wherein the immunotherapy is or comprises administration of one or more of CTLA-4 blockade therapies.

31. The method of any one of claim 19-21, wherein the immunotherapy is a combination of one or more of PD-1 blockade therapy and CTLA-4 blockade therapy.

32. The method of any one of claim 19-21, wherein the immunotherapy is selected from the group comprising of atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab, and combinations therein.

33. A method comprising steps of:
administering immunotherapy to a subject who has received prior immunotherapy, displays a tumor mutational load above a threshold that has been correlated with a statistically significant probability of responding to immunotherapy and displays HLA class I heterozygosity.

34. The method of claim 33, wherein the subject displays heterozygosity at one or more HLA class I loci.

35. The method of claim 34, wherein the subject displays maximum heterozygosity at HLA class I loci.

36. The method of claim 33, wherein the HLA class I heterozygosity is determined by sequencing.

37. The method of claim 33, wherein the HLA class I heterozygosity is determined by an HLA typing assay.

38. The method of claim 33, wherein the cancer is a solid type tumor.

39. The method of claim 33, wherein the cancer is selected from the group consisting of bladder cancer, breast cancer, esophagogastric cancer, glioma, head and neck cancer, melanoma, non-small cell lung cancer, renal cell carcinoma, and combinations thereof.

40. The method of claim 33, wherein the immunotherapy is or comprises administration of an immune checkpoint modulator.

41. The method of claim 33, wherein the immunotherapy is or comprises administration of an antibody agent.

42. The method of claim 33, wherein the immunotherapy is or comprises administration of a monoclonal antibody.

43. The method of claim 33, wherein the immunotherapy is or comprises administration of one or more of PD-1 or PD-L1 blockade therapies.

44. The method of claim 33, wherein the immunotherapy is or comprises administration of one or more of CTLA-4 blockade therapies.

45. The method of claim 33, wherein the immunotherapy is a combination of one or more of PD-1 blockade therapy and CTLA-4 blockade therapy.

46. The method of claim 33, wherein the immunotherapy is selected from the group comprising of atezolizumab, avelumab, durvalumab, ipilimumab, nivolumab, pembrolizumab, or tremelimumab, and combinations therein.

47. The method of claim 33, wherein the displayed tumor mutational load is or was determined by use of a targeted sequence panel.

48. The method of claim 33, further comprising a step of:
measuring tumor mutational load in the subject, which measuring step is performed at a time selected from the group consisting of prior to the administering, during the administering, after the administering, and combinations thereof.

49. The method of claim 33, wherein the tumor mutational load is measured by next-generation sequencing.

50. The method of claim 33, wherein the tumor mutational load is measured by Mutation Profiling of Actionable Cancer Targets (MSK-IMPACT).

51. The method of claim 33, wherein the subject has a cancer included below and the tumor mutational load threshold after immune checkpoint modulator treatment is as set forth below:

Cancer Type	**Threshold**
Bladder Cancer	About 7 to about 27
Breast Cancer	About 1 to about 14
Esophagogastric Cancer	About 1 to about 21
Glioma	About 1 to about 15
Head and Neck Cancer	About 1 to about 18
Melanoma	About 1 to about 31
Non-Small Cell Lung Cancer	About 1 to about 29
Renal Cell Carcinoma	About 1 to about 12

52. The method of claim 33, wherein the subject has a cancer included below and the tumor mutational load threshold after immune checkpoint modulator treatment is as set forth below:

Cancer Type	**Threshold**
Bladder Cancer	about 16
Breast Cancer	about 4
Esophagogastric Cancer	about 11
Glioma	about 5
Head and Neck Cancer	about 8
Melanoma	about 11
Non-Small Cell Lung Cancer	about 18
Renal Cell Carcinoma	about 2

53. The method of claim 33, wherein the immunotherapy is or comprises therapy demonstrated to have a statistically significant probability of improving overall survival when administered to a population displaying the tumor mutational load above the threshold.

54. The method of claim 33, wherein the statistically significant probability of responding has been established by demonstration of a statistically significant improvement in overall survival.

Figure 1

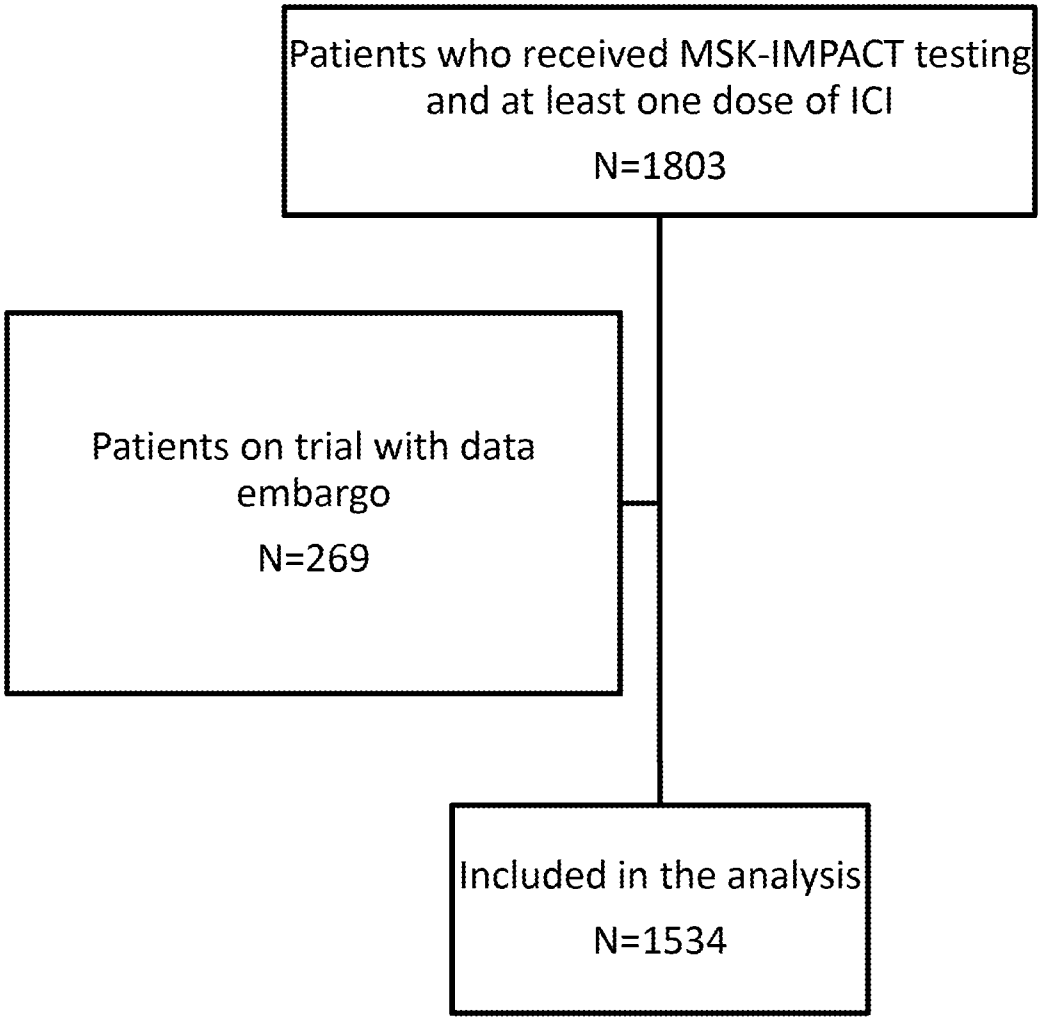
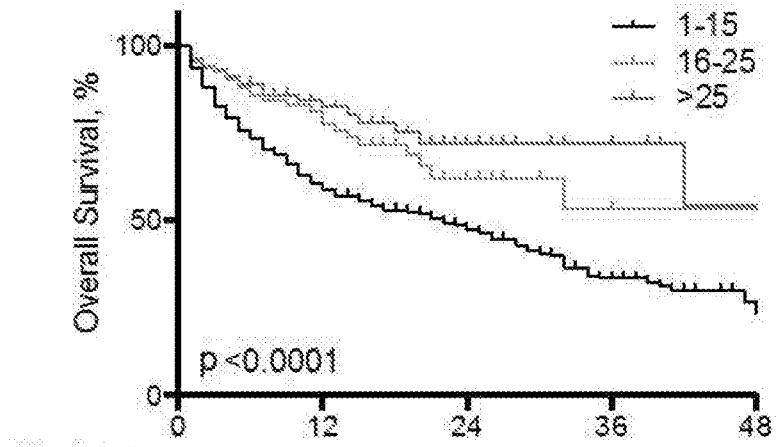
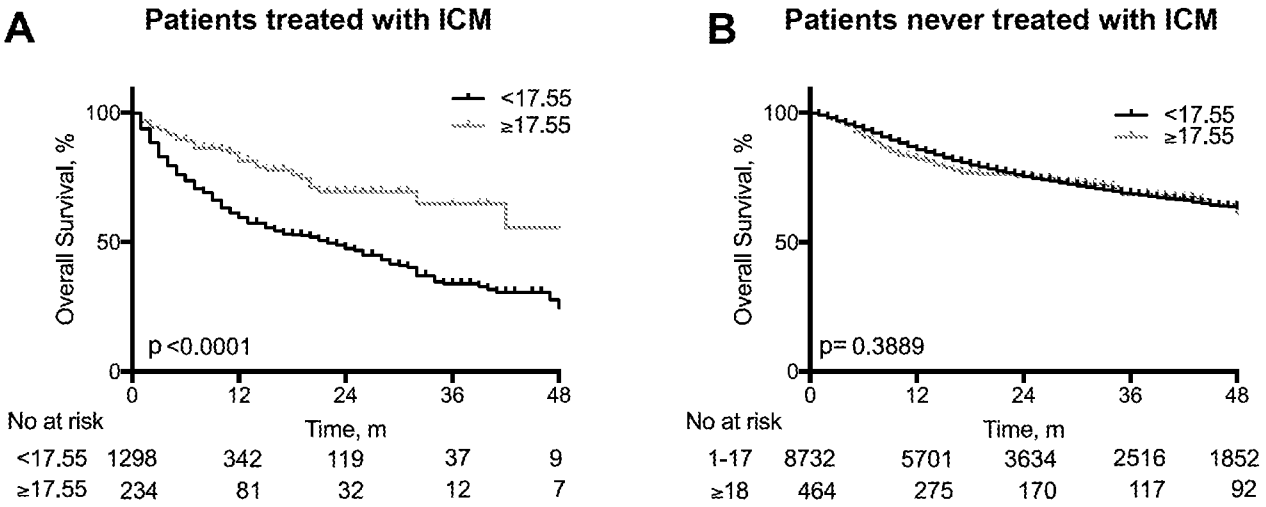

Patients who received MSK-IMPACT testing and at least one dose of ICI
N=1803
Patients on trial with data embargo
N=269
Included in the analysis
N=1534

Figure 2



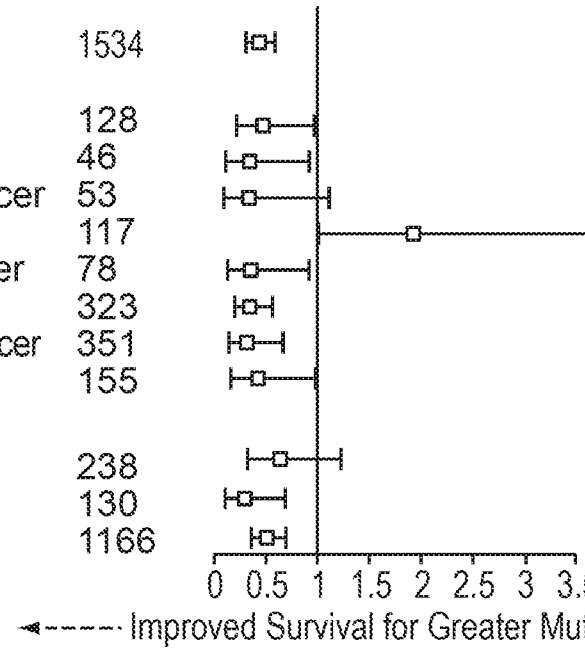
No at risk					
1-15	1264	333	117	36	8
16-25	126	44	14	5	5
>25	142	46	20	8	8

Figure 3


A
Patients treated with ICM
<17.55
≥17.55
Overall Survival, %
100
50
0
p <0.0001
0
12
24
36
48
Time, m
No at risk
<17.55 1298 342 119 37 9
≥17.55 234 81 32 12 7
B
Patients never treated with ICM
<17.55
≥17.55
Overall Survival, %
100
50
0
p= 0.3889
0
12
24
36
48
Time, m
No at risk
1-17 8732 5701 3634 2516 1852
≥18 464 275 170 117 92

A

	No. of Patients	Cutoff	P Value
Pan Cancer	1534	17.55	3.00×10^{-8}
Cancer Type			
Bladder Cancer	128	16.73	0.037
Breast Cancer	46	3.51	0.025
Esophagogastric Cancer	53	10.82	0.065
Glioma	117	4.46	0.043
Head and Neck Cancer	78	7.87	0.028
Melanoma	323	11.15	1.11×10^{-5}
Non-Small Cell Lung Cancer	351	17.84	4.69×10^{-4}
Renal Cell Carcinoma	155	1.76	0.038
Drug Class			
Combination	238	17.55	0.115
CTLA4	130	17.55	2.93×10^{-3}
PD-1/PDL-1	1166	17.55	6.89×10^{-5}



B

	No. of Patients	Cutoff	P Value
Pan Cancer	9196	17.55	0.277
Cancer Type			
Bladder Cancer	283	16.73	0.184
Breast Cancer	104	2.23	0.442
Breast Cancer	1414	3.51	0.838
Cancer of Unknown Primary	174	25.58	0.698
Esophagogastric Cancer	287	10.82	0.953
Glioma	356	4.46	0.388
Head and Neck Cancer	110	7.87	0.417
Hepatobility Cancer	320	1.12	0.695
Melanoma	37	11.15	0.307
Mesothelioma	91	2.63	0.711
Non-Hodgkin Lymphoma	170	16.72	0.132
Non-Small Cell Lung Cancer	1132	17.84	0.345
Pancreatic Cancer	558	9.84	0.188
Prostate Cancer	798	32.34	0.039
Renal Cell Carcinoma	155	1.76	0.167
Skin Cancer, Non-Melanoma	66	4.46	0.171
Small Cell Lung Cancer	72	16.72	0.070
Soft Tissue Sarcoma	345	3.94	0.587
Thyroid Cancer	169	2.23	0.108

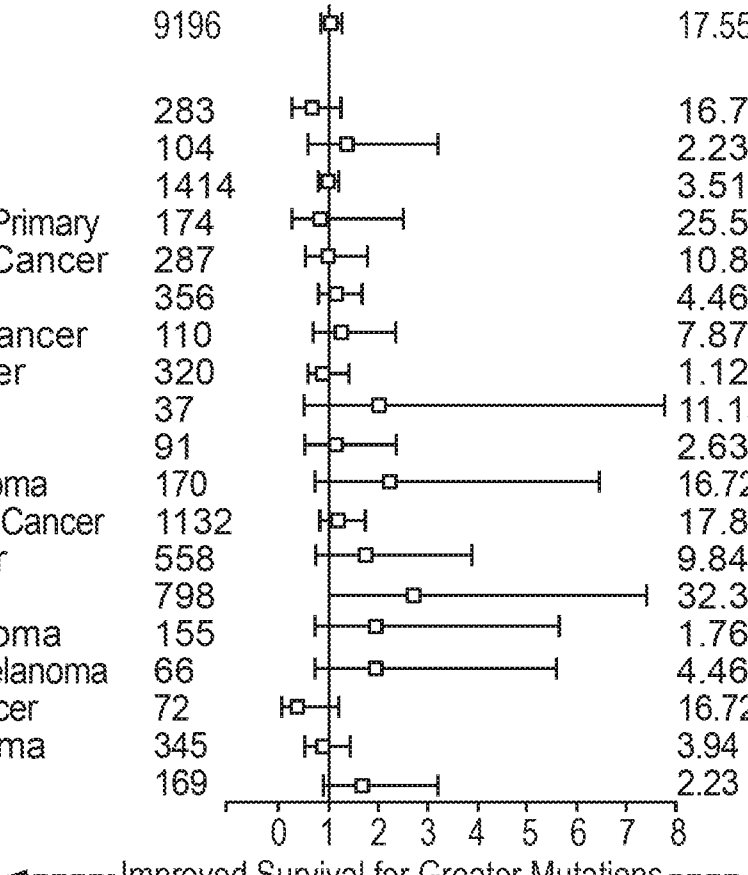


FIG. 4

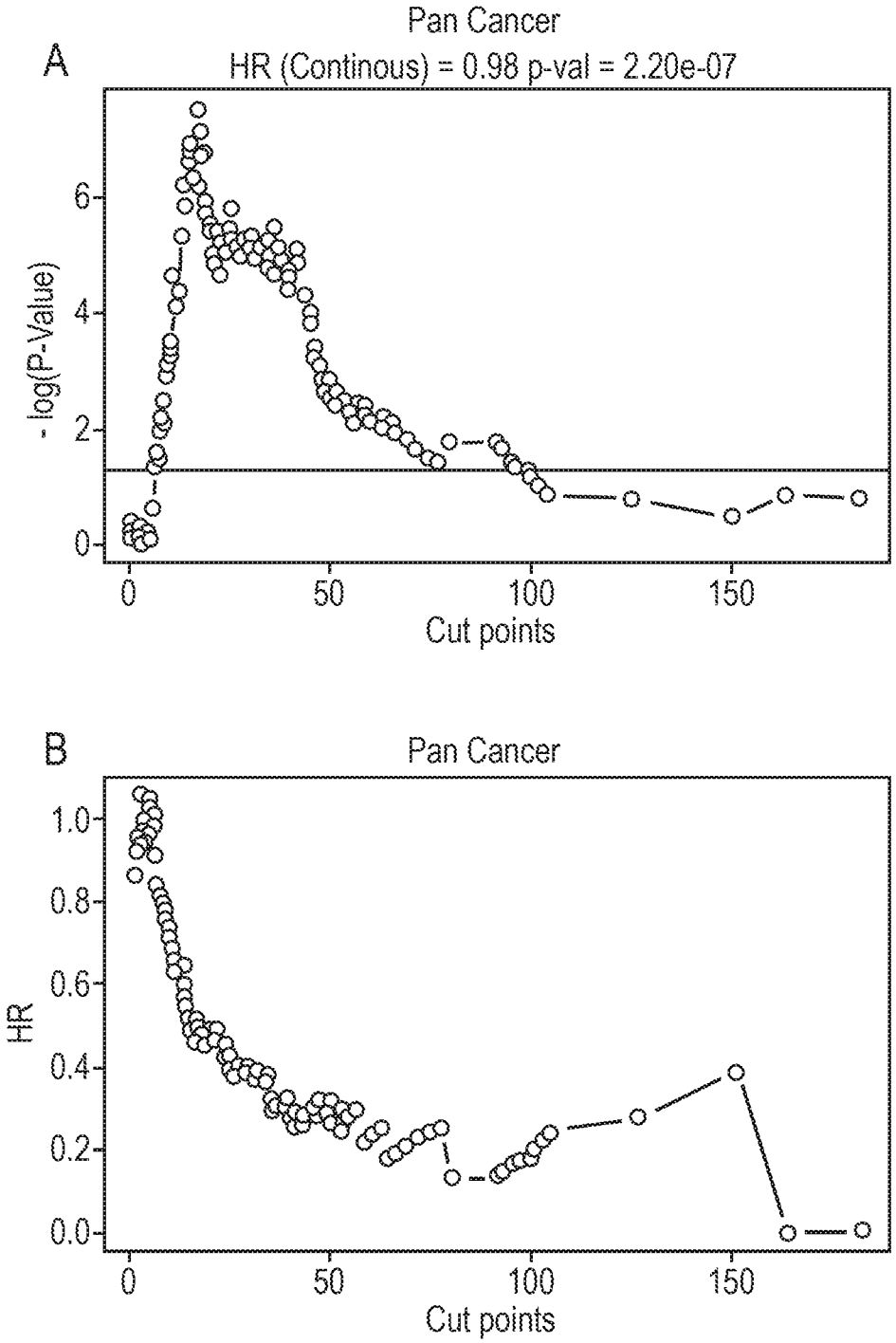

A
Pan Cancer
HR (Continous) = 0.98 p-val = 2.20e-07
- log(P-Value)
0
2
4
6
0
50
100
150
Cut points
B
Pan Cancer
HR
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
Cut points

FIG. 5

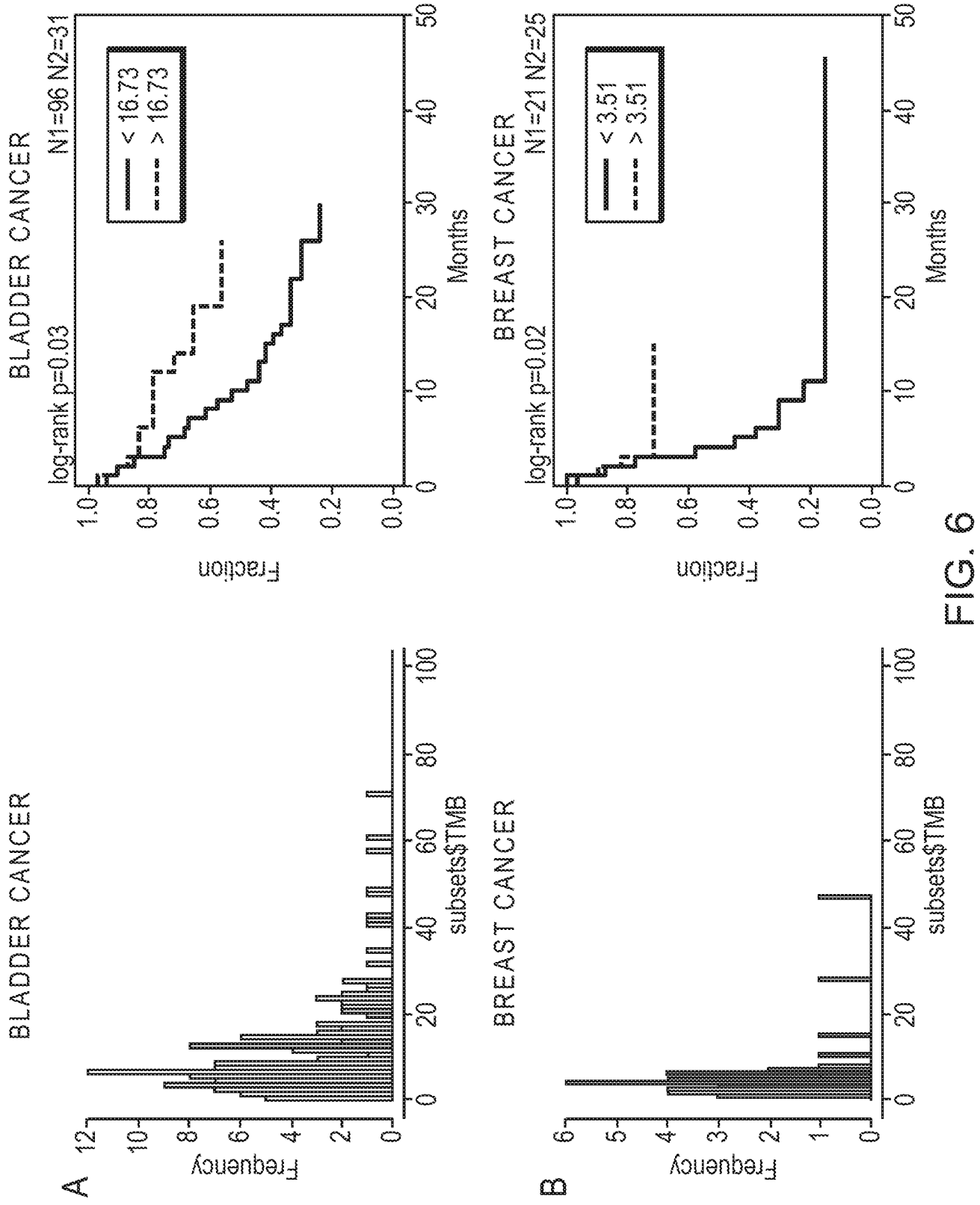

BLADDER CANCER
log-rank p=0.03
N1=96 N2=31
< 16.73
> 16.73
Fraction
Months
BREAST CANCER
log-rank p=0.02
N1=21 N2=25
< 3.51
> 3.51
Fraction
Months
A
BLADDER CANCER
Frequency
subsets$TMB
B
BREAST CANCER
Frequency
subsets$TMB

FIG. 6

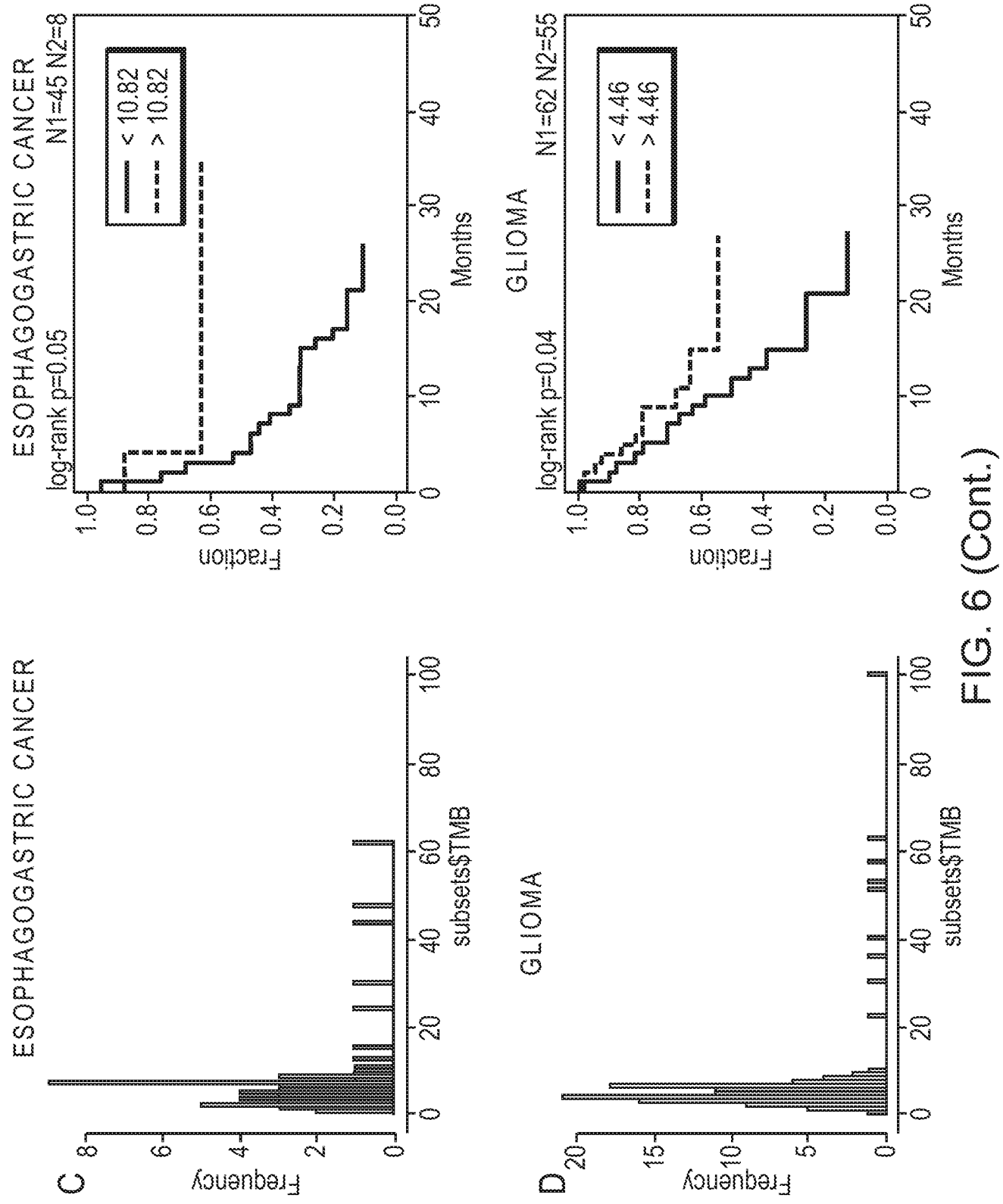

ESOPHAGOGASTRIC CANCER
N1=45 N2=8
log-rank p=0.05
< 10.82
> 10.82
Fraction
Months
GLIOMA
N1=62 N2=55
log-rank p=0.04
< 4.46
> 4.46
Fraction
Months
C
ESOPHAGOGASTRIC CANCER
Frequency
subsets$TMB
D
GLIOMA
Frequency
subsets$TMB

FIG. 6 (Cont.)

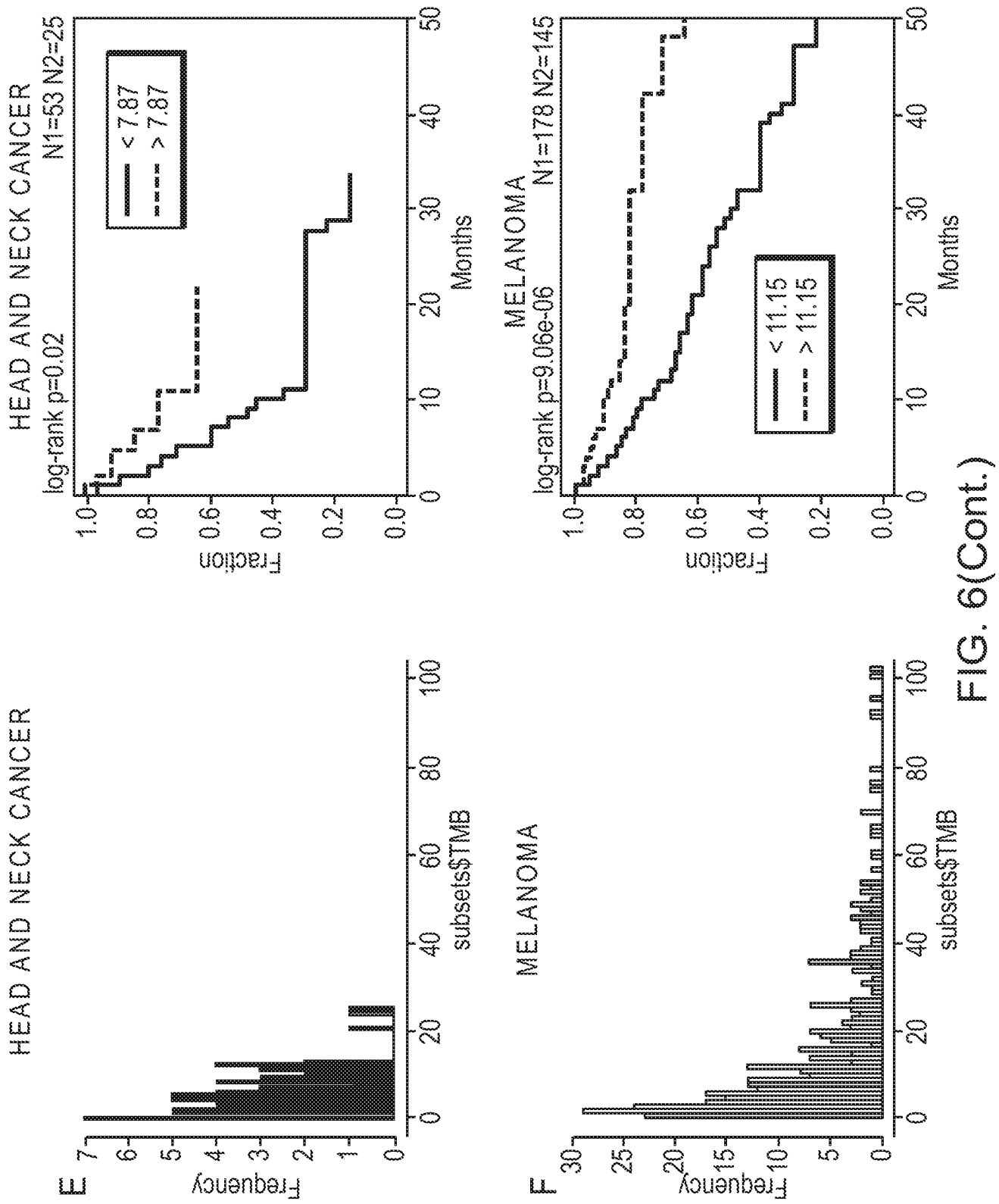

HEAD AND NECK CANCER
log-rank p=0.02
N1=53 N2=25
< 7.87
> 7.87
Fraction
Months
MELANOMA
log-rank p=9.06e-06
N1=178 N2=145
< 11.15
> 11.15
Fraction
Months
HEAD AND NECK CANCER
Frequency
subsets$TMB
MELANOMA
Frequency
subsets$TMB

FIG. 6(Cont.)

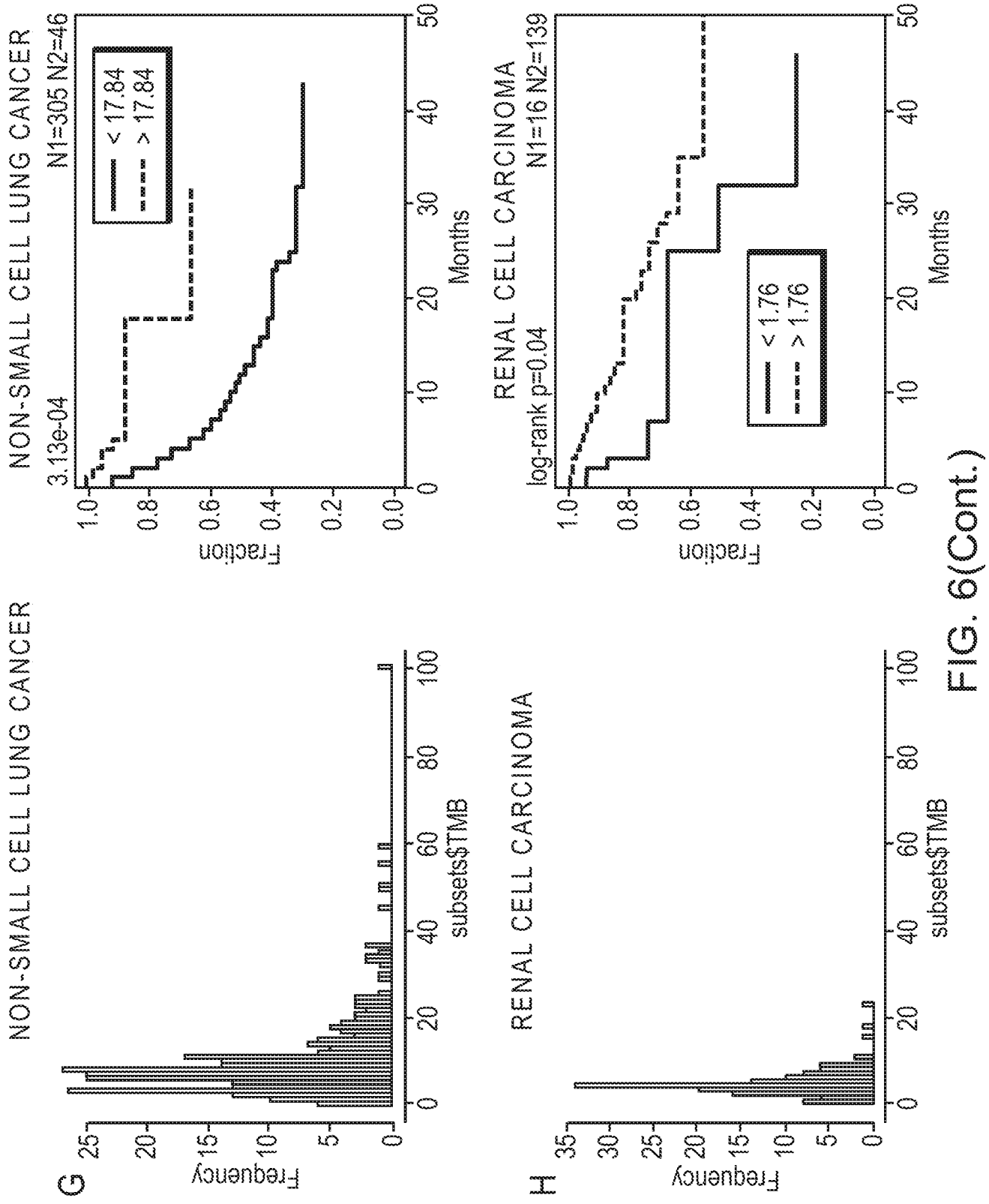

NON-SMALL CELL LUNG CANCER
N1=305 N2=46
3.13e-04
< 17.84
> 17.84
Fraction
Months
RENAL CELL CARCINOMA
N1=16 N2=139
log-rank p=0.04
< 1.76
> 1.76
Fraction
Months
G
NON-SMALL CELL LUNG CANCER
Frequency
subsets$TMB
H
RENAL CELL CARCINOMA
Frequency
subsets$TMB

FIG. 6(Cont.)

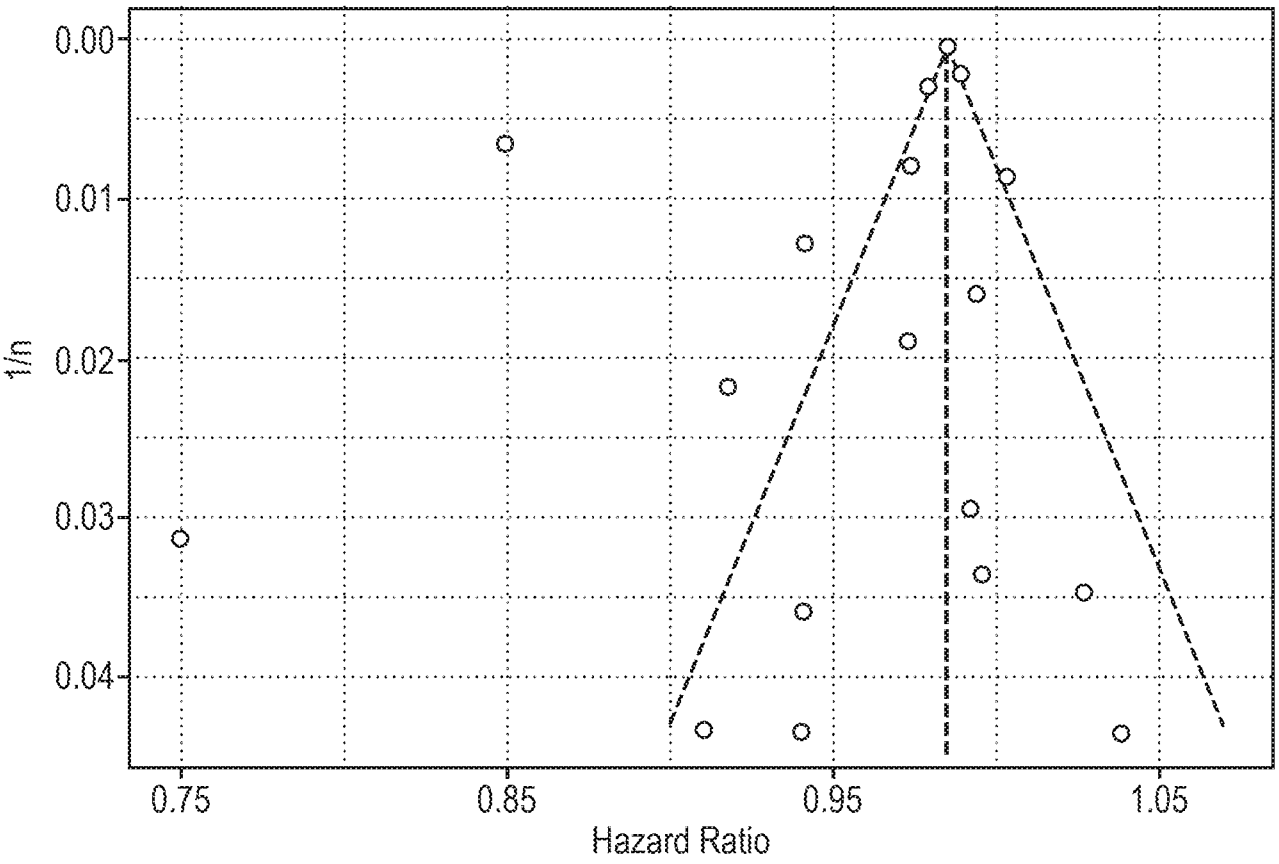
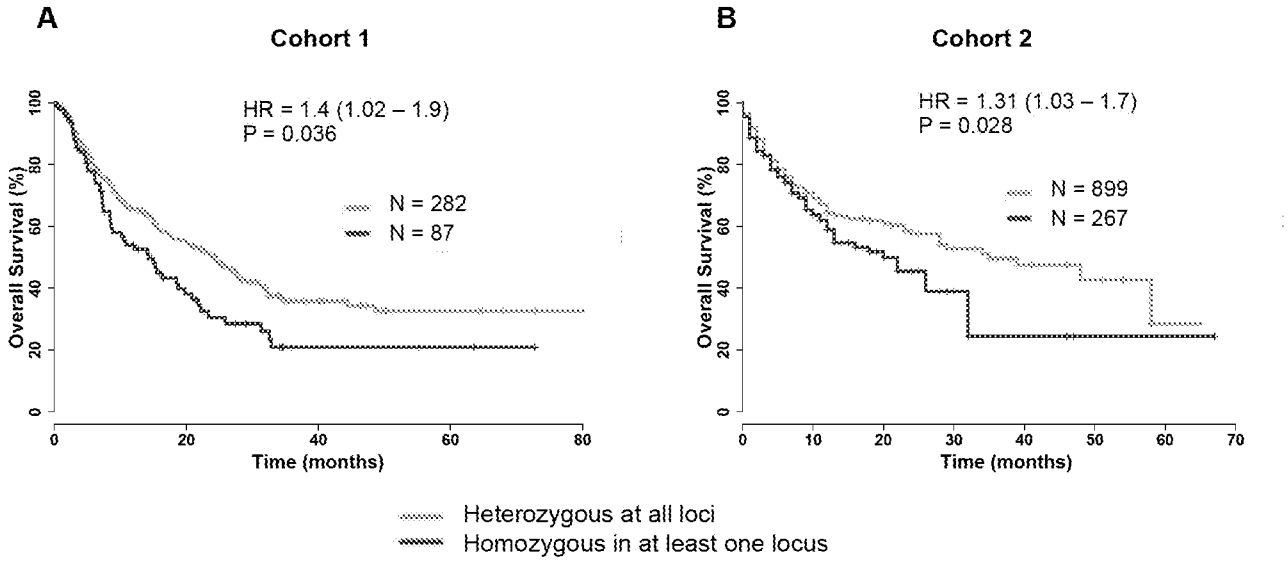


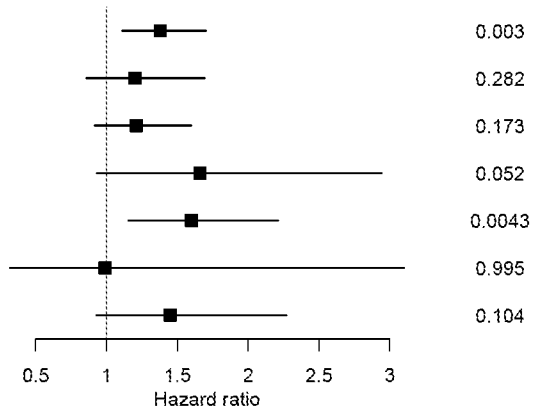
FIG. 7

Figure 8



C

	N	N with Homozyg.	P value
Homozygous at 1 locus	1439	258	0.003
Homozygous at 2 or 3 loci	1277	96	0.282
Homozygous at HLA-A only	1334	153	0.173
Homozygous at HLA-B only	1202	21	0.052
Homozygous at HLA-C only	1265	84	0.0043
Homozygous at HLA -A and -C only	1188	7	0.995
Homozygous at HLA -B and -C only	1229	48	0.104



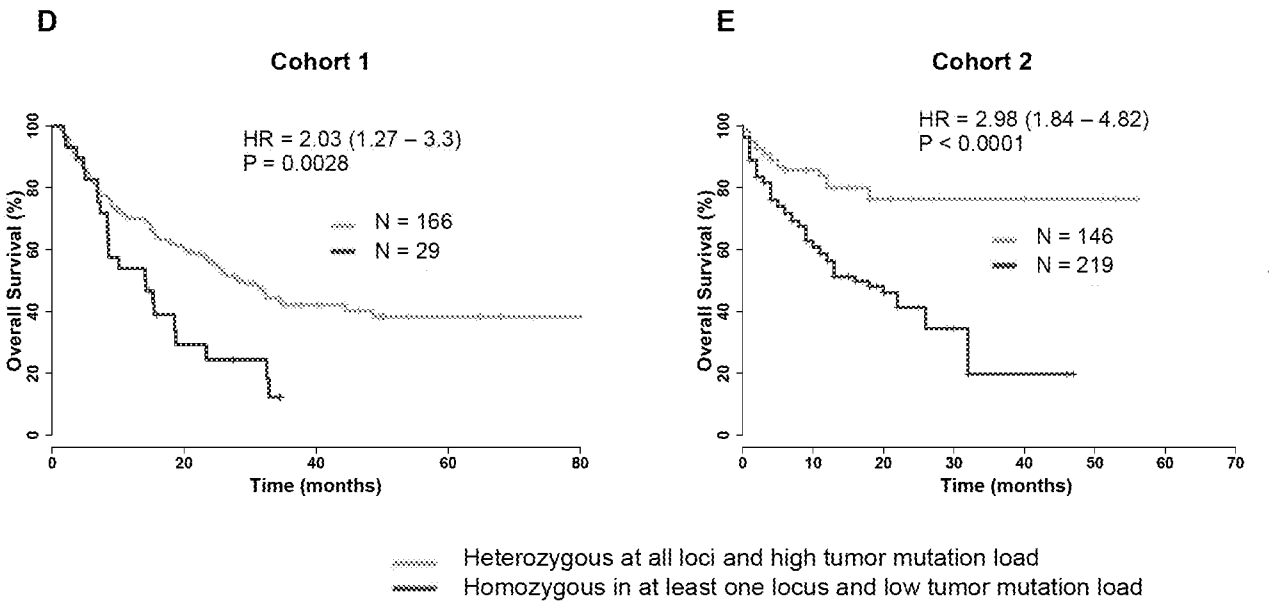
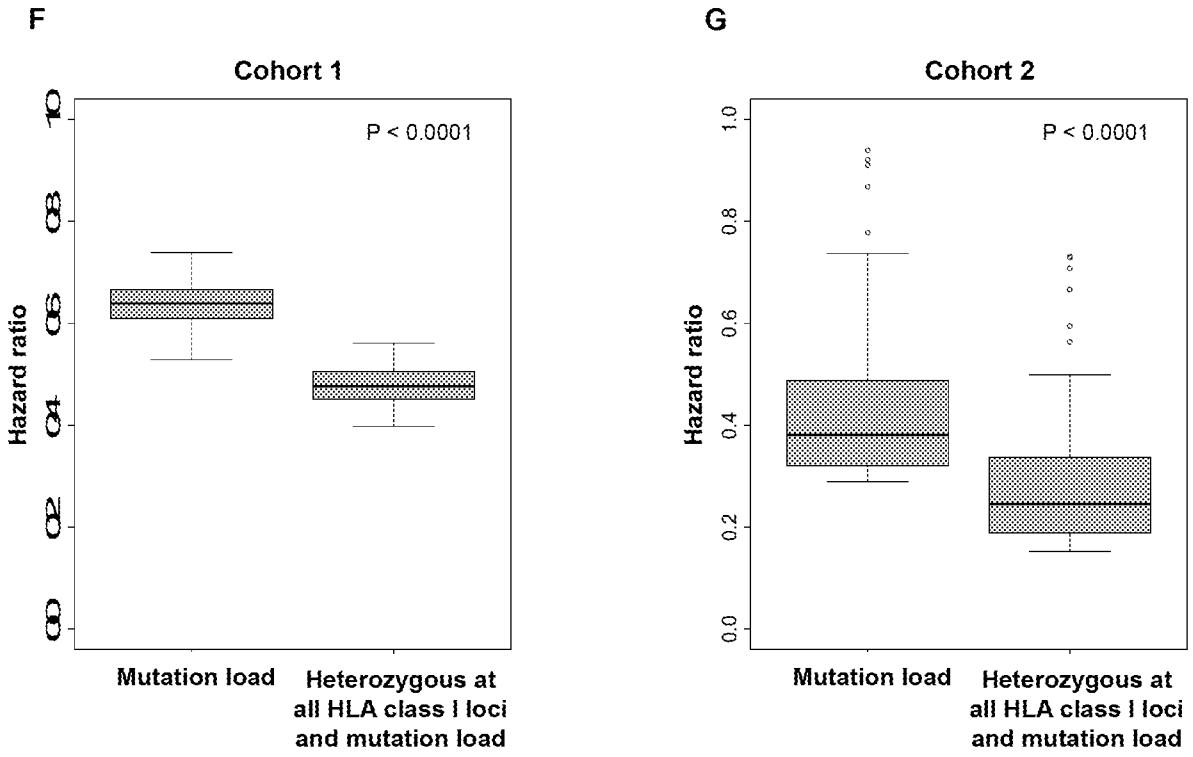
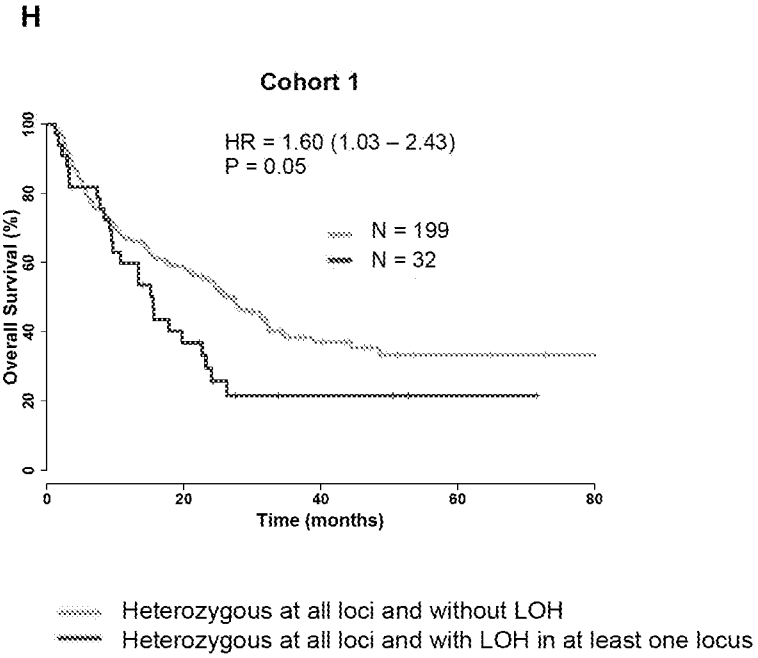


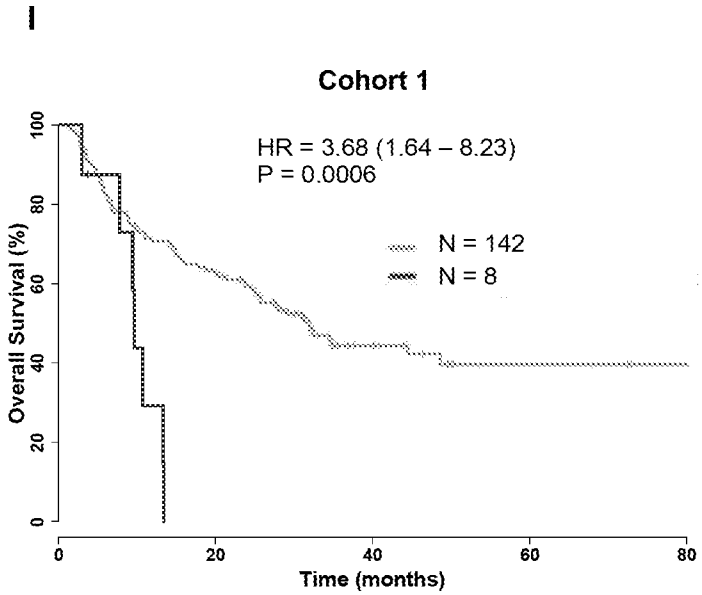
Figure 8 (cont.)





Heterozygous at all loci and without LOH
Heterozygous at all loci and with LOH in at least one locus

Figure 8 (Cont.)



Heterozygous at all loci, without LOH, and high mutation load
Heterozygous at all loci, with LOH in at least one locus, and low mutation load

Figure 9

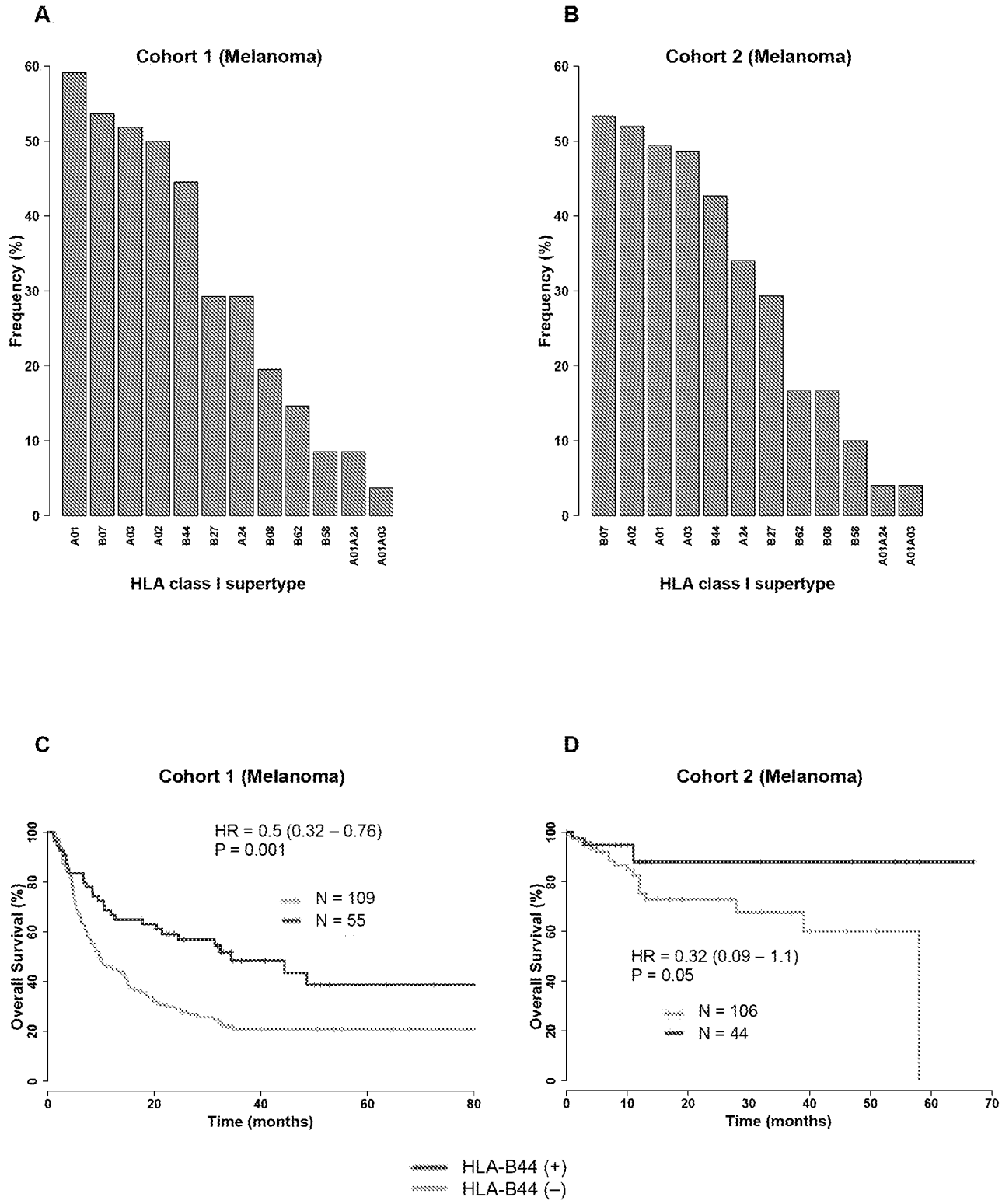

A
Cohort 1 (Melanoma)
Frequency (%)
HLA class I supertype
A01
B07
A03
A02
B44
B27
A24
B08
B62
B58
A01A24
A01A03
B
Cohort 2 (Melanoma)
Frequency (%)
HLA class I supertype
B07
A02
A01
A03
B44
A24
B27
B62
B08
B58
A01A24
A01A03
C
Cohort 1 (Melanoma)
HR = 0.5 (0.32 – 0.76)
P = 0.001
N = 109
N = 55
Overall Survival (%)
Time (months)
D
Cohort 2 (Melanoma)
HR = 0.32 (0.09 – 1.1)
P = 0.05
N = 106
N = 44
Overall Survival (%)
Time (months)
HLA-B44 (+)
HLA-B44 (–)

Figure 9 (cont.)

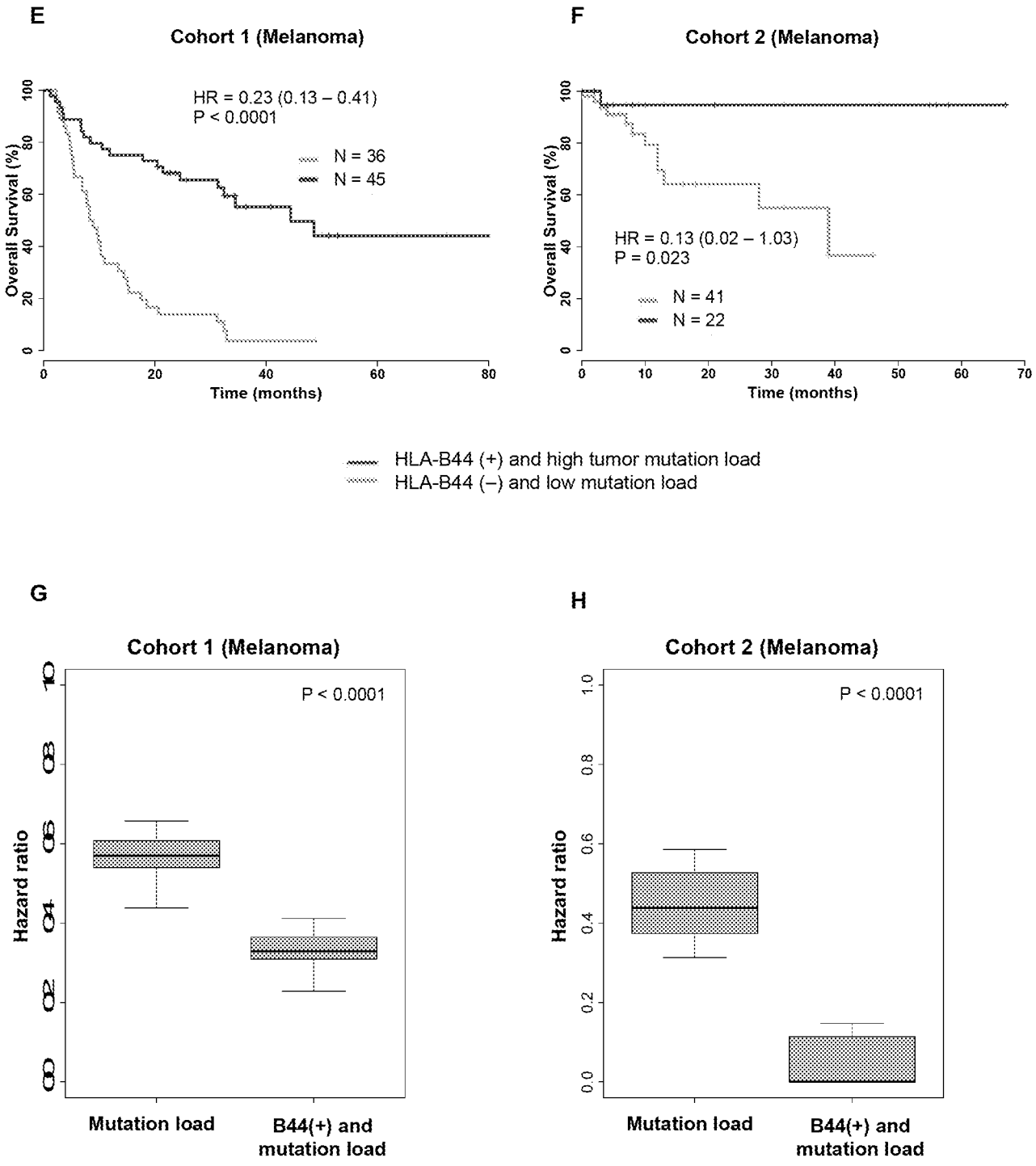
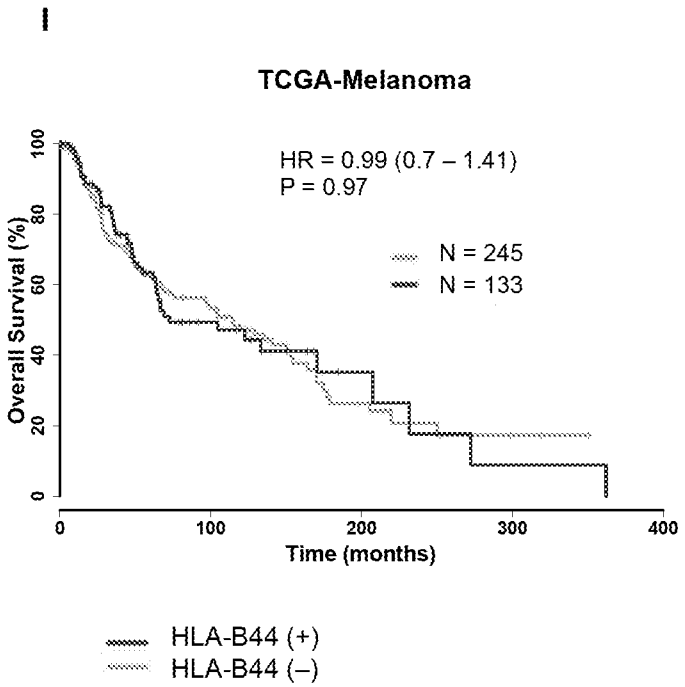


Figure 9 (cont.)



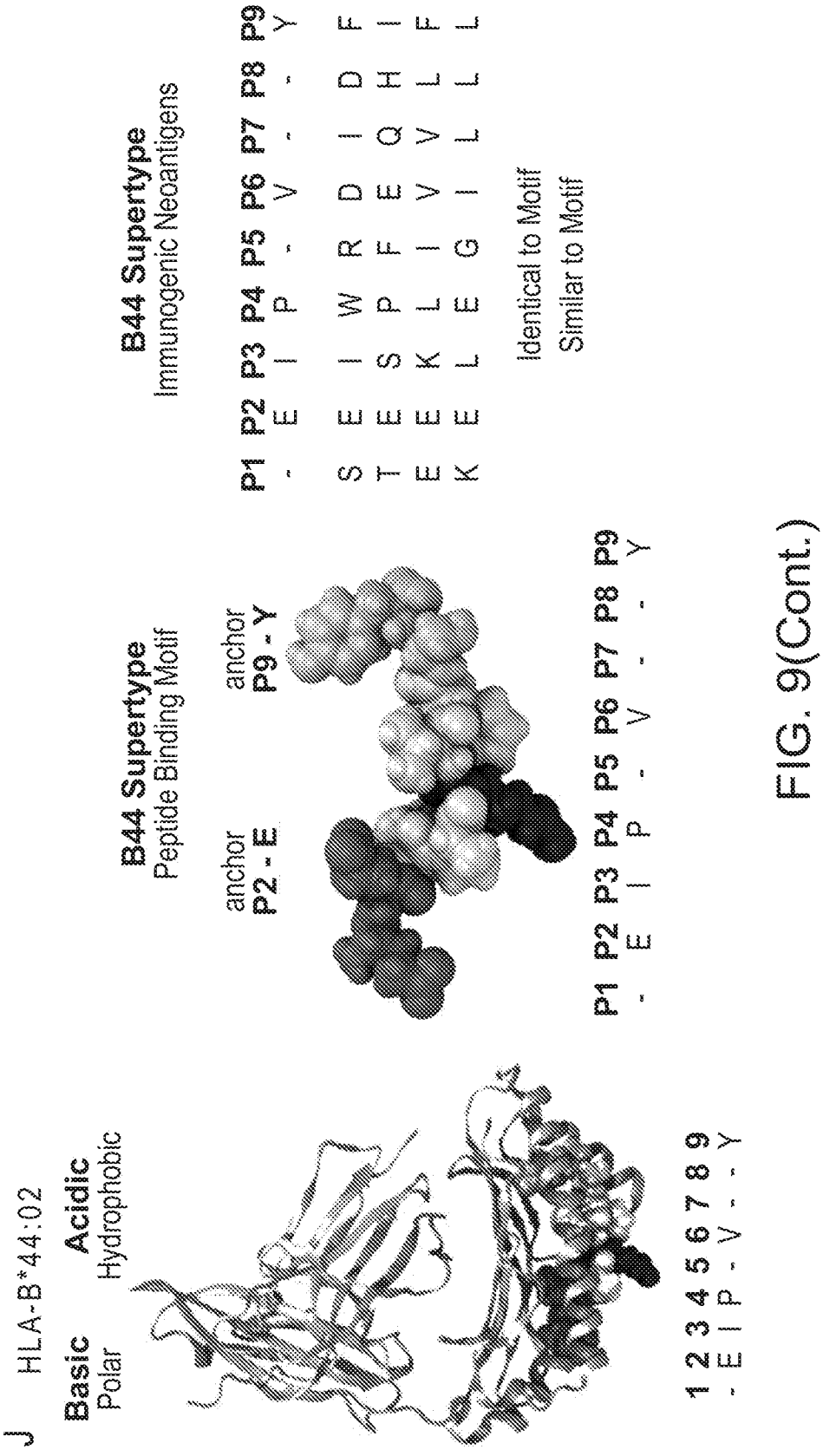

J HLA-B*44:02
Basic Polar
Acidic Hydrophobic
1 2 3 4 5 6 7 8 9
- E I P - V - - Y
B44 Supertype
Peptide Binding Motif
anchor
P2 - E
anchor
P9 - Y
P1 P2 P3 P4 P5 P6 P7 P8 P9
- E I P - V - - Y
B44 Supertype
Immunogenic Neoantigens
P1 P2 P3 P4 P5 P6 P7 P8 P9
- E I P - V - - Y
S E I W R D I D F
T E S P F E Q H I
E E K L I V V L F
K E L E G I L L L
Identical to Motif
Similar to Motif

FIG. 9(Cont.)

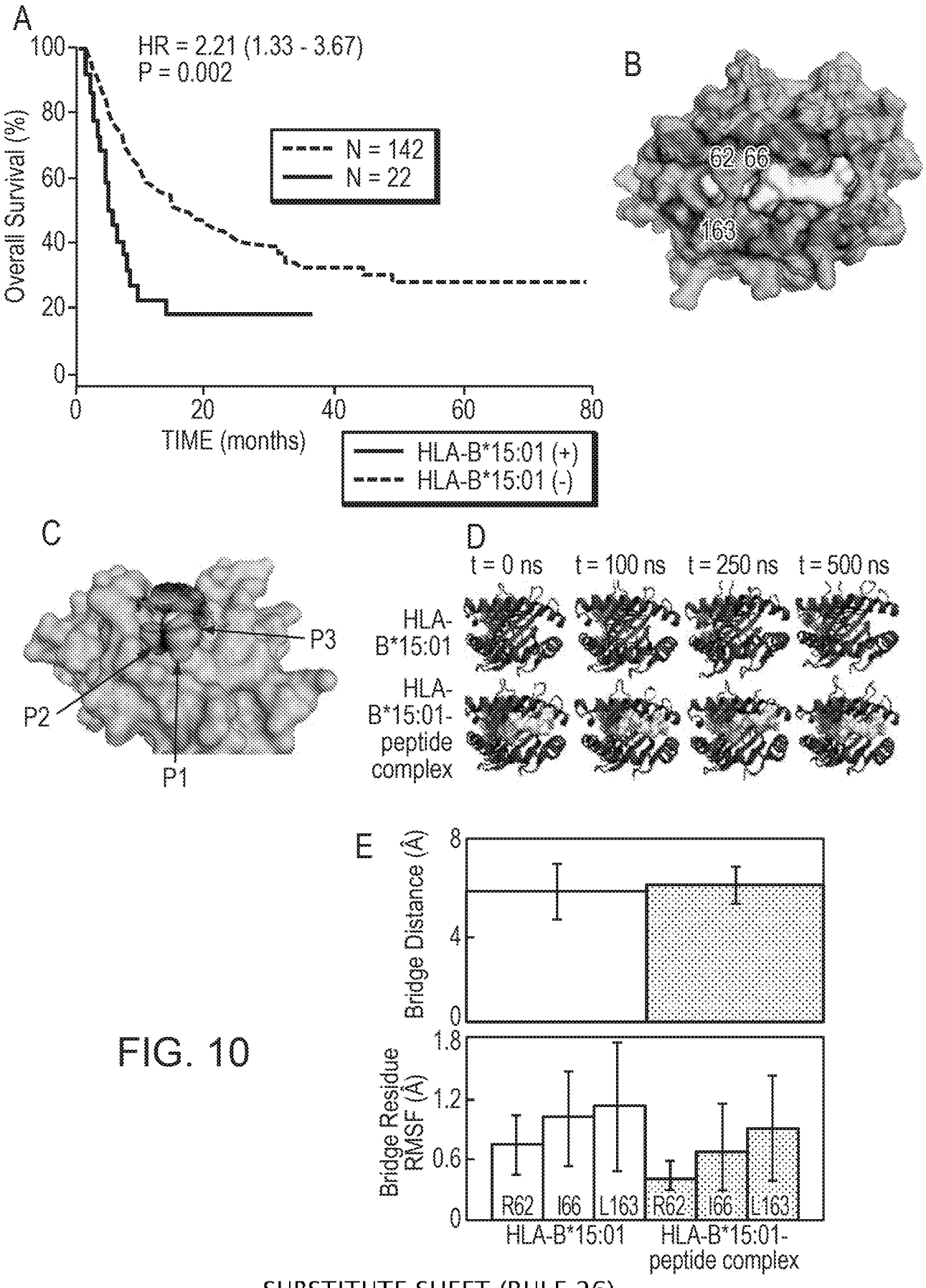
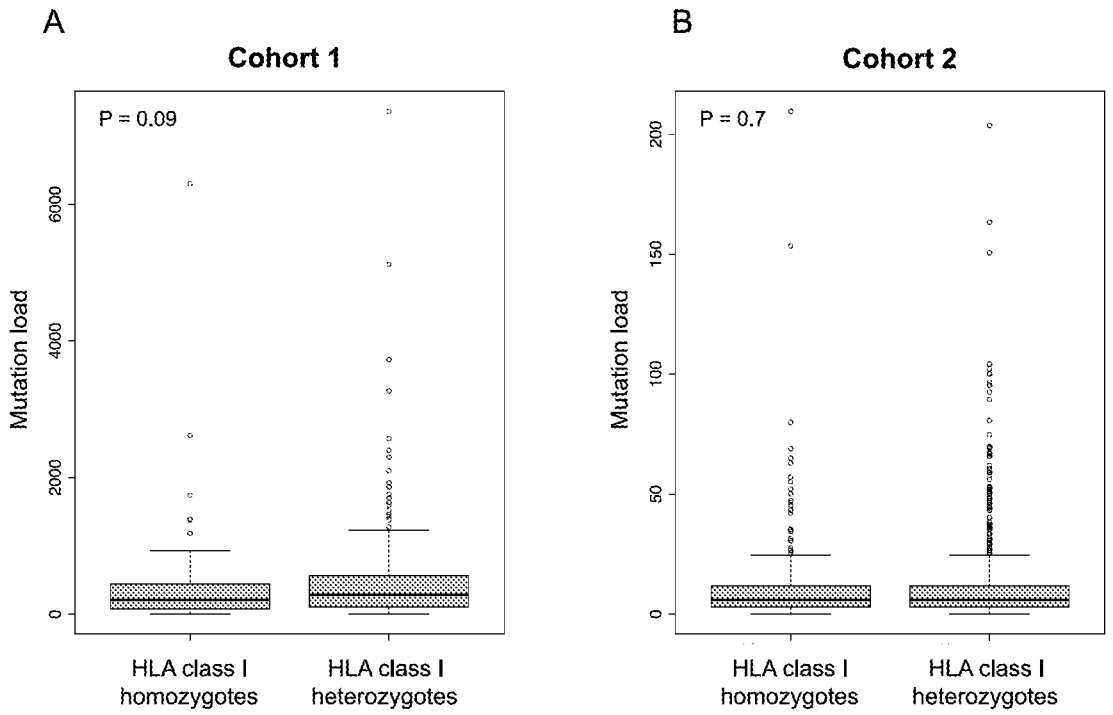

A
HR = 2.21 (1.33 - 3.67)
P = 0.002
N = 142
N = 22
Overall Survival (%)
TIME (months)
HLA-B*15:01 (+)
HLA-B*15:01 (-)
B
62
66
163
C
P3
P2
P1
D
t = 0 ns
t = 100 ns
t = 250 ns
t = 500 ns
HLA-B*15:01
HLA-B*15:01-peptide complex
E
Bridge Distance (Å)
Bridge Residue RMSF (Å)
R62
I66
L163
HLA-B*15:01
HLA-B*15:01-peptide complex

FIG. 10

Figure 11


A
Cohort 1
P = 0.09
Mutation load
0
2000
4000
6000
HLA class I homozygotes
HLA class I heterozygotes
B
Cohort 2
P = 0.7
Mutation load
0
50
100
150
200
HLA class I homozygotes
HLA class I heterozygotes

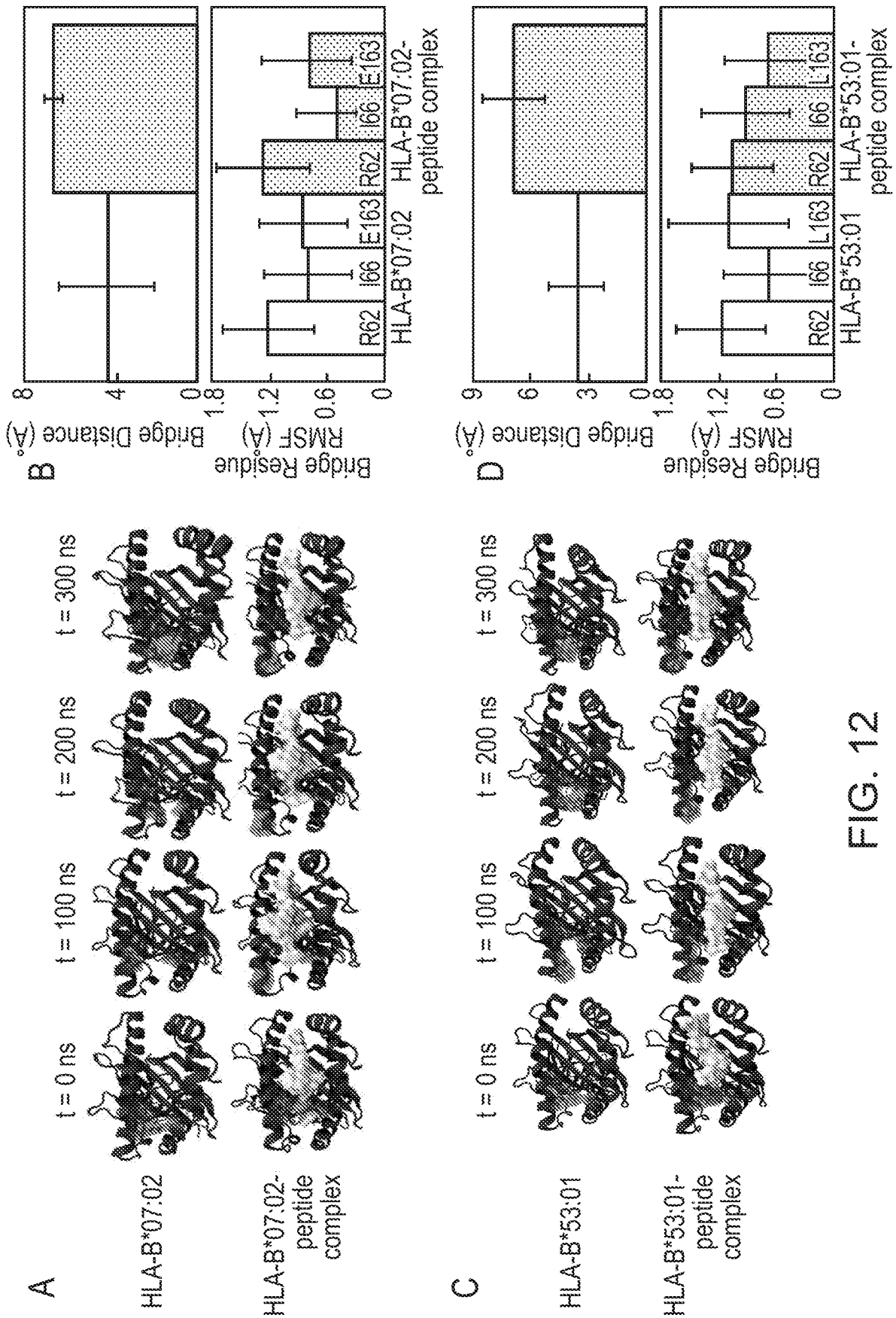

A
t = 0 ns
t = 100 ns
t = 200 ns
t = 300 ns
HLA-B*07:02
HLA-B*07:02-peptide complex
C
HLA-B*53:01
HLA-B*53:01-peptide complex
B
Bridge Distance (Å)
Bridge Residue RMSF (Å)
R62
I66
E163
HLA-B*07:02
HLA-B*07:02-peptide complex
D
Bridge Distance (Å)
Bridge Residue RMSF (Å)
R62
I66
L163
HLA-B*53:01
HLA-B*53:01-peptide complex

FIG. 12

Figure 13

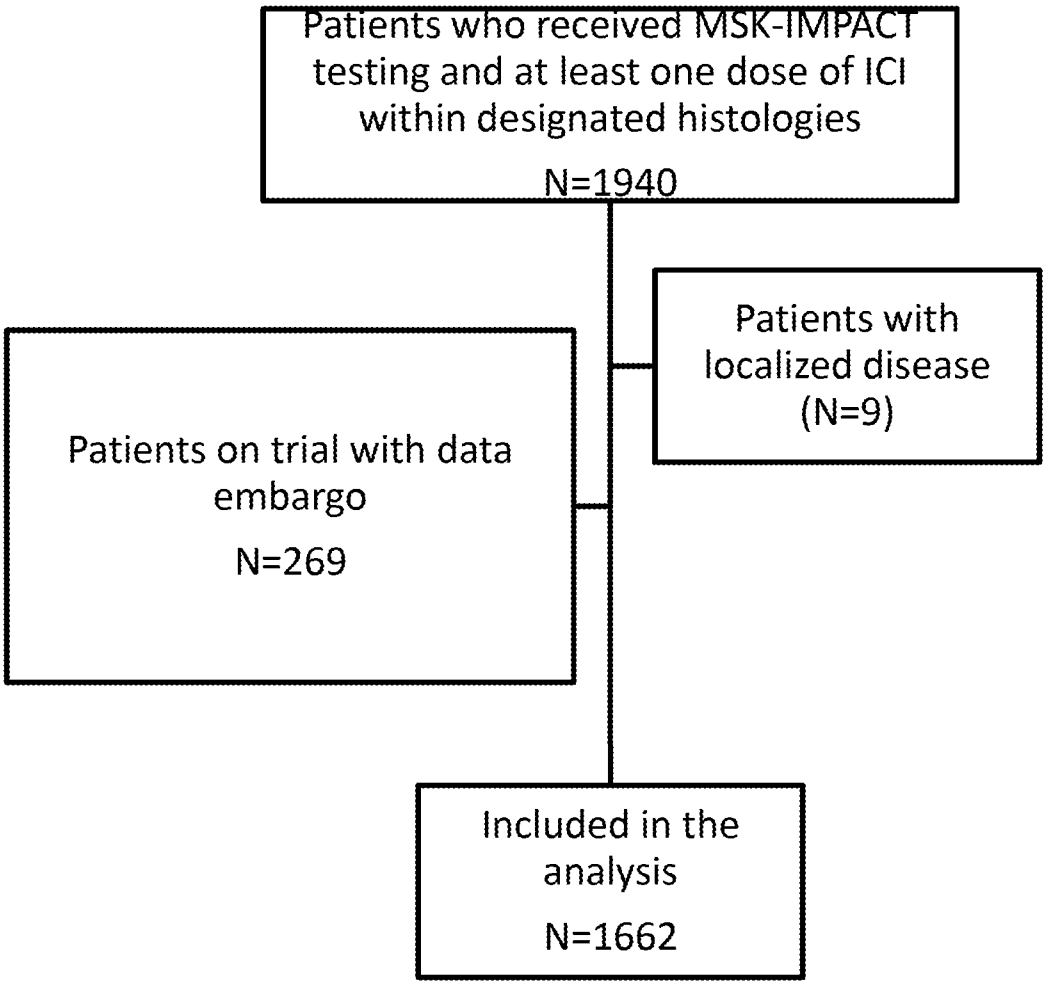
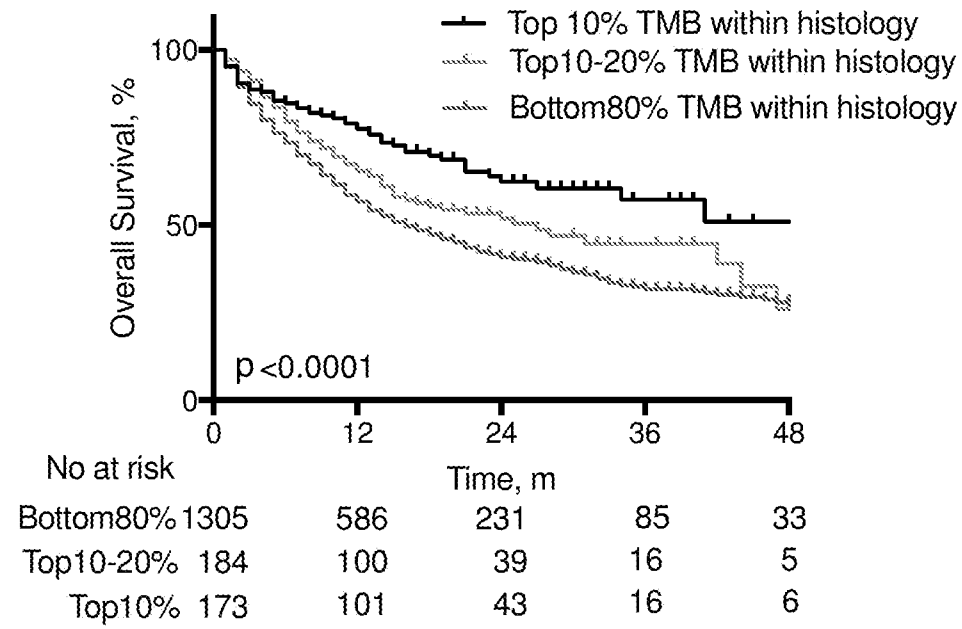

Patients who received MSK-IMPACT testing and at least one dose of ICI within designated histologies
N=1940
Patients with localized disease (N=9)
Patients on trial with data embargo
N=269
Included in the analysis
N=1662

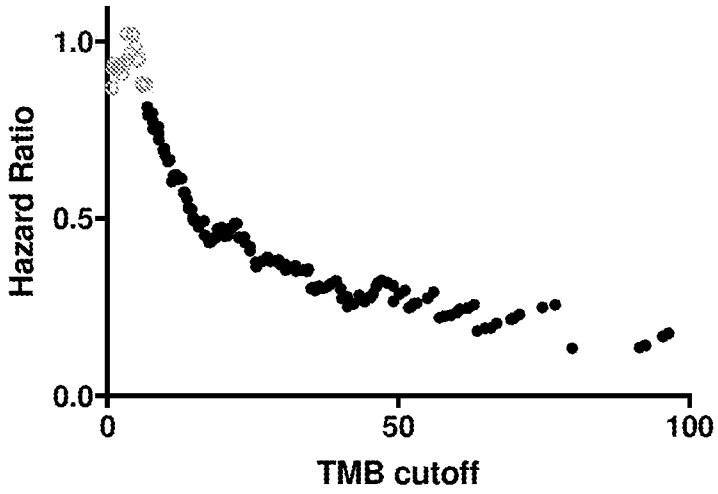
Figure 14

A



No at risk					
Bottom80%	1305	586	231	85	33
Top10-20%	184	100	39	16	5
Top10%	173	101	43	16	6

B



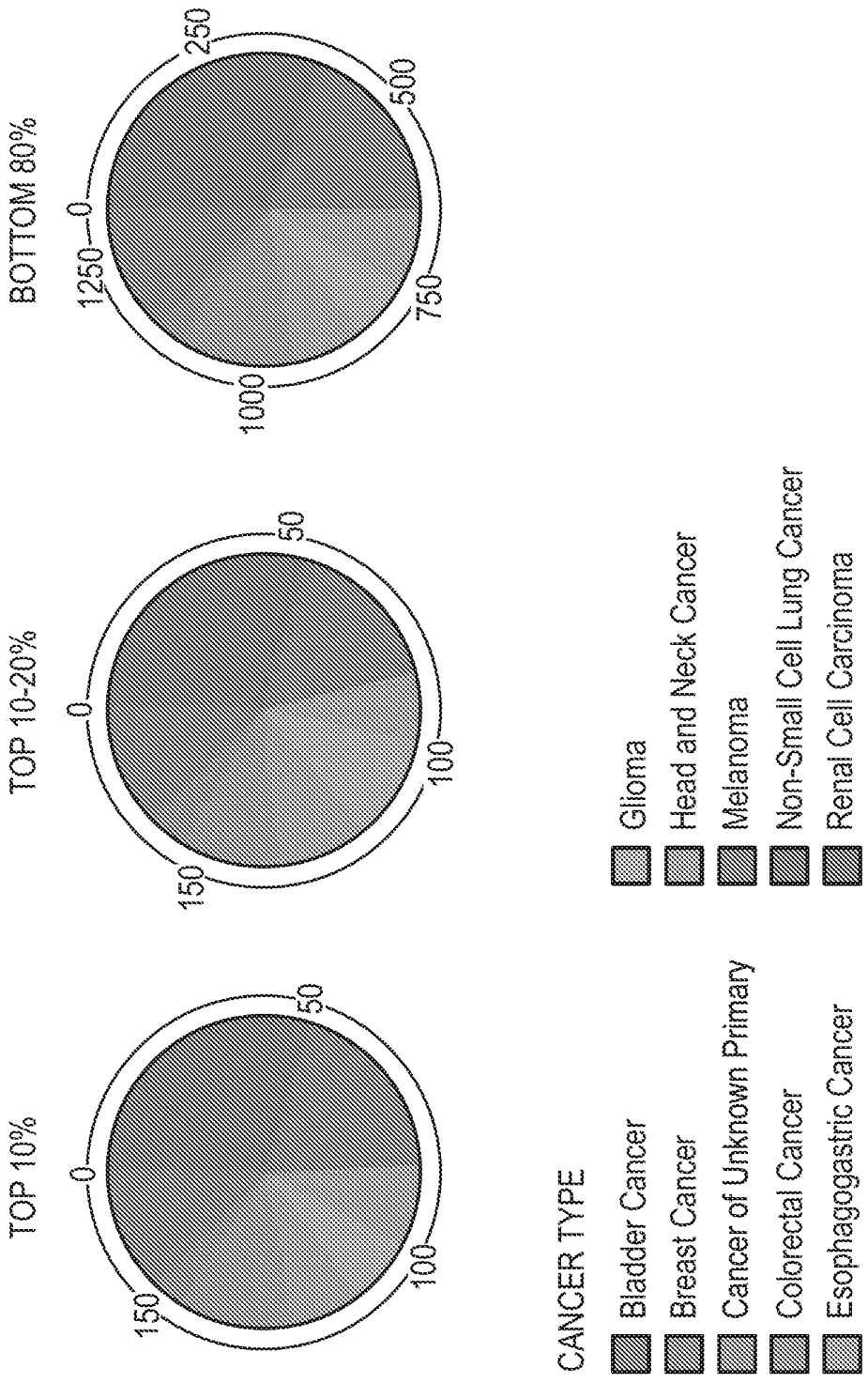

TOP 10%
0
50
100
150
TOP 10-20%
0
50
100
150
BOTTOM 80%
0
250
500
750
1000
1250
CANCER TYPE
Bladder Cancer
Breast Cancer
Cancer of Unknown Primary
Colorectal Cancer
Esophagogastric Cancer
Glioma
Head and Neck Cancer
Melanoma
Non-Small Cell Lung Cancer
Renal Cell Carcinoma

FIG. 15

Figure 16

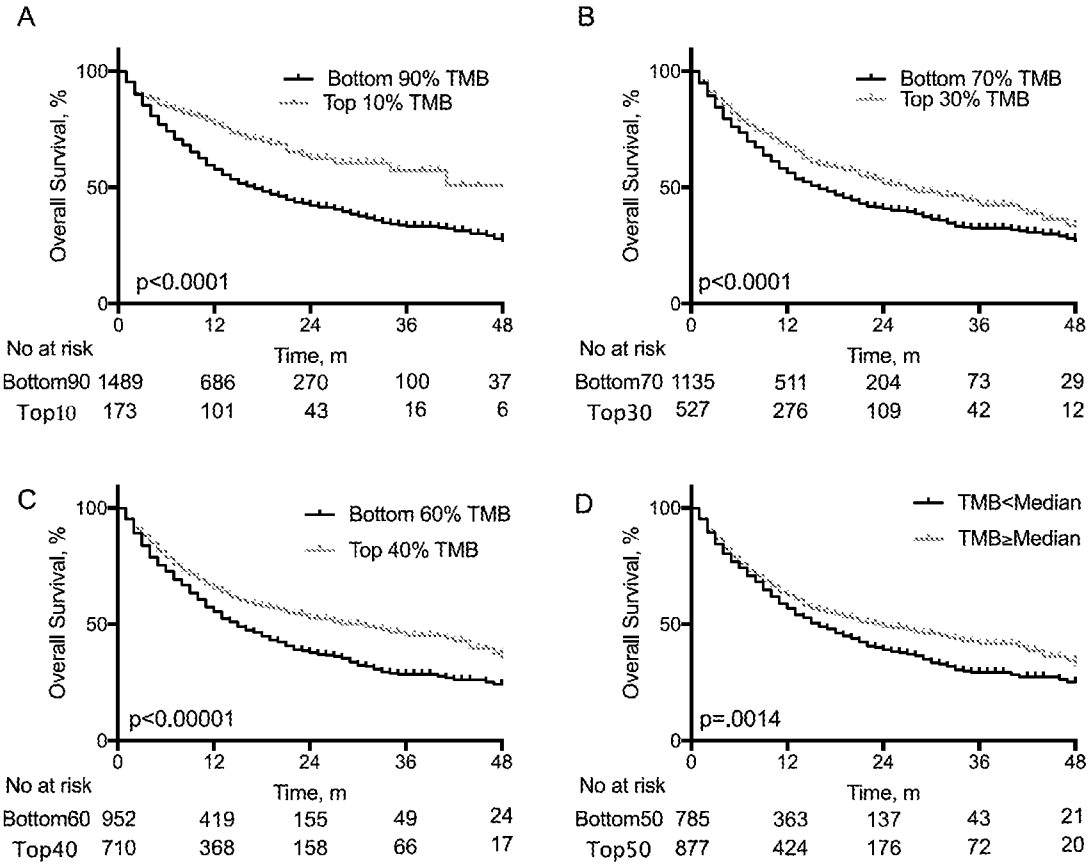

A
Overall Survival, %
100
50
0
Bottom 90% TMB
Top 10% TMB
p<0.0001
0 12 24 36 48
Time, m
No at risk
Bottom90 1489 686 270 100 37
Top10 173 101 43 16 6
B
Overall Survival, %
100
50
0
Bottom 70% TMB
Top 30% TMB
p<0.0001
0 12 24 36 48
Time, m
No at risk
Bottom70 1135 511 204 73 29
Top30 527 276 109 42 12
C
Overall Survival, %
100
50
0
Bottom 60% TMB
Top 40% TMB
p<0.00001
0 12 24 36 48
Time, m
No at risk
Bottom60 952 419 155 49 24
Top40 710 368 158 66 17
D
Overall Survival, %
100
50
0
TMB<Median
TMB≥Median
p=.0014
0 12 24 36 48
Time, m
No at risk
Bottom50 785 363 137 43 21
Top50 877 424 176 72 20

Figure 17

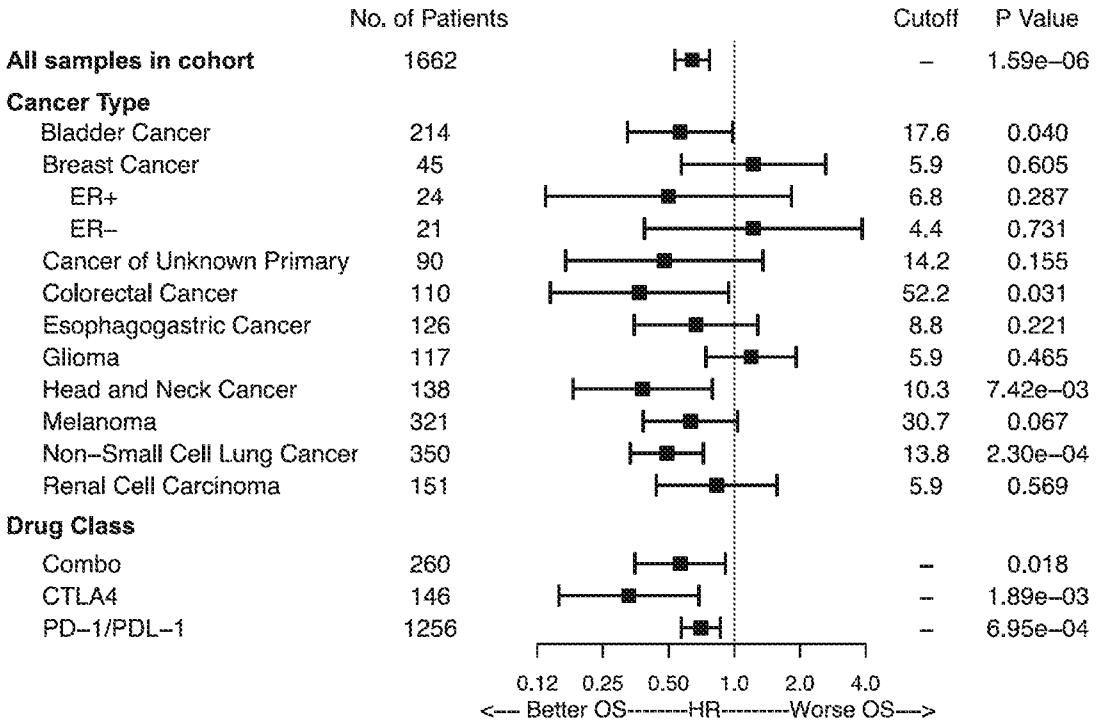
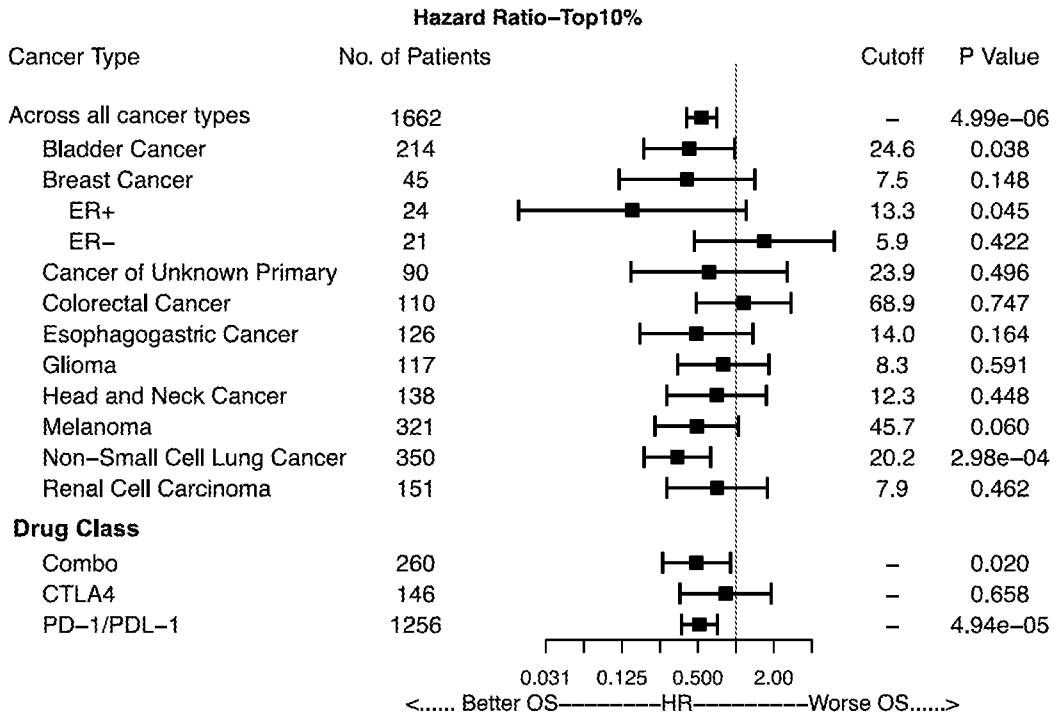
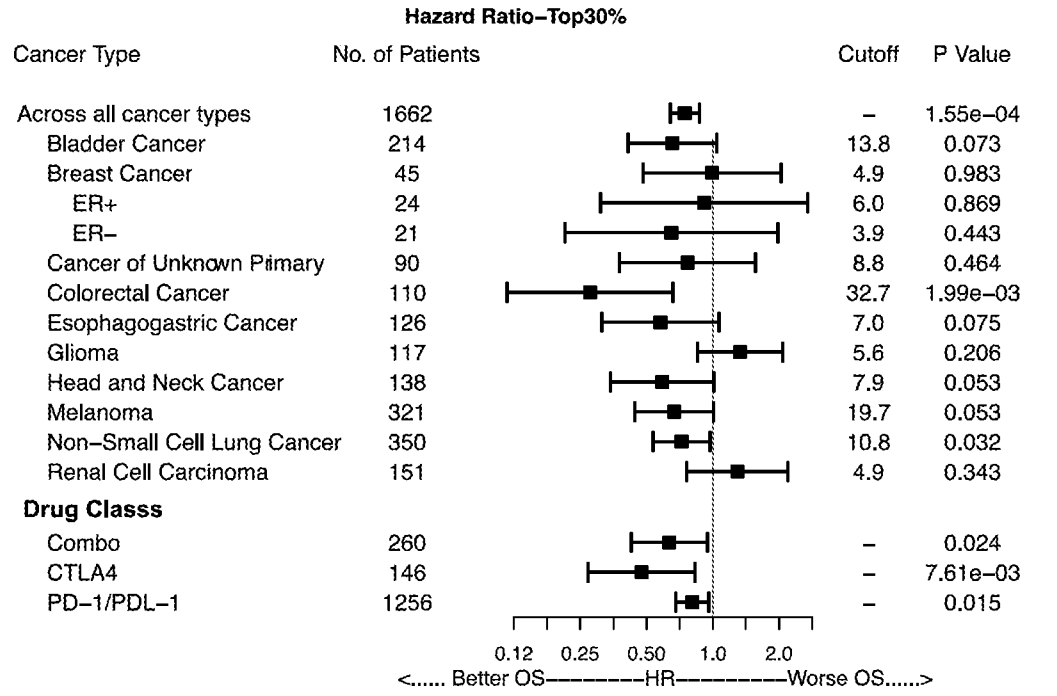

No. of Patients
Cutoff
P Value
All samples in cohort 1662 – 1.59e–06
Cancer Type
Bladder Cancer 214 17.6 0.040
Breast Cancer 45 5.9 0.605
ER+ 24 6.8 0.287
ER– 21 4.4 0.731
Cancer of Unknown Primary 90 14.2 0.155
Colorectal Cancer 110 52.2 0.031
Esophagogastric Cancer 126 8.8 0.221
Glioma 117 5.9 0.465
Head and Neck Cancer 138 10.3 7.42e–03
Melanoma 321 30.7 0.067
Non–Small Cell Lung Cancer 350 13.8 2.30e–04
Renal Cell Carcinoma 151 5.9 0.569
Drug Class
Combo 260 – 0.018
CTLA4 146 – 1.89e–03
PD–1/PDL–1 1256 – 6.95e–04
0.12 0.25 0.50 1.0 2.0 4.0
<— Better OS--------HR--------Worse OS—>

Figure 18

A


Hazard Ratio–Top10%
Cancer Type
No. of Patients
Cutoff
P Value
Across all cancer types 1662 – 4.99e–06
Bladder Cancer 214 24.6 0.038
Breast Cancer 45 7.5 0.148
ER+ 24 13.3 0.045
ER– 21 5.9 0.422
Cancer of Unknown Primary 90 23.9 0.496
Colorectal Cancer 110 68.9 0.747
Esophagogastric Cancer 126 14.0 0.164
Glioma 117 8.3 0.591
Head and Neck Cancer 138 12.3 0.448
Melanoma 321 45.7 0.060
Non–Small Cell Lung Cancer 350 20.2 2.98e–04
Renal Cell Carcinoma 151 7.9 0.462
Drug Class
Combo 260 – 0.020
CTLA4 146 – 0.658
PD–1/PDL–1 1256 – 4.94e–05
0.031 0.125 0.500 2.00
<..... Better OS----------HR----------Worse OS.....>

B


Hazard Ratio–Top30%
Cancer Type
No. of Patients
Cutoff
P Value
Across all cancer types 1662 – 1.55e–04
Bladder Cancer 214 13.8 0.073
Breast Cancer 45 4.9 0.983
ER+ 24 6.0 0.869
ER– 21 3.9 0.443
Cancer of Unknown Primary 90 8.8 0.464
Colorectal Cancer 110 32.7 1.99e–03
Esophagogastric Cancer 126 7.0 0.075
Glioma 117 5.6 0.206
Head and Neck Cancer 138 7.9 0.053
Melanoma 321 19.7 0.053
Non–Small Cell Lung Cancer 350 10.8 0.032
Renal Cell Carcinoma 151 4.9 0.343
Drug Classs
Combo 260 – 0.024
CTLA4 146 – 7.61e–03
PD–1/PDL–1 1256 – 0.015
0.12 0.25 0.50 1.0 2.0
<..... Better OS----------HR----------Worse OS.....>

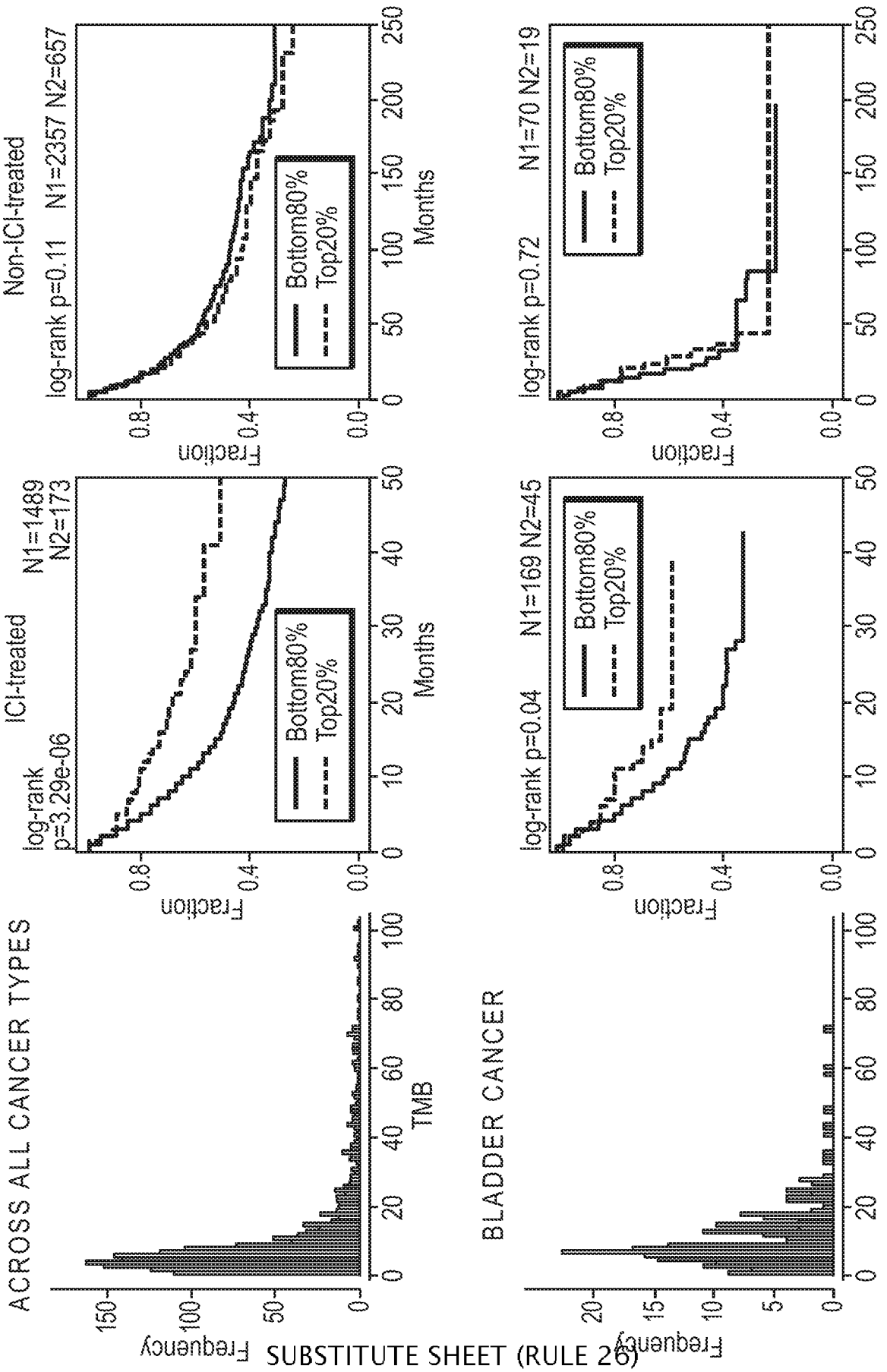

ACROSS ALL CANCER TYPES
BLADDER CANCER
ICI-treated
Non-ICI-treated
log-rank p=3.29e-06
N1=1489
N2=173
log-rank p=0.11
N1=2357 N2=657
log-rank p=0.04
N1=169 N2=45
log-rank p=0.72
N1=70 N2=19
Bottom80%
Top20%
Fraction
Months
TMB
Frequency

FIG. 19

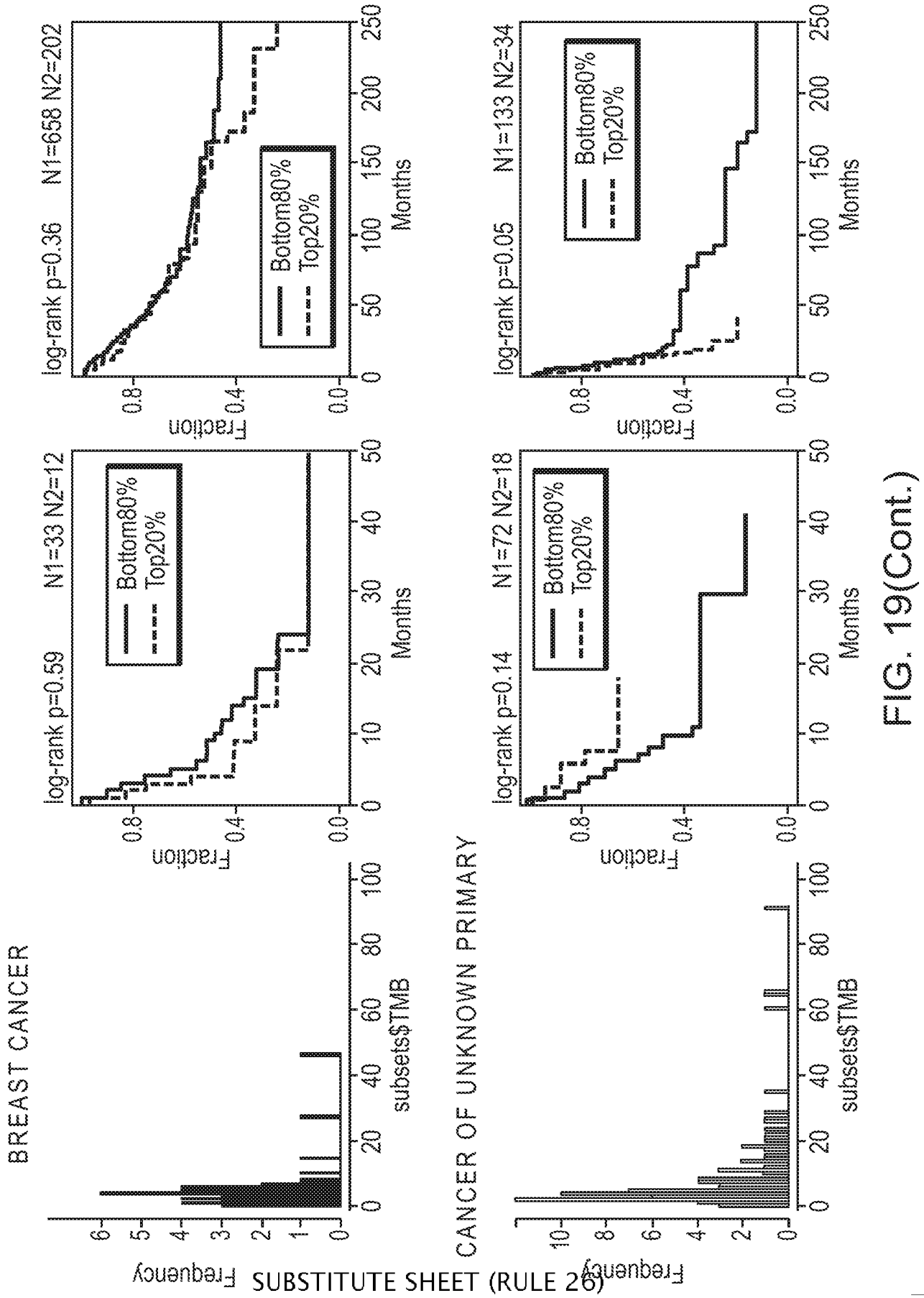

BREAST CANCER
CANCER OF UNKNOWN PRIMARY
log-rank p=0.36
N1=658 N2=202
log-rank p=0.05
N1=133 N2=34
log-rank p=0.59
N1=33 N2=12
log-rank p=0.14
N1=72 N2=18
Bottom80%
Top20%
Fraction
Months
Frequency
subsets$TMB

FIG. 19(Cont.)

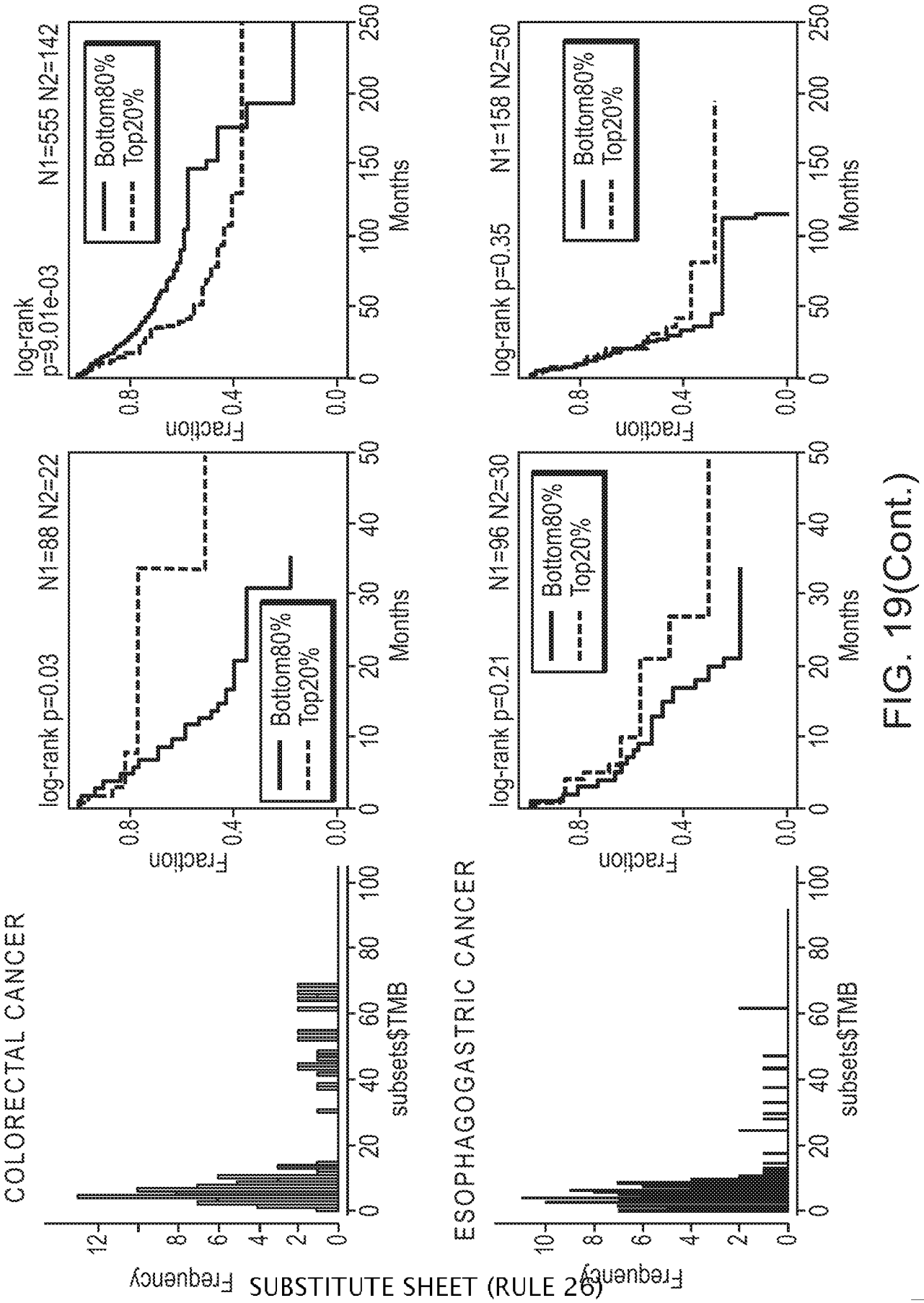

COLORECTAL CANCER
ESOPHAGOGASTRIC CANCER
Frequency
subsets$TMB
Fraction
Months
log-rank p=0.03
N1=88 N2=22
log-rank p=9.01e-03
N1=555 N2=142
log-rank p=0.21
N1=96 N2=30
log-rank p=0.35
N1=158 N2=50
Bottom80%
Top20%

FIG. 19(Cont.)

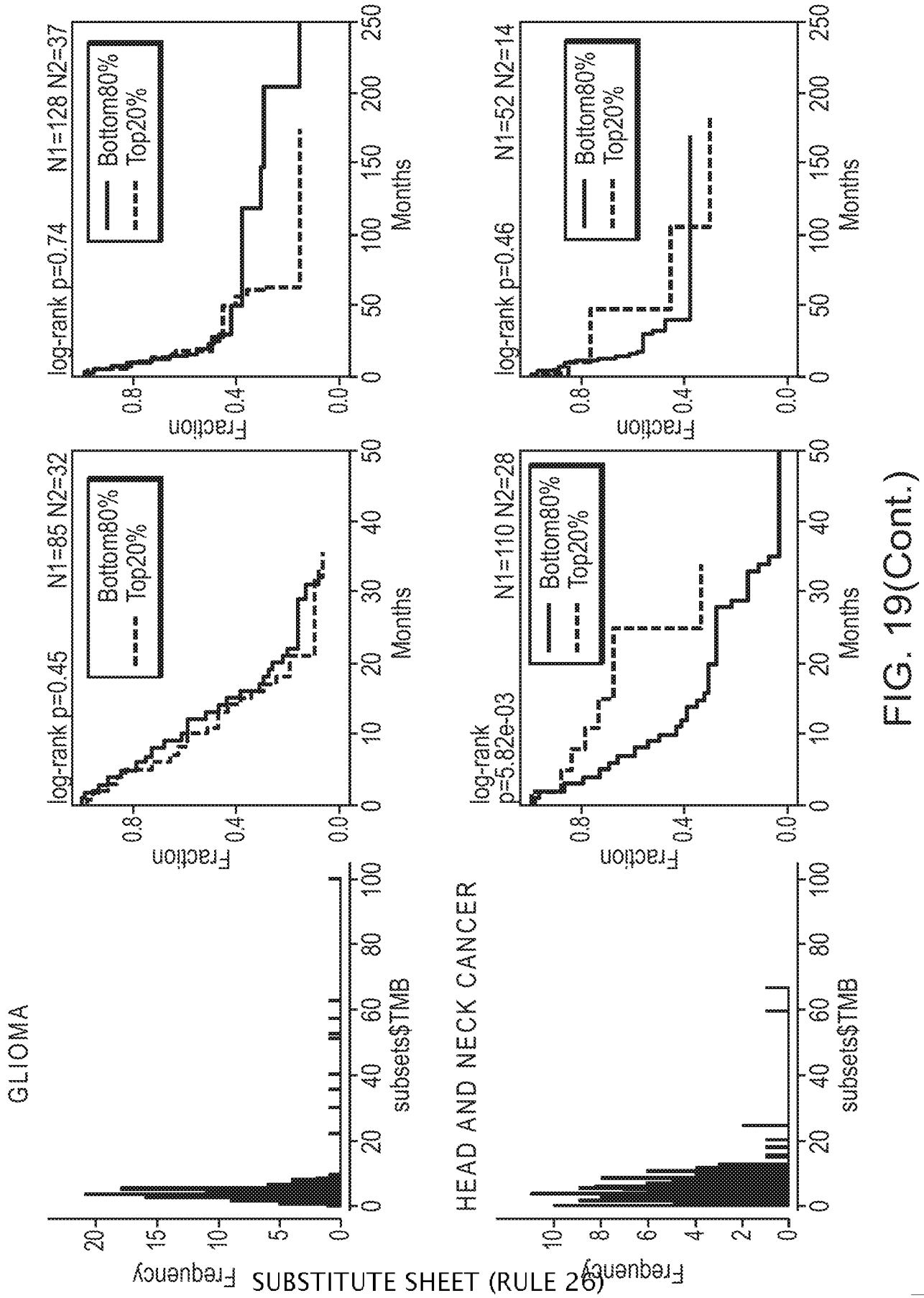

GLIOMA
HEAD AND NECK CANCER
Frequency
subsets$TMB
Fraction
Months
log-rank p=0.45
N1=85 N2=32
log-rank p=0.74
N1=128 N2=37
log-rank p=5.82e-03
N1=110 N2=28
log-rank p=0.46
N1=52 N2=14
Bottom80%
Top20%

FIG. 19(Cont.)

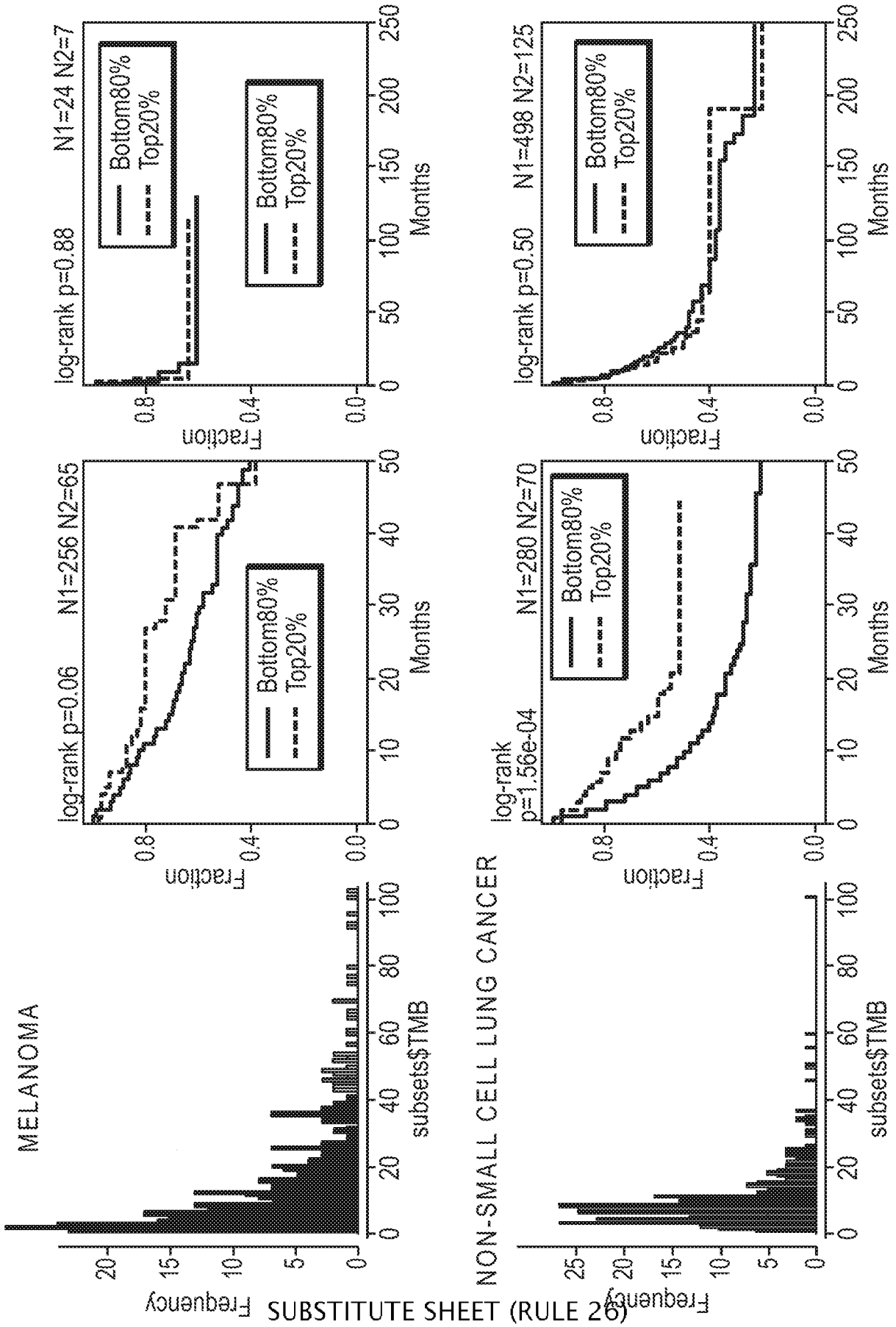

MELANOMA
NON-SMALL CELL LUNG CANCER
Frequency
subsets$TMB
Fraction
Months
log-rank p=0.88
N1=24 N2=7
log-rank p=0.06
N1=256 N2=65
log-rank p=0.50
N1=498 N2=125
log-rank p=1.56e-04
N1=280 N2=70
Bottom80%
Top20%

FIG. 19(Cont)

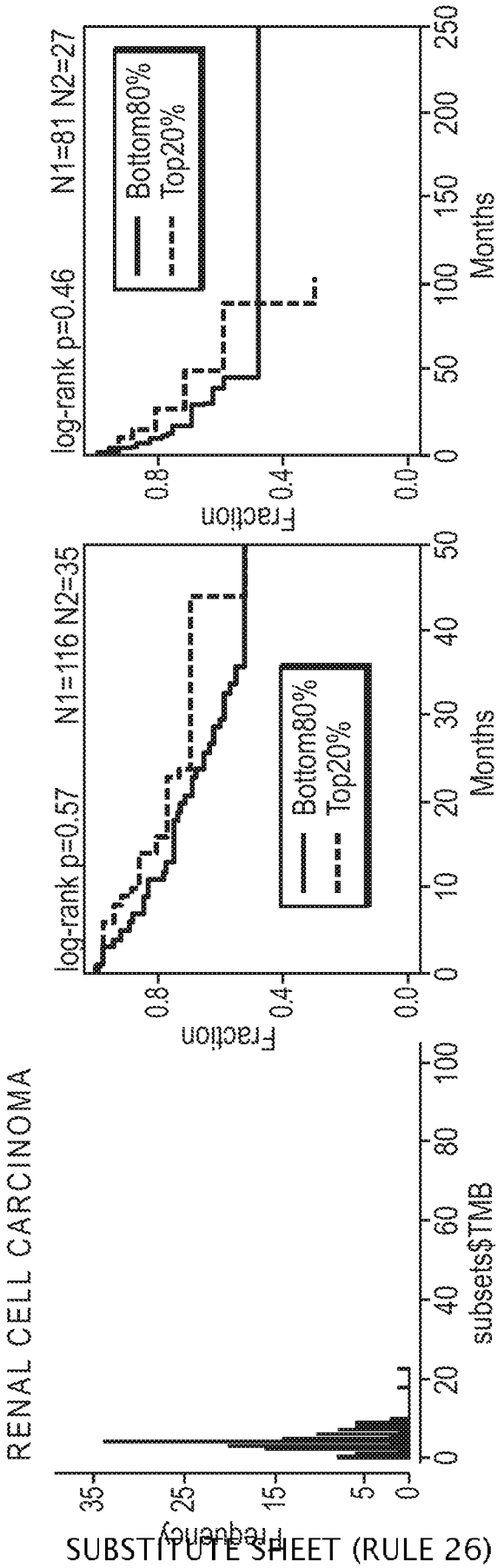

RENAL CELL CARCINOMA
Frequency
subsets$TMB
log-rank p=0.57 N1=116 N2=35
Fraction
Months
Bottom80%
Top20%
log-rank p=0.46 N1=81 N2=27
Fraction
Months
Bottom80%
Top20%

FIG. 19(Cont.)

Figure 20

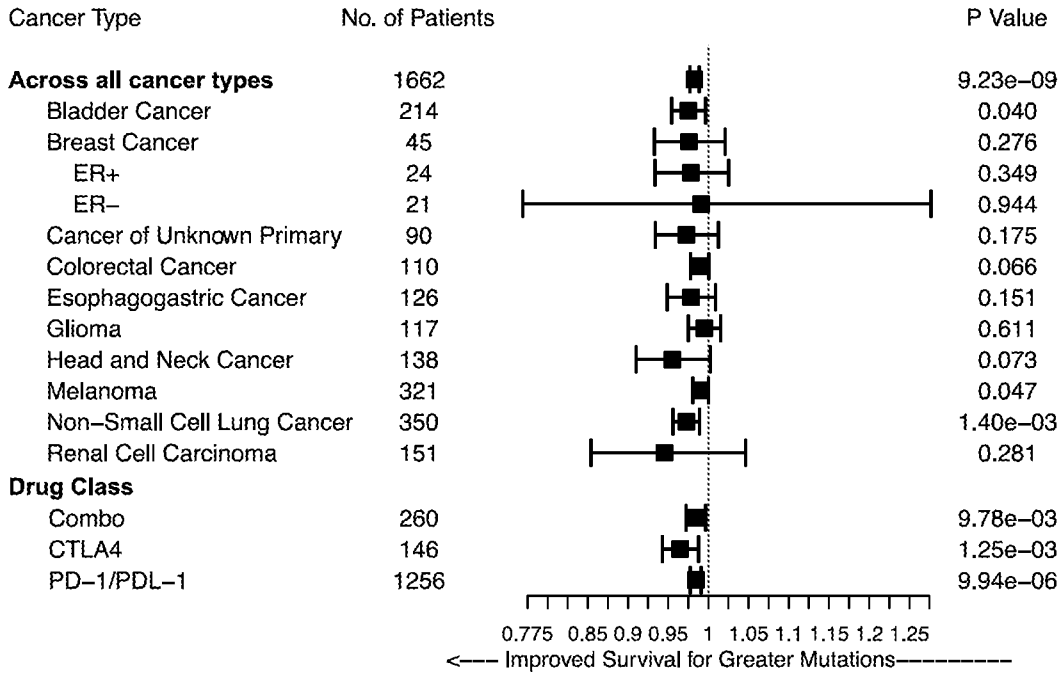

Cancer Type
No. of Patients
P Value
Across all cancer types 1662 9.23e−09
Bladder Cancer 214 0.040
Breast Cancer 45 0.276
ER+ 24 0.349
ER− 21 0.944
Cancer of Unknown Primary 90 0.175
Colorectal Cancer 110 0.066
Esophagogastric Cancer 126 0.151
Glioma 117 0.611
Head and Neck Cancer 138 0.073
Melanoma 321 0.047
Non−Small Cell Lung Cancer 350 1.40e−03
Renal Cell Carcinoma 151 0.281
Drug Class
Combo 260 9.78e−03
CTLA4 146 1.25e−03
PD−1/PDL−1 1256 9.94e−06
0.775 0.85 0.9 0.95 1 1.05 1.1 1.15 1.2 1.25
<−−− Improved Survival for Greater Mutations−−−−−−−−−

Figure 21

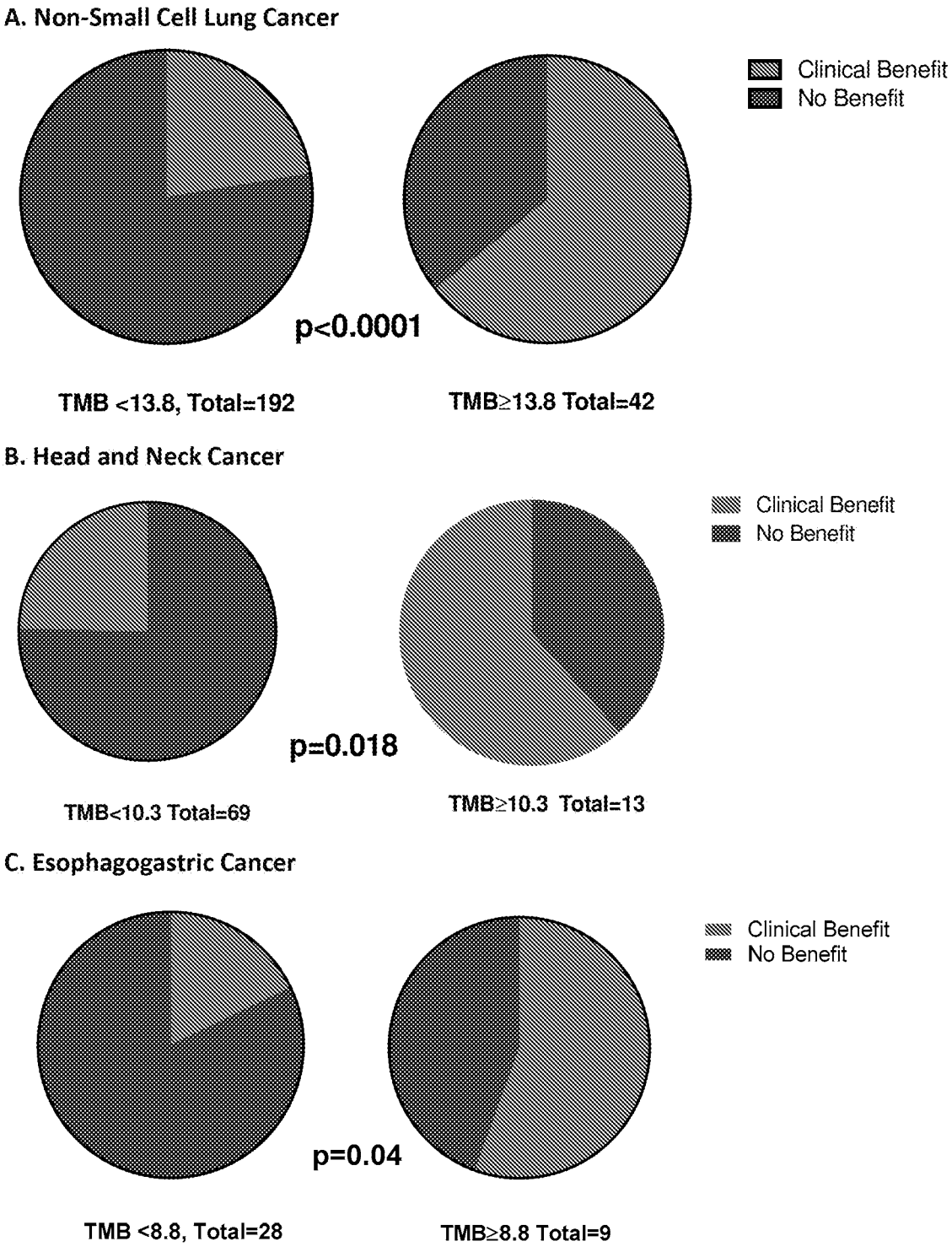
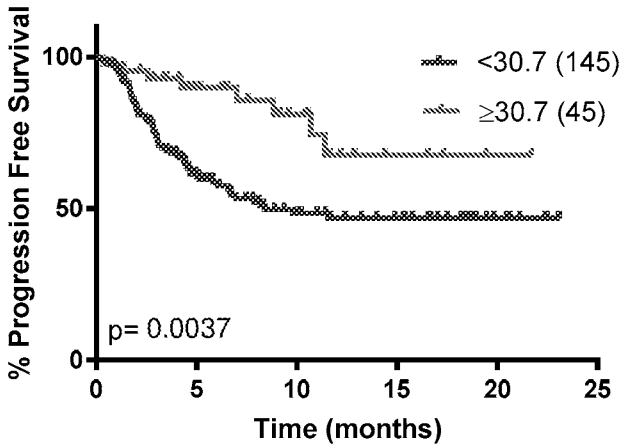
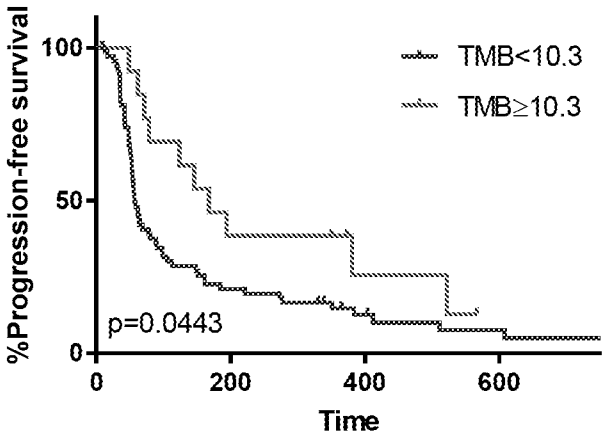

A. Non-Small Cell Lung Cancer
Clinical Benefit
No Benefit
p<0.0001
TMB <13.8, Total=192
TMB≥13.8 Total=42
B. Head and Neck Cancer
Clinical Benefit
No Benefit
p=0.018
TMB<10.3 Total=69
TMB≥10.3 Total=13
C. Esophagogastric Cancer
Clinical Benefit
No Benefit
p=0.04
TMB <8.8, Total=28
TMB≥8.8 Total=9

Figure 22

A. Melanoma



B. Head and Neck Cancer



C. Esophagogastric Cancer

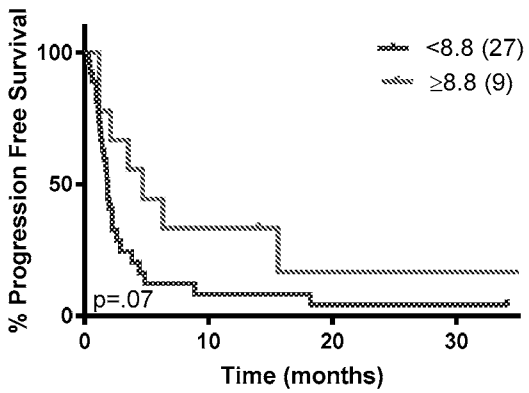


Figure 22(cont.)

D. Renal Cell Carcinoma

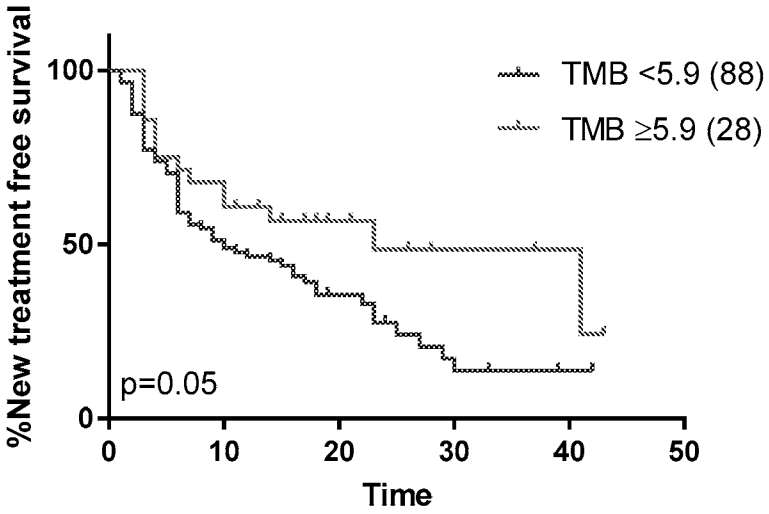


Figure 23

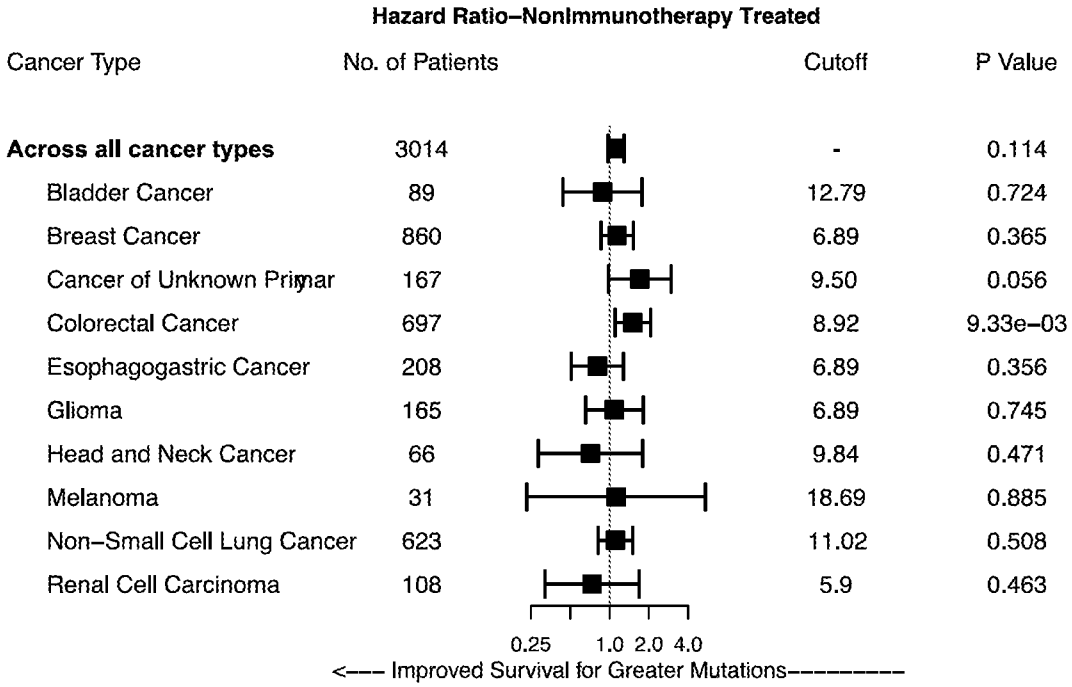
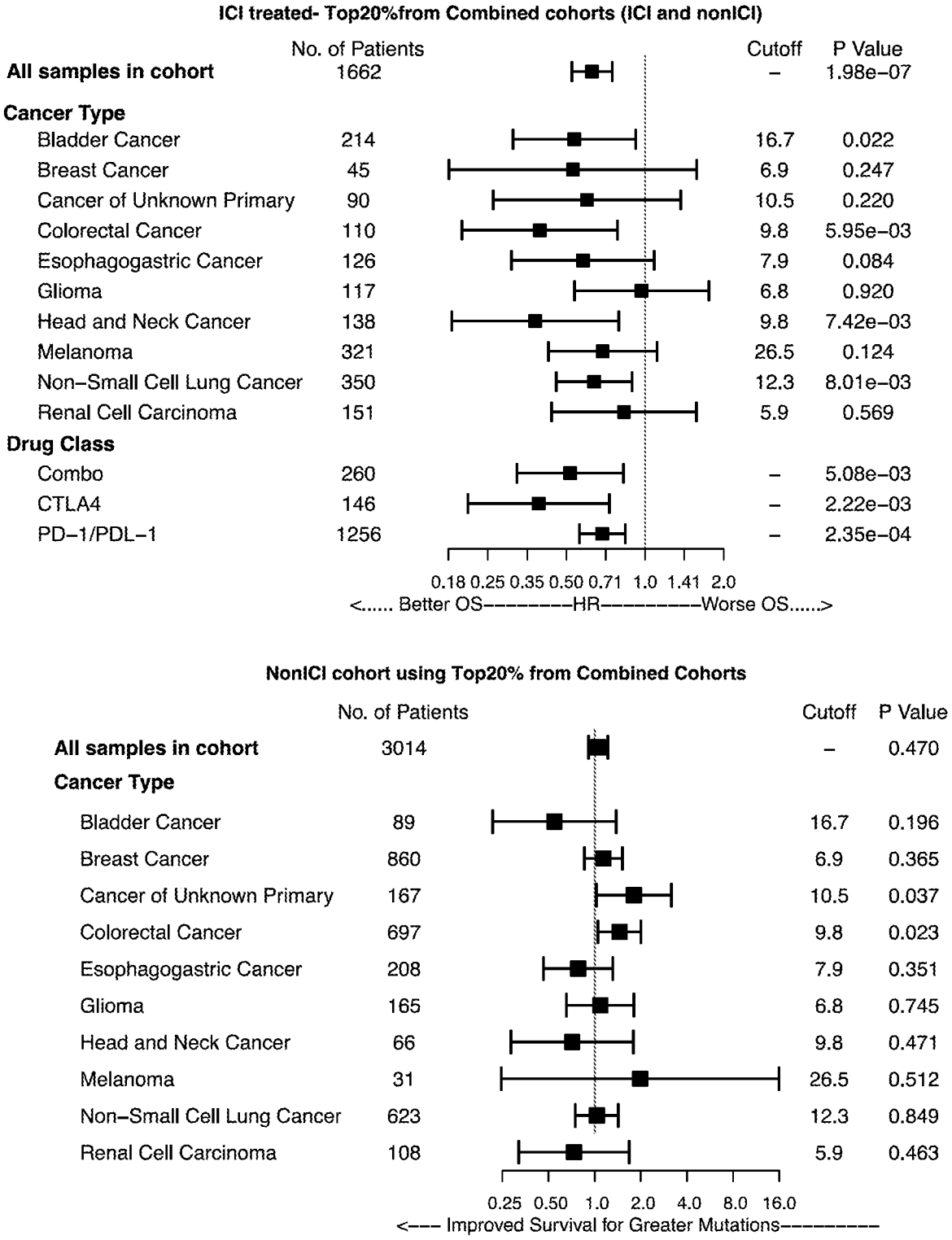

Hazard Ratio–NonImmunotherapy Treated
Cancer Type
No. of Patients
Cutoff
P Value
Across all cancer types 3014 - 0.114
Bladder Cancer 89 12.79 0.724
Breast Cancer 860 6.89 0.365
Cancer of Unknown Primar 167 9.50 0.056
Colorectal Cancer 697 8.92 9.33e–03
Esophagogastric Cancer 208 6.89 0.356
Glioma 165 6.89 0.745
Head and Neck Cancer 66 9.84 0.471
Melanoma 31 18.69 0.885
Non–Small Cell Lung Cancer 623 11.02 0.508
Renal Cell Carcinoma 108 5.9 0.463
0.25
1.0
2.0
4.0
<--- Improved Survival for Greater Mutations----------

Figure 24


ICI treated- Top20%from Combined cohorts (ICI and nonICI)
No. of Patients
Cutoff
P Value
All samples in cohort 1662 – 1.98e−07
Cancer Type
Bladder Cancer 214 16.7 0.022
Breast Cancer 45 6.9 0.247
Cancer of Unknown Primary 90 10.5 0.220
Colorectal Cancer 110 9.8 5.95e−03
Esophagogastric Cancer 126 7.9 0.084
Glioma 117 6.8 0.920
Head and Neck Cancer 138 9.8 7.42e−03
Melanoma 321 26.5 0.124
Non−Small Cell Lung Cancer 350 12.3 8.01e−03
Renal Cell Carcinoma 151 5.9 0.569
Drug Class
Combo 260 – 5.08e−03
CTLA4 146 – 2.22e−03
PD−1/PDL−1 1256 – 2.35e−04
0.18 0.25 0.35 0.50 0.71 1.0 1.41 2.0
<..... Better OS--------HR---------Worse OS.....>
NonICI cohort using Top20% from Combined Cohorts
No. of Patients
Cutoff
P Value
All samples in cohort 3014 – 0.470
Cancer Type
Bladder Cancer 89 16.7 0.196
Breast Cancer 860 6.9 0.365
Cancer of Unknown Primary 167 10.5 0.037
Colorectal Cancer 697 9.8 0.023
Esophagogastric Cancer 208 7.9 0.351
Glioma 165 6.8 0.745
Head and Neck Cancer 66 9.8 0.471
Melanoma 31 26.5 0.512
Non−Small Cell Lung Cancer 623 12.3 0.849
Renal Cell Carcinoma 108 5.9 0.463
0.25 0.50 1.0 2.0 4.0 8.0 16.0
<--- Improved Survival for Greater Mutations---------

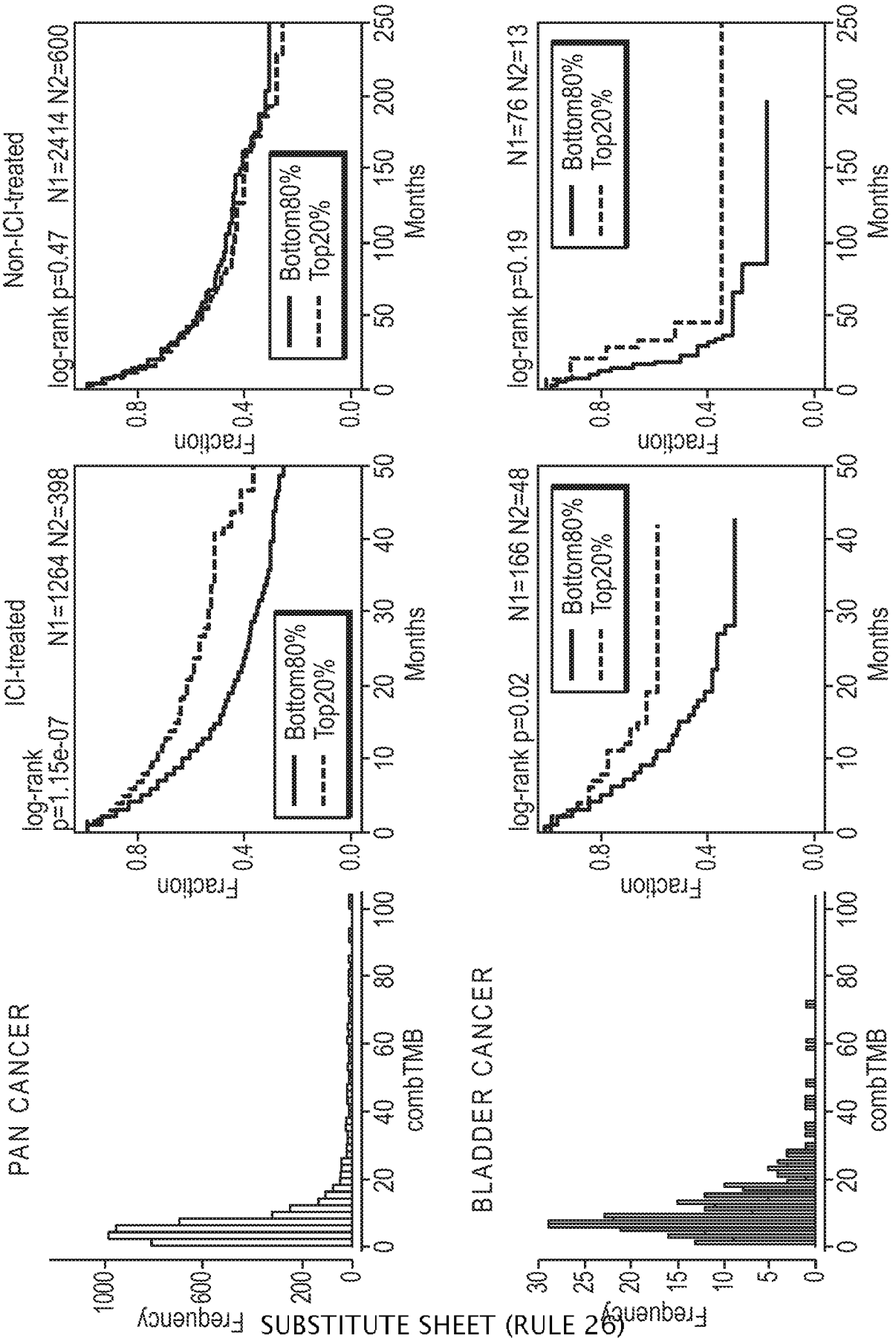

PAN CANCER
ICI-treated
log-rank p=1.15e-07 N1=1264 N2=398
Non-ICI-treated
log-rank p=0.47 N1=2414 N2=600
BLADDER CANCER
log-rank p=0.02 N1=166 N2=48
log-rank p=0.19 N1=76 N2=13
Bottom80%
Top20%
Fraction
Months
Frequency
combTMB

FIG. 25

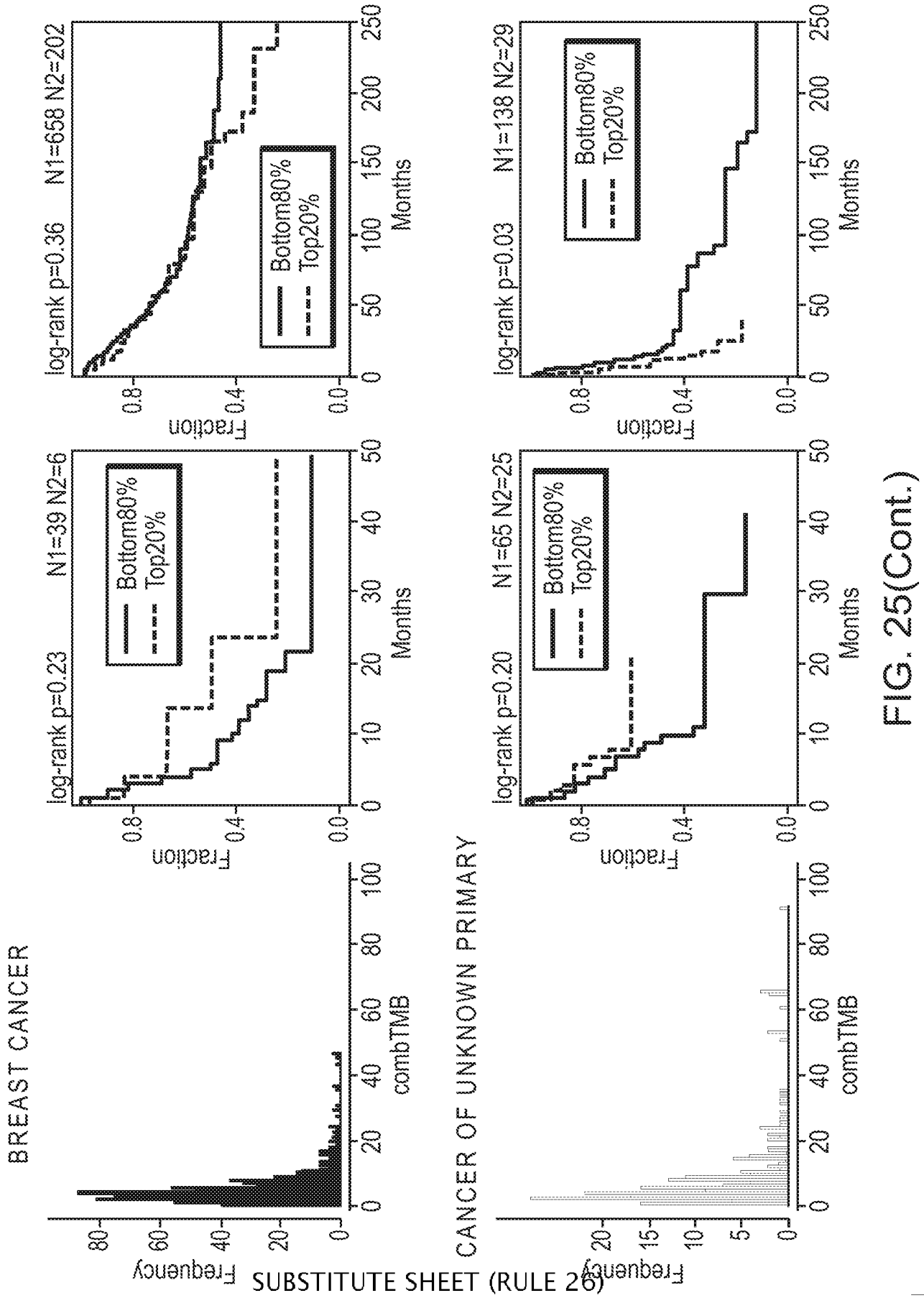

BREAST CANCER
CANCER OF UNKNOWN PRIMARY
Frequency
combTMB
log-rank p=0.23
N1=39 N2=6
log-rank p=0.36
N1=658 N2=202
log-rank p=0.20
N1=65 N2=25
log-rank p=0.03
N1=138 N2=29
Bottom80%
Top20%
Fraction
Months

FIG. 25(Cont.)

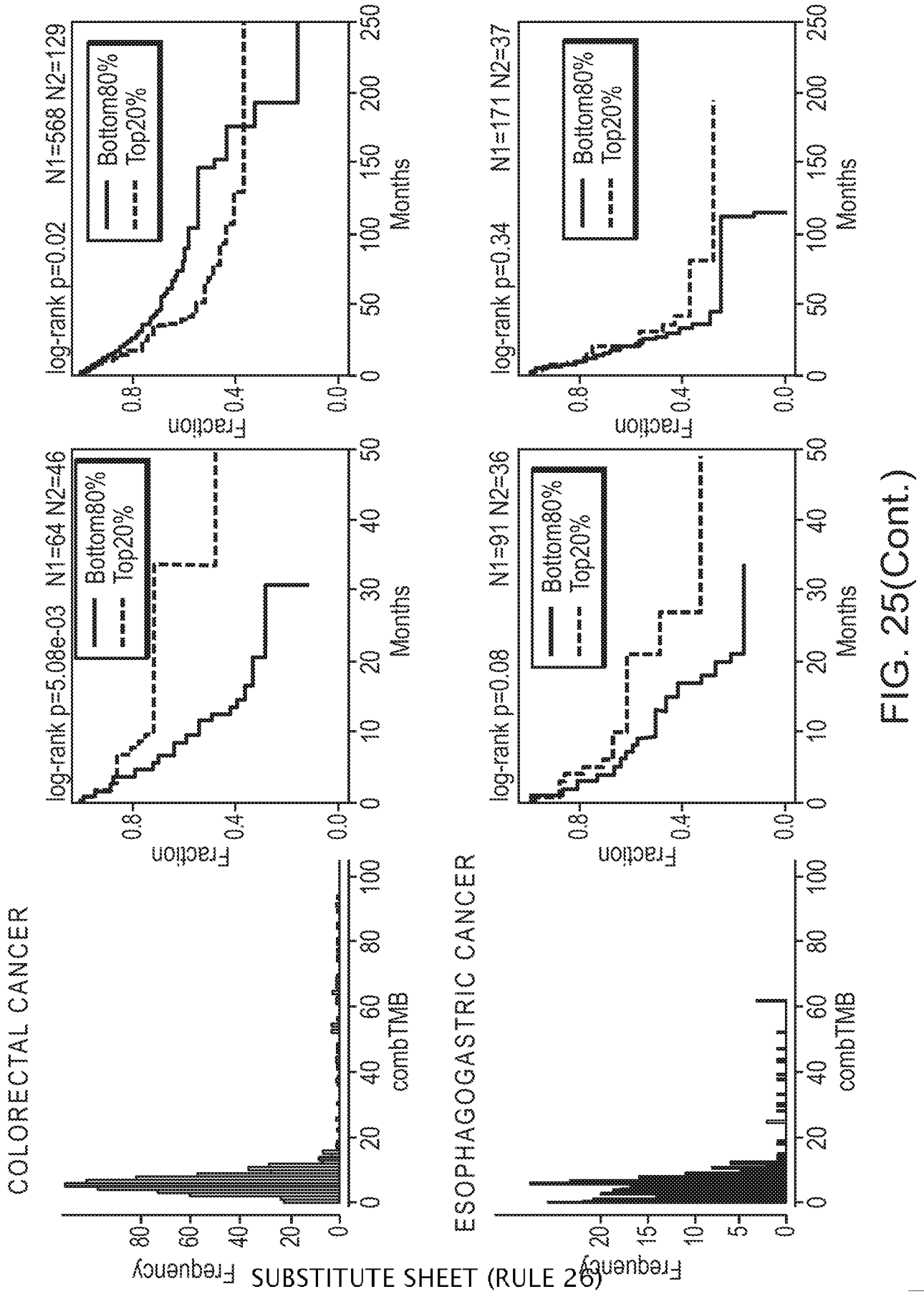

COLORECTAL CANCER
ESOPHAGOGASTRIC CANCER
Frequency
combTMB
Fraction
Months
Bottom80%
Top20%
log-rank p=5.08e-03 N1=64 N2=46
log-rank p=0.02 N1=568 N2=129
log-rank p=0.08 N1=91 N2=36
log-rank p=0.34 N1=171 N2=37

FIG. 25(Cont.)

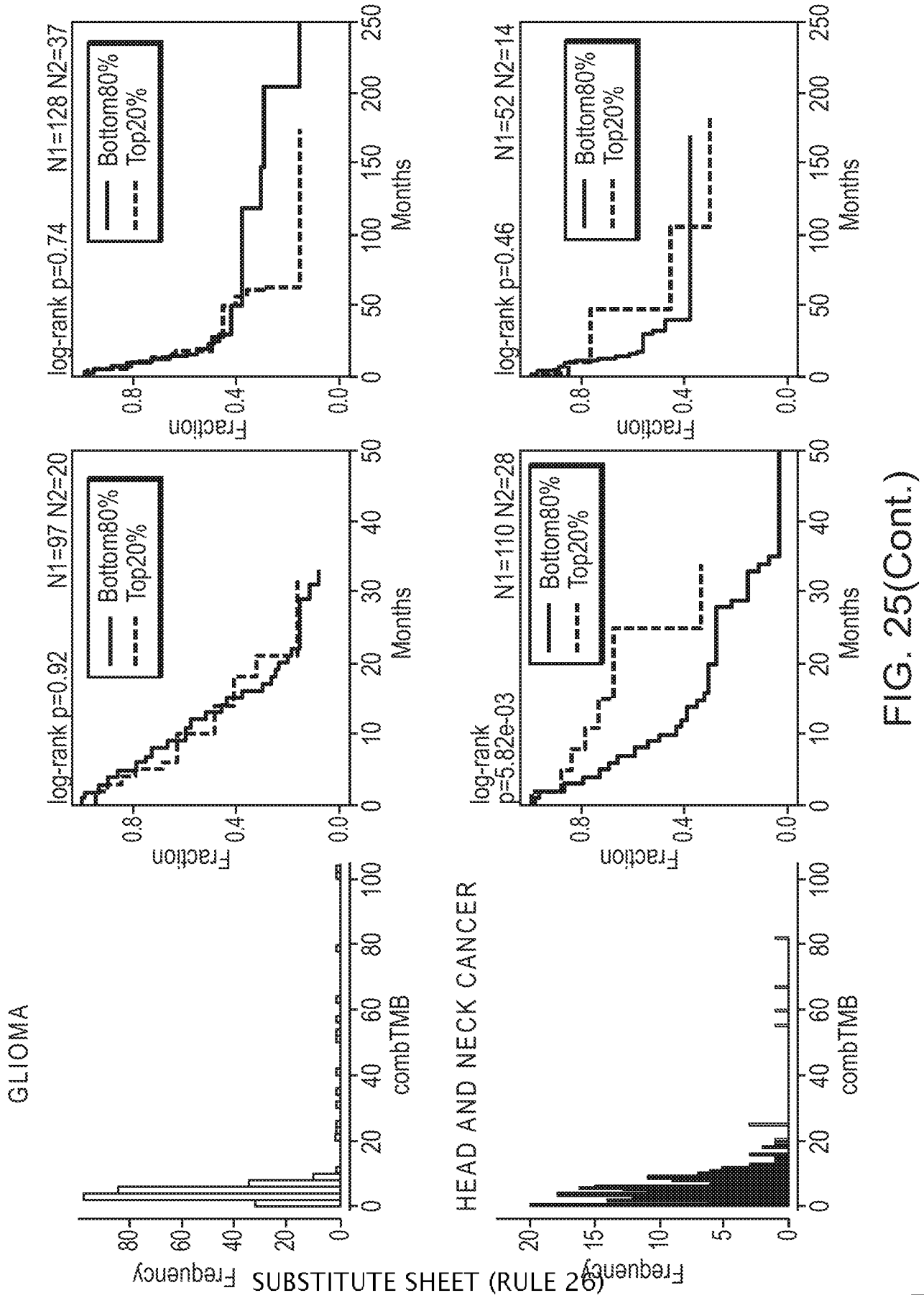

GLIOMA
HEAD AND NECK CANCER
log-rank p=0.74
N1=128 N2=37
log-rank p=0.46
N1=52 N2=14
log-rank p=0.92
N1=97 N2=20
log-rank p=5.82e-03
N1=110 N2=28
Bottom80%
Top20%
Fraction
Months
Frequency
combTMB

FIG. 25(Cont.)

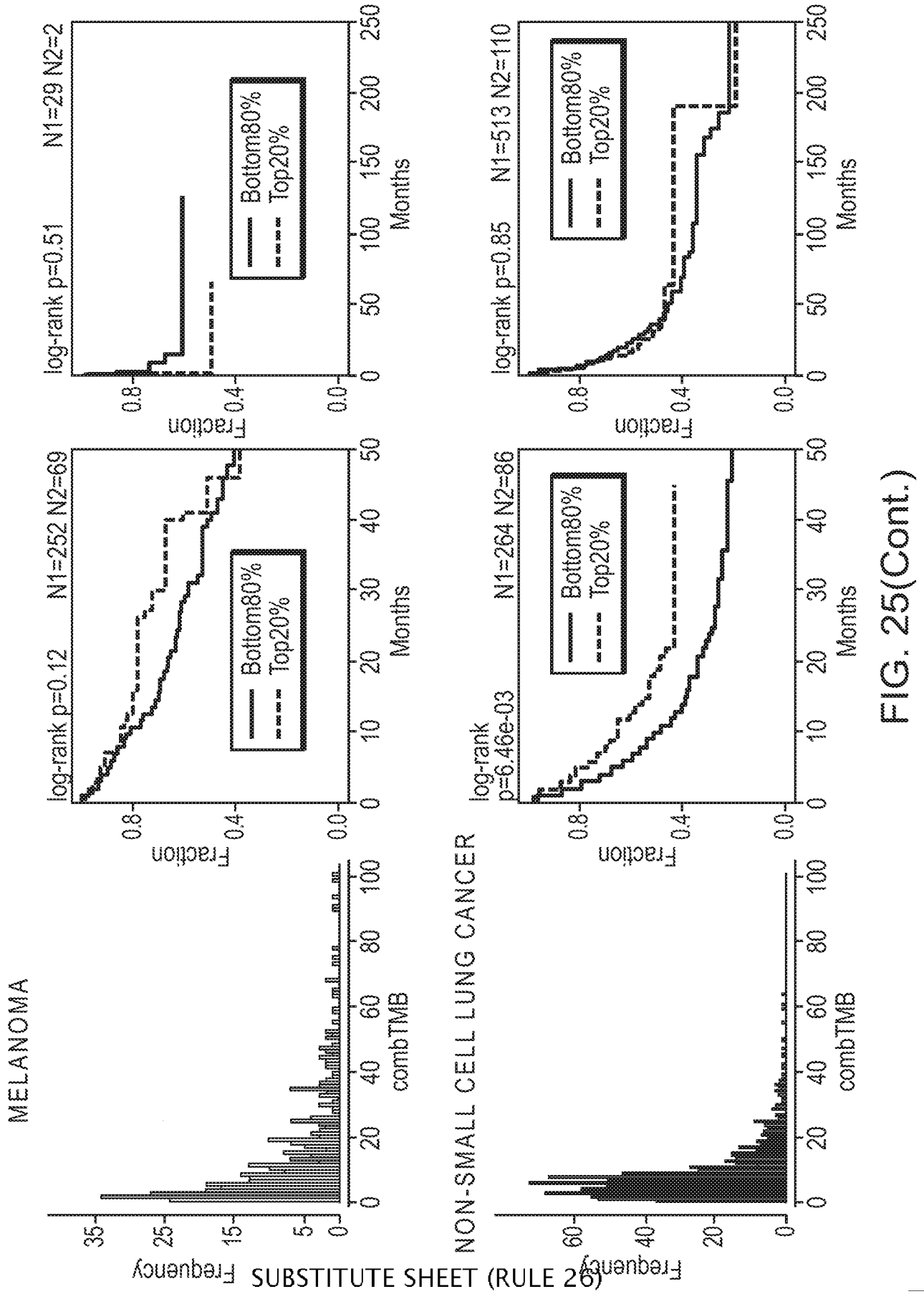

MELANOMA
NON-SMALL CELL LUNG CANCER
log-rank p=0.51
N1=29 N2=2
log-rank p=0.12
N1=252 N2=69
log-rank p=0.85
N1=513 N2=110
log-rank p=6.46e-03
N1=264 N2=86
Bottom80%
Top20%
Fraction
Months
Frequency
combTMB

FIG. 25(Cont.)

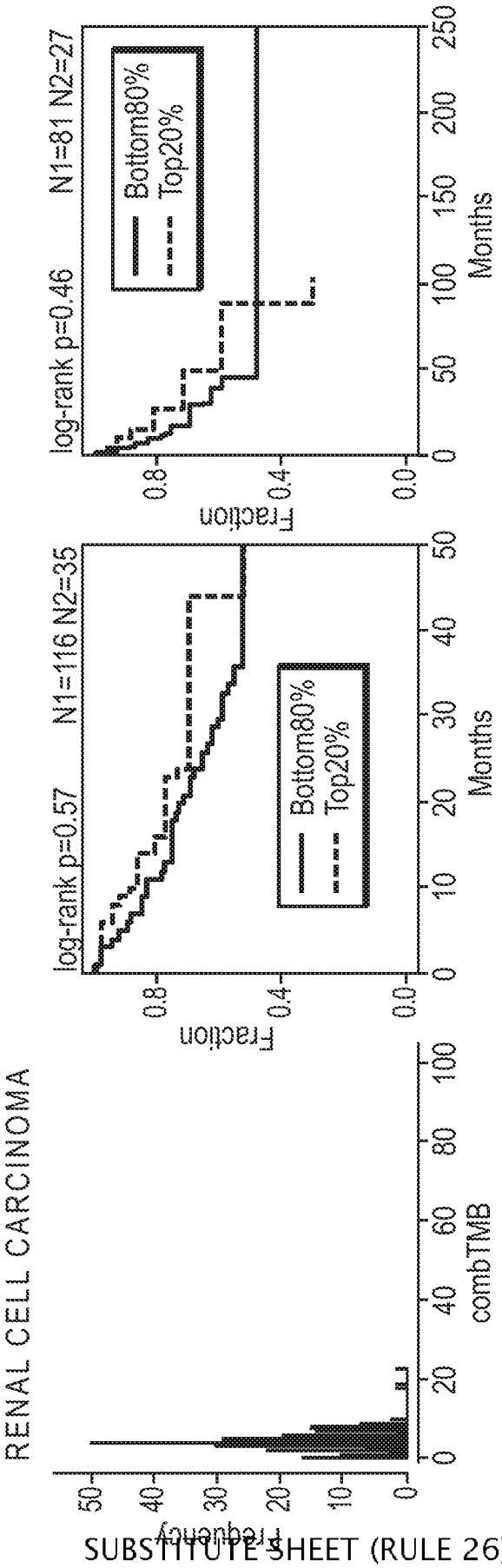

RENAL CELL CARCINOMA
Frequency
combTMB
Fraction
log-rank p=0.57
N1=116 N2=35
Bottom80%
Top20%
Months
log-rank p=0.46
N1=81 N2=27
Bottom80%
Top20%
Months

FIG. 25(Cont.)

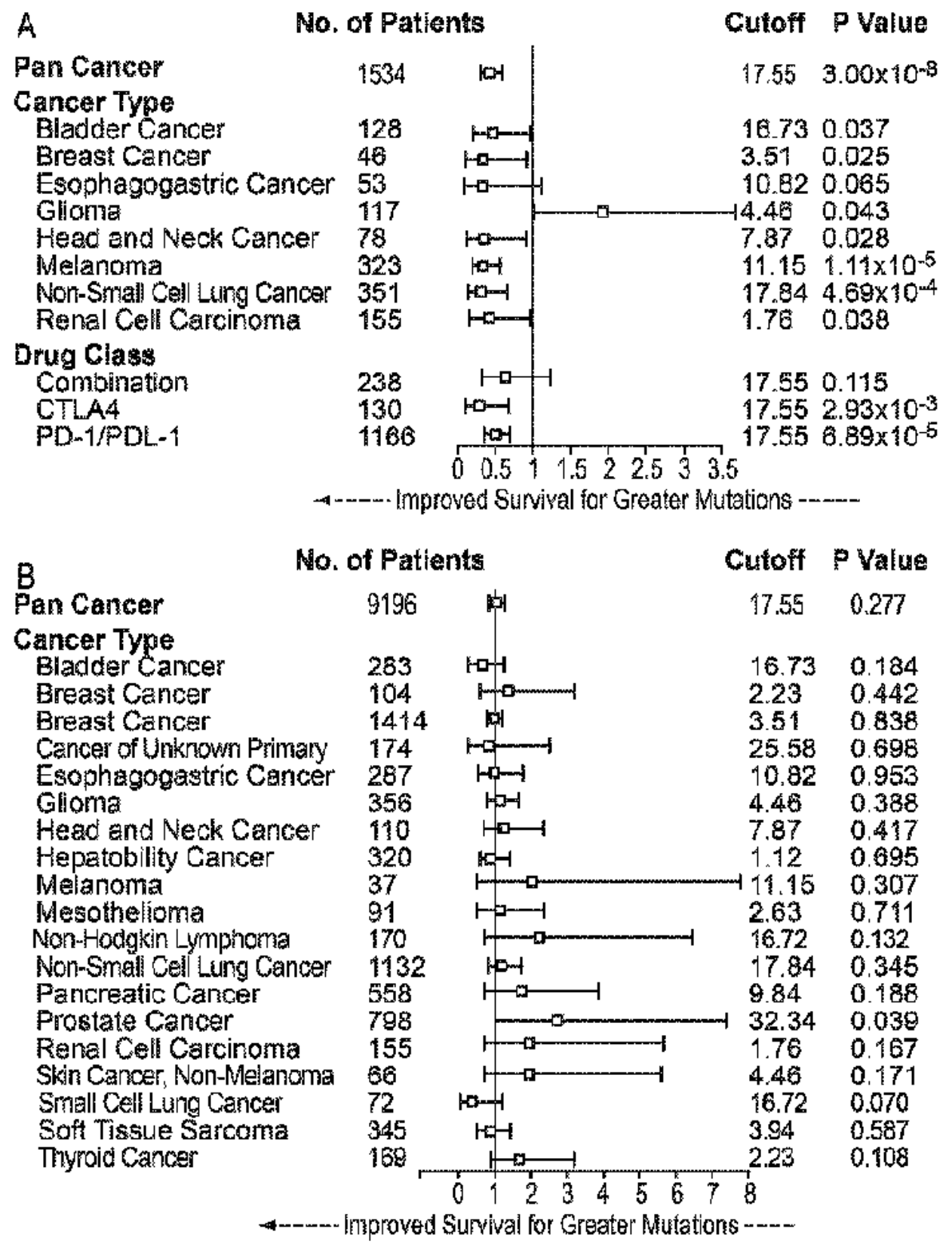

A
No. of Patients
Cutoff
P Value
Pan Cancer
1534
17.55
3.00x10-8
Cancer Type
Bladder Cancer
128
16.73
0.037
Breast Cancer
46
3.51
0.025
Esophagogastric Cancer
53
10.82
0.065
Glioma
117
4.46
0.043
Head and Neck Cancer
78
7.87
0.028
Melanoma
323
11.15
1.11x10-5
Non-Small Cell Lung Cancer
351
17.84
4.69x10-4
Renal Cell Carcinoma
155
1.76
0.038
Drug Class
Combination
238
17.55
0.115
CTLA4
130
17.55
2.93x10-3
PD-1/PDL-1
1166
17.55
6.89x10-5
0 0.5 1 1.5 2 2.5 3 3.5
Improved Survival for Greater Mutations
B
No. of Patients
Cutoff
P Value
Pan Cancer
9196
17.55
0.277
Cancer Type
Bladder Cancer
283
16.73
0.184
Breast Cancer
104
2.23
0.442
Breast Cancer
1414
3.51
0.838
Cancer of Unknown Primary
174
25.58
0.698
Esophagogastric Cancer
287
10.82
0.953
Glioma
356
4.46
0.388
Head and Neck Cancer
110
7.87
0.417
Hepatobility Cancer
320
1.12
0.695
Melanoma
37
11.15
0.307
Mesothelioma
91
2.63
0.711
Non-Hodgkin Lymphoma
170
16.72
0.132
Non-Small Cell Lung Cancer
1132
17.84
0.345
Pancreatic Cancer
558
9.84
0.188
Prostate Cancer
798
32.34
0.039
Renal Cell Carcinoma
155
1.76
0.167
Skin Cancer, Non-Melanoma
66
4.46
0.171
Small Cell Lung Cancer
72
16.72
0.070
Soft Tissue Sarcoma
345
3.94
0.587
Thyroid Cancer
169
2.23
0.108
0 1 2 3 4 5 6 7 8
Improved Survival for Greater Mutations

FIG 4