Policy Statement

Genetic testing should be performed in a setting that has suitably trained health care providers who can give appropriate pre- and posttest counseling and that has access to a Clinical Laboratory Improvement Amendments-licensed laboratory that offers comprehensive variant analysis (see Policy Guidelines section: Comprehensive Variant Analysis). As other genes have become associated with hereditary breast and ovarian cancer, small panels (using CPT code 81432) are now the preferred tests (rather than just testing for BRCA1 and BRCA2, such as 81162).

Patients With Cancer or With a Personal History of Cancer

Full sequence and duplication/deletion analysis genetic testing for BRCA1 and BRCA2 gene variants (including when part of an approved small panel such as 81432) in cancer-affected individuals may be considered medically necessary under any of the following circumstances:

I. Individuals meeting criteria for medically necessary testing below but with previous limited testing (e.g., single gene and/or absent deletion duplication analysis)

II. Individuals with any close blood relative with a known pathogenic/likely pathogenic variant in a cancer susceptibility gene (included in the small panel)

III. Personal history of breast cancer (including invasive and ductal carcinoma in situ) and one or more of the following:
   A. Diagnosed at age 45 or younger
   B. Diagnosed 46 to 50 years of age and one or more of the following:
      1. An additional breast cancer primary at any age
      2. One or more close relative (see Policy Guidelines) with breast, ovarian, pancreatic, or prostate cancer at any age
      3. An unknown or limited family history
   C. Diagnosed on or before 60 years of age with
      1. Triple-negative breast cancer (estrogen receptor-negative, progesterone receptor-negative, human epidermal growth factor receptor 2–negative)
   D. Diagnosed at any age with one or more of the following:
      1. One or more close blood relative with one or more of the following:
         a. Breast cancer diagnosed on or before 50 years of age
         b. Ovarian carcinoma
         c. Metastatic or intraductal/cribriform prostate cancer, or high-risk group or very-high-risk group (see Policy Guidelines) prostate cancer
         d. Pancreatic cancer
      2. Three or more total diagnoses of breast cancer in patient and/or close blood relative
      3. Ashkenazi Jewish ancestry
   IV. Personal history of one or more of the following at any age:
      A. Male breast cancer
      B. Epithelial ovarian carcinoma (including fallopian tube cancer or peritoneal cancer)
      C. Exocrine pancreatic cancer
      D. Metastatic, intraductal/cribriform histology prostate cancer or high-risk group or very-high-risk group prostate cancer
      E. Prostate cancer with one or more of the following:
         1. One or more close blood relative with ovarian carcinoma, pancreatic cancer, or metastatic or intraductal/cribriform prostate cancer at any age, or breast cancer at age 50 or younger
         2. Two or more close blood relatives with breast or prostate cancer (any grade) at any age
3. Ashkenazi Jewish ancestry
F. Any cancer and a mutation identified on tumor genomic testing that has clinical implications if also identified in the germline
G. Any cancer and to aid in systemic therapy decision-making, such as for PARP-inhibitors for human epidermal receptor 2 (HER2)-negative metastatic breast cancer, ovarian cancer, prostate cancer, pancreatic cancer; platinum therapy for prostate cancer and pancreatic cancer

Patients Without Cancer or With any Other Personal History of Cancer (not noted above)

(See Policy Guidelines section: Testing Unaffected Individuals)

Genetic testing for BRCA1 and BRCA2 (including deletions and duplications) variants of individuals without cancer or any other type of cancer (not noted above) may be considered medically necessary under the following circumstance:

I. Has a probability of greater than 5% of a BRCA 1/2 pathogenic variant based on prior probability models (e.g. Tyrer-Cuzick, BRCAPro, PennII)

Genetic testing for BRCA1 and BRCA2 variants in cancer-affected individuals or of cancer-unaffected individuals with or without a family history of cancer when criteria above are not met (including genetic screening in the general population) is considered investigational.

Genetic testing in minors (younger than age 18) for BRCA1 and BRCA2 variants is considered investigational.

Confirmatory BRCA Testing

Confirmatory BRCA testing may be considered medically necessary for patients who underwent over-the-counter (OTC) U.S. Food and Drug Administration (FDA) approved genetic screening and were found to have a pathogenic BRCA1 or BRCA2 mutation (including one of the three Ashkenazi founder mutations).

Large multi-gene panels including multiple genes that are not highly associated with hereditary breast and ovarian cancer (see Policy Guidelines) are considered investigational.

NOTE: Refer to Appendix A to see the policy statement changes (if any) from the previous version.

Policy Guidelines

When criteria are met, small panel testing using CPT code 81432 is the preferred testing for breast and ovarian cancer risk. As an alternative, 81162 is allowed for BRCA 1 and 2 testing. If BRCA testing in 81162 is negative, PALB2 (81406 molecular pathology procedure level 7) testing can also be allowed (see 2.04.126 Gene Variants Associated with Breast Cancer in Individuals at High Breast Cancer Risk). After 81162 is performed, the remaining genes in the 81432 or similar panels (with the exception of PALB2) are considered investigational and are not covered if requested at a later time.

Testing related to hereditary colorectal cancer, see Blue Shield of California Medical Policy: Genetic Testing for Lynch Syndrome and Other Inherited Colon Cancer Syndromes.
Panel testing related to non-small-cell lung cancer, see Blue Shield of California Medical Policy: Circulating Tumor DNA for Management of Non-Small-Cell Lung Cancer (Liquid Biopsy).

Panel testing related to cancers other than breast, ovarian, colorectal, and non-small-cell lung cancer, see Blue Shield of California Medical Policy: Genetic Cancer Susceptibility Panels Using Next-Generation Sequencing.

Current U.S. Preventive Services Task Force guidelines recommend screening women with a personal or family history of breast, ovarian, tubal, or peritoneal cancer or who have an ancestry
2.04.02 Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers

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associated with BRCA1/2 gene mutation. Women with a positive result on the risk assessment tool should receive genetic counseling and, if indicated after counseling, genetic testing (B recommendation).

Recommended screening tools designed to identify a family history that may be associated with an increased risk for potentially harmful variants in BRCA1 or BRCA2 are:

- Ontario Family History Assessment Tool (FHAT)
- Manchester Scoring System
- Referral Screening Tool (RST)
- Pedigree Assessment Tool (PAT)
- Family History Screen (FHS-7).
- International Breast Cancer Intervention Study instrument (Tyrer-Cuziak)
- Brief versions of the BRCAPRO

Note: For payment authorization, this testing will be limited to single-site analysis of the mutation identified and will be performed at contracted laboratories.

Close Relatives
Close relatives are blood related family members including 1st-, 2nd-, and 3rd-degree relatives on the same side of the family (maternal or paternal).

- 1st-degree relatives are parents, siblings, and children.
- 2nd-degree relatives are grandparents, aunts, uncles, nieces, nephews, grandchildren, and half-siblings.
- 3rd-degree relatives are great-grandparents, great-aunts, great-uncles, great-grandchildren, and first cousins.

Prostate Cancer Risk Groups
Risk groups for prostate cancer in this policy include high-risk groups and very-high-risk groups.

High-risk group: no very-high-risk features and are T3a (American Joint Committee on Cancer staging T3a = tumor has extended outside of the prostate but has not spread to the seminal vesicles); OR Grade Group 4 or 5; OR prostate specific antigen of 20 ng/ml or greater

Very-high-risk group: T3b-T4 (tumor invades seminal vesicle(s); or tumor is fixed or invades adjacent structures other than seminal vesicles such as external sphincter, rectum, bladder, levator muscles, and/or pelvic wall); OR Primary Gleason Pattern 5; OR 2 or 3 high-risk features; OR greater than 4 cores with Grade Group 4 or 5

Recommended Testing Strategies
As other genes have become associated with hereditary breast and ovarian cancer and as ethnicity becomes more mixed, small panels (using CPT code 81432) are now the preferred tests (rather than just testing for BRCA1 and BRCA2, such as 81162), or testing for founder mutations in those of Ashkenazi descent). Complete testing includes at a minimum: Full sequence and duplication/deletion analysis of BRCA1 and BRCA2. PALB2 is indicated if initial testing is negative (or preferably to be included in an initial limited panel).

Patients who meet criteria for genetic testing as outlined in the policy statements above should have complete testing. Additional testing does not need to continue once a known harmful (pathogenic) variant is found:

- In patients with a known familial BRCA variant, targeted testing for the specific variant is recommended as the first step.
- In patients with unknown familial BRCA variant:
  - To identify clinically significant variants, National Comprehensive Cancer Network (NCCN) advises testing a relative who has early-onset disease, bilateral disease, or multiple primaries, because that individual has the highest likelihood of obtaining a positive test result.
**Comprehensive Variant Analysis**

Standard comprehensive variant analysis (e.g. 81162) currently includes sequencing the coding regions and intron and exon splice sites, as well as testing to detect large deletions and rearrangements that can be missed with sequence analysis alone. In addition, before August 2006, testing for large deletions and rearrangements was not performed, thus some patients with familial breast cancer who had negative BRCA testing before this time may consider repeat testing for the rearrangements (see Policy section for criteria).

- More than 90% of BRCA variants will be detected by full sequencing alone
- Adding common deletions and duplications will detect another 2.5%
- Adding uncommon large deletions and duplications (e.g., previously known as BART or BRCA Analysis Rearrangement Test) detects less than 1% more
- Standard comprehensive testing will detect 93.5% of BRCA related variants

**High-Risk Ethnic Groups**

Testing of eligible individuals who belong to ethnic populations in which there are well-characterized founder mutations can begin with tests specifically for these variants. For example, founder mutations account for approximately three-quarters of the BRCA variants found in Ashkenazi Jewish populations (see Rationale section). When testing for founder mutations is negative, comprehensive variant analysis should then be performed. However, as ethnicities become more mixed and harder to identify, standard small panel testing is preferred.

**Testing Unaffected Individuals**

In unaffected family members of potential BRCA variant families, most test results will be negative and uninformative. Therefore, it is strongly recommended that an affected family member be tested first whenever possible to adequately interpret the test. Should a BRCA variant be found in an affected family member(s), DNA from an unaffected family member can be tested specifically for the same variant of the affected family member without having to sequence the entire gene. Interpreting test results for an unaffected family member without knowing the genetic status of the family may be possible in the case of a positive result for an established disease-associated variant but leads to difficulties in interpreting negative test results (uninformative negative) or variants of uncertain significance because the possibility of a causative BRCA variant is not ruled out.

**Testing Minors**

The use of genetic testing for BRCA variants has limited or no clinical utility in minors, because there is no change in management for minors as a result of knowledge of the presence or absence of a deleterious variant. In addition, there are potential harms related to stigmatization and discrimination.

**Prostate Cancer**

Patients with BRCA variants have an increased risk of prostate cancer, and patients with known BRCA variants may, therefore, consider more aggressive screening approaches for prostate cancer. However, the presence of prostate cancer in an individual, or in a family, is not itself considered sufficient justification for BRCA testing.

**Panel Testing**

Limited genetic panels (such as CPT code 81432, including but not limited to: BRCA1, BRCA2, CDH1, MLH1, MSH2, MSH6, PALB2, STK11, PTEN, and TP53), when they include both full sequence and deletion/duplication analysis, may be considered medically necessary as an alternative to serial testing of individual genes when criteria are met for genetic testing of hereditary breast and ovarian cancer.

**Genetics Nomenclature Update**

The Human Genome Variation Society nomenclature is used to report information on variants found in DNA and serves as an international standard in DNA diagnostics. It is being
implemented for genetic testing medical evidence review updates starting in 2017 (see Table PG1). The Society's nomenclature is recommended by the Human Variome Project, the HUman Genome Organization, and by the Human Genome Variation Society itself.

The American College of Medical Genetics and Genomics and the Association for Molecular Pathology standards and guidelines for interpretation of sequence variants represent expert opinion from both organizations, in addition to the College of American Pathologists. These recommendations primarily apply to genetic tests used in clinical laboratories, including genotyping, single genes, panels, exomes, and genomes. Table PG2 shows the recommended standard terminology- "pathogenic," "likely pathogenic," "uncertain significance," "likely benign," and "benign"- to describe variants identified that cause Mendelian disorders.

<table>
<thead>
<tr>
<th>Previous</th>
<th>Updated</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutation</td>
<td>Disease-associated variant</td>
<td>Disease-associated change in the DNA sequence</td>
</tr>
<tr>
<td></td>
<td>Variant</td>
<td>Change in the DNA sequence</td>
</tr>
<tr>
<td></td>
<td>Familial variant</td>
<td>Disease-associated variant identified in a proband for use in subsequent targeted genetic testing in first-degree relatives</td>
</tr>
</tbody>
</table>

Table PG2. ACMG-AMP Standards and Guidelines for Variant Classification

<table>
<thead>
<tr>
<th>Variant Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathogenic</td>
<td>Disease-causing change in the DNA sequence</td>
</tr>
<tr>
<td>Likely pathogenic</td>
<td>Likely disease-causing change in the DNA sequence</td>
</tr>
<tr>
<td>Variant of uncertain significance</td>
<td>Change in DNA sequence with uncertain effects on disease</td>
</tr>
<tr>
<td>Likely benign</td>
<td>Likely benign change in the DNA sequence</td>
</tr>
<tr>
<td>Benign</td>
<td>Benign change in the DNA sequence</td>
</tr>
</tbody>
</table>

ACMG-AMP: American College of Medical Genetics and Genomics and the Association for Molecular Pathology.

**Genetic Counseling**

Genetic counseling is primarily aimed at patients who are at risk for inherited disorders, and experts recommend formal genetic counseling in most cases when genetic testing for an inherited condition is considered. The interpretation of the results of genetic tests and the understanding of risk factors can be very difficult and complex. Therefore, genetic counseling will assist individuals in understanding the possible benefits and harms of genetic testing, including the possible impact of the information on the individual's family. Genetic counseling may alter the utilization of genetic testing substantially and may reduce inappropriate testing. Genetic counseling should be performed by an individual with experience and expertise in genetic medicine and genetic testing methods.

**Coding**

The following CPT codes may be used for genetic testing for BRCA1 and BRCA2 variants:

- **81162**: BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis and full duplication/deletion analysis (i.e., detection of large gene rearrangements)
  
  **Note**: This code includes both 81163 and 81164 (and previously 81211 and 81213).

- **81163**: BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis

- **81164**: BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full duplication/deletion analysis (i.e., detection of large gene rearrangements)

- **81165**: BRCA1 (BRCA1, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis
Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers

- **81166**: BRCA1 (BRCA1, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full duplication/deletion analysis (i.e., detection of large gene rearrangements)
- **81167**: BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full duplication/deletion analysis (i.e., detection of large gene rearrangements)
- **81212**: BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; 185delAG, 5385insC, 6174delT variants
- **81215**: BRCA1 (BRCA1, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; known familial variant
- **81216**: BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis
- **81217**: BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; known familial variant
- **81432**: Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer); genomic sequence analysis panel, must include sequencing of at least 10 genes, always including BRCA1, BRCA2, CDH1, MLH1, MSH2, MSH6, PALB2, PTEN, STK11, and TP53
- **81433**: Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer); duplication/deletion analysis panel, must include analyses for BRCA1, BRCA2, MLH1, MSH2, and STK11

**Effective July 1, 2020**, The following test is not used for hereditary BRCA testing and this policy does not apply to it. It represents the myChoice test by Myriad. It is done as a companion test (related to drug use) on tumor tissue (not blood) to see if there is a mutation present that would make the tumor susceptible to either Zejula (ovarian cancer) or Lynparza (prostate cancer). Since somatic (tumor) mutations can occur independent of inherited (germline) genetics, it is indicated even if prior BRCA hereditary testing is negative, and to confirm the presence of the mutation in the tumor when germline testing was positive:

- **0172U**: Oncology (solid tumor as indicated by the label) somatic mutation analysis of BRCA1 (BRCA1 DNA repair associated) BRCA2 (BRCA2 DNA repair associated) and analysis of homologous recombination deficiency pathways DNA formalin-fixed paraffin-embedded tissue algorithm quantifying tumor genomic instability score

### Description

Hereditary breast and ovarian cancer syndrome describe the familial cancer syndromes related to variants in the BRCA genes (BRCA1 located on chromosome 17q21, BRCA2 located on chromosome 13q12-13). Families with hereditary breast and ovarian cancer syndrome have an increased susceptibility to the following types of cancer: breast cancer occurring at a young age, bilateral breast cancer, male breast cancer, ovarian cancer (at any age), cancer of the fallopian tube, primary peritoneal cancer, prostate cancer, pancreatic cancer, gastrointestinal cancers, melanoma, and laryngeal cancer.

### Related Policies

- Gene Variants Associated with Breast Cancer in Individuals at High Breast Cancer Risk
- Genetic Cancer Susceptibility Panels Using Next-Generation Sequencing

### Benefit Application

Benefit determinations should be based in all cases on the applicable contract language. To the extent there are any conflicts between these guidelines and the contract language, the contract language will control. Please refer to the member's contract benefits in effect at the
time of service to determine coverage or non-coverage of these services as it applies to an individual member.

Some state or federal mandates (e.g., Federal Employee Program [FEP]) prohibits plans from denying Food and Drug Administration (FDA)-approved technologies as investigational. In these instances, plans may have to consider the coverage eligibility of FDA-approved technologies on the basis of medical necessity alone.

**Regulatory Status**

Clinical laboratories may develop and validate tests in-house and market them as a laboratory service; laboratory-developed tests must meet the general regulatory standards of the Clinical Laboratory Improvement Amendments. Genetic tests reviewed in this evidence review are available under the auspices of the Clinical Laboratory Improvement Amendments. Laboratories that offer laboratory-developed tests must be licensed by the Clinical Laboratory Improvement Amendments for high-complexity testing. To date, the U.S. Food and Drug Administration (FDA) has chosen not to require any regulatory review of this test.

**FDA Approved Companion Diagnostics**

FDA has approved various companion diagnostics to identify patients with BRCA mutations who may benefit from treatment with a targeted therapy (i.e., PARP inhibitor drugs). FDA product codes: PQP, PJG

For example, FDA has approved BRACAnalysis CDx® to detect germline BRCA1 and BRCA2 variants to identify patients with breast or ovarian cancer who may be considered for treatment with various PARP inhibitor drugs.

In addition to the various individual variant tests which are the focus of this policy, numerous other multigene panel tests exist that include BRCA1/2 among other genes. For example, FoundationOne CDx” (F1CDx) is an FDA approved companion diagnostic for use of olaparib and rucaparib in accordance with their respective FDA labels in women with ovarian cancer. F1CDx is FDA approved to assess BRCA1/2 and other homologous recombination pathway genes (e.g. ATM, BRIP1, CHEK2, FANCA, FANCL, FANCM, NBN, RAD51C, RAD51D, and RAD54L as well as MSI and DNA mismatch repair genes (MLH1, MSH2, MSH6, PMS2). FoundationOne C Dx is also FDA approved for determining homologous recombination deficiency based on genomic loss of heterozygosity (LOH) and BRCA mutant status. Also, FoundationOne Liquid CDx is FDA approved for detection of BRCA1 and BRCA2 alterations in individuals with prostate cancer considering treatment with rucaparib. However, further discussion of these multigene panel tests are outside of the scope of this review, but can be found in policies 2.04.115 and 2.04.141.

**Poly (Adenosine Diphosphate–Ribose) Polymerase (PARP) Inhibitors**

Poly (adenosine diphosphate–ribose) polymerase (PARP) inhibitors drugs are oral targeted therapies used to treat certain types of cancers that have damaged DNA repair pathways (e.g., BRCA mutation). Table 1 provides a list of FDA approved PARP inhibitor drugs and their BRCA mutation-related approved indications.

<table>
<thead>
<tr>
<th>PARP Inhibitor</th>
<th>Year Approved</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olaparib</td>
<td>2018</td>
<td>Maintenance treatment of adult patients with deleterious or suspected deleterious germline or somatic BRCA-mutated advanced epithelial ovarian, fallopian tube or primary peritoneal cancer who are in complete or partial response to first-line platinum-based chemotherapy. Select patients for therapy based on an FDA-approved companion diagnostic</td>
</tr>
<tr>
<td>PARP Inhibitor</td>
<td>Year Approved</td>
<td>Indication</td>
</tr>
<tr>
<td>----------------</td>
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</tr>
<tr>
<td><strong>Niraparib</strong></td>
<td>2018</td>
<td>Treatment of adult patients with deleterious or suspected deleterious germine BRCA-mutated (gBRCAm) advanced ovarian cancer who have been treated with 3 or more prior lines of chemotherapy. Select patients for therapy based on an FDA-approved companion diagnostic.</td>
</tr>
<tr>
<td><strong>Niraparib</strong></td>
<td>2019</td>
<td>Maintenance treatment of adult patients with deleterious or suspected deleterious gBRCAm metastatic pancreatic adenocarcinoma whose disease has not progressed on at least 16 weeks of a first-line platinum-based chemotherapy regimen. Select patients for therapy based on an FDA-approved companion diagnostic.</td>
</tr>
<tr>
<td><strong>Niraparib</strong></td>
<td>2019</td>
<td>For the maintenance treatment of adult patients with recurrent epithelial ovarian, fallopian tube, or primary peritoneal cancer who are in a complete or partial response to platinum-based chemotherapy.</td>
</tr>
<tr>
<td><strong>Rucaparib</strong></td>
<td>2019</td>
<td>Treatment of adult patients with advanced ovarian, fallopian tube, or primary peritoneal cancer who have been treated with 3 or more prior chemotherapy regimens and whose cancer is associated with homologous recombination deficiency positive status defined by either a deleterious or suspected deleterious BRCA mutation, or genomic instability and who have progressed more than 6 months after response to the last platinum-based chemotherapy. Select patients for therapy based on an FDA-approved companion diagnostic.</td>
</tr>
<tr>
<td><strong>Rucaparib</strong></td>
<td>2020</td>
<td>Treatment of patients with deleterious BRCA mutation-associated epithelial ovarian, fallopian tube, or primary peritoneal cancer who have been treated with 2 or more chemotherapies. Select patients for therapy based on an FDA-approved companion diagnostic.</td>
</tr>
<tr>
<td><strong>Rucaparib</strong></td>
<td>2020</td>
<td>Treatment of adult patients with a deleterious BRCA mutation (germline and/or somatic)-associated metastatic castration-resistant prostate cancer (mCRPC) who have been treated with androgen receptor-directed therapy and a taxane based chemotherapy.</td>
</tr>
<tr>
<td><strong>Talazoparib</strong></td>
<td>2018</td>
<td>Treatment of adult patients with deleterious or suspected deleterious germine BRCA-mutated (gBRCAm) HER2-negative locally advanced or metastatic breast cancer. Select patients for therapy based on an FDA-approved companion diagnostic.</td>
</tr>
</tbody>
</table>

*This indication is approved under accelerated approval based on objective response rate and duration of response. Continued approval for this indication may be contingent upon verification and description of clinical benefit in confirmatory trials. The ongoing FDA-required confirmatory trial is TRITON3 (NCT02975934), which is a randomized, phase 3 study evaluating rucaparib 600 mg BID vs physician's choice treatment in patients with mCRPC and a deleterious germline or somatic BRCA1, BRCA2, or ATM mutation and powered to measure progression-free survival as its primary outcome.*

**BRCA:** BReast CAncer gene; **FDA:** U.S. Food and Drug Administration; **gBRCAm:** germine BRCA mutated; **HER2:** human epidermal growth factor receptor 2; **PARP:** Poly (adenosine diphosphate-ribose) polymerase
Rationale

Background

Hereditary Breast and Ovarian Cancer Syndrome

Several genetic syndromes with an autosomal dominant pattern of inheritance that features breast cancer have been identified. Of these, HBOC and some cases of hereditary site-specific breast cancer have in common causative variants in BRCA (breast cancer susceptibility) genes. Families suspected of having HBOC syndrome are characterized by an increased susceptibility to breast cancer occurring at a young age, bilateral breast cancer, male breast cancer, ovarian cancer at any age, as well as cancer of the fallopian tube and primary peritoneal cancer. Other cancers, such as prostate cancer, pancreatic cancer, gastrointestinal cancers, melanoma, and laryngeal cancer, occur more frequently in HBOC families. Hereditary site-specific breast cancer families are characterized by early-onset breast cancer with or without male cases, but without ovarian cancer. For this evidence review, BCBSA refers collectively to both as hereditary breast and/or ovarian cancer.

Germline variants in the BRCA1 and BRCA2 genes are responsible for the cancer susceptibility in most HBOC families, especially if ovarian cancer or male breast cancer are features. However, in site-specific cancer, BRCA variants are responsible only for a proportion of affected families. BRCA gene variants are inherited in an autosomal dominant fashion through maternal or paternal lineage. It is possible to test for abnormalities in BRCA1 and BRCA2 genes to identify the specific variant in cancer cases and to identify family members at increased cancer risk. Family members without existing cancer who are found to have BRCA variants can consider preventive interventions for reducing risk and mortality.

Clinical Features Suggestive of BRCA Variant

Young age of onset of breast cancer, even in the absence of family history, is a risk factor for BRCA1 variants. Winchester (1996) estimated that hereditary breast cancers account for 36% to 85% of patients diagnosed before age 30. In several studies, BRCA variants were independently predicted by early age at onset, being present in 6% to 10% of breast cancer cases diagnosed at ages younger than various premenopausal age cutoffs (age range, 35-50 years). In cancer-prone families, the mean age of breast cancer diagnosis among women carrying BRCA1 or BRCA2 variants is in the 40s. In the Ashkenazi Jewish population, Frank et al (2002) reported that 13% of 248 cases with no known family history and diagnosed before 50 years of age had BRCA variants. In a similar study by Gershoni-Baruch et al (2000), 31% of Ashkenazi Jewish women, unselected for family history, diagnosed with breast cancer at younger than 42 years of age had BRCA variants. Other studies have indicated that early age of breast cancer diagnosis is a significant predictor of BRCA variants in the absence of family history in this population.

As in the general population, a family history of breast or ovarian cancer, particularly of early age onset, is a significant risk factor for a BRCA variant in ethnic populations characterized by founder mutations. For example, in unaffected individuals of Ashkenazi Jewish descent, 12% to 31% will have a BRCA variant depending on the extent and nature of the family history. Several other studies have documented the significant influence of family history.

In patients with “triple-negative” breast cancer (i.e., negative for expression of estrogen, progesterone, and overexpression of human epidermal growth factor receptor 2 receptors), there is an increased prevalence of BRCA variants. Pathophysiologic research has suggested that the physiologic pathway for the development of triple-negative breast cancer is similar to that for BRCA-associated breast cancer. In 200 randomly selected patients with triple-negative breast cancer from a tertiary care center, Kandel et al (2006) reported there was a greater than 3-fold increase in the expected rate of BRCA variants. BRCA1 variants were found in 39.1% of patients and BRCA2 variants in 8.7%. Young et al (2009) studied 54 women with high-grade, triple-negative breast cancer with no family history of breast or ovarian cancer, representing a group that previously was not recommended for BRCA testing. Six BRCA variants (5 BRCA1,
1 BRCA2) were found, for a variant rate of 11%. Finally, Gonzalez-Angulo et al (2011) in a study of 77 patients with triple-negative breast cancer, reported that 15 patients (19.5%) had BRCA variants (12 in BRCA1, 3 in BRCA2).14

**Literature Review**
This review was informed by a Blue Cross Blue Shield Association Technology Evaluation Center (TEC) Assessment (1997).15

Evidence reviews assess whether a medical test is clinically useful. A useful test provides information to make a clinical management decision that improves the net health outcome. That is, the balance of benefits and harms is better when the test is used to manage the condition than when another test or no test is used to manage the condition.

The first step in assessing a medical test is to formulate the clinical context and purpose of the test. The test must be technically reliable, clinically valid, and clinically useful for that purpose. Evidence reviews assess the evidence on whether a test is clinically valid and clinically useful. Technical reliability is outside the scope of these reviews, and credible information on technical reliability is available from other sources.

**Testing for BRCA1 and BRCA2 Variants in Individuals at Risk for Hereditary Breast/Ovarian Cancer Syndrome or Other High-Risk Cancers**

**Clinical Context and Test Purpose**
The purpose of testing for BRCA1 and BRCA2 variants in individuals at high-risk for HBOC syndrome is to evaluate whether variants are present and if so, to determine the appropriate surveillance and treatment to decrease the risk of mortality from breast and/or ovarian cancer.

The question addressed in this evidence review is: Does testing for BRCA1 and BRCA2 variants improve the net health outcome in individuals with or suspected of having HBOC syndrome or other high-risk cancers?

The following PICO was used to select literature to inform this review.

**Populations**
The relevant population of interest is patients with cancer (i.e., breast cancer, epithelial ovarian, fallopian tube, primary peritoneal cancer), or patients with a personal or family history of cancer and criteria that might suggest they are at risk of HBOC syndrome.

**Intervention**
The intervention of interest is BRCA1 and BRCA2 variant testing.

For patients without a cancer diagnosis who are assessing cancer risk, results may guide potential prophylactic measures such as surveillance, chemoprevention, or prophylactic mastectomy, and/or oophorectomy.

For patients with a cancer diagnosis, results may guide treatment decisions.

Testing for BRCA1 and BRCA2 variants is conducted in adults when appropriate treatment and/or prophylactic treatment options are available. Variant testing is offered in a primary care setting (e.g., for people without cancer) or the specialty setting (e.g., multidisciplinary oncology care) through various test manufacturers and institutions.

**Comparator**
The following practice is currently being used to manage HBOC syndrome or other high-risk cancers: standard of care without genetic testing.
Outcomes
The outcomes of interest are overall survival (OS), disease-specific (breast and ovarian cancer) survival, test validity, and quality of life (QOL; e.g., anxiety).

Study Selection Criteria
For the evaluation of clinical validity, studies of variant prevalence and cancer risk were included. For the evaluation of clinical utility, studies that represent the intended clinical use of the technology in the intended population were included. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings.

Evidence for the 2 indications is presented together because there is overlap in the evidence base for the 2 populations: (1) patients at risk of HBOC syndrome, and (2) patients with other high-risk cancers such as cancers of the fallopian tube, pancreas, and prostate.

Technically Reliable
Assessment of technical reliability focuses on specific tests and operators and requires a review of unpublished and often proprietary information. Review of specific tests, operators, and unpublished data are outside the scope of this evidence review and alternative sources exist. This evidence review focuses on the clinical validity and clinical utility.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

Prevalence of BRCA Variants and Risks of Cancer and Survival
The prevalence of BRCA variants is approximately 0.1% to 0.2% in the general population. The prevalence may be much higher for particular ethnic groups with characterized founder mutations (e.g., 2.5% [1/40] in the Ashkenazi Jewish population). Family history of breast and ovarian cancer is an important risk factor for the BRCA variant; additionally, age and ethnicity could be independent risk factors.

Systematic Reviews
A systematic review published by Zhu et al (2016) found a significantly lower risk of OS in breast cancer patients with BRCA1 (pooled hazard ratio [HR], 1.69; 95% confidence interval [CI], 1.35 to 2.12) and with BRCA2 (pooled HR, 1.50; 95% CI, 1.02 to 2.09; p = 0.034). However, in patients with breast cancer, BRCA1 and BRCA2 were not associated with a lower breast cancer-specific survival.

Nelson et al (2013) conducted a systematic review that included meta-analytic estimates of the prevalence and penetrance of BRCA variants; this review was used to update the U.S. Preventive Services Task Force (USPSTF) recommendation for risk assessment, genetic counseling, and genetic testing for BRCA-related cancer. In high-risk women with positive test results, cumulative risks for developing breast cancer by age 70 were 46% for BRCA1 and 50% for BRCA2 when a single family member was tested, and 70% for BRCA1 and 71% for BRCA2 when multiple family members were tested; cumulative risks for developing ovarian cancer by age 70 were 41% for BRCA1 and 17% for BRCA2 when a single family member was tested; and 46% for BRCA1 and 23% for BRCA2 when multiple family members were tested. For Ashkenazi Jewish women with positive test results, cumulative risks for developing breast or ovarian cancer by age 75 were 34% and 21% respectively. Nelson et al (2013) included meta-analytic estimates of BRCA prevalence in their review for USPSTF. In unselected women, BRCA variant prevalence estimates were 0.2% to 0.3% in women with breast cancer, 1.8% for BRCA1 and 1.3% for BRCA2; in women with breast cancer onset at age 40 years or younger, 6% in women from high-risk families, 13.6% for BRCA1, 7.9% for BRCA2, and 19.8% for BRCA1 or BRCA2; in unselected Ashkenazi Jewish women, 2.1% and in Ashkenazi Jewish women from high-risk families, 10.2%.
Estimates of lifetime risk of cancer for BRCA variant carriers (penetrance), based on studies of families with an extensive history of the disease, have been as high as 85%. For example, Kuchenbaecker et al (2017) found that the cumulative risk of breast cancer up to age 80 was 72% in BRCA1 carriers and 69% in BRCA2 carriers. Because other factors that influence risk may be present in families with extensive breast and ovarian cancer histories, early penetrance estimates may have been biased upward. Studies of founder mutations in ethnic populations (e.g., Ashkenazi Jewish, Polish, Icelandic populations) unselected for family history have indicated lower penetrance estimates, in the range of 40% to 60% for BRCA1 and 25% to 40% for BRCA2. However, a genotyping study of Ashkenazi Jewish women with incident invasive breast cancer, selected regardless of family history of cancer and their family members, resulted in an 82% lifetime risk of breast cancer for carriers of any of 3 BRCA founder mutations (185delAG, 5382insC, 6174delT). Importantly, the risk of cancer in variant carriers from families with little history of cancer (~50% of all carriers) did not differ significantly. Lifetime risk estimates of ovarian cancer were 54% for BRCA1 and 23% for BRCA2 variant carriers.

Prospective Studies
Women with a history of breast cancer and a BRCA variant have a significant risk of contralateral breast cancer. In a prospective study by Metcalfe et al (2004), the 10-year risk was 29.5% for women with initial stage I or II diseases. In a prospective study, Epidemiological Study of Familial Breast Cancer, Mavaddat et al (2013) reported that the cumulative risk of contralateral breast cancer by age 70 years was 83% in the BRCA1 variant carriers, and 62% for BRCA2 variant carriers. These investigators also reported cumulative risks of breast cancer by age 70 in women without previous cancer (60% in BRCA1 carriers, 55% in BRCA2 carriers). Similarly, the cumulative risk estimates of ovarian cancer by age 70 years in women without previous ovarian cancer were 59% for BRCA1 carriers and 17% for BRCA2 carriers.

BRCA Variant Rates Associated With Ovarian Cancer
Women with a personal history of ovarian cancer have an increased rate of BRCA variants. In a systematic review of 23 studies, Trainer et al (2010) estimated the rate of BRCA variants among women with ovarian cancer to be 3% to 15%. In this review, 3 U.S. studies tested for both BRCA1 and BRCA2; incidences of BRCA variants were 11.3%, 15.3%, and 9.5%. In the systematic review for USPSTF by Nelson et al (2013), meta-analytic estimates of BRCA prevalence among women with ovarian cancer were 4.4% for BRCA1 and 5.6% for BRCA2. Table 2 lists the results from several additional studies measuring the presence of BRCA variants among patients with ovarian cancer. One study noted that variant prevalence was higher for women in their 40s (24%) and for women with serous ovarian cancer (18%). Ethnicity was another risk factor for BRCA, with higher rates seen in women of Italian (43.5%), Jewish (30%), and Indo-Pakistani (29.4%) origin.

Table 2. BRCA Variant Rates in Patients With Ovarian Cancer

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>N</th>
<th>BRCA Variant, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>BRCA1</td>
</tr>
<tr>
<td>Harter et al</td>
<td>Patients with invasive ovarian cancer across 20</td>
<td>523</td>
<td>81 (15.5)</td>
</tr>
<tr>
<td>(2017)</td>
<td>medical centers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kurian et al</td>
<td>Patients with invasive ovarian cancer tested for</td>
<td>5020</td>
<td>255 (15.5)</td>
</tr>
<tr>
<td>(2017)</td>
<td>hereditary cancer risk from a commercial database</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Langer et al</td>
<td>Patients with ovarian cancer tested for hereditary</td>
<td>3088</td>
<td>153 (4.9)</td>
</tr>
<tr>
<td>(2016)</td>
<td>cancer risk from a commercial laboratory database</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norquist et al</td>
<td>Patients with invasive ovarian cancer, from 2 phase</td>
<td>1915</td>
<td>182 (9.5)</td>
</tr>
<tr>
<td>(2016)</td>
<td>3 clinical trials and a gynecologic oncology tissue bank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhang et al</td>
<td>Patients with invasive ovarian cancer</td>
<td>1342</td>
<td>107 (8.0)</td>
</tr>
</tbody>
</table>

* Total N was reported as 5020, however, the percentage of BRCA variants as reported in article is inconsistent with 5020 as the denominator.
BRCA Variant Rates Associated With Fallopian Tube Cancer

A study by Hirst et al (2009) described the high rate of occult fallopian tube cancers in at-risk women having prophylactic bilateral salpingo-oophorectomy.\(^{30}\) In this prospective series of 45 women, 4 (9%) had fallopian tube malignancies. Reviewers noted that these findings supported other studies that have demonstrated the fimbrial end of the fallopian tube as an important site of cancer in those with BRCA1 or BRCA2 variants.

A long-term study by Powell et al (2013; median follow-up, 7 years; range, 3-14 years) followed 32 BRCA variant carriers with occult malignancy (4 ovarian, 23 fallopian tube, 5 ovarian and fallopian tube) diagnosed of prophylactic salpingo-oophorectomy.\(^ {31}\) Among 15 women with invasive carcinoma (median age, 50 years), 7 (47%) experienced recurrence at a median of 33 months, and OS was 73%. Among 17 women with noninvasive neoplasia (median age, 53 years), 4 (24%) received chemotherapy, none of whom experienced recurrence. One (6%) patient who did not receive chemotherapy experienced recurrence at 43 months. OS was 100%. The authors concluded that, in BRCA variant carriers, unsuspected invasive carcinoma has a relatively high rate of recurrence, but noninvasive neoplasms rarely recur and may not require adjuvant chemotherapy.

BRCA Variant Rates Associated With Pancreatic Cancer

Unaffected individuals also may be at high-risk due to other patterns of non-breast-cancer malignancies. A personal history of pancreatic cancer is estimated to raise the risk of a BRCA variant by 3.5- to 10-fold over the general population.\(^ {32}\) Table 3 lists the results from several studies measuring the presence of BRCA variants among patients with pancreatic adenocarcinoma.\(^ {33,34,35,36,37,38}\) Patients with pancreatic adenocarcinoma of Jewish descent appear to have a higher prevalence of BRCA variants compared with the general population of patients with pancreatic adenocarcinoma.

<table>
<thead>
<tr>
<th>Table 3. BRCA Variant Rates in Patients With Pancreatic Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study</td>
</tr>
<tr>
<td>Hu et al (2018)(^ {38,40})</td>
</tr>
<tr>
<td>Yurgelun et al (2018)(^ {37})</td>
</tr>
<tr>
<td>Shindo et al (2017)(^ {36})</td>
</tr>
<tr>
<td>Holter et al (2015)(^ {35})</td>
</tr>
<tr>
<td>Ferrone et al (2009)(^ {34})</td>
</tr>
<tr>
<td>Couch et al (2007)(^ {33})</td>
</tr>
</tbody>
</table>

\(^{a}\) Case-control study; rates for BRCA1 and BRCA2 variants in controls were 0.2 and 0.3, respectively.

BRCA Variant Rates Associated With Prostate Cancer

Table 4 lists the results from several studies measuring the presence of BRCA variants among patients with prostate cancer.\(^ {39,40,41}\)

<table>
<thead>
<tr>
<th>Table 4. BRCA Variant Rates in Patients With Prostate Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study</td>
</tr>
<tr>
<td>Abida et al (2017)(^ {40})</td>
</tr>
<tr>
<td>Pritchard et al (2016)(^ {41})</td>
</tr>
</tbody>
</table>
Testing for Large BRCA Rearrangements

A number of studies have shown that a significant percentage of women with a strong family history of breast cancer and negative tests for BRCA variants have large genomic rearrangements (including deletions or duplications) in 1 of these genes. For example, Walsh et al (2006) reported on probands from 300 U.S. families with 4 or more cases of breast or ovarian cancer but with negative (wild-type) commercial genetic tests for BRCA1 and BRCA2. These patients underwent screening with additional multiple DNA-based and RNA-based methods. Of these 300 patients, 17% carried previously undetected variants, including 35 (12%) with genomic rearrangement of BRCA1 or BRCA2.

A study by Palma et al (2008) evaluated 251 patients with an estimated BRCA variant prevalence using the Myriad II model of at least 10%. In 136 non-Ashkenazi Jewish probands, 36 (26%) had BRCA point mutations and 8 (6%) had genomic rearrangements (7 in BRCA1, 1 in BRCA2). Genomic rearrangements comprised 18% of all identified BRCA variants. No genomic rearrangements were identified in the 115 Ashkenazi Jewish probands, but 47 (40%) had point mutations. The authors indicated that the estimated prevalence of a variant did not predict the presence of a genomic rearrangement.

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from randomized controlled trials (RCTs). In their systematic review for the USPSTF, Nelson et al (2019) confirmed that they identified no studies that compared health outcomes for patients managed with and without BRCA variant testing.

Knowledge of variant status in individuals at potentially increased risk of a BRCA variant may impact health care decisions to reduce risk. Risk-reducing options include intensive surveillance, chemoprevention, prophylactic mastectomy, or prophylactic oophorectomy.

Prophylactic mastectomy reduces the risk of breast cancer in high-risk women (based on family history) by 90%. Prophylactic oophorectomy significantly reduces the risk of ovarian cancer by 80% or more, and reduces the risk of breast cancer by approximately 50%. In women who have already had breast cancer, prophylactic oophorectomy reduces the risk of cancer relapse. Prophylactic oophorectomy or salpingo-oophorectomy in women with BRCA1 or BRCA2 reduced the risk of all-cause mortality by 60% to 77%. For patients at risk for both breast and ovarian cancer, a study by Elmi et al (2018), drawing on data from the American College of Surgeon’s National Surgical Quality Improvement Program dataset, found that prophylactic mastectomy with concurrent salpingo-oophorectomy was not associated with significant additional morbidity compared with prophylactic mastectomy alone.

Systematic reviews of observational studies comparing prophylactic surgeries with observation in women who had BRCA1 and BRCA2 variants have demonstrated that contralateral prophylactic mastectomy in women with breast cancer is associated with significantly lower all-cause mortality while bilateral prophylactic mastectomy was not associated with all-cause mortality. Studies have indicated that the results of genotyping significantly influenced treatment choices.
In a systematic review for the USPSTF, Nelson et al (2019) assessed the efficacy of risk-reducing surgery in BRCA-positive women. The literature search was conducted through March 2019. A total of 13 observational studies (n=9938) provided consistent and moderate-strength evidence of the benefits of risk-reducing surgery. For high-risk women and variant carriers, bilateral mastectomy reduced breast cancer incidence by 90% to 100% and breast cancer mortality by 81% to 100% oophorectomy or salpingo-oophorectomy reduced breast cancer incidence by 37% to 83% ovarian cancer incidence by 69% to 100% Some women experienced reduced anxiety. Limitations of the studies of benefits included lack of comparison groups, variations in methodology and enrollment criteria, and heterogeneous outcome measures. Additionally, a total of 14 observational studies (n=3073) provided low-strength evidence of the harms of risk-reducing surgery. Adverse events included physical complications of the surgery, postsurgical symptoms, and changes in body image. Studies of harms shared the same limitations as the studies of benefits as noted above, with the addition that their findings were inconsistent and the sample sizes were smaller. As reviewers observed, it is still currently unknown whether BRCA variant testing reduces cause-specific or all-cause mortality, or if it improves the QOL. Harms associated with false-negative results or variants of uncertain significance also are unknown.

Other studies have looked at the results of prostate cancer screening in men with BRCA variants. The Immunotherapy for Prostate Adenocarcinoma Treatment study (2011) evaluated the results of screening in 205 men 40 to 69 years of age who were BRCA variant carriers and 95 control patients. At the baseline screen, biopsies were performed in 7.0% of men with a prostate-specific antigen level greater than 3.0 ng/mL and prostate cancer was identified in 3.3%. This resulted in a positive predictive value of 47.6%, which is considerably higher than that estimated for men at normal risk. Moreover, the grade of tumor identified was intermediate in 67% of cancers and high in 11%. This differs from the expected distribution of cancer grade in average-risk men, with more than 60% expected to have low-grade cancer.

**Section Summary: Testing for BRCA1 and BRCA2 Variants in Individuals at Risk for HBOC Syndrome or Other High-Risk Cancers**

Evidence for the clinical validity of BRCA1 and BRCA2 variant testing consists of multiple studies that calculated BRCA1 and BRCA2 variant prevalence among samples of patients with HBOC syndrome, fallopian tube cancer, pancreatic cancer, and prostate cancer.

Regarding clinical utility of BRCA1 and BRCA2 variant testing, current evidence has not directly evaluated management with and without genetic testing. In terms of prophylactic measures (mastectomy and oophorectomy), RCTs would be difficult to conduct. However, retrospective analyses have shown that prophylactic mastectomy and/or oophorectomy greatly reduced the risk of breast cancer (90-100%) and ovarian cancer (69%-100%).

**Testing for BRCA1 and BRCA2 Variants to Guide Systemic Therapy Decisions in Individuals with HBOC Syndrome or Other High-Risk Cancers**

**Clinical Context and Test Purpose**

The purpose of testing for BRCA1 and BRCA2 variants in individuals with HBOC Syndrome or other high-risk cancers considering systemic therapy options (i.e., poly(adenosine diphosphate-ribose) polymerase [PARP] inhibitors for ovarian, prostate, or pancreatic cancer and metastatic human epidermal receptor 2 [HER]-negative breast cancer; platinum therapy for prostate cancer and pancreatic cancer) is to guide treatment selection.

The question addressed in this evidence review is: Does testing for BRCA1 and BRCA2 variants in individuals with HBOC Syndrome or other high-risk cancers to guide systematic therapy decisions improve the net health outcome?

The following PICO was used to select literature to inform this review.
Populations
The relevant population of interest is individuals with HBOC Syndrome or other high-risk cancers considering systemic therapy.

Intervention
The test being considered is BRCA1 and BRCA2 variant testing.

Comparator
The following practice is currently being used to manage HBOC syndrome or other high-risk cancers: standard of care without genetic testing.

Outcomes
The outcomes of interest are overall survival (OS), disease-specific (breast and ovarian cancer) survival, test validity, and quality of life (QOL; e.g., anxiety).

Technically Reliable
Assessment of technical reliability focuses on specific tests and operators and requires a review of unpublished and often proprietary information. Review of specific tests, operators, and unpublished data are outside the scope of this evidence review and alternative sources exist. This evidence review focuses on the clinical validity and clinical utility.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

Study Selection Criteria
For the evaluation of the clinical validity of the genetic test, studies that reported on the sensitivity and specificity and/or diagnostic yield of the test were considered.

Clinically Useful
A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Study Selection Criteria
Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs.

Clinical Utility
Direct Evidence
There are no direct outcome data on the clinical usefulness of testing for confirmation of a BRCA1 or BRCA2 variant in patients with HBOC syndrome or other high-risk cancers (i.e., no studies have reported outcomes data for patients tested and not tested for a variant).

Indirect Evidence
A chain of indirect evidence would demonstrate that genetic testing can identify individuals with a BRCA1 or BRCA2 variant associated with HBOC syndrome or other high-risk cancers who would not otherwise be identified, that treatments are available for these patients that would not otherwise be given to patients with HBOC syndrome or other high-risk cancers, and that these treatments improve health outcomes.

Clinical Validity
Studies of the clinical validity of testing for BRCA1 or BRCA2 variants associated with HBOC syndrome or other high-risk cancers are previously summarized.
Clinical Utility
Numerous clinical trials have been conducted to evaluate the effectiveness of PARP inhibitor drugs in individuals with HBOC Syndrome or other high-risk cancers confirmed to have a BRCA1/2 mutation. Summarized below are the pivotal trials that supported the BRCA mutation-related U.S. Food and Drug Administration (FDA) approved indications.

Olaparib
OlympiAD is a phase 3 RCT in which patients with human epidermal growth factor receptor 2 (HER2)-negative metastatic breast cancer and a germline BRCA variant were randomized to olaparib (n=205) or standard therapy (n=97).\(^{60}\) BRCA1/2 mutation was detected by BRACAnalysis testing. In its initial publication, Robson et al (2017) reported that after a median follow-up of 14.5 months, patients receiving olaparib experienced significantly longer progression-free survival compared with patients receiving standard therapy (HR, 0.6; 95% CI, 0.4 to 0.8).\(^{61}\) The rate of grade 3 or higher adverse events was lower in the group receiving olaparib (37%) compared with the group receiving standard therapy (51%). However, regarding OS, in their subsequent publication, Robson et al (2019) further reported that although improvement with olaparib was not significant overall (19.3 vs 17.1 months; HR, 0.90; 95% CI, 0.66 to 1.23) there may be a benefit in the subgroup of patients who had not received chemotherapy for metastatic disease (HR, 0.51; 95% CI 0.29-0.90).\(^{62}\)

Moore et al (2018) published results from the phase 3, international, multi-center, double-blind, placebo-controlled trial of maintenance olaparib 300 mg twice daily in 391 patients with newly diagnosed advanced high-grade serous or endometrioid ovarian cancer, primary peritoneal cancer, and/or fallopian-tube cancer with a BRCA1/2 mutation following a complete or partial clinical response following platinum-based chemotherapy (SOLO-1). A total of 177 sites participated across 15 countries (United States, Australia, Brazil, Canada, China, France, Israel, Italy, Japan, Korea, Netherlands, Poland, New Zealand, Russian Federation, Spain, United Kingdom). Participants were enrolled between September 2013 and March 2015. The primary tumor location was the ovary in 85% of participants. The primary end point was progression-free survival, which was assessed by investigators and defined as the time from randomization to objective disease progression on imaging (according to modified Response Evaluation Criteria in Solid Tumors [RECIST], version 1.1) or death from any cause. Median follow-up was 41 months. Median progression-free survival was 13.8 months in the placebo group and not reported for the olaparib group. At 3 years, the proportions of patients free from disease progression and from death was 60% for olaparib and 27% for placebo, resulting in a 70% lower risk of disease progression or death for olaparib (HR 0.30; 95% CI, 0.23 to 0.41). Grade 3 or higher adverse events occurred in 39% of the olaparib group and 18% of the placebo group, with the most common events being anemia (22%) and neutropenia (9%).

Pujade-Lauraine et al (2017) published results from the phase 3, international, multi-center, double-blind, placebo-controlled trial of maintenance olaparib 300 mg twice daily in 295 patients with platinum-sensitive, relapsed, high-grade serous ovarian cancer or high-grade endometrioid cancer, including primary peritoneal or fallopian tube cancer, with a BRCA1/2 mutation who had received at least 2 lines of previous chemotherapy (SOLO-2). A total of 123 sites participated across 16 countries (United States, Australia, Belgium, Brazil, Canada, France, Germany, Israel, Italy, Japan, Korea, Netherlands, Poland, Russian Federation, Spain, United Kingdom). Participants were enrolled between September 2013 and November 2014. The primary tumor location was the ovary in 85% of participants. The primary endpoint was investigator-assessed progression-free survival, defined as the time from randomization until objective radiological disease progression or death using modified RECIST version 1.1. Median follow-up was 22.1 months in the olaparib group and 22.2 months in the placebo group. Olaparib resulted in a significantly longer progression-free survival (19.1 vs 5.5 months; HR 0.30, 95% CI, 0.22 to 0.41). Grades 3 and 4 adverse events occurred in 32% and 4% of olaparib patients, respectively and 15% and 3% of the placebo group. The most common grade 3 or higher adverse event in the olaparib group was anemia (19%).
Niraparib

Mirza et al (2016) published results from the phase 3, international, multi-center, double-blind, placebo-controlled trial of 553 patients with platinum-sensitive recurrent epithelial ovarian, fallopian tube, or primary peritoneal cancer that evaluated maintenance treatment with niraparib 300 mg once daily (NOVA).65 This trial was conducted by the European Network for Gynecological Oncological Trial groups and investigators across 107 sites in the United States, Canada, and Hungary. Two independent cohorts were separately evaluated on the basis of the presence or absence of a germline BRCA mutation (gBRCA cohort and non-gBRCA cohort), as determined on BRACAnalysis testing. Participants were enrolled between August 2013 and June 2016 and the majority had stage III or IV ovarian cancer. The gBRCA cohort consisted of 201 individuals (36.3%). The primary endpoint was progression-free survival. Overall median follow-up duration was 16.9 months. Progression-free survival was significantly longer in the niraparib group, regardless of the presence or absence of gBRCA mutations (gBRCA cohort: 21.0 vs 5.5 months; HR 0.27, 95% CI, 0.17 to 0.41; non-gBRCA cohort: 9.3 vs 3.9 months; HR 0.45, 95% CI, 0.34 to 0.61). Thrombocytopenia (33.8%), anemia (25.3%), and neutropenia (19.6%) were the most common grade 3 or higher adverse events in the niraparib group.

Moore et al (2019) published results from the phase 2, multi-center, single-arm clinical trial of niraparib monotherapy 300 mg once daily in individuals with relapsed, high-grade serous (grade 2 or 3) epithelial ovarian, fallopian tube, or primary peritoneal cancer who had been treated with 3 or more previous chemotherapy regimens (QUADRA).63 Between April 2015 and November 2017, this trial enrolled 463 patients across 56 sites in the United States and Canada. All participants underwent tumor homologous recombination deficiency (HRD) testing and blood germline BRCA-mutated status testing and were stratified into 4 cohorts: BRCA-mutated, HRD-positive/non-BRCA-mutated, HRD-negative, and HRD-unknown. The majority of participants had ovarian cancer (79%). The BRCA-mutated cohort consisted of 87 (19%) participants. In the BRCA-mutated cohort, the primary endpoint of investigator-assessed confirmed overall response was met by 30% (95% CI, 17% to 64%) and 36% of patients with stable disease at 24 weeks had a progression-free survival ratio greater than 1.3 (9/25). In the overall population, anemia (24%) and thrombocytopenia (21%) were the most frequent grade 3 or higher adverse events. A key limitation of this trial is its lack of a control group.

Rucaparib

Coleman et al (2017) published results from the phase 3, international, multi-center, double-blind trial of 564 patients with recurrent epithelial ovarian, fallopian tube, or primary peritoneal cancer that compared rucaparib maintenance treatment to placebo following response to second-line or later platinum-based chemotherapy (ARIEL3).66 A total of 87 sites participated across 11 countries (United States, Australia, Belgium, Canada, France, Germany, Israel, Italy, New Zealand, Spain, United Kingdom). Germline mutations were identified using the BRACAnalysis CDx test. Tumor tissue samples were tested using a clinical trial assay and the FoundationFocus CDx test. Three nested cohorts were evaluated: patients with BRCA mutations, patient with homologous recombination deficiencies, and the intention-to-treat populations. Participants were enrolled between April 2014 and July 2016 and the majority had epithelial ovarian cancer (84%). A total of 196 (34.8%) had BRCA1/2 mutations. The primary endpoint was progression-free survival, which was significantly longer in the rucaparib group in the BRCA-mutant cohort (16.6 months vs 5.4 months; HR 0.23, 95% CI, 0.16 to 0.34), the homologous recombination deficient carcinoma cohort (13.6 months vs 5.4 months; HR 0.32, 95% CI, 0.24 to 0.42), and in the intention-to-treat cohort (10.8 months vs 5.4 months; HR 0.36, 95% CI, 0.30 to 0.45). Grade 3 or higher adverse events were reported in 56% of patients in the rucaparib group compared with 15% in the placebo group. The most common of these were anemia or decreased hemoglobin concentration.

Kristeleit et al (2019) published integrated results from 2 multi-center, single-arm, open-label trials of rucaparib 600 mg twice daily (Study 10 and ARIEL2) in patients with high-grade serous or endometrioid epithelial ovarian, fallopian tube, or primary peritoneal cancer and a
deleterious BRCA1 or BRCA2 mutation who had progressed after receiving 2 or more prior chemotherapies (including 2 or more platinum-based therapies). The majority of patients had epithelial ovarian cancer (87.3%). The efficacy population consisted of 79 patients who took at least 1 dose of rucaparib. Median treatment and follow-up durations were not reported. The primary end point was investigator-assessed, confirmed objective response rate, which was 64.6% (95% CI, 53.0% to 75.0%). Median progression-free survival was 332 days (95% CI, 255 to 391). Grade 3 or greater adverse events occurred in 63.2% of patients, which were most frequently decreased hemoglobin (24.2%), asthenia/fatigue (11.3%) and alanine/aspartate aminotransferase increased (10.8%).

Abida et al (2020) published results from the phase 2, multi-center, single-arm clinical trial of rucaparib in patients with BRCA-mutated metastatic castration-resistant prostate cancer (mCRPC) that supported its accelerated FDA approval in 2020 (TRITON2). This trial enrolled 115 patients who were treated with rucaparib 600 mg twice daily. For the efficacy population, median treatment duration was 8.1 months and median follow-up was 17.1 months. The primary endpoint of objective response rate, which was rated by blinded, independent radiology review, was 43.5% (95% CI, 31.0% to 56.7%). Median radiographic progression-free survival duration was 9.0 months (95% CI, 8.3 to 13.5). Anemia was the most frequent grade 3 or higher adverse event (25.2%). A key limitation of this trial is its lack of a control group. Continued approval for this indication for rucaparib may be contingent upon verification of progression-free survival in the ongoing confirmatory TRITON3 trial (NCT02975934), which is a randomized, controlled phase 3 trial evaluating rucaparib 600 mg twice daily versus physician’s choice treatment in patients with mCRPC and a deleterious germline or somatic BRCA1, BRCA2, or ATM mutation.

**Talazoparib**

Litton et al (2018) published results from a phase 3, randomized, open-label trial of 431 patients with advanced breast cancer and a germline BRCA1/2 mutation that compared talazoparib 1 mg once daily to standard single-agent therapy (EMBRACA). BRCA1/2 mutation was detected by BRACAnalysis testing. The primary endpoint was progression-free survival. Median duration of follow-up for that endpoint was 11.2 months. Progression-free survival was significantly longer in the talazoparib group (8.6 months vs 5.6 months; HR 0.54, 95% CI, 0.41 to 0.71). The rate of overall grade 3 or higher adverse events was similar for talazoparib compared with the standard care (25.5% vs 25.4%), but hematologic grade 3-4 adverse events (primarily anemia) were more frequent for talazoparib (55% vs 38%) compared with nonhematologic grade 3-4 adverse events (32% vs 38%). Based on the European Organization for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire (QLQ-C30), compared to baseline, there was a significant improvement in the talazoparib group (+3.0; 95% CI, 1.2 to 4.8) and a significant decline in the standard therapy group (-5.4; 95% CI, -8.8 to -2.0). Although the trial was open-label, assessment of the primary outcome was based on blinded independent central review.

**Section Summary: Testing for BRCA1 and BRCA2 Variants to Guide Treatment in Individuals with HBOC Syndrome or Other High-Risk Cancers**

No studies were identified that have directly compared health outcomes in patients with HBOC syndrome or other high-risk cancers who did and did not use BRCA1 and BRCA2 variant testing to guide systemic treatment decisions. Evidence for the use of testing for BRCA1 and BRCA2 variants in individuals with HBOC Syndrome or other high-risk cancers to guide systematic therapy decisions consists of a chain of indirect studies demonstrating that genetic testing can identify individuals with a BRCA1 or BRCA2 variant associated with HBOC syndrome or other high-risk cancers who would not otherwise be identified, that treatments are available for these patients that would not otherwise be given to patients with HBOC syndrome or other high-risk cancers, and that these treatments improve health outcomes. The numerous placebo-controlled RCTs of PARP inhibitor drugs have consistently demonstrated that, in individuals identified by genetic testing as having a BRCA1 or BRCA2 variant associated with HBOC syndrome or other high-risk cancers, treatment with PARP inhibitor drugs significantly improve progression-free survival time. In individuals with ovarian cancer and
a BRCA1 or BRCA2 mutation that were followed for a median of 17 to 36 months, treatment with a PARP inhibitor drug resulted in a 70% to 77% lower risk of disease progression or death. In individuals with a BRCA1/2 mutation and either HER2-negative metastatic breast cancer or other advanced breast cancer who were followed for 11-12 months, treatment with a PARP inhibitor drug resulted in a 40% to 46% lower risk of disease progression or death. In individuals with BRCA-mutated metastatic castration-resistant prostate cancer, the accelerated FDA approval of rucaparib was based on a phase 2, multi-center, single-arm clinical trial which demonstrated a benefit on a surrogate outcome of objective response rate. Continued approval for this indication for rucaparib may be contingent upon verification of the clinical outcome, progression-free survival in the ongoing randomized, standard care-controlled confirmatory TRITON3 trial (NCT02975934). Rates of overall Grade 3 or 4 adverse events ranged from 25.5% to 63.2% across PARP inhibitor drugs.

Summary of Evidence
For individuals who have cancer or a personal or family cancer history and meet criteria suggesting a risk of hereditary breast and ovarian cancer (HBOC) syndrome who receive genetic testing for a BRCA1 or BRCA2 variant, the evidence includes a TEC Assessment and studies of variant prevalence and cancer risk. Relevant outcomes are overall survival (OS), disease-specific survival, test validity, and quality of life. The accuracy of variant testing has been shown to be high. Studies of lifetime risk of cancer for carriers of a BRCA variant have shown a risk as high as 85%. Knowledge of BRCA variant status in individuals at risk of a BRCA variant may impact health care decisions to reduce risk, including intensive surveillance, chemoprevention, and/or prophylactic intervention. In individuals with BRCA1 or BRCA2 variants, prophylactic mastectomy and oophorectomy have been found to significantly increase disease-specific survival and OS. Knowledge of BRCA variant status in individuals diagnosed with breast cancer may impact treatment decisions.

For individuals who have other high-risk cancers (e.g., cancers of the fallopian tube, pancreas, prostate) who receive genetic testing for a BRCA1 or BRCA2 variant, the evidence includes studies of variant prevalence and cancer risk. Relevant outcomes are OS, disease-specific survival, test validity, and quality of life. The accuracy of variant testing has been shown to be high. Knowledge of BRCA variant status in individuals with other high-risk cancers can inform decisions regarding genetic counseling, chemotherapy, and enrollment in clinical trials. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals with HBOC Syndrome or other high-risk cancers considering systemic therapy options who receive genetic testing for a BRCA1 or BRCA2 variant, the evidence includes several randomized controlled trials (RCT) and single-arm trials. Relevant outcomes are OS, disease-specific survival, test validity, and quality of life. The numerous placebo-controlled RCTs of PARP inhibitor drugs have consistently demonstrated that, in individuals with HER2-negative metastatic breast cancer, other advanced breast cancer, or ovarian cancer and a germline BRCA variant, treatment with PARP inhibitor drugs significantly improve progression-free survival time. In individuals with BRCA-mutated metastatic castration-resistant prostate cancer, a single-arm clinical trial of rucaparib demonstrated a benefit on a surrogate outcome of objective response rate and evaluation of its effects on progression-free survival is pending completion of the ongoing randomized, standard care-controlled confirmatory TRITON3 trial (NCT02975934). Rates of overall Grade 3 or 4 adverse events ranged from 25.5% to 63.2% across PARP inhibitor drugs. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

Supplemental Information
Clinical Input From Physician Specialty Societies and Academic Medical Centers
While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate
Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers

In response to requests from Blue Cross Blue Shield Association, input was received for 3 physician specialty societies (5 reviewers) and 3 academic medical centers (5 reviewers) in 2010. Those providing input were in general agreement with the Policy statements considering testing for genomic rearrangements of BRCA1 and BRCA2 as medically necessary and with adding fallopian tube and primary peritoneal cancer as BRCA-associated malignancies to assess when obtaining the family history.

Practice Guidelines and Position Statements
National Comprehensive Cancer Network

Breast Cancer and Ovarian Cancer
Current NCCN (v.1.2021) guidelines on the genetic and familial high-risk assessment of breast and ovarian cancers include criteria for identifying individuals who should be referred for further risk assessment and separate criteria for genetic testing. Patients who satisfy any of the testing criteria listed in Table 5 should undergo “further personalized risk assessment, genetic counseling, and often genetic testing and management.” For these criteria, both invasive and in situ breast cancers were included. Maternal and paternal sides of the family should be considered independently for familial patterns of cancer. Testing of unaffected individuals should be considered “only when an appropriate affected family member is unavailable for testing.”

BRCA1 and BRCA2 somatic variants are uncommon. The NCCN recommends if a somatic variant is identified through tumor profiling, then BRCA1 and BRCA2 germline testing is recommended.

Table 5. BRCA1 and BRCA2 Testing Criteria for Hereditary Breast and Ovarian Cancer Syndrome

<table>
<thead>
<tr>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing is clinically indicated in the following scenarios:</td>
</tr>
<tr>
<td>1. Individuals with any blood relative with a known pathogenic/likely pathogenic variant in a cancer susceptibility gene.</td>
</tr>
<tr>
<td>2. Individuals meeting the criteria below but with previous limited testing (e.g., single gene and/or absent deletion duplication analysis) interested in pursuing multi-gene testing.</td>
</tr>
<tr>
<td>3. Personal history of cancer</td>
</tr>
<tr>
<td>o Breast Cancer with at least 1 of the following:</td>
</tr>
<tr>
<td>a. Diagnosed age ≤45 years</td>
</tr>
<tr>
<td>b. Diagnosed age ≤ 46 to 50 years AND:</td>
</tr>
<tr>
<td>▪ Unknown or limited family history; or</td>
</tr>
<tr>
<td>▪ A second breast cancer diagnosed at any age; or</td>
</tr>
<tr>
<td>▪ ≥1 close blood relative with breast, ovarian, pancreatic or prostate cancer at any age</td>
</tr>
<tr>
<td>c. Diagnosed age ≤60 years with a triple-negative (ER-, PR-, HER2-) breast cancer</td>
</tr>
<tr>
<td>d. Diagnosed any age AND:</td>
</tr>
<tr>
<td>▪ Ashkenazi Jewish Ancestry; or</td>
</tr>
<tr>
<td>▪ ≥1 close blood relative with breast cancer at age ≤50 y or ovarian, pancreatic, or metastatic or intraductal/cribriform prostate cancer at any age or high-risk group or very-high-risk group prostate cancer at any age; or</td>
</tr>
<tr>
<td>▪ ≥ 3 total diagnoses of breast cancer in patient and/or close blood relatives</td>
</tr>
<tr>
<td>e. Diagnosed any age with male breast cancer.</td>
</tr>
<tr>
<td>o Personal history of epithelial ovarian cancer (including fallopian tube cancer or peritoneal cancer) at any age</td>
</tr>
<tr>
<td>o Exocrine pancreatic cancer at any age</td>
</tr>
<tr>
<td>o Metastatic or intraductal/cribriform prostate cancer at any age; or high-risk or very-high-risk prostate cancer</td>
</tr>
<tr>
<td>o Prostate cancer at any age with:</td>
</tr>
<tr>
<td>a. Ashkenazi Jewish ancestry; or</td>
</tr>
</tbody>
</table>
Recommendations

b. ≥1 close relative with breast cancer at age ≤50 y or ovarian, pancreatic, or metastatic or intraductal/cribriform prostate cancer at any age; or

c. ≥2 close relatives with breast or prostate cancer (any grade) at any age.

- A mutation identified on tumor genomic testing that has clinical implications if also identified in the germline
- To aid in systemic therapy decision-making, such as for HER2-negative metastatic breast cancer (e.g., PARP inhibitors for ovarian cancer, prostate cancer, pancreatic cancer, and metastatic HER2-negative breast cancer; platinum therapy for prostate cancer and pancreatic cancer)

4. Family history of cancer

- An affected or unaffected individual with a first- or second-degree blood relative meeting any of the criteria listed above (except individuals who meet criteria only for systemic therapy decision-making) (this may be extended to an affected third-degree relative if related through 2 male relatives [e.g., paternal grandfather's mother or sister]). Note: if the individual with cancer has pancreatic cancer or prostate cancer (metastatic or intraductal/cribriform or high-risk group or very-high-risk group) then only first-degree relatives should be offered testing unless there are other family history indications for testing.

- An affected or unaffected individual who does not meet the criteria above but has a probability >5% of a BRCA1/2 pathogenic variant based on prior probability models (e.g., Tyrer Cuzick, BRCAPro, Pennll).

Testing may be considered in the following scenarios (with appropriate pre-test education and access to post-test management):

1. Bilateral breast cancer, first diagnosed between the ages of 50 and 65 y.
2. An unaffected Ashkenazi Jewish individual (Testing for 3 founder mutations of BRCA ½ may be offered to Jewish ancestry, irrespective of cancer history in the family, as part of longitudinal studies)
3. An affected or unaffected individual who otherwise does not meet any of the above criteria but with a 2.5%-5% probability of BRCA1/2 pathogenic variant based on prior probability models (e.g., Tyrer-Cuzick, BRCAPro, Pennll)

There is a low probability (<2.5%) that testing will have findings of documented clinical utility in the following scenarios:

1. Women diagnosed with breast cancer at age >65 y, with no close relative with breast, ovarian, pancreatic, or prostate cancer.
2. Men diagnosed with localized prostate cancer with Gleason Score <7 and no close relative with breast, ovarian, pancreatic, or prostate cancer.

ER: estrogen receptor; HER2: human epidermal growth factor receptor 2; PR: progesterone receptor.

Additionally, the NCCN Ovarian Cancer guidelines (v1.2020) recommend tumor molecular testing prior to initiation of therapy for persistent/recurrent disease (OV-6) and describe in multiple algorithms that testing should include at least BRCA1/2 and microsatellite instability or DNA mismatch repair, and evaluation of homologous recombination deficiency can be considered (OV-6, OV-7, OV-B Principles of Pathology, OV-C Principles of Systemic Therapy).

Pancreatic Adenocarcinoma

Current NCCN guidelines for pancreatic adenocarcinoma (v.1.2020) refers to the NCCN guidelines on genetic/familial high-risk assessment of breast and ovarian detailed above, and state: “Germline testing is recommended for any patient with confirmed pancreatic cancer, using comprehensive gene panels for hereditary cancer syndromes.”

Prostate Cancer

The current NCCN guidelines for prostate cancer are version 1.2020. The Principles of Genetics section (PROS-B) includes the following statements regarding Germline Testing:

- Germline genetic testing is recommended for patients with prostate cancer and a family history of high-risk germline mutations (e.g., BRCA1/2, Lynch mutation)
- "Family history for known germline variants and genetic testing for germline variants should include MLH1, MSH2, MSH6, and PMS2 (for Lynch Syndrome) and homologous recombination genes BRCA1, BRCA2, ATM, PALB2, and CHEK2. Consider cancer
Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers

The Principles of Genetics section (PROS-B) includes the following statements regarding Somatic Tumor Testing:

- “Recommend evaluating tumor for alterations in homologous recombination DNA repair such as: BRCA1, BRCA2, ATM, PALB2, FANCA, RAD51D, CHEK2 and CDK12, in patients with metastatic prostate cancer. This testing can be considered in men with regional prostate cancer.”
- “At present, this information may be used for genetic counseling, early use of platinum chemotherapy, olaparib, and/or eligibility for clinical trials (e.g., PARP inhibitors).”
- “If mutations in BRCA2, BRCA1, ATM, CHEK2, or PALB2 are found and/or there is a strong family history of cancer, refer to genetic counseling for confirmatory germline testing.”

American Society of Clinical Oncology

The American Society of Clinical Oncology (ASCO) has released statements on genetic and genomic testing for cancer susceptibility since 1996. The ASCO (2003) recommended that cancer predisposition testing be offered when 3 factors are at play: (1) there is a personal or family history suggesting genetic cancer susceptibility, (2) the test can be adequately interpreted, and (3) results will influence medical management of the patient or family member at hereditary risk of cancer.72 A 2010 update of this statement recommended that “genetic tests with uncertain clinical utility, including genomic risk assessment, be administered in the context of clinical trials.”73 A 2015 update affirmed that multigene panel testing “is sufficient for cancer risk assessment to evaluate genes of established clinical utility that are suggested by the patient’s personal and/or family history.”74

Society of Gynecologic Oncology

In 2015, the Society of Gynecologic Oncology (SGO) published an evidence-based consensus statement on risk assessment for inherited gynecologic cancer.75 The statement included criteria for recommending genetic assessment (counseling with or without testing) to patients who may be genetically predisposed to breast or ovarian cancer. Overall, the SGO and the NCCN recommendations are very similar; the main differences are the exclusion of women with breast cancer onset at age 50 years or younger who have 1 or more first-, second-, or third-degree relatives with breast cancer at any age; women with breast cancer or history of breast cancer who have a first-, second-, or third-degree male relative with breast cancer; and men with a personal history of breast cancer. Additionally, SGO recommended genetic assessment for unaffected women who have a male relative with breast cancer. Moreover, SGO indicated that some patients who do not satisfy criteria may still benefit from genetic assessment (e.g., few female relatives, hysterectomy, or oophorectomy at a young age in multiple family members, or adoption in the lineage).

American College of Obstetricians and Gynecologists

The American College of Obstetricians and Gynecologists (2017, reaffirmed 2019) published a Practice Bulletin on hereditary breast and ovarian cancer syndrome.76 The following recommendation was based primarily on consensus and expert opinion (level C): “Genetic testing is recommended when the results of a detailed risk assessment that is performed as part of genetic counseling suggest the presence of an inherited cancer syndrome for which specific genes have been identified and when the results of testing are likely to influence medical management.”

National Institute for Health and Care Excellence

In 2019, the National Institute for Health and Care Excellence published technical appraisal guidance on olaparib for maintenance treatment of BRCA mutation-positive advanced ovarian, fallopian tube or peritoneal cancer after response to first-line platinum-based chemotherapy (TA598).77 This guidance recommended olaparib as an option for the maintenance treatment of BRCA mutation-positive, advanced (Federation of Gynecology and
Obstetrics [FIGO] stages 3 and 4), high-grade epithelial ovarian, fallopian tube or primary peritoneal cancer that has responded to first-line platinum-based chemotherapy in adults.

**U.S. Preventive Services Task Force**

Current USPSTF recommendations (2019) for genetic testing of BRCA1 and BRCA2 variants in women state:

"The USPSTF recommends that primary care clinicians assess women with a personal or family history of breast, ovarian, tubal, or peritoneal cancer or who have an ancestry associated with BRCA1/2 gene mutation with an appropriate brief familial risk assessment tool. Women with a positive result on the risk assessment tool should receive genetic counseling and, if indicated after counseling, genetic testing (B recommendation). The USPSTF recommends against routine risk assessment, genetic counseling, or genetic testing for women who's personal or family history or ancestry is not associated with potentially harmful BRCA1/2 gene mutations. (D recommendation)"

Recommended screening tools included the Ontario Family History Assessment Tool, Manchester Scoring System, Referral Screening Tool, Pedigree Assessment Tool, 7-Question Family History Screening Tool, International Breast Cancer Intervention Study instrument (Tyrer-Cuziak), and brief versions of the BRCAPRO.

**Medicare National Coverage**

There are no national coverage determinations. In the absence of a national coverage determination, coverage decisions are left to the discretion of local Medicare carriers.

**Ongoing and Unpublished Clinical Trials**

Some currently unpublished trials that might influence this review are listed in Table 6.

**Table 6. Summary of Key Trials**

<table>
<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
</tr>
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<tbody>
<tr>
<td>Ongoing</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>NCT02154672</td>
<td>Prostate Cancer Screening in Men With Germline BRCA2 Mutations</td>
<td>100</td>
<td>May 2018 (unknown)</td>
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<tr>
<td>NCT02225015</td>
<td>Cancer Prevention in Women With a BRCA Mutation</td>
<td>300</td>
<td>Jun 2019 (unknown)</td>
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<tr>
<td>NCT02975934</td>
<td>TRITON3: A Multicenter, Randomized, Open Label Phase 3 Study of Rucaparib Versus Physician’s Choice of Therapy for Patients With Metastatic Castration Resistant Prostate Cancer Associated With Homologous Recombination Deficiency</td>
<td>400</td>
<td>Apr 2022</td>
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<tr>
<td>NCT03246841</td>
<td>Investigation of Tumour Spectrum, Penetration and Clinical Utility of Germline Mutations in New Breast and Ovarian Cancer Susceptibility Genes</td>
<td>500</td>
<td>Dec 2023</td>
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<tr>
<td>NCT02855944</td>
<td>ARIEL4 (Assessment of Rucaparib In Ovarian Cancer Trial): A Phase 3 Multicenter, Randomized Study of Rucaparib Versus Chemotherapy in Patients With Relapsed, BRCA Mutant, High Grade Epithelial Ovarian, Fallopian Tube, or Primary Peritoneal Cancer</td>
<td>345</td>
<td>Jun 2024</td>
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<tr>
<td>NCT02321228</td>
<td>Early Salpingectomy (Tubectomy) With Delayed Oophorectomy in BRCA1/2 Gene Mutation Carriers (TUBA)</td>
<td>510</td>
<td>Jan 2035</td>
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<tr>
<td>NCT04090567</td>
<td>Overcoming PARP Inhibitor Resistance in BRCA Germline Mutation Positive Advanced Breast Cancer</td>
<td>60</td>
<td>June 2021</td>
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<tr>
<td>NCT03740165</td>
<td>A Randomized Phase 3, Double-Blind Study of Chemotherapy With or Without Pembrolizumab Followed by Maintenance With Olaparib or Placebo</td>
<td>1086</td>
<td>August 2025</td>
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</table>
Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers

<table>
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<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date (status if beyond Completion Date)</th>
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<tbody>
<tr>
<td>NCT02032823</td>
<td>for the First-Line Treatment of BRCA Non-mutated Advanced Epithelial Ovarian Cancer (EOC) (KEYLYNK-001/ENGOT-ov43)</td>
<td>1836</td>
<td>Nov 2028</td>
</tr>
</tbody>
</table>

NCT: national clinical trial.

References

15. Blue Cross and Blue Shield Association Technology Evaluation Center (TEC). BRCA1 and BRCA2 testing to determine the risk of breast and ovarian cancer. TEC Assessments. 1997; Volume 12: Tab 4.


42. Walsh T, Casa del S, Coats KH, et al. Spectrum of mutations in BRCA1, BRCA2, CHEK2, and TP53 in families at high risk of breast cancer. JAMA. Mar 22 2006; 295(12): 1379-88. PMID 16551709


2.04.02 Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers


**Documentation for Clinical Review**

Please provide the following documentation:
- History and physical and/or consultation notes including:
  - Ethnicity/Ancestry
  - Personal and/or family history of cancer (if applicable) including:
    - Family relationship(s): (maternal or paternal), (family member [e.g., sibling, aunt, grandparent]), (living or deceased) (if applicable)
    - Site(s) of cancer
    - Age at diagnosis (including family members)
    - If breast cancer, indicate if bilateral, premenopausal, or triple negative cancer
  - BRCA1/BRCA2 mutation history (if applicable)
  - Genetic counseling/professional results (if applicable)
  - Laboratory or Pathology reports

**Post Service** (in addition to the above, please include the following):
- Procedure report(s)

**Coding**

This Policy relates only to the services or supplies described herein. Benefits may vary according to product design; therefore, contract language should be reviewed before applying the terms of the Policy. Inclusion or exclusion of codes does not constitute or imply member coverage or provider reimbursement.

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>CPT</td>
<td>0102U</td>
<td>Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer), genomic sequence analysis panel utilizing a combination of NGS, Sanger, MLPA, and array CGH, with mRNA analytics to resolve</td>
</tr>
</tbody>
</table>
### Genetic Testing for BRCA1 or BRCA2 for Hereditary Breast/Ovarian Cancer Syndrome and Other High-Risk Cancers

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0103U</td>
<td>Variants of unknown significance when indicated (17 genes [sequencing and deletion/duplication])</td>
</tr>
<tr>
<td></td>
<td>0129U</td>
<td>Hereditary ovarian cancer (e.g., hereditary ovarian cancer, hereditary endometrial cancer), genomic sequence analysis panel utilizing a combination of NGS, Sanger, MLPA, and array CGH, with mRNA analytics to resolve variants of unknown significance when indicated (24 genes [sequencing and deletion/duplication], EPCAM [deletion/duplication only])</td>
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<tr>
<td></td>
<td>0131U</td>
<td>Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer), genomic sequence analysis and deletion/duplication analysis panel (ATM, BRCA1, BRCA2, CDH1, CHEK2, PALB2, PTEN, and TP53)</td>
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<td></td>
<td>0132U</td>
<td>Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer), targeted mRNA sequence analysis panel (13 genes) (List separately in addition to code for primary procedure)</td>
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<td></td>
<td>0135U</td>
<td>Hereditary gynecological cancer (e.g., hereditary breast and ovarian cancer, hereditary endometrial cancer, hereditary colorectal cancer), targeted mRNA sequence analysis panel (12 genes) (List separately in addition to code for primary procedure)</td>
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<td></td>
<td>0138U</td>
<td>BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) mRNA sequence analysis (List separately in addition to code for primary procedure)</td>
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<tr>
<td></td>
<td>0172U</td>
<td>Oncology (solid tumor as indicated by the label), somatic mutation analysis of BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) and analysis of homologous recombination deficiency pathways, DNA, formalin-fixed paraffin-embedded tissue, algorithm quantifying tumor genomic instability score (Code effective 7/1/2020)</td>
</tr>
<tr>
<td>81162</td>
<td>BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis and full duplication/deletion analysis (i.e., detection of large gene rearrangements)</td>
<td></td>
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<tr>
<td>81163</td>
<td>BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis</td>
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<td>81164</td>
<td>BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full duplication/deletion analysis (i.e., detection of large gene rearrangements)</td>
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<tr>
<td>81165</td>
<td>BRCA1 (BRCA1, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis</td>
<td></td>
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<tr>
<td>81166</td>
<td>BRCA1 (BRCA1, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full duplication/deletion analysis (i.e., detection of large gene rearrangements)</td>
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<tr>
<td>81167</td>
<td>BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full duplication/deletion analysis (i.e., detection of large gene rearrangements)</td>
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<tr>
<td>Type</td>
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<td>81212</td>
<td>BRCA1 (BRCA1, DNA repair associated), BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; 185delAG, 5385insC, 6174delT variants</td>
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<td>BRCA1 (BRCA1, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; known familial variant</td>
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<td>81216</td>
<td>BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; full sequence analysis</td>
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<td>81217</td>
<td>BRCA2 (BRCA2, DNA repair associated) (e.g., hereditary breast and ovarian cancer) gene analysis; known familial variant</td>
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<td>81307</td>
<td>PALB2 (partner and localizer of BRCA2) (e.g., breast and pancreatic cancer) gene analysis; full gene sequence</td>
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<td>81308</td>
<td>PALB2 (partner and localizer of BRCA2) (e.g., breast and pancreatic cancer) gene analysis; known familial variant</td>
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<td>81432</td>
<td>Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer); genomic sequence analysis panel, must include sequencing of at least 10 genes, always including BRCA1, BRCA2, CDH1, MLH1, MSH2, MSH6, PALB2, PTEN, STK11, and TP53</td>
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<td>Hereditary breast cancer-related disorders (e.g., hereditary breast cancer, hereditary ovarian cancer, hereditary endometrial cancer); duplication/deletion analysis panel, must include analyses for BRCA1, BRCA2, MLH1, MSH2, and STK11</td>
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<tr>
<td></td>
<td>81479</td>
<td>Unlisted molecular pathology procedure</td>
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</tbody>
</table>

**Policy History**

This section provides a chronological history of the activities, updates and changes that have occurred with this Medical Policy.

<table>
<thead>
<tr>
<th>Effective Date</th>
<th>Action</th>
</tr>
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<tbody>
<tr>
<td>10/15/1997</td>
<td>New Policy Adoption</td>
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<td>06/01/1999</td>
<td>BCBSA Medical Policy adoption</td>
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<td>05/01/2001</td>
<td>Administrative Review</td>
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<td>BCBSA Medical Policy adoption</td>
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<td>Administrative Review</td>
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<td>Policy Revision</td>
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<td>05/06/2009</td>
<td>Coding Update</td>
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<td>07/28/2009</td>
<td>Criteria Revised</td>
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<td>11/04/2009</td>
<td>Coding update</td>
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<tr>
<td>04/02/2010</td>
<td>Policy revision with position change to clarify BART testing</td>
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<tr>
<td>07/15/2010</td>
<td>Policy Revision with position change adopting 2010 NCCN guidelines</td>
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<tr>
<td>09/13/2010</td>
<td>Coding Update</td>
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<tr>
<td>03/30/2012</td>
<td>Title change from BRCA1 and BRCA2 Genetic Testing with position change</td>
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<tr>
<td>06/13/2012</td>
<td>Coding Update</td>
</tr>
<tr>
<td>08/21/2012</td>
<td>Administrative Update (Clarification of Policy Guideline)</td>
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<td>02/22/2013</td>
<td>Coding Update</td>
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<tr>
<td>03/29/2013</td>
<td>Policy revision with position change</td>
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<td>10/9/2013</td>
<td>Administrative Update (Clarification of BART testing policy statement)</td>
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<tr>
<td>12/19/2013</td>
<td>Policy revision with position change</td>
</tr>
<tr>
<td>03/30/2015</td>
<td>Administrative Update (Revision and clarification of the Documentation Required section)</td>
</tr>
</tbody>
</table>
### Definitions of Decision Determinations

**Medically Necessary:** Services that are Medically Necessary include only those which have been established as safe and effective, are furnished under generally accepted professional standards to treat illness, injury or medical condition, and which, as determined by Blue Shield, are: (a) consistent with Blue Shield medical policy; (b) consistent with the symptoms or diagnosis; (c) not furnished primarily for the convenience of the patient, the attending Physician or other provider; (d) furnished at the most appropriate level which can be provided safely and effectively to the patient; and (e) not more costly than an alternative service or sequence of services at least as likely to produce equivalent therapeutic or diagnostic results as to the diagnosis or treatment of the Member's illness, injury, or disease.

**Investigational/Experimental:** A treatment, procedure, or drug is investigational when it has not been recognized as safe and effective for use in treating the particular condition in accordance with generally accepted professional medical standards. This includes services where approval by the federal or state governmental is required prior to use, but has not yet been granted.

**Split Evaluation:** Blue Shield of California/Blue Shield of California Life & Health Insurance Company (Blue Shield) policy review can result in a split evaluation, where a treatment, procedure, or drug will be considered to be investigational for certain indications or conditions, but will be deemed safe and effective for other indications or conditions, and therefore potentially medically necessary in those instances.

### Prior Authorization Requirements (as applicable to your plan)

Within five days before the actual date of service, the provider must confirm with Blue Shield that the member's health plan coverage is still in effect. Blue Shield reserves the right to revoke an
authorization prior to services being rendered based on cancellation of the member's eligibility. Final determination of benefits will be made after review of the claim for limitations or exclusions.

Questions regarding the applicability of this policy should be directed to the Prior Authorization Department at (800) 541-6652, or the Transplant Case Management Department at (800) 637-2066 ext. 3507708 or visit the provider portal at www.blueshieldca.com/provider.

Disclaimer: This medical policy is a guide in evaluating the medical necessity of a particular service or treatment. Blue Shield of California may consider published peer-reviewed scientific literature, national guidelines, and local standards of practice in developing its medical policy. Federal and state law, as well as contract language, including definitions and specific contract provisions/exclusions, take precedence over medical policy and must be considered first in determining covered services. Member contracts may differ in their benefits. Blue Shield reserves the right to review and update policies as appropriate.
Appendix A

<table>
<thead>
<tr>
<th>POLICY STATEMENT</th>
</tr>
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<tbody>
<tr>
<td><strong>BEFORE</strong></td>
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<tr>
<td><strong>AFTER</strong></td>
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</table>

**Policy Statement**
Genetic testing should be performed in a setting that has suitably trained health care providers who can give appropriate pre- and posttest counseling and that has access to a Clinical Laboratory Improvement Amendments-licensed laboratory that offers comprehensive variant analysis (see Policy Guidelines section: Comprehensive Variant Analysis). As other genes have become associated with hereditary breast and ovarian cancer, small panels (using CPT code 81432) are now the preferred tests (rather than just testing for BRCA1 and BRCA2, such as 81162).

**Patients With Cancer or With a Personal History of Cancer**
Full sequence and duplication/deletion analysis genetic testing for BRCA1 and BRCA2 gene variants (including when part of an approved small panel such as 81432) in cancer-affected individuals may be considered **medically necessary** under any of the following circumstances:

I. Individuals meeting criteria for medically necessary testing below but with previous limited testing (e.g., single gene and/or absent deletion duplication analysis)

II. Individuals with any close blood relative with a known pathogenic/likely pathogenic variant in a cancer susceptibility gene

III. Personal history of breast cancer (including invasive and ductal carcinoma in situ) and **one or more** of the following:
   A. Diagnosed at age 45 or younger
   B. Diagnosed 46 to 50 years of age and **one or more** of the following:
      1. An additional breast cancer primary at any age
      2. One or more close relative (see Policy Guidelines) with breast, ovarian, pancreatic, or **prostate cancer** at any age

**AFTER**
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I. Individuals meeting criteria for medically necessary testing below but with previous limited testing (e.g., single gene and/or absent deletion duplication analysis)

II. Individuals with any close blood relative with a known pathogenic/likely pathogenic variant in a cancer susceptibility gene (included in the small panel)

III. Personal history of breast cancer (including invasive and ductal carcinoma in situ) and **one or more** of the following:
   A. Diagnosed at age 45 or younger
   B. Diagnosed 46 to 50 years of age and **one or more** of the following:
      1. An additional breast cancer primary at any age
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### POLICY STATEMENT

<table>
<thead>
<tr>
<th>BEFORE</th>
<th>AFTER</th>
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<tbody>
<tr>
<td>3. An unknown or limited family history</td>
<td>3. An unknown or limited family history</td>
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<tr>
<td>C. Diagnosed on or before 60 years of age with</td>
<td>C. Diagnosed on or before 60 years of age with</td>
</tr>
<tr>
<td>1. Triple-negative breast cancer (estrogen receptor-negative,</td>
<td>1. Triple-negative breast cancer (estrogen receptor-negative,</td>
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<tr>
<td>progesterone receptor-negative, human epidermal growth factor receptor 2-negative)</td>
<td>progesterone receptor-negative, human epidermal growth factor receptor 2-negative)</td>
</tr>
<tr>
<td>D. Diagnosed at any age with <strong>one or more</strong> of the following:</td>
<td>D. Diagnosed at any age with <strong>one or more</strong> of the following:</td>
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<tr>
<td>1. One or more close blood relative with <strong>one or more</strong> of the</td>
<td>1. One or more close blood relative with <strong>one or more</strong> of the</td>
</tr>
<tr>
<td>following:</td>
<td>following:</td>
</tr>
<tr>
<td>a. Breast cancer diagnosed on or before 50 years of age</td>
<td>a. Breast cancer diagnosed on or before 50 years of age</td>
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<tr>
<td>b. Ovarian carcinoma</td>
<td>b. Ovarian carcinoma</td>
</tr>
<tr>
<td>c. Metastatic or intraductal/cribriform prostate cancer, or high-risk</td>
<td>c. Metastatic or intraductal/cribriform prostate cancer, or high-risk</td>
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<tr>
<td>group or very-high-risk group (see Policy Guidelines) prostate cancer</td>
<td>group or very-high-risk group (see Policy Guidelines) prostate cancer</td>
</tr>
<tr>
<td>d. Pancreatic cancer</td>
<td>d. Pancreatic cancer</td>
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<tr>
<td>2. Three or more total diagnoses of breast cancer in patient and/or</td>
<td>2. Three or more total diagnoses of breast cancer in patient and/or</td>
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<tr>
<td>close blood relative</td>
<td>close blood relative</td>
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<tr>
<td>3. Ashkenazi Jewish ancestry</td>
<td>3. Ashkenazi Jewish ancestry</td>
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<tr>
<td>IV. Personal history of <strong>one or more</strong> of the following at any age:</td>
<td>IV. Personal history of <strong>one or more</strong> of the following at any age:</td>
</tr>
<tr>
<td>A. Male breast cancer</td>
<td>A. Male breast cancer</td>
</tr>
<tr>
<td>B. Epithelial ovarian carcinoma (including fallopian tube cancer or</td>
<td>B. Epithelial ovarian carcinoma (including fallopian tube cancer or</td>
</tr>
<tr>
<td>peritoneal cancer)</td>
<td>peritoneal cancer)</td>
</tr>
<tr>
<td>C. Exocrine pancreatic cancer</td>
<td>C. Exocrine pancreatic cancer</td>
</tr>
<tr>
<td>D. Metastatic, intraductal/cribriform prostate cancer, or high-risk</td>
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</tr>
<tr>
<td>group or very-high-risk group prostate cancer</td>
<td>group or very-high-risk group prostate cancer</td>
</tr>
<tr>
<td>E. <strong>Prostate cancer</strong> with <strong>one or more</strong> of the following:</td>
<td>E. <strong>Prostate cancer</strong> with <strong>one or more</strong> of the following:</td>
</tr>
<tr>
<td>1. One or more close blood relative with ovarian carcinoma, pancreatic</td>
<td>1. One or more close blood relative with ovarian carcinoma, pancreatic</td>
</tr>
<tr>
<td>cancer, or metastatic or intraductal/cribriform prostate cancer at any</td>
<td>cancer, or metastatic or intraductal/cribriform prostate cancer at any</td>
</tr>
<tr>
<td>age, or breast cancer at age 50 or younger</td>
<td>age, or breast cancer at age 50 or younger</td>
</tr>
<tr>
<td>2. Two or more close blood relatives with breast or prostate cancer</td>
<td>2. Two or more close blood relatives with breast or prostate cancer</td>
</tr>
<tr>
<td>(any grade) at any age</td>
<td>(any grade) at any age</td>
</tr>
<tr>
<td>3. Ashkenazi Jewish ancestry</td>
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</tr>
<tr>
<td>F. Any cancer and a mutation identified on tumor genomic testing that</td>
<td>F. Any cancer and a mutation identified on tumor genomic testing that</td>
</tr>
<tr>
<td>has clinical implications if also identified in the germline</td>
<td>has clinical implications if also identified in the germline</td>
</tr>
<tr>
<td>G. Any cancer and to aid in systemic therapy decision-making, such as</td>
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</tr>
<tr>
<td>for PARP-inhibitors for human epidermal receptor 2</td>
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### POLICY STATEMENT

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<table>
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<tr>
<th>(HER2)-negative metastatic breast cancer, ovarian cancer, prostate cancer, pancreatic cancer, platinum therapy for prostate cancer and pancreatic cancer</th>
</tr>
</thead>
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**Patients Without Cancer or With any Other Personal History of Cancer (not noted above)**  
(See Policy Guidelines section: Testing Unaffected Individuals)

Genetic testing for \textit{BRCA1} and \textit{BRCA2} (including deletions and duplications) variants of individuals without cancer or any other type of cancer (not noted above) may be considered \textbf{medically necessary} under the following circumstance:

- Has a probability of greater than 5\% of a \textit{BRCA} 1/2 pathogenic variant based on prior probability models (e.g. Tyrer-Cuzick, BRCAPro, Pennill)

Genetic testing for \textit{BRCA1} and \textit{BRCA2} variants in cancer-affected individuals or of cancer-unaffected individuals with or without a family history of cancer when criteria above are not met (including genetic screening in the general population) is considered \textbf{investigational}.

Genetic testing in minors (younger than age 18) for \textit{BRCA1} and \textit{BRCA2} variants is considered \textbf{investigational}.

**Confirmatory BRCA Testing**

Confirmatory BRCA testing may be considered \textbf{medically necessary} for patients who underwent over-the-counter (OTC) U.S. Food and Drug Administration (FDA) approved genetic screening and were found to have a pathogenic \textit{BRCA1} or \textit{BRCA2} mutation (including one of the three Ashkenazi founder mutations).

Large multi-gene panels including multiple genes that are not highly associated with hereditary breast and ovarian cancer (see Policy Guidelines) are considered \textbf{investigational}.

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