Expanded carrier screening
Information for Doctors

Screens for more than 400 heritable genetic disorders
Reproductive carrier screening can identify individuals or couples at high risk of having a child with a serious inherited condition. Best performed prior to conception, this test is becoming an essential part of prenatal care planning. It allows people the opportunity to explore their reproductive options, and helps ensure they can make properly informed decisions.

Expanded carrier screening

Sonic Genetics provides the Beacon expanded carrier screen, developed in the US by Fulgent Genetics. This is a comprehensive and accurate carrier screen which provides you and your patients with valuable information for pregnancy and family planning.
What is a carrier?

Every person has many thousands of genes. Most of those genes are present in pairs (autosomal genes), with each person inheriting one copy from each parent. Each person will have many autosomal genes in which one of the pair of genes has been inactivated by a genetic error (mutation), that is, the person is a carrier for the condition caused by that gene. For autosomal recessive conditions this causes no medical problem because the second copy of the gene is working normally. However, there is a 50% chance that a child will inherit the abnormal gene from that person.

If a couple are both carriers for the same autosomal recessive disorder, then there is a 25% chance with each pregnancy that a child will inherit an abnormal gene from each parent and be affected by that condition. This applies to both boys and girls.

If one of the parents is a carrier for X-linked recessive disorder, then there is a 50% risk of the child being a carrier for the condition caused by that gene. For autosomal recessive or X-linked conditions, with both or one of the parents being carriers of the disorder respectively.

Almost everyone is a carrier for at least one genetic disorder, but most people are not aware of their carrier status. A carrier may only become aware of his or her status after the birth of a child with the disorder or by having a carrier screen.

A carrier screen can identify carriers of autosomal recessive or X-linked disorders that are serious, childhood onset, and for which there are limited therapeutic options. This test does not include mild disorders, autosomal dominant disorders, adult onset disorders, or disorders for which there are effective interventions available in Australia, for example, haemochromatosis, factor V Leiden, MTHFR variants and familial breast cancer. A comprehensive list of the genes and disorders included in the Beacon expanded carrier screen is available from www.somicogenetics.com.au/ics/beacon.

Carrier screening is designed for individuals and couples who are not aware of a family history of an autosomal or X-linked condition. Carrier screening may not be the best test for a person who is likely to be a carrier for a specific condition. If there is a family history or other reason for high pre-test carrier risk, it may be more appropriate for a couple to be referred for genetic counselling and testing that is specific for that condition.

A carrier screen cannot identify all new genetic disorders which occur for the first time during a pregnancy; for example, trisomy 21 and new autosomal dominant disorders, such as achondroplasia. Carrier screening does not provide information about the probability of a child having a congenital malformation due to the interaction of multiple genes or the influence of non-genetic factors, such as prenatal infections.

Why should I offer carrier screening to my patients?

There are hundreds of inherited genetic disorders which can affect children. Each of these conditions is individually rare, but together, they are more common than familiar chromosomal disorders, such as Down syndrome. In Australia, approximately one in 200 babies is born with a serious inherited disorder that will affect them during childhood. These disorders are inherited as autosomal recessive or X-linked conditions, with both or one in the parents being carriers of the disorder respectively.

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For couples considering carrier screening, the test should be offered to women before conception, to their reproductive partners, and to genetic (egg or sperm) donors and recipients. Carrier screening will assist in preconception planning and prenatal diagnostic testing for those couples identified as carriers. Carrier screening is also possible during early pregnancy; however, the subsequent options for intervention are more limited and may be more stressful for the patient than preconception testing.

If a couple is found to be at 25% risk of having an affected child, a number of reproductive options can be considered prior to conception, for example, preimplantation genetic diagnosis and IVF, the use of donor eggs or sperm, prenatal diagnosis, or making an informed decision to accept the risk. The reproductive options that are available after conception are limited to prenatal diagnosis and making an informed decision to accept the risk.

Professional medical associations in Australia and across the globe, such as the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG), American College of Obstetricians and Gynaecologists (ACOG) and the American College of Medical Genetics and Genomics (ACMG), have published guidelines on expanded carrier screening and its importance in reproductive care.

Please note that carrier screening is not recommended for children. Being a carrier for a condition does not place a child at increased risk of developing a childhood-onset disorder. Carrier screening should be deferred until adulthood so that the person being tested can make their own decision about having the test. This also provides a better opportunity for testing of the reproductive partner.
Why choose the Beacon expanded carrier screen?

There are many hundreds of genes which can cause serious childhood-onset disorders, and many screening tests are available through laboratories in Australia and overseas. It is tempting to think that the best measure of the value of a screening test is the number of genes analysed by the test. However, three additional factors must also be considered for each gene analysed: the frequency of mutations in the gene, the ability of a test to detect those mutations, and the mode of inheritance of the disorder caused by the gene.

A number of Australian laboratories (including Sonic Genetics) provide carrier screening for three of the most common familial disorders in Australia: cystic fibrosis, spinal muscular atrophy and fragile X syndrome. Approximately one in 160 couples (0.6%) will be identified by this three-gene panel as being at high risk of having an affected child. Some laboratories offer carrier screens of more than 100 genes which, despite examining many more genes, fail to identify more at-risk couples than the three-gene panel. This highlights the problem of relying on the number of genes analysed as the measure of a test’s value.

Sonic Genetics has carefully evaluated the potential performance of nine popular carrier screens provided by laboratories in Australia and overseas. The number of genes tested by these laboratories varied from three to more than 400. We assessed the value of each test by calculating the proportion of Australian couples who would be identified as being at high risk of having a child with an autosomal recessive or X-linked disorder (see Figure 1).

The best performance by far was obtained by the Beacon expanded carrier screen. Approximately one in 20 couples (5%) would be identified as being at high risk of having a child with an autosomal recessive or X-linked disorder (see Figure 1). The test identifies eight times more couples at risk of having an affected child, who can then make informed reproductive choices, than would be identified by the three-gene carrier screen and some large screens from other well-known providers.

The success of the Beacon test is due to the number of genes analysed (more than 400), the frequency of mutations in these genes, the high detection rate for mutations (>98%), and the inclusion of more than 50 X-linked genes.

The Beacon expanded carrier screen

The Beacon expanded carrier screen consists of genes for more than 350 autosomal recessive disorders and more than 50 genes for X-linked disorders. For female patients, we test the genes for both types of disorder (more than 400 genes in all); for male patients, we test only for autosomal recessive disorders, as it is assumed that the man does not have a severe childhood-onset X-linked recessive disorder.

Overall, the Beacon expanded carrier screen will identify approximately 75% of Australian women as being a carrier of one or more disorders. The chance is slightly lower in men, as it is assumed that they do not have a severe childhood-onset X-linked recessive disorder. If a person is identified as a carrier of an autosomal recessive disorder, this is of little consequence unless the reproductive partner is also identified as being a carrier of the same condition. The probability of a person being identified as a carrier of one or more autosomal recessive disorders is shown in Figure 2. There is a 25% chance of a person not being shown to be a carrier for an autosomal recessive disorder, a 35% chance of being shown to be a carrier of one autosomal recessive disorder, and a 40% chance of being shown to be a carrier of two or more autosomal recessive disorders. Approximately one in 60 couples (1.6%) will be identified in which both partners are carriers of the same autosomal recessive disorder.

If a woman is identified as a carrier of an X-linked disorder, this is of immediate consequence in reproductive planning, as there is a 50% chance that her son would inherit the abnormal gene and be affected. Approximately one in 30 women (3.4%) will be identified by the Beacon test as being a carrier of an X-linked disorder. It is uncommon for a woman to be identified as a carrier of more than one X-linked disorder.

Overall, approximately one in 20 couples (5%) tested with the Beacon expanded carrier screen will be identified as being at high reproductive risk of having a child with a severe, childhood-onset disorder.
Methodology

The Beacon expanded carrier screen is performed by the developers of the test, Fulgent Genetics, in their laboratory in California. In Australia, the Beacon test is available exclusively through Sonic Genetics.

The Beacon expanded carrier screen covers hundreds of genes, using a cost-effective and highly accurate technology. The Beacon test is not limited to common mutations in genes.

With a handful of exceptions, the Beacon test looks for different mutations in each gene, including sequence variants and deletions.

The few exceptions are conditions in which a single type of mutation in one gene accounts for the great majority of diagnoses, for example, haemophilia A and fragile X syndrome. More than 50,000 mutations can be detected in the more than 400 genes using the methods described below.

The Beacon expanded carrier screen offers sequencing and deletion/duplication analysis of more than 350 genes. Next generation sequencing (NGS) is used to analyse exons in multiple genes simultaneously. Fulgent Genetics has developed a sophisticated analysis, CNVexon®, which detects sequence changes and deletion/duplication via NGS; this methodology is only available through Sonic Genetics in Australia.

Sequence analyses can be compromised by pseudogenes (non-functioning DNA sequences which resemble genes) and by families of functional genes that contain highly similar sequences. Fulgent Genetics has developed highly sensitive tools that clearly separate genes from pseudogenes. When testing for fragile X syndrome, the mutation (a CGG repeat expansion) is not reliably detected by NGS and a PCR method is used.

Detection rates and test limitations

The Fulgent laboratory uses a variety of laboratory and computer methods to detect mutations in gene sequence, splice junctions and deletions. The analytical detection rate for all genes is >98%. However, there remains a small chance that a person will have an undetected mutation in a gene and hence be an undetected carrier for a specific disorder. The Beacon report provides an estimate of this ‘residual risk’ of being an undetected carrier for an individual or couple.
Requesting expanded carrier screening

If there is a family history of a specific condition, the risks in a pregnancy should be clarified specifically for that condition, possibly by referral for genetic counselling; carrier screening may not be the appropriate test for that specific condition. This does not preclude the individual or couple having carrier screening for other conditions.

Planning the test

We strongly recommend that carrier screening be performed prior to conception. This gives the doctor and individual, or couple, time to consider their options and make informed choices.

If a person is identified as a carrier of one or more autosomal recessive disorders, the reproductive partner should be screened to clarify the risk of an autosomal recessive disorder for the child. This is not necessary if a woman is identified as a carrier of an X-linked disorder, the male partner need not be screened for X-linked disorders.

Testing of a couple can be done sequentially, that is, test the woman first and then test her reproductive partner if indicated, or concurrently, by testing the couple at the same time. There are a number of reasons for proposing concurrent testing:

- The testing process will be quicker. Approximately 75% of women will be identified as carriers for at least one autosomal recessive disorder and testing of their male partners would then be recommended. This means that most couples will require testing of both partners.
- It is less expensive for the male partner to have the full expanded carrier screen.
- Of the women who are identified as carriers of autosomal recessive disorders, half will be carriers for more than one condition. Testing the partner to determine his carrier status for two or more conditions rapidly becomes more expensive than doing the Beacon expanded carrier screen.
- A comprehensive pathology report will be provided with a succinct summary on the first page detailing exactly what genes the couple carry that could affect any offspring.
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Pre-test considerations

- An individual or couple having carrier screening must provide informed consent for the test and accept the following points:
  - The purpose of carrier screening is to inform reproductive decisions and is not designed to diagnose current disease or the risk of future disease. There is an important exception to this general rule: female carriers of fragile X syndrome are at increased risk of premature menopause and of late-onset tremor/ataxia, and should be referred for genetic counselling.
  - It is impractical to provide detailed information for each of the more than 400 conditions screened by the Beacon test. The person being tested should be advised that the test screens for carriers of severe childhood-onset conditions. It does not screen for carriers of autosomal dominant disorders, adult-onset disorders, mild disorders, or all recessive disorders, and does not replace prenatal screening for chromosomal conditions.
  - If a person is identified as a carrier for an autosomal or X-linked disorder, we recommend that they advise close genetic relatives. These relatives may also be carriers and may wish to use this information for their own reproductive planning. Please note that notification of relatives is recommended but not mandated.
- The genetic advice provided by carrier screening is only applicable to the couple who has been tested. If a patient has a different partner in the future, the reproductive risks need to be re-evaluated. Further testing may be required.
- Pre-test genetic counselling is available throughout Australia on a fee-for-service basis. Please visit our website, www.sonicgenetics.com.au/counselling/services.

Price

Please refer to the Sonic Genetics website, www.sonicgenetics.com.au/becs, for current pricing. Please note that we do not screen for the X-linked conditions in males. Payment is required prior to sample processing.

There is currently no Medicare rebate for carrier screening. If there is a family history of a known mutation, the Beacon expanded carrier screen may not be the most appropriate test and a rebate may be available for the appropriate genetic test (please check with the laboratory).


Sample collection and processing

Samples may be collected at any Sonic Pathology Australia collection centre. We require 1 x 4 mL blood EDTA tube. Buccal swabs can be used by prior arrangement, and the collection centre will need to be contacted to ensure the swab stock is readily available. However, this method of collection is not recommended because it does not provide DNA of equal quality and quantity to that of a blood sample.

We recommend that you use barcode labelling of request forms and sample tubes, particularly if a couple is having samples collected at the same time. All samples are also tagged with molecular barcodes upon receipt in the Fulgent laboratory prior to analysis, enabling them to ensure the quality of sample processing. Sonic Genetics will transport the sample to the Fulgent Genetics accredited laboratory in the U.S.

Turnaround time

Once the sample is received at the genetics laboratory, the results will typically be sent to your doctor within three to five weeks.

Request forms

Please use our Expanded carrier screening request form which is available from your local Sonic Pathology Australia practice, from the Sonic Genetics website or request through most popular practice management software platforms. This form prompts you to provide information necessary for us to deliver an accurate interpretation of the genetic analysis. It also provides billing and collection information for the patient, along with informed consent to perform the test. Please ensure that details of carrier screening for the reproductive partner are included if applicable.

Please note, under Australian legislation, a partner report will not be provided unless both partners provide consent for their results to be shared with each other and their healthcare provider.

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If a test is cancelled prior to processing (typically within 24 hours), a full refund may be possible. If a test is cancelled after sample processing has been initiated, but before a report is generated, there may be an administration charge per patient, with the balance being refunded.
Post-test review

Reports

Each person has millions of variations in their DNA sequence when compared to a reference sequence. It can be challenging to determine if a given variant in a gene is serious enough to potentially cause a recessive disorder, or is a mild or benign variant of no clinical or reproductive consequence. Fulgent Genetics utilizes their own experience of many thousands of Beacon tests, together with the pooled experience in international databases, to categorize each variant according to the internationally recognized ACMG system. The Beacon report will only include variants which are classified as ‘pathogenic’ or ‘likely pathogenic’ using this standard. Variants which are categorized as ‘benign’, ‘likely benign’, or ‘of uncertain clinical significance’ will not be reported.

The Beacon report details the mutations that have been identified in the genes analysed. The report will also identify the recessive disorder for which the patient is a carrier. If two people have been tested as a couple, an integrated report will be provided which sets to one side carrier information that is not of direct relevance for reproductive planning for the couple. In this way, the couple report is focused on the material issues to be considered prior to a pregnancy.

Sonic Genetics has medical specialists in genetic pathology and clinical genetics, who are available to address your enquiries about these reports.

Genetic counselling

Sonic Genetics provides free post-test genetic counselling in specific situations:

- For a woman who has been identified by the Beacon expanded carrier screen as being a carrier of an X-linked disorder
- For a couple who has been identified as being at 25% risk of having a child with an autosomal recessive disorder; at least one of the partners must have had the Beacon expanded carrier screen.

Genetic counselling is provided by telephone by genetic counsellors on the basis of a referral from the doctor responsible for the care of the patient or couple. The genetic counsellors are located in Australia and qualified through a training program accredited by the Human Genetics Society of Australia.

Referrals for free counselling need to be received by Sonic Genetics within two months of the latest Beacon report being issued and are subject to certain terms and conditions detailed online at www.sonicgenetics.com.au/clinicians/featured-tests/rcs/gc/.

Free counselling is limited to one episode per couple. A couple or individual is free to make their own subsequent arrangements with the genetic counsellor.

The free genetic counselling addresses informational and psychological issues arising from the Beacon report; the counsellor will not be responsible for the subsequent reproductive management.

Privacy

Patient information, samples and reports that are handled within Australia will be managed in accordance with the relevant legislation and professional standards. A couple report will not be produced unless both partners provide consent for their results to be shared with each other and their healthcare provider.

Identifying details about each patient, together with pathology samples, will be sent overseas to the Fulgent Genetics laboratory in the US. Each patient will be required to acknowledge this on the dedicated Expanded Carrier Screening Request Form. The Fulgent laboratory is accredited by regulatory and professional bodies in the US and complies with US legal requirements for handling health-related information. All data analyses are performed on private server centres. This means that their personal information will be subject to the privacy and data protection rules of Fulgent Genetics in the US, which may be different from those of Australia.

Why you should choose Sonic Genetics

Our genetic pathologists and medical scientists work in NATA-accredited laboratories throughout Australia to provide quality testing and clinical support.

We are part of Sonic Healthcare, an acknowledged world leader, and Australia’s largest pathology provider.

We are supported by Sonic’s extensive network of state and regional laboratories, and benefit from the interdisciplinary collaboration between a large cohort of pathologists and scientists working across all specialties. Many are recognised nationally and internationally; they have established academic reputations and are actively involved in professional and regulatory oversight in Australia and overseas.
Follow-up testing provided to couples

Sonic Genetics provides prenatal testing through Fulgent Genetics for any couple identified by the Beacon expanded carrier screen as being at high risk of having an affected child. For a rare condition, there may be few accredited laboratories that provide such a prenatal test, and some providers of carrier screening do not offer prenatal testing for the conditions they cover. Sonic Genetics will provide such testing for any at-risk couple identified through the Beacon expanded carrier screen.

Microarray can be included with the prenatal testing and will screen the pregnancy for additional chromosomal abnormalities that may be present. FISH testing can also be included in the prenatal screen.

Sonic Genetics is part of Sonic Pathology Australia, the largest pathology provider in the country. Our state-of-the-art laboratories and extensive network of collection centres serve each state and territory capital, as well as regional and rural Australia.

Douglass Hanly Moir Pathology
Sullivan Nicolaides Pathology
Melbourne Pathology
Barratt & Smith Pathology
Capital Pathology
Clinipath Pathology
Bunbury Pathology
Clinpath Pathology
Hobart Pathology
Launceston Pathology
North West Pathology
Southern.IML Pathology

For further information please refer to our website, www.sonicgenetics.com.au or call us on 1800 010 447

14 Giffnock Avenue, Macquarie Park, NSW 2113, Australia
T 1800 010 447 | E info@sonicgenetics.com.au
www.sonicgenetics.com.au