



REVIEW ARTICLE

The importance of preventative medicine in conjunction with modern day genetic studies

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Abstract Genetic screening in the primary care setting is the future of preventative medicine. Genetic testing is an important medical tool for assessing various inheritable diseases, conditions, and cancers. The ability to diagnose patients before symptoms surface can help lessen the severity of symptoms and promote quality of life. However, genetic screening can cause psychological distress from the knowledge of test results, in some cases only serving to increase the risk of developing a condition due to stress. Genetic testing can be conducted anytime in life, even before birth. In this review, a compilation of genetic testing's definitions and boundaries, factors influencing an individual's test outcomes, and an overview of a wide variety of diseases, conditions and cancers were collected.

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Introduction

In the world of modern health care, innovation leads the way to not only better patient care, but also a deeper understanding of preventative medicine. The ability to treat a genetic disease before it may become severe is a scientific feat that, until recent years, has been unknown to physicians. Genetic testing saves countless lives that would otherwise fall prey to congenital diseases (i.e. Tay Sachs and Cystic Fibrosis) and cancers (i.e. breast and colon).^{1–3} By understanding at a genetic level how a patient may be predisposed to certain health conditions, the planning for their care can start before an unfavorable prognosis, and

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not hastily chasing after one.⁴ Primary care physicians possessing the advantage of an early start on planned treatment gives us the ability to elude health issues that may later consume a patient's life. As a result, this surge in genetic screening in primary care physician offices can change lives.²

Unfortunately, for many diseases today genetic analysis will not be able to cure the patient completely ahead of the racing clock. However, it may have the ability to soften the blow of a debilitating disease by lessening the severity of symptoms or preventing it from manifesting early in life.⁴ A physician's mission to care, cure, and comfort is enhanced with genetic screening. The faculty to understand and treat preventively can massively enhance the quality of life for a patient. In short, genetic testing in a primary care setting can transform otherwise sick lives into healthier, or even healthy lives.⁴

Genetic disorders

Genetic testing works by analyzing changes in DNA that have been linked to certain diseases, conditions and cancers.^{5–8} There are over 7000 disorders that are believed to be linked to Mendelian genetics, and over 700 tests available currently.⁹ Analyzing these changes through genetic testing is most useful when an individual has had family members affected by the condition, or if the disease could be linked to inheritance through the process of Mendelian genetics.^{10,11} By seeing patterns of diagnosis in relatives, primary care physicians can use those past cases to recommend specific genetic tests to their patients.⁵ Different diseases can be inherited in a variety of ways depending on the magnitude of influence the gene (or genes) being investigated may have.⁴ If it is recessive or dominant, or if the severity is dependent on being heterozygous or homozygous in nature, this may also impact the severity of the condition.^{6,12,13} More often than not, the severity of a disease or the probability of manifesting a disease's detrimental symptoms is increased when familial cases are common.⁴ Genetic testing can also identify those that have a higher chance of showing symptoms of the condition or those that are at risk of passing it on if they have progeny.^{6,7,10,12,14} This allows for primary care physicians to collect patient data for future generations, aiding in the tracking and prediction of future diagnoses.¹⁵

Various unavoidable genetic diseases that impact an individual from birth are critical to identify early in a patient's life. This is in order to make informed decisions about choices of planned care to improve quality of life.^{6,7,12} Inherited genetic diseases of a recessive nature have been shown to account for nearly 20% of total infant mortality and 10% of infant hospitalization in the United States.¹² Other conditions, such as congenital deafness, can also be linked to hereditary causes.⁷

Down syndrome

The age of a mother has also been shown to have a negative impact on the occurrence of genetic diseases such as Down syndrome, with higher incidence development of negative reactions to drugs found in women who give birth older than 35 years of age.¹⁶ Due to rising popularity in screening,

older mothers can obtain a better understanding of how probable passing on a hereditary condition such as Down syndrome would be.^{16,17} Screening for these genetic diseases from preconception has been shown to greatly reduce these statistics and reduce mortality in infant cases stemming from these genetic conditions.^{12,13}

Cystic Fibrosis, Tay Sachs, familial dysautonomia, and BRCA genes

Multiple factors influence whether an individual will be tested, two of which include considerations such as family history and ethnicity.¹⁴ As stated before, genetic testing is best utilized when closely related individuals to the patient have tested positive for the mutation or have the condition.^{10,14} Certain ethnicities are more likely to carry certain genes. For example, due to the knowledge obtained from genetic screening, individuals of Ashkenazi Jewish descent have a higher percentage of particular genetic disorders including as Cystic Fibrosis, Tay Sachs, familial dysautonomia, and the development of BRCA genes.^{1,6,11,14,16} Thus, as part of primary care a physician may recommend screening due to a patient's background.⁴ This enables the physician to preventatively identify conditions before they may have the ability to become debilitating. Genetic screening has seen a surge in popularity among demographics such as individuals of Ashkenazi Jewish descent, and this increase in screening has shown to decrease the number of Tay Sachs cases in said population.^{11,14} With genetics becoming underlined as a point of study in modern primary care, other diseases could see similar patterns.^{11,18} This would result in early diagnosis, as well as the disease prevalence in its respective population decreasing in a similar fashion to Tay Sachs. This means that looking forward, genetic testing can be applied to any disease's preventative treatment so long as the disease has proven to be hereditary.

Tay Sachs in the Ashkenazi Jewish population has greatly diminished from testing as well.^{1,6} Early diagnosis of conditions such as Tay Sachs has been proven to favorably impact the survival and quality of life for those patients.^{8,19}

Cancer

Colorectal cancer

One of the more understood hereditary cancers is colorectal cancer.²⁰ Several diversified genes have been linked to different cancers of the colon such as familial adenomatous polyposis (FAP), hereditary nonpolyposis colorectal cancer (HNPCC), and Turcot's syndrome which has been linked to the same genes being altered from FAP and HNPCC.²¹ Mutations, or altering of the gene(s) involved, occurs in the germ lining which can subsequently lead to the development of cancer.^{3,8,14,21} Testing positive for FAP, HNPCC or Turcot's syndrome does not guarantee an individual will develop cancer.²⁰ However, it does mean that an individual will have an increased likelihood of developing cancer and are without a doubt carrying the gene for its existence.²¹ Thus, they have the ability to pass it on.²¹ As with many cancers, testing positive for these different gene mutations increases the chance of developing the cancer.²⁰

Nonetheless it should be said that environmental and lifestyle factors (i.e. diet and exercise) have the potential to largely influence the development of the colorectal cancer.^{3,20} External factors of an individual's life can also negatively or positively influence other mutations to genes that are not testable at this time with modern techniques.¹⁴ The colorectal cancers are autosomal dominant in inheritance; meaning that if one of the parents is a carrier, the offspring has a 50% chance of inheriting the mutated gene that is predisposed for the development of cancerous polyps.¹⁴ Genetic screening will enable possible parents to take their inherited high probability of developing colorectal cancer into account when and if deciding to have children.^{3,20}

Breast and ovarian cancer

Breast and ovarian cancer can also be hereditary with approximately 5–10% of all patients diagnosed having a genetic link to the autosomal dominant mutation of the BRCA1 or BRCA2 genes.²² As stated before with the colorectal cancers, the presence of BRCA1 or BRCA2 genes means that an individual has a higher predisposition to developing cancer than someone without the gene present.¹⁹ The gene is inherited in an autosomal dominant fashion, and thus can affect both men and women.²² When at least one of these mutations is present, it is more likely that the cancer develops in an individual at a younger age and tumors will be identified bilaterally in the body.¹⁴ Overall, the mutation of these genes are rare: estimated at 1 in 500 or 1 in 833.¹⁴ These mutations in the BRCA genes are 10 times more common in those of Ashkenazi Jewish descent.¹⁴

Genetic testing is important for identifying those at higher risk of cancer but can also be used for identifying cases where prevention and treatment are useful for understanding underlying genetics.^{8,19} In both breast/ovarian cancer and colorectal cancer, the predictive test for the respective gene mutations for each cancer aids in raising awareness of symptoms as they present, so treatment may be done in a timely matter.^{3,8} There is also data that exists suggesting that chemoprevention can help reduce the risk of breast cancer with those who have tested positive for only one of the BRCA genes.²³ Testing positive for the gene has also shown to have a positive impact on individuals because it allows them to live a healthier lifestyle by being more aware of their bodily health.⁸

Neurological disorders

Alzheimer's disease

Some genetic diseases are more likely to affect individuals later on in life, such as the cancer, Alzheimer's, and Huntington's disease.^{3,5} Many diseases that are linked to genetic inheritance have tests still in development.¹³ Alzheimer's disease has been shown to have genetic inheritance, however the genetic testing may not be as useful as other tests.²⁴ This is solely because there is no stopping or preventing the disease progression in a method that exists yet in modern medical science. Because of this, a

potential patient may not want to spend time and money on a genetic test for Alzheimer's when getting early treatment will do nothing to heighten quality of life with the disease as it progresses.^{24,25} To add, the information given very early to a patient about the existence of the disease may be worse in the long run due to psychological impacts and long-term heightened stress.^{19,24,25}

Huntington's disease

Genetic screenings play an integral role in preconception planning as symptoms may not have evolved to prominence yet in newborns, but have the capacity to subsequently be expressed during their lives.^{2,8,14} For Huntington's disease, symptoms do not usually display themselves until after the point of reproductive maturity at which point an individual tries to have a child. This leads to higher chances of the autosomal dominant gene being passed on. Screening for Huntington's can be done at any time, pre-or post-natal which makes it easily operative to those susceptible.^{23,26}

Cardiovascular disorders

Cardiovascular diseases have many different components but some have multigenic or monogenic causes which can be tested for. One monogenic cause that can lead to early cardiovascular disease is familial hypercholesterolemia. With cardiovascular disease, there are often many factors to consider and thus genetic testing can only show a predisposition.²⁵ Other diseases such as hypertension, hemochromatosis, polycystic kidney disease, and diabetes that have been linked to genetics also have existing tests.^{5,27}

Blood disorders

Beta thalassaemia

Genetic testing is useful in countless ways: from being a preventative method with cancer to reducing the prevalence of genetically predictable conditions overall.^{6,28} Beta thalassaemia has had an 80–100% decrease in new births in Mediterranean countries where prenatal and postnatal genetic testing was implemented in the primary care environment.²⁸

Sickle cell anemia

Diseases can vary in severity depending on how the symptoms manifest and by which route the condition was inherited.¹³ For example, sickle cell anemia is an inherited autosomal recessive disease. However, in its heterozygous state it is survivable with symptoms ranging from rare to none if the person is a carrier. Having genetic testing conducted allows a better chance for autosomal recessive survival, because treatment can start quickly and lead to an improved prognosis.²⁸ It also enables carriers to be aware of their unseen genetic mutation and take that into account if in the future they would want to conceive a child.

Endocrine disorders

Examples of preventative measures after diagnosis via preventive genetic testing in multiple endocrine neoplasia type 2 has been shown.¹⁹ Those that are carriers have benefited from preventative measures such as thyroidectomy which greatly reduces the chance of dying from thyroid cancer or an inherited disorder of the thyroid gland.¹⁹

Treatment effects

A new future in curing diseases via pharmaceuticals and other treatments, even if they are unrelated to hereditary, can be paved due to genetic testing for familial diseases.¹³ As discussed before, certain ethnicities have various genetic patterns that can increase their likelihood of developing diseases, however these genetic patterns can also lead to development of negative reactions to drugs.¹⁴ Response from drugs and varying levels of toxicity could have a large impact on the body due to an individual's genetics and certain genes.¹³

Genetic testing methods

Genetic testing can be accomplished through several different methods. Blood, saliva and amniotic fluid can be tested to find abnormal genomic sequences that may lead to familial conditions.^{8,14,29} These bodily fluids are easily accessible by primary care physicians, and are thus samples that can be optimally collected in that setting.^{4,15} Testing can also be conducted at practically any stage during a patient's life.¹¹ Individuals who know they are or can become carriers, and are seeking to have a child, may wish to have preconception genetic testing done to ensure their child will not be affected.¹¹ Testing can occur before a baby is born in the prenatal environment of the mother's womb via amniocentesis.²⁹ Testing can also be executed postnatally any time after birth.¹⁵ More often than not, patients choose to have a genetic test conducted either when symptoms arise or as a preventative measure in patients with a family history of the condition.^{11,23} The ease of collecting sample genetic material from a patient, as well as the flexibility of testing a patient anytime throughout their life are both positive attributes to introducing genetic testing in the primary care physician setting more throughout the coming decades.

Testing can also be performed in hospitals. Genetic counselors in the hospital setting may recommend screening when a patient is administered due to symptoms noticed or analyzing patterns in a patient's family medical history.⁴ Additionally, genetic testing is being introduced in the more informal setting via a primary care physician.^{7,18} The introduction of genetic testing and screening programs into primary care is becoming paramount as it increases opportunities for people to become tested.² The more opportunities for easy and unintimidating genetic testing, the more people will be in charge of their medical future and plan of care. As a result, the people tested acquire a deeper understanding of genetics which can lead to quicker and more efficient treatment that ultimately leads to decreased mortality.^{10,19}

Factors influencing genetic screening participation

There are some individuals who would prefer not to know if a familial affliction has been passed on to them for psychological reasons (i.e. trauma over realization of an inherited fatal disease). However, many individuals would like to know if a mutation is present within their genome to prepare for treatment and understand the potential the disease may influence on their future.^{23,24} Many different factors play into getting tested such as financial security in order to pay for the test, psychological reasons as mentioned previously for reacting to austere results (including family members who may become alerted as well to the possibility of their own genetic mutations), and insurance companies reacting to the results and how their control may hike medical costs drastically for a patient.^{23,26} All of these factors can impact an individual's decision to get tested or not.²⁶

Conclusion

Genetic testing is a valuable source of a patient's medical wellbeing. If wielded productively, it can provide vital data to help predict hereditary disease contraction as well as provide time to plan for care if a detrimental genetic disease such as Tay Sachs, Alzheimer's disease, or Down syndrome, is confirmed.^{1,15,23} In recent years the introduction of genetic screening via primary care physicians has ultimately lead to the prevention of and heightened quality of treatment for several familial diseases in countless cases.^{2,12} In the years to come genetic tests will become increasingly more accessible in familiar outlets for efficient family health care, especially in the primary care setting. Only time will reveal how DNA tests will evolve to reach more people, utilizing cutting edge scientific research as its cornerstones to propel itself to new heights.

Conflict of interest

None.

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