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An Overview of Health Research Involving Genetics

Introduction Each of us has our own unique DNA – carried in our genes – that is present in every cell of our bodies. Genes contain instructions about how to build the proteins and cells that make up the structure of the body. Our genes are passed down biologically from parent to child: we receive half of our genes from our mothers and half from our fathers. Certain things about us – such as eye color– are directly determined by our genes. Other things – including height – are influenced by our genes in combination with environmental factors, such as whether we have healthy foods to eat when we are growing up. The study of genes plays an increasing role in health research. *The purpose of this handout is to provide background on different types of genetic research and how they are related to understanding health conditions or improving health care.*

Background: Genetics and health Some health conditions are known to be caused by changes (or "mutations") in specific genes. For example, cystic fibrosis is a genetic condition involving repeated lung infections and loss of lung function over time. Cystic fibrosis is caused by mutations in a gene called "*cystic fibrosis transmembrane conductance regulator"* (or CFTR) that disrupts the way this gene works in the body. In genetic diseases like this, a key change in the DNA code of just one gene means the person will develop the disease.

Genetics can also play a role in the development of common conditions, such as diabetes, asthma, and heart disease. But in contrast to purely genetic diseases (like cystic fibrosis), minor changes in many different genes may increase the chance of developing these conditions. These genes usually have only small effects, and often interact with other risk factors. In the case of diabetes, for example, other risk factors such as a lack of exercise and a diet high in fats and sugar also affect whether or not someone becomes diabetic. The genetic part of risk for common diseases is a result of gene *variation*, meaning that genes come in slightly different versions of normal. In other words, a gene *variant* is a small difference in a gene between people. These *gene variants* are the basis for typical physical differences we observe in people, such as eye or hair color. Gene variants can also explain why some people are more or less likely to get common conditions. In the case of diabetes, many gene variants are linked to a higher risk of getting diabetes. The effect of these gene variants is small. Many people who have them will not get diabetes, especially if they exercise and eat a healthy diet.

THREE GOALS OF GENETIC RESEARCH

- **Identify gene mutations and variants associated with health conditions.**
- **Use genetic knowledge to understand diseases better in order to help develop new or improved preventive measures and treatments.**
- **Use genetic knowledge to develop and evaluate genetic tests to improve health care.**

Types of genetic health research Most genetic health research involves the collection of an individual's health information and a biological sample (e.g., blood, a tissue biopsy, or saliva) for DNA analysis. Studies may differ in the amount of health information collected from a person or group of people and in the specific genes that are studied.

Some research studies are designed to explore if there are links between gene variants and a particular health condition. These studies help researchers to understand the genetic factors that might contribute to a person's likelihood for developing a disease. Two specific types of health studies that examine gene variants are:

Family Studies: Family studies provide information about how diseases run in families, and they can help to define the health problems that occur in a particular condition. They also allow researchers to identify the specific genes associated with genetic conditions. Usually a person with a certain genetic disease is asked to participate in research together with family members, as people in the same family share aspects of their genetic makeup.

Gene-Disease Association Studies: Research that aims to identify gene variants associated with a common disease requires large numbers of people. This is because a broad sample of variants are needed to compare genetic information between individuals or populations and identify if there are associations with certain diseases. Some studies also include environmental risk factors, in order to study the effect of both genes and the environment on the disease. People are usually invited to participate in these studies by letter or by an invitation at the place where they receive health care. Two study designs are commonly used:

> *Case-control* – In this approach, a group of people with a particular health condition is identified. Individuals affected by the condition are referred to as the *cases*. People who do not have the disease are referred to as the *controls*. For instance, the control group might include people receiving care at the same clinic as the case group but who do not have the health condition that is being studied. Gene variants associated with the condition are identified by comparing the case group and control group for differences in specific sections of genes, called DNA markers.
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> *Cohort* – In this approach, a group of people is identified on the basis of age, place of care, residence, or other similar factors. This group of people, called a *cohort*, is then followed over time to see what factors—both genetic and environmental—make certain individuals more likely to develop a disease.

Other research studies are aimed at improving treatments or prevention strategies for diseases. These studies include *clinical trials* and *pharmacogenetic studies*.

Clinical Trials: Clinical trials are studies that compare new health care approaches with existing ones to determine which works better. A group of people with a condition is divided into two groups, one receiving standard care and the other receiving a new health care approach. For example, cystic fibrosis patients might be divided into one group receiving usual antibiotic treatment for lung infections (pills and injections) and another group receiving usual care plus an inhaled antibiotic medication to prevent infection. The goal would be to see whether the group receiving antibiotics had fewer infections. Clinical trials are also used to assess whether genetic testing can promote healthy behavior. For example, one group of people might get genetic testing to see if they have a susceptibility to diabetes, while a comparison group does not get testing. Both groups would be advised about exercise and a healthy diet. The goal would be to see if people for whom testing showed that they are susceptible to diabetes improved their exercise and eating habits.

Pharmacogenetic Studies: These studies determine whether gene variants affect how individuals respond to medications. They include both gene-disease association and clinical trials focusing on gene variants that cause individuals to process certain chemical compounds differently. These genetic differences between people can affect how well a medication will work, or whether it will cause side

effects. An example of a genetic association study would be one that compares DNA markers for people who respond well to a medication versus those who do not. A clinical pharmacogenetic trial might examine whether genetic testing helps health care providers to choose drugs that are safer or more effective for their patients.

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