

Genetic Testing

Overview

Genetic testing has become extremely popular in the past decade. People have begun making use of the wide variety of resources at hand to test their susceptibility to disease, learn about their ancestry, or even discover their athletic ability. As the science of genetic testing continues to develop and provide us with new information about our DNA, certain ethical questions regarding the proper use of these tests arise. Certain genetic tests may be beneficial to individuals with specific diseases, but these tests may also provoke fear of and preoccupation with what the future may hold. Would you like to know you were prone to an untreatable terminal disease? What about your children? Who should deliver results of genetic tests, and how should we regulate information? This module employs a case-based approach to foster critical thinking and discussion about particular people and demonstrates cases as a springboard to discuss deeper ethical issues.

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Learning Outcomes

1. Understand the different methods of genetic testing and how they are used.
2. Think critically about the benefits and drawbacks that come with genetic tests.
3. Understand arguments for and against prenatal genetic testing for disease and disability.
4. Formulate ethical opinions on the use of direct-to-consumer tests and whether anyone other than trained genetic counselors or doctors should be allowed to deliver the results of genetic tests.

Procedures and Activities

This unit uses a student-centered and interactive approach to teaching. Activities are designed to allow for a maximum degree of student participation and collaboration. Each activity is marked as an individual, partner, or group activity, or as a teacher-directed class discussion.

The following terms are used to designate the different types of activities:

- Individual Activity
- Partner Activity
- Group Activity
- Teacher-directed Class Discussion

1. Introduction to Topic

Individual Activity

Students should answer these questions individually at the start of the unit. The purpose of the activity is to collect the students' individual thoughts before being presented with any information in the unit, so teachers should avoid answering too many questions about terminology that is used.

1. What genetic disorders or diseases do you know about? Have you or anyone you know used genetic testing to diagnose a genetic disorder? What about to learn their risk of developing certain diseases?
2. What should parents be able to screen for in a fetus? Should they be able to test for anything from athleticism to eye color, only for potential medical conditions, or not at all?
3. Have you or anyone you know used services like 23andMe or Ancestry.com? What kind of information can be learned from those services? How was it used?
4. Should everyone be told if they are at an increased risk for certain diseases, such as breast cancer or Alzheimer's, or do we maintain a right *not* to know?
5. Do you think there is anything fundamentally wrong with genetic testing?

2. What is Genetic Testing?

Teacher-Directed Class Discussion

Review the nuts and bolts of genetic testing.

Overview

Genetic testing begins with the extraction of a biological specimen, such as blood or tissue and uses advanced laboratory methods to analyze your genetic information. Genes are the basic physical unit of inheritance. Genes are passed from parents to offspring and contain the information needed for the coding and expression of traits. Each gene has a

unique DNA sequence. Genes are arranged on chromosomes.

Genetic testing looks for variations among genes that are associated with disease or other traits. The results of a genetic test can be used to confirm or rule out a suspected genetic disease or to determine the likelihood of a person passing on a mutation to their offspring. Genetic testing may be performed on any biological sample, from shortly after fertilization to even after death.

Genetic tests can help to:

- Diagnose diseases that are directly caused by mutations on individual genes. Sickle cell disease is one example.
- Diagnose diseases that are caused by chromosomal abnormalities, typically the addition or deletion of an entire chromosome, such as Down syndrome or Trisomy 18.
- Identify gene changes that may increase the risk of developing a disease, such as BRCA mutations, that are linked to a higher incidence of breast cancer. These genetic flags do not mean that person will necessarily get the disease.
- Determine whether someone is a carrier for a gene that is linked to disease. Carriers may show no sign of disease; however, they may pass on the mutation to their biological children.
- Discover information about ancestry.
- Determine the sex, eye color, and other non-disease traits of embryos or fetuses. Increasingly, scientists are using genetic data to support the hypothesis that certain genes or patterns of genes correlate with IQ, body type, enhanced memory, athleticism, and other talents.

Disease-Specific Testing vs. Whole Genome Sequencing

Disease-specific testing

Today, most genetic testing is designed to search for mutations on one or a few genes rather than scan the entire genome. For a handful of diseases, researchers have identified the chromosomal mutation or gene mutation that is associated with disease. For example, doctors and researchers know that a third copy of chromosome 21 is the marker of Down syndrome, and that sickle cell disease is caused by mutations in one of

the genes that encode the hemoglobin protein. The most commonly used genetic tests only provide information about those genes or chromosomes that doctors know are associated with disease.

Whole genome sequencing

The genome is the entire set of genetic instructions found in a cell. In humans, the genome consists of 23 pairs of chromosomes, found in the nucleus, as well as a small chromosome found in the cells' mitochondria. Each set of 23 chromosomes contains approximately 3.1 billion bases of DNA sequence. Whole genome sequencing can be conducted on any biological sample, including fetal DNA from an embryo. This process has become much more accessible and affordable in recent years, allowing individuals to map their genomes or parents to map their children's entire genetic code for under \$1,000. Unlike other prenatal tests that test for specific disorders (e.g. Down syndrome, Trisomy 18), whole genome sequencing provides a map to the entire genome. Much of the data presented in the genome may be ambiguous and not helpful to parents or doctors, since there is still so much unknown about the role that specific genes play in the development of illness or other traits.

Genome sequencing can be performed on any biological sample. Parents may sequence the whole genome of an embryo, a fetus, a child, or themselves. Adults also do whole genome sequencing to discover more information about their genes, ancestry, and disease susceptibility. Scientists use the data from whole genome sequencing to support hypotheses about which genes correlate with which traits.

Prenatal Testing

The following genetic prenatal tests are done before pregnancy:

Carrier testing

This test may be conducted any time during a person's lifetime. It takes a sample of both parents' blood and tests the DNA to see if the mother or father is a carrier of genetic diseases like cystic fibrosis or Huntington's. If either parent carries the mutation, they may elect different options for having a baby (such as in vitro

fertilization or adoption) to avoid passing the gene on to their children.

Pre-implantation genetic diagnosis (PGD)

Sometimes parents use in vitro fertilization to conceive a child. In vitro literally means “in glass.” Using this method, doctors harvest an egg (or eggs) and sperm from the biological parents. The sperm is fused with the egg, a process called fertilization, in vitro—in a glass petri dish. The zygote formed quickly multiplies to become a several-celled embryo. At this point, the embryo already contains all of the baby’s genetic material. The embryo is implanted into the mother’s uterus a few days after fertilization.

PGD may be performed on an embryo before implantation when an embryo is generated by IVF. Doctors get a tiny sample of embryonic DNA to see if the embryo has a genetic defect rendering it more susceptible to disease in the future. Usually, many embryos are created at once during IVF. PGD allows parents to choose among embryos the ones they want to implant. Parents may also discover the sex of the baby, eye color, and other hereditary traits at this point.

The following procedures are performed during pregnancy. They allow doctors to get a sample of fetal DNA for genetic testing.

Cell-free fetal DNA testing

This test is conducted after 10 weeks of pregnancy. It involves getting a sample of the mother’s blood and identifying within the sample specks of fetal DNA. Scientists then isolate the fetal DNA to check for certain chromosomal mutations such as Down syndrome, Trisomy 18, Edward syndrome, or Patau syndrome. The test determines the likelihood a fetus is to have one of these, or other, diseases. Doctors may recommend this test if something comes up in the ultrasound that may cause the doctor to believe that the fetus may have a birth defect, or if a patient is pregnant with multiple babies.

Recent trials on cell-free fetal DNA testing show that the non-invasive maternal blood draw outperforms other prenatal tests (amniocentesis, for example) for accuracy and

safety. This means that the future of genetic prenatal testing is likely to change rapidly, as it is projected that cell-free fetal DNA testing will soon be conducted routinely for all pregnant women. It is much less risky and easier to perform than other methods of genetic testing for fetuses, like those below.

Chorionic villus sampling (CVS)

This invasive test is conducted at 10 to 12 weeks of pregnancy. Doctors obtain a sample of tissue from the placenta, which is rich with fetal DNA, and test it for genetic defects that may cause heritable diseases. Doctors may recommend this test if a patient is older than 35, has a history of genetic disease in her family, or if something is flagged in the cell-free fetal DNA testing that may cause the doctor to believe that the fetus possesses a chromosomal abnormality.

Amniocentesis

This invasive test is conducted at 15 to 20 weeks of pregnancy. Doctors obtain a sample of amniotic fluid, which surrounds the baby inside of the placenta.

Amniocentesis obtains a sample of fetal DNA that can be mapped and tested to determine the sex of the baby or detect chromosomal abnormalities. Doctors may recommend this test if a patient is older than 35, has genetic conditions in her family, or if concerns arise during the cell-free fetal DNA testing, as previously mentioned. While this is the most common prenatal test, it is also known to result in spontaneous abortion (about 1 in 400).

Genetic Testing in Adults

Carrier testing

These forms of genetic tests may be done with a physician and usually take place when a patient is considering or planning on having children.

Patients will take the test to find out if they are carriers of certain hereditary diseases to learn whether they should or should not have biological children or undergo IVF to prevent their offspring from having the mutation.

Tests for mutations/diseases

Recent legislation requires that these disease-specific genetic tests are only to be

conducted with a doctor or genetic counselor. Individuals may not receive information about disease susceptibility from direct-to-consumer companies like 23ndMe or Ancestry.com. Patients provide their physician with a sample of their DNA so that they can learn whether they have a certain genetic predispositions or have an increased risk of developing a type of disease in the future, such as Alzheimer's, breast cancer, colon cancer, cardiac problems, etc., that have been shown to correlate with the presence of a particular genetic mutation.

Direct-to-consumer (DTC) & ancestry testing DTC genetic testing is a form of testing sold directly from private companies to consumers through any marketing venue that does not involve doctors or medical professionals. Direct-to-consumer tests can only provide information about ancestry, not about disease susceptibility or carrier testing. Consumers provide genetic testing labs with their DNA (usually saliva) so that they can learn their ancestry and what their DNA says about where they come from. Companies that provide DTC results and ancestry data may not provide any medically relevant information. Only researchers, doctors, and genetic counselors are licensed to discuss results of genetic tests that include medical information, such as the presence of a genetic mutation associated with disease.

3. Why Test?

Teacher-Directed Class Discussion

In a large group, teachers will discuss with their students which of these tests (if any) they would want to conduct, if they haven't done so already. Teachers should be prepared to ask students why they would take this test or why they took it in the past, and those students unwilling to take any genetic tests should explain their stances as well.

Here are some documented reasons as to why parents opted for their children (usually at the embryonic or fetal stage) to be genetically tested:

- To learn about the presence of a disease that would cause the parent to terminate

pregnancy (ex. If they don't want to raise a child with Down syndrome)

- To prepare financially and emotionally for a child with potentially significant disabilities
- To discover a disease and potentially treat the fetus (through surgery, with drugs)
- To obtain information about the future baby (though unnecessary to know during pregnancy) such as eye color, sex, their carrier status, their susceptibility to certain diseases that may not threaten them until adulthood, etc.
- Contribution to the scientific understanding of genes and genetic mutations

Here are cited reasons why adults undergo genetic tests:

- To find out if they are a carrier of a disease that their future children would be at risk of inheriting (and then make reproductive decisions based on this information)
- To find out if they are susceptible or likely to contract certain diseases in the future
- If they are genetically susceptible to diseases that may harm them in years to come, testing may be an opportunity to learn about preventative steps that can be taken or to prepare psychologically, financially, etc.
- To function as a guide for doctors regarding the best way to proceed/provide medical treatment for a disease based on a patient's genome
- To find out if they are genetically related to a child (paternity test), which may result in settling financial disputes regarding childcare, spending more/less time with child, etc.
- To learn about one's roots, discover new relatives, learn more about their family history

4. Ethical Issues

Prenatal Testing

Individual Activity

Provide each student with the chart below. Ask them to complete the chart based on what they have learned so far. A “yes” answer means, “Yes, it’s okay to test an embryo or fetus for this trait.” If the students think “No” instead, they should provide a reason.

You might encourage students to think about the following questions before filling out the chart:

- 1. As we shift toward a culture of personalized genetic awareness, will parents feel obligated to take part in such testing and genome sequencing without necessarily wanting to? Might this be damaging?
- 2. Should you be able to test for non-medical traits (talent, intelligence, inclination toward crime), even if this might affect the way you raise your kids? For example, if genetic tests show that your child could have low IQ, it’s possible that parents will lower expectations for academic achievement. Is that okay?
- 3. Should parents have the right to learn non-essential information at the fetal stage (e.g. carrier information that will be useful when the fetus becomes an adult who wants to have children)? Keep in mind that the child/early adult might not want to know this information.

Now, fill out the chart.

CHARACTERISTIC	Yes	No (because...)
Eye color		
Hair color		
Sex		
Height		

CHARACTERISTIC	Yes	No (because...)
IQ/intelligence		
Sexual orientation		
Down syndrome		
Cancer predisposition		
Alzheimer's disease susceptibility		
Obesity		
Nearsightedness		

Partner Activity

Once students have completed the chart individually, ask them to compare their answers with those of a partner. Do they differ on any characteristics? Why?

Selecting for Disability

Present to students the case of Chloe's Law:

Teacher-Directed Classroom Activity

Chloe Kondrich is a young Pennsylvania native who was born with Down syndrome. Chloe's father was appalled when he discovered how most parents reacted to the knowledge genome: 92% of women with a positive prenatal diagnosis of Down syndrome terminate the increased use of the safe and effective cell-free fetal DNA test, more pregnant mothers than e as a standard part of prenatal care. Disability activists are concerned about the effect of wide with disabilities.

Thus, in 2014, with the help of anti-abortion and disability activists, the Kondrich family was able to push the enactment of Chloe's Law in Pennsylvania. The law requires physicians to provide parents whose fetus has Down syndrome with up-to-date information on support services for those with the disorder. The purpose is to give families in-depth information on the life of a child with Down to reduce stigma of the disorder, and, ultimately, convince families not to terminate pregnancies because of a Down syndrome diagnosis.

Chloe's Law requires that physicians or genetic counselors provide positive information about living with Down syndrome. This violates the longstanding commitment to neutrality among genetic counselors. Since the introduction of prenatal testing in the 1970s, physicians have used a clear method in providing genetic information to parents so that parents didn't feel pressured to take any significant action in response to the news. This is a way of respecting parents' freedom to make choices that are consistent with their values and lifestyle.

Chloe's Law—and other laws being passed around the country—says that doctors cannot be neutral; they must present living with Down syndrome in a balanced, positive light.

Consider the following questions in a classroom-wide discussion:

- Should the standard procedure of delivering genetic information be changed?
- Now that new testing methods are revolutionizing the way we use and discuss genetics, should we ensure that all doctors across the country relay genetic information in a positive light?
- Finally, imagine a future where nearly all disorders can and will be determined with prenatal genetic tests. Do you think that with the increase in detectable abnormalities, abortions will continue to increase without an intervening physician spinning a positive light on a baby's disease?

“Cadillac” Genome Testing

When it first started in 2006, [23andme.com](https://www.23andme.com) provided “Cadillac” genome testing. Here’s a description:

For just under \$1,000, [23andme] will sequence your entire genome and provide a report that lets you compare yourself with others in terms of height, intelligence, the ability to avoid decisional errors, and many other traits. You can also discover your risk for a variety of conditions and traits such as addictions, as well as genetic factoids like earwax type and sensitivity to the smell of sweat” (Press 2008).

At the time, 23andme and similar companies also provided medical information, such as predicting adverse reactions to specific medications, estimating predisposition to various complex diseases, and diagnosing predominantly genetic disorders.

However, 23andme was issued several warnings by the U.S. government for illicitly conveying medical information without providing access to doctors or medical services through the company. The agency warned 23andMe to stop marketing its genetic tests because the company didn’t have regulatory approval from the FDA to administer said tests.

As a result, 23andme and similar companies now provide only ancestry information. Let’s discuss whether the limitations on 23andme’s activities are appropriate.

Students will visit [23andme.com](https://www.23andme.com) and roam the website to the direct-to-consumer genetic testing service 23andMe. At the bottom of the page under “Legal” there is a Family Considerations page.

Students should be directed to read this page very carefully.

Student questions:

1. If a DTC company provides individuals with a negative test result, do you think this will create a false reassurance in clients and keep them from visiting a doctor? How

harmful might this be?

2. Which of the following characteristics would you personally want to learn about from a DTC test? Which should people be allowed to learn about through a DTC test?

CHARACTERISTIC	Yes	No (because...)
Carrier of a disorder		
Intelligence		
Ancestry		
Cancer predisposition		
Paternity		
Alzheimer's disease susceptibility		

Should private companies have the ability to conduct genetic tests on everything, only non-medical information, or nothing? Do you agree with the legal ruling stated on the 23andMe website?

Ancestry Testing

Group Activity

Students will read the following case study, thinking about the impact DTC testing can have on an individual. After reading, students should answer discussion questions.

Case #1

Adapted from “With genetic testing, I gave my parents the gift of divorce,” by George Doe:

George Doe was a stem cell and reproductive biologist, whose interests focused on genetics and DNA. Thus, when he came across the 23andMe genetic tests offered for

only \$99 online, he was very excited. He ordered the test right away, and even bought two extra kits to give to his parents as gifts. George was captivated by the idea of a quick and easy means to find out if he was predisposed to any cancers that could be traced back to previous generations. He also got the bonus of discovering details about his ancestry and learning new things about his family.

What was once an opportunity for harmless exploration quickly became an extreme ordeal.

While he was thrilled to see that he wasn't at high risk for cancer, he also learned that he shared about 22% of his genes with a man named Thomas, who was labeled his grandfather in his line of ancestry. George was baffled by what appeared to be an odd mistake, for he knew both his grandfathers and neither one of them was named Thomas. However, what he also knew was that people could share 25% of their DNA with someone that is their grandfather, uncle, or half-sibling, so while Thomas couldn't be George's grandfather, there was a large possibility they were related by blood.

George decided to check with his father and understand whether he too found Thomas in his ancestral lineage, only to learn that while his father didn't know who Thomas was, the 23andMe website declared that they share about 50% of their DNA with one another, and that Thomas was his father's son.

George wanted to reach out to Thomas, but what he discovered in the process was too much a burden for the Does to handle—turmoil and separation amongst family members quickly ensued.

Discussion questions:

1. Should companies sell genetic tests on ancestry if that risks harming individuals, and families, and their sense of self?
2. Would you want to take an ancestry test even after hearing the possibilities of it going awry? Can you think of other ways that discovering the “unknown” could unexpectedly complicate things?

Reactions to Testing

False reassurance

Individual Activity

Students should write down the inherited disorders they are aware of and make note of any such occurrences in their families. If students who do have genetic disorders in their lineage are comfortable, they should be encouraged to answer the following question. Would you want to know if you had the gene connected to a disorder or not? Before you have kids, would you want to test if you are a carrier and/or affected by the disorder?

Teacher-Directed Class Activity

Teachers should begin by reading the following hypothetical scenario to their classes:

A genetic form of breast cancer that can be connected to certain genes runs in your family. You have already seen your mother, grandmother, and cousin fall ill to the disease, and you are thinking about having a child. You want to learn if you are susceptible to the cancer as well, because if you are you will not have a child that is genetically yours out of fear of passing on the gene. You take a genetic test with your doctor, and when the results come back you make an appointment to discuss the results.

However, given the complexity of genetic markers, the discernment of certain future diseases in your future is at best a very highly educated guess based on proven science and empiricism. You learn that there is a strong likelihood you will not have the disease, though, years later, you develop the same cancer your mother had, but you experience an even quicker decline. Could this have been prevented had you opted for mammograms sooner and more frequently? Not necessarily, but it is one of many questions you may ask in search of answers as to why this happened.

1. Can “false reassurance” enable people to take less care of themselves or forgo preventive measures to help protect them from disease, such as mammograms in the case of breast cancer?
2. Is it harmful to undergo genetic tests that present likelihoods instead of clear results? If doctors cannot definitively diagnose patients with a disease, should

they be allowed to report any information at all?

3. Would you subject yourself to testing knowing that it would yield no definitive answer but rather indicate the mere likelihood of developing an illness?

Self-fulfilling prophecy

Individual Activity

Students will read the following report on a trial that focused on the aftereffects of informing participants of the presence in their genome of an abnormality associated with the development of Alzheimer's disease. The objective of this exercise is to get students to think about the harm that may come from learning about one's susceptibility to a genetic disease before the disease manifests, if it does at all.

Adapted from: "Effect of knowledge of APOE genotype on subjective and objective memory performance in healthy older adults," by Lineweaver, et al.

Background

The most important gene for the detection of the susceptibility of Alzheimer's and dementia is the e4 allele of the apolipoprotein E (APOE) gene.

Ethical researchers have been dedicating effort and putting forth studies to determine whether the benefits of learning about one's susceptibility to dementia outweigh the risks to better understand how and if testing for these incurable, terminal diseases should occur. The trial, conducted at the UCSD Shiley-Marcos Alzheimer's Disease Research Center, examined the psychological impact that knowing one's possession of the APOE gene has on patients. The goal was to identify if and to what extent the expectation of dementia influences cognition and overall psycho-emotional functioning over time.

Method

Participants in the trial were brought in through a request for cognitively healthy individuals between the ages of 52 and 89. They were then genotyped for the e4 APOE

allele and split into four groups: one that was told they carried the Alzheimer's gene, one that was told they did not carry the Alzheimer's gene, one that carried the Alzheimer's gene but was not given any genetic information, and one that did not carry the Alzheimer's gene and was not given any genetic information. All four of these groups then underwent the same tests: objective memory tests and subjective memory scales. Of the former category, specific tests such as the Wechsler Memory Scale-Revised has patients listen to two stories and then recount the important 25 ideas of each story directly after listening and 30 minutes after listening; patients were then scored out of 50 points. The subjective memory scales include a questionnaire forcing the adults to recount their subjective impressions of their own memory. They are asked questions that make them rate their daily memory abilities on a 1-5 scale (1=never, 5=always), with higher scores indicating better subjective memory abilities.

Results

In terms of the subjective memory scales, participants who were told they tested positive for the e4 allele judged their memories much more harshly than participants who were not told they tested positive. Moreover, participants who were told they tested negative for the e4 allele judged their memories more positively than those who were not told that they tested negative. Results from the objective memory tests, however, show that participants who do not have the gene for Alzheimer's, regardless of whether they were told so, performed on the same level. On the other hand, participants who were told they had the Alzheimer's gene performed worse on the objective tests than those who were not told.

Conclusion

The findings of the UCSD study on the psychological effects of e4 allele genetic testing proves that knowledge of a prospective illness can have negative effects on one's health and mental state. This means that merely being aware of one's susceptibility to Alzheimer's can have a significant impact on one's psyche, even before clinical symptoms appear.

Student questions:

1. In your own words, describe the difference in results of patients who were told

- whether or not they had the APOE gene and patients who were not told.
2. Would you want to know if you were a carrier for the APOE gene? Why or why not?
 3. Have you ever lost small items such as keys, glasses, phone, etc.? If you were told that you carried the gene that detected Alzheimer's, do you think you would blame these simple misplacements on your impending disease? In other words, do you predict that knowledge about the gene could affect you psychologically in your own life?

How do we use info from genetic testing?

Individual Activity

Now that students have read about the potentially harmful psychological effects certain genetic test results may have on the individual, students will read another report on diabetes prevention. The objective of this exercise is to get students thinking about the other ways in which genetic testing can affect one's mental state.

Adapted from "Personalized genetic risk counseling to motivate diabetes prevention: A randomized trial," by Grant et al.

Background

Diabetes is one of the most commonly diagnosed diseases, with nearly 90 million Americans currently at risk of developing diabetes (CDC). Clinical studies and research show that with exercise and proper diet, many at risk patients can easily reduce their chances of becoming ill. The objective of this study (the Genetic Counseling/Lifestyle Change study, or GC/LC) was to determine whether the awareness of a genetic predisposition to diabetes might motivate patients to take greater care of their bodies. The two hypotheses of the trial were: 1) having a higher genetic risk for type 2 diabetes would increase participation in the 12-week diabetes prevention program and 2) having a lower genetic risk for type 2 diabetes would decrease participation in the 12-week diabetes prevention program.

Method

Participants for the trial were recruited based on the following criteria: they needed to be age 21 or older, overweight, and with no existing type 2 diabetes diagnosis. The participants were then given blood tests and genetic analyses; the 25% of participants with the highest risk of diabetes and the 25% with the lowest risk of diabetes were kept for further study, while the median 50% were sent away. The two groups were then enrolled in a 12-week diabetes prevention program that could be attended at their leisure. The following two factors were taken into account while assessing the effects of the trial: 1) the difference in weight/BMI for both low risk and high risk patients from baseline to end of 12 weeks and 2) the variation in program attendance between low risk and high risk patients.

Results

Attendance at the 12-week diabetes prevention program did not differ significantly between high and low risk participants, as they attended an average of 6.8 ± 4.3 sessions. Confidence and motivation to exercise did not differ significantly between the two groups, as these factors increased throughout the 12-week program for both groups. Higher risk participants reported being more motivated to participate than lower risk participants, but weight loss did not significantly differ between groups.

Student Questions

1. What can you conclude from this study?
2. If informing patients about susceptibility to a disease such as diabetes does not greatly increase their motivation/outcome, is it still important to genetically test for these traits?
3. How do you think the study would have resulted differently without the 12-week program? Do you hypothesize that the weight loss between high risk and low risk patients would vary significantly or not at all?
4. How does the outcome of this study differ from that of the Alzheimer's study? Do you think that this was due to the fact that one disease is terminal and incurable whereas another test provided participants with an opportunity to proactively improve their health? Compare the reactions of those who knew they had the Alzheimer's gene vs. those who knew they had the type 2 diabetes genes. What is similar/different?

Right to know (or not)

Consider the following scenario: A father in kidney failure brings his son to the hospital to find out if they are enough of a match for transplantation. The men undergo testing, but doctors discover that not only are they not compatible but that the pair is not even genetically related. Do the father and son have a right to know even though the test was not taken for any reason other than medical, or do they have a right not to know, because it would possibly rip a family apart without them requesting the information?

Group Activity

Students will be divided into two groups, each assigned either: 1) father and son have the right to know or 2) father and son have the right not to know. Within these groups, students will prepare for a short debate and then discuss between groups whether physicians should disclose genetic information that patients did not request.

Consider the following questions:

1. Do people have the right to know all possible details regarding information extracted from their genomes?
2. Would you want to know the latter even if you didn't necessarily ask or it wasn't the purpose of the testing you underwent?
3. Should parents have the right to know about a defect present in their child's genotype even if that gene won't affect the child until she is an adult?
4. How should parents who genetically test their children handle telling their children certain information? For example, parents may know that their child is a carrier of a disease or will have a disease like Alzheimer's as an adult. The child may not be given the opportunity to decide whether or not he wants to know about these genes for herself.

Insurance

Partner Activity

Students will be split up into pairs to read the following case study. Once they finish, they must decide with their partners whether they agree or disagree with the decisions of the soldiers.

Adapted from “2 Marines who refused to comply with genetic-testing order face a court-martial,” by Neil Lewis.

Joseph Vlacovsky and John Mayfield were Marine corporals stationed in Hawaii. In 1995, they were ordered to give a sample of their blood to receive a genetic test, but they refused to take part. In spite of the difficulty in doing so, the men held their ground, stating they did not want to take part and shouldn’t have to because they were never told about the test during military enrollment.

Regardless of their explanations as to why the DNA tests ought not to be required, the soldiers had another reason. The original purpose of the large-scale test was to make sure that, if soldiers were to die during war and their remains were too mangled to be identified, there would be DNA to test the body with so that generals could find out who died and give families closure. The fear of Vlacovsky and Mayfield, however, was that whatever genetic findings would result from the test would be disclosed to future insurers and employers.

The Marines and the U.S. government reassured soldiers that such things would never happen, but for fear of being unemployed or not receiving adequate health or life insurance, Vlacovsky and Mayfield persisted and declined testing. (Note: At this time GINA, or the Genetic Information Nondiscrimination Act, had not yet been passed.)

Do you agree or disagree with Vlacovsky’s and Mayfield’s refusal to take the DNA test?

Teacher-Directed Class Activity

Teachers will now present their students with the current law on genetic discrimination (GINA).

For more information on GINA see: “What are the drawbacks of genetic testing” on the American Cancer Society website.

Passed in 2009, GINA prohibits the discrimination by employers and health insurance companies based on applicants’ genetic information. This act was passed to assure people about the privacy of their genetic information so that they do not fear the ways in which the disclosure of such information can harm them.

The federal law bars genetic discrimination by employers with more than 15 employees and health insurance companies. It defines genetic information as a person’s genetic test results, their family’s test results, and their family’s documented predisposition to genetic disorders.

Employers may not use the genetic information of their employees to make decisions such as hiring, firing, pay, promotions, assignments, etc.

Employers may not ask for genetic testing except for under limited exceptions (e.g., hazardous workplace where employers must check susceptibility to certain diseases), in which case employers are not allowed to disclose such information to anyone other than employee.

Health insurers are barred from using genetic information to refuse coverage or increase premiums of patients. GINA also bars health insurers from requiring or requesting genetic tests.

Individual Activity

After reading about GINA, students will come up with exceptions or loopholes that could still result in instances of genetic discrimination. (Possible answers include: GINA does not cover life insurance, disability insurance, or long-term care insurance. Companies with fewer than 15 employees are not regulated.)

Group Activity

While GINA is a federal law, different states may implement stricter laws on genetic information that cover more ground than what is nationally enforced. Students will get into groups and each group will research the more protective laws of different states. They might choose their own state and neighboring states and then compare laws.

5. In the News

Group Activity

The purpose of this section is to present the students with actual news stories about the ethical issues involving genetic testing while also having them formulate their own opinions about different topics. Teachers should split the class up into equal groups, one for each article. They should read and prepare a presentation for the class that includes the following:

- Brief summary of the story
 - How it relates to the topics learned in this module
 - Their personal opinions on the topic
1. People Need Protection from Unreliable Genetic Tests
http://www.washingtonpost.com/wp-dyn/content/article/2008/05/27/AR2008052701_500.html
 2. Genetic Testing: One Family Faces Down Huntington's Disease
<http://articles.latimes.com/2011/apr/19/news/la-heb-family-huntingtons-genetic-testing-20110419>
 3. 23andMe Suspends Health Related Genetic Tests after FDA Warning
<http://articles.latimes.com/2013/dec/06/business/la-fi-tn-23andme-suspends-tests-fda-20131205>
 4. DNA Blueprint for Fetus Built Using Tests of Parents
<http://www.nytimes.com/2012/06/07/health/tests-of-parents-are-used-to-map-genes->

6. Conclusion

Students should return to the original questions in order to give informed answers:

1. Is there anything fundamentally wrong with genetic testing? Does it push the boundaries of medicine too far?

What should you be able to screen for in a fetus? Should you be able to test for anything from athleticism to eye color or solely medical information?

2. What ethical concerns do you have with companies who test consumers' DNA without a doctor's service or approval?
3. Should everyone be told if they have a terminal disease in their genetics, or do we have a right not to know?

Students should compare their answers from before the unit to after the unit. Have they changed? If so, do you know why?

7. References and Additional Resources

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