

Trisomy 21 (Down Syndrome)

Editor's Note: The following article contains discussion of terms that, as of 2022, are no longer acceptable for describing people with disabilities. Terms such as "Mongolism" belong to the people who originally used them and do not reflect the views of the Embryo Project authors and editors.

As of 2022, Trisomy 21 is the most common type of trisomy, or a condition where the person has three instead of the normal two copies of one of the chromosomes. Trisomy occurs when abnormal cell division takes place leading to an extra copy of a chromosome. That extra copy of chromosome 21 results in a congenital disorder called Down syndrome, which is characterized by a cluster of specific traits including intellectual disabilities, atypical facial appearance, and a high risk of heart disease. Trisomy 21 changes the way in which a fetus's brain develops, which accounts for many intellectual disabilities. The United States Centers for Disease Control and Prevention, or CDC, estimates Trisomy 21 occurs approximately once in every 700 human births, averaging about 6,000 live Down syndrome births every year in the US. Down syndrome is a lifelong developmental condition, but there are many resources available to those living with Down syndrome and their families.

Trisomy, in general, describes disorders that occur whenever extra chromosomal material is present in the cell's nucleus, and it often causes development atypicalities. A chromosome is a tightly coiled package of DNA, or genetic information, and varies in shape and size. Chromosomes are thread-like structures found in the nucleus of living cells made up of proteins and DNA and vary in shape and size. Each pair of chromosomes carries specific genes, which determine an organism's traits. Each cell in the human body normally contains twenty-three pairs of chromosomes, which totals to forty-six chromosomes. Of the twenty-three pairs, twenty-two are called autosomes, which are the chromosomes present in both males and females. When the cells that parents pass down to their children undergo cell division and the chromosomes do not separate correctly, the offspring may retain an extra copy or some extra chromosomal material resulting in some form of trisomy.

John Langdon Down, a physician working in England, was one of the first people to provide a clinical description of the disorder known as Down syndrome in 1866. That same year, Down published a paper in *The London Hospital Reports* called "Observations on the Ethnic Classification of Idiots." There he refers to what scientists call Down syndrome, named after Down himself, as of 2022, as "Mongolism" and states that Down syndrome is a condition that affects those of European descent, making them appear as if they were Mongolian.

In 1959, Jerome Lejeune, a geneticist working in France, improved the understanding of Down syndrome when he discovered the chromosomal abnormality that causes it. On 26 January 1959, the French Academy of Sciences published his work. That was one of the first times scientists were able to find a link between chromosomal abnormalities and intellectual disabilities. Lejeune was one of the first to explain many anomalies in heredity with that finding.

Chromosome 21 is the smallest autosome found in human cells. When there is an extra copy or extra material of that chromosome, it disrupts typical development, causing the traits associated with Down syndrome. The extra copy of chromosome 21 results in Trisomy 21. The atypicalities occur during fertilization, when the sperm and egg fuse and combine their genetic material to form offspring. In the case of Trisomy 21, the sperm usually provides one copy of chromosome 21 and the egg provides two copies of chromosome 21. Nearly ninety-five percent of those with Down syndrome have Trisomy 21, which happens when there is complete extra copy of the chromosome present. Another three percent of those with Down syndrome inherit extra chromosome 21 genes attached to another chromosome, but not an entire extra chromosome. That type of Down syndrome is called translocation Down syndrome. The other two percent of those with Down syndrome inherit extra

chromosome 21 material, but only in some of the cells in their body. That type of Down syndrome is called mosaic Down syndrome and will have less severe symptoms than those with other types of the syndrome.

There is no cure for or way to prevent Trisomy 21, but there are ways to detect it during pregnancy. Women over the age of thirty-five have a higher chance of carrying a fetus with Trisomy 21 and can select to have Trisomy 21 screening. Younger mothers undergo Trisomy 21 screening less frequently. Women older than thirty-five have a higher chance of carrying a fetus with Trisomy 21 because their egg cells wait longer to finish their development and can accumulate more issues in their DNA. Since chromosome 21 is the one of the smallest chromosomes, it is especially susceptible to trisomy.

There are two separate types of detection methods available for Trisomy 21, which are screening tests and diagnostic tests. The screening tests in utero determine the chances of the fetus having the condition. A common screening test is sequential integrated screening, and it is non-invasive, meaning a physician does not have to insert any instruments into the patient's body. Sequential integrated screening came about after the findings of Dennis Lo, a researcher working in China, who discovered the presence of fetal DNA in maternal blood in 1997. Lo's contributions demonstrated a connection between the contents of a pregnant woman's blood and the condition of a developing fetus. Sequential integrated screening involves taking and examining two blood samples from the pregnant woman because when a woman is pregnant, the hormones the fetus produces go back into the woman's blood. The woman's body also produces hormones that help the fetus develop. If either of those hormone levels are abnormal, it indicates that something is wrong with the fetus's development. The physician takes the first blood test around eleven to thirteen weeks and if the results come back abnormal, the patient will undergo a second blood test around fifteen to eighteen weeks to determine whether the hormone production is still irregular. If both blood tests show abnormal results, then the physician considers the pregnancy high-risk for Down syndrome, and doctors will perform an ultrasound, an imaging technique with which they are able to photograph the fetus. The doctors performing the ultrasound will look for nuchal translucency, which is the buildup of fluid behind the fetus's neck during development. The presence of that fluid indicates a chromosomal abnormality. If the ultrasound shows nuchal translucency the doctor will recommend further testing.

The second category of tests for Trisomy 21 is diagnostic tests, which more accurately diagnose a genetic abnormality. The main types of diagnostic tests are amniocentesis and chorionic villus sampling. Mark Steele and William Roy Berg, geneticists working in the US, performed the first amniocentesis with the aim of collecting a fetus's chromosomes to create a karyotype in 1966. Amniocentesis uses a sample of amniotic fluid, at typically between fifteen and twenty weeks of pregnancy, to create a karyotype of the fetus, which is a collection of the individual's chromosomes. Amniotic fluid is the fluid surrounding the fetus in the amniotic sac to protect and nourish the fetus. Medical professionals observe the karyotype for any chromosomal abnormalities, such as Trisomy 21. Chorionic villus sampling, or CVS, is the second form of diagnostic testing used to detect Trisomy 21. Jan Mohr, a geneticist working in Denmark, performed the first CVS in 1968, but the technique did not become safe or effective until 1984. CVS is similar to an amniocentesis but instead of using amniotic fluid to create the karyotype, the physicians use a piece of the mother's placenta. The placenta is the organ that connects the fetus to the uterine wall and provides nutrients while the fetus develops. Additionally, patients typically undergo CVS between ten and twelve weeks of pregnancy.

People with Down syndrome have a higher risk of developing many physical health problems at different times in their lives. The health problems include hearing loss, sleeping disorders, ear infections, eye disease and compromised vision, and mild to severe congenital heart defects. According to the CDC, approximately fifty to seventy-five percent of people with Down syndrome have one or more of those conditions. Congenital heart defects are malformations of the heart that are present at birth. Twelve percent of people with Down syndrome are born with bowel obstructions, which are blockages that prevent material from moving through the intestines. Four to eighteen percent of people with Down syndrome develop thyroid disease. A thyroid disease includes any abnormalities of the thyroid gland and hormones that it produces. Ten to thirteen percent have some form of anemia. Anemia refers to low red blood cell count or low hemoglobin levels, which

can impair the body's ability to transport oxygen and carbon dioxide. Six percent of people with Down syndrome have frequent hip dislocations that can require surgery. Approximately one percent of people with Down syndrome develop leukemia. Leukemia is a type of cancer that affects blood-forming tissue and makes it hard for the body to fight infection. Due to the high risk of life-threatening diseases involved with Trisomy 21, life spans of people with the condition are generally shorter than average.

There are different financial options in the US to assist people who have Down syndrome. One of the more common options is Supplemental Security Income, or SSI, a form of financial aid from the US Social Security Administration. While everyone with Down syndrome technically qualifies for SSI, the benefits primarily go to those in dire financial need. For example, as of 2018, an adult with Down syndrome could not have more than \$2,000 US saved and could not be making more than \$750 US per month to receive SSI. A parent or legal guardian with a child who has Down syndrome applying for SSI follows slightly more lenient guidelines. The larger the household the family member is taking care of, the larger the income is allowed to be while still receiving SSI.

According to the National Down Syndrome Society, many people living with Down Syndrome have had accomplished careers. A few of those people are Zack Gottsagen, Chelsea Werner, and Éléonore Laloux. An actor named Zack Gottsagen became the first person with Down syndrome to present an award at the Oscars in 2020. Gottsagen starred in the blockbuster movie *The Peanut Butter Falcon* alongside Shia LaBeouf in 2019. According to LaBeouf, Gottsagen's friendship helped him to recover from alcoholism. Chelsea Werner is a four-time medalist at the Special Olympics in gymnastics. Despite not being able to walk until the time she was two years old due to low muscle tone, Werner defied the doctor's predictions that she would be in a wheelchair for life and went on to become a Special Olympics athlete and medalist. As of 2020, she is a model. Éléonore Laloux became the first elected official with Down syndrome in France when she won a local council seat in Arras, France, in 2020. Laloux's political work focuses on improving the cleanliness of her town and improving accessibility for people with disabilities.

A major ethical dilemma surrounding Trisomy 21 is high abortion rate after a positive screening. As of 2018, in the US, approximately sixty-seven percent of mothers with confirmed Trisomy 21 cases terminate their pregnancies. Sara Hart Weir, the president of the National Down Syndrome Society at the time, stated that their organization is highly concerned about those statistics and what they suggest about the type of information pregnant women are receiving from their medical professionals about a Trisomy 21 diagnosis. In 2016, legislators in Missouri tried to place a ban on abortion as a result of a positive Down syndrome screening, but the bill failed. Planned Parenthood Advocates of Missouri, an abortion advocacy group, commented on the attempt, saying that there is no way to know the reason behind a woman's decision to choose abortion and that the proposed legislation was a covert way to ban abortion.

As of 2022, Trisomy 21 is the most common type of trisomy. The existence of the condition has prompted extensive research into genetic disorders as well as ethical debates surrounding disability and abortion. As of 2022, people with Down syndrome continue to advocate for accommodations and fair treatment.

Sources

1. Abboud, Alexis, "Dennis Lo (1963-)". Embryo Project Encyclopedia (2014-11-04). ISSN: 1940-5030 <http://embryo.asu.edu/handle/10776/8233> (Accessed August 1, 2022).
2. Ataman, Ahmet Doğan, Emine Elif Vatanoğlu-Lutz, and Gazi Yıldırım. "Medicine in Stamps: History of Down Syndrome through Philately." *Journal of the Turkish German Gynecological Association* 13 (2012): 267-9. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3881714/> (Accessed August 1, 2022).
3. Brind'Amour, Katherine, "Chorionic Villus Sampling". Embryo Project Encyclopedia (2009-01-21). ISSN: 1940-5030 <http://embryo.asu.edu/handle/10776/1947> (Accessed August 1, 2022).
4. CDC. "Facts about Down Syndrome." Centers for Disease Control and Prevention, Specific Birth Defects. Last modified April 6, 2021. <https://www.cdc.gov/ncbddd/birthdefects/downsy>

- ndrome.html (Accessed August 1, 2022).
5. Clift, Dean, and Melina Schuh. "Restarting Life: Fertilization and the Transition from Meiosis to Mitosis." *Nature Reviews Molecular Cell Biology* 14 (2013): 549-62. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4021448/> (Accessed August 1, 2022).
 6. Davidson, Colette. "Éléonore Laloux Helps France See Disability Differently." *The Christian Science Monitor*, October 15, 2021. <https://www.csmonitor.com/World/Europe/2021/1015/Eleonore-Laloux-helps-France-see-disability-differently> (Accessed August 1, 2022).
 7. Ettinger, Zoe. "13 People with Down Syndrome Who Are Breaking Barriers in Entertainment, Athletics, Fashion, and More." *Insider*, March 10, 2020. <https://www.insider.com/people-with-down-syndrome-breaking-barriers> (Accessed August 1, 2022).
 8. Kelley, Kristin, "Amniocentesis Prior to 1980". *Embryo Project Encyclopedia* (2010-09-02). ISSN: 1940-5030 <http://embryo.asu.edu/handle/10776/2072> (Accessed August 1, 2022).
 9. Kendig, Rose. "Qualifying for Social Security Disability Benefits- Individuals with Down Syndrome." *Chesapeake Down Syndrome Parent Group Baltimore, MD*. Last modified June 18, 2018. <http://courtney-dunevant.squarespace.com/blog/2018/6/18/qualifying-for-social-security-disability-benefits-individuals-with-down-syndrome> *Accessed August 1, 2022).
 10. Langdon Down, John. "Observations on an Ethnic Classification of Idiots." *London Hospital Reports* 3 (1866): 259-62.
 11. MedlinePlus Genetics. "Chromosome 21." *MedlinePlus, U.S. National Library of Medicine*. Last modified June 1, 2021. <https://medlineplus.gov/genetics/chromosome/21/> (Accessed August 1, 2022).
 12. Mégarbané, André, Aimé Ravel, Clotilde Mircher, Franck Sturtz, Yann Grattau, Marie-Odile Rethoré, Jean-Maurice Delabar, and William C. Mobley. "The 50th Anniversary of the Discovery of Trisomy 21: The Past, Present, and Future of Research and Treatment of Down Syndrome." *Genetics in Medicine* 11 (2009): 611-6. <https://www.sciencedirect.com/science/article/pii/S1098360021039599?via%3Dihub> (Accessed August 1, 2022).
 13. National Center for Biotechnology Information (US). "Chromosome Map." *Genes and Disease* [Internet]. U.S. National Library of Medicine. <https://www.ncbi.nlm.nih.gov/books/NBK22266/> (Accessed August 1, 2022).
 14. National Down Syndrome Society. "Down Syndrome Facts: National Down Syndrome Society." *NDSS*. <https://www.ndss.org/about-down-syndrome/down-syndrome-facts/> (Accessed August 1, 2022).
 15. Reuters. "This 34-Year-Old Could Become France's First Local Politician with Down Syndrome." *New York Post*, March 4, 2020. <https://nypost.com/2020/03/04/this-34-year-old-could-become-frances-first-local-politician-with-down-syndrome/> (Accessed August 1, 2022).
 16. The Fetal Medicine Foundation. "Nuchal Translucency Scan." *The Fetal Medicine Foundation*. <https://fetalmedicine.org/fmf-certification-2/nuchal-translucency-scan> (Accessed August 1, 2022).
 17. Social Security Administration. "Understanding Supplemental Security Income SSI for Children - 2022 Edition." *SSA*. <https://www.ssa.gov/ssi/text-child-ussi.htm> (Accessed August 1, 2022).
 18. University of California San Francisco Health. "Prenatal Testing for Down Syndrome." *UCSF Health*. <https://www.ucsfhealth.org/education/prenatal-testing-for-down-syndrome> (Accessed August 1, 2022).
 19. Wakeman, Jessica. "The Debate Over Terminating Down Syndrome Pregnancies." *Healthline Media*. Last modified December 6, 2018. <http://www.healthline.com/health-news/the-debate-over-terminating-down-syndrome-pregnancies> (Accessed August 1, 2022).