

## Assistive technologies to support people with disabilities

### SUMMARY

'Disability' is complex and multi-dimensional. It denotes impairments, limitations on activity and restrictions on participation – a combination of medical and contextual factors. People with disabilities are a diverse group. Some are born with a disabling condition, others acquire a disability through injury or a chronic disease, yet others develop a disability in older age.

The health needs of disabled people vary depending on the type of limitation and the primary health condition. Some may result in high healthcare needs, while others do not. On the whole, however, people with disabilities have a poorer health status than the general population. Several factors contribute to these health disparities.

The way disability is addressed has shifted from a purely medical approach to one that focuses on maximum functioning and well-being. Assistive technologies to support people with disabilities have also evolved. They now cover sophisticated ICT, software, cyber-physical and stem-cell applications. A range of examples are provided from the five broad categories of motor, vision, hearing, cognitive and communication disabilities. They include non-invasive and invasive brain-computer interfaces, wearable devices, stem-cell applications, neuroprosthetics, humanoid robots and applications (apps).

The EU has funded several research projects on the development of assistive technologies under its research and innovation framework programmes.



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**Glossary<sup>1</sup>**

**Age-related macular degeneration (AMRD):** an eye disease that progressively destroys the macula, the oval-shaped pigmented area near the centre of the retina, thereby impairing central vision. The disease occurs most commonly in people over 60 years of age.

**Amyotrophic lateral sclerosis (ALS) or motor neurone disease:** a progressive nervous-system disease that attacks the nerve cells (neurons) that control muscles voluntarily. Both the upper motor neurons and the lower motor neurons degenerate or die, ceasing to send messages to the muscles. Unable to function, the muscles gradually weaken, waste away and twitch. Eventually, the ability of the brain to start and control voluntary movement is lost.

**Assistive technologies (AT):** an umbrella term that includes assistive, adaptive and rehabilitative devices for people with disabilities.

**Cerebral palsy:** a group of disorders that affect a person's ability to move and to maintain balance and posture. The disorders appear in the first few years of life and usually do not worsen over time. People with cerebral palsy may have difficulty walking and trouble with tasks such as writing. Some have other medical conditions, including seizure disorders or mental impairment.

**Co-morbid condition:** an additional condition independent of and unrelated to the primary health condition, but that can later adversely affect the health of people with disabilities. Examples of co-morbid conditions include cancer or hypertension for a person with an intellectual impairment.

**Dyslexia:** a reading disability that occurs when the brain does not properly recognise and process certain symbols.

**Glaucoma:** a condition in which the fluid pressure in a person's eyes slowly rises, damaging their optic nerve.

**Locked-in syndrome:** a rare neurological disorder characterised by complete paralysis of voluntary muscles in all parts of the body except for those that control eye movement. It may result, among other things, from traumatic brain injury, diseases of the circulatory system or medication overdose.

**Paralysis:** the loss of muscle function. It can be partial or complete. Most paralysis is due to strokes, or injuries such as spinal cord injury or a broken neck.

**Paraplegia:** paralysis of the lower half of the body, including both legs.

**Primary health condition:** the possible starting point for impairment or activity limitation. Examples include depression, arthritis, cerebral palsy and Down syndrome.

**Quadriplegia or tetraplegia:** paralysis of the arms and legs.

**Secondary condition:** a condition that occurs subsequently, with a lapse in time, to a primary condition. Examples include pressure ulcers, urinary tract infections and depression. Secondary conditions can reduce functioning, lower the quality of life and lead to premature mortality.

**Spina bifida:** a type of birth defect of the brain, spine or spinal cord. It happens if the spinal column of the foetus does not close completely during the first month of pregnancy.

**Spinal cord injury (SCI):** an injury to the spinal cord. It may be **traumatic** (stemming from a blow to the spine that fractures, dislocates or crushes one or more vertebrae) or **non-traumatic** (caused by arthritis, cancer, infections, or disk degeneration of the spine).

### Disability: definition, concept, prevalence

#### Definition

'Disability' is complex and multi-dimensional. The [International Classification of Functioning Disability and Health](#) (ICF) of the World Health Organization (WHO) defines it as an 'umbrella term for impairments, activity limitations and participation restrictions'. According to this [definition](#), disability results from the negative interaction between an individual with a health condition (e.g. cerebral palsy) and that individual's contextual (in other words, personal and environmental) factors (e.g. negative attitudes, inaccessible transportation).

#### Concept

This understanding of disability as a combination of medical and contextual factors is also mirrored in the [United Nations Convention on the Rights of Persons with Disabilities](#) (UNCRPD), namely that people with disabilities 'include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others'. People with disabilities are a [diverse group](#): some are born with a disabling condition (e.g. Down syndrome) or demonstrate a condition early in life (e.g. autism). Others acquire a disability through injury (e.g. spinal cord injury) or a chronic disease (e.g. loss of a limb because of diabetes). Still others develop a disability in later stages of life (e.g. dementia, age-related mobility disability).

#### Prevalence

Around 44 million people aged 15 to 64 in the EU28 have [reported](#) a disability.<sup>2</sup> According to Eurostat [data](#)<sup>3</sup> from 2011, about 26% of people aged 16 years or over living in the EU28 declared health-related, long-term (lasting more than six months) limitations in usual activities; 8.2% of them [reported](#) a severe, and 17.5% a moderate, disability. The prevalence of disability increases with age and is higher in people aged 65 or more (about 54%) compared to people aged 16 to 64 (18%).

### Specific healthcare needs of the disabled

The health needs of disabled people vary depending on the type of limitation (e.g. the ICF categories, musculoskeletal, cardiopulmonary, neurological) and the condition underlying the disability, that is, the primary health condition (e.g. spina bifida). Some may result in high healthcare needs (as in the case of people with multiple sclerosis, cystic fibrosis or schizophrenia), while others do not (a person born blind may not specifically require ongoing healthcare). On the whole, however, people with disabilities have a poorer health status than the general population. According to the [WHO World report on disability](#), several factors contribute to such differing levels of health, or 'health disparities'.

#### *Risk of developing secondary conditions and co-morbid conditions*

Some disabled people have a higher risk of secondary conditions, such as depression and osteoporosis. Others may be more susceptible to developing (or experience an earlier onset of) chronic diseases, for instance due to inactivity. Moreover, some groups of people with disabilities have increased rates of co-morbid conditions such as high blood pressure, cardiovascular disease or diabetes (e.g. in the case of people with schizophrenia).

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### *Greater vulnerability to age-related conditions*

The ageing process begins earlier than usual for some groups of disabled people, and age-related conditions may be more common among them. People with Down syndrome, for instance, have a higher risk of developing Alzheimer's disease.

### *Increased rates of behaviour causing risks to health*

People with disabilities are more likely to be overweight or obese, present higher rates of smoking, and tend to be less physically active.

### *Higher risk of unintentional injury*

Some groups of disabled people are at higher risk of injury from road-traffic crashes, burns, falls and accidents.

### *Higher risk of premature death*

While mortality rates vary depending on the primary health condition, people with schizophrenia, learning impairments or mental health disorders generally have lower life expectancy.

### **Approach to disability: a shift towards maximising functioning**

The way disability is addressed has evolved from a purely medical model – in terms of patients adjusting to their limitations – to one of overcoming the barriers imposed by specific physical impairments. Harvard Medical School Professor [Lisa Iezzoni](#) has called this 'a shift from prevention or cure to maximising functioning and well-being'. Along the same lines, Article 4(1)g of the UNCRPD obliges parties 'to promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies, mobility aids, devices and assistive technologies, suitable for persons with disabilities, giving priority to technologies at an affordable cost'.

## **Trends in assistive technologies**

According to the international standard ISO 9999:2011, an assistive product is 'any product (including devices, equipment, instruments and software), especially produced or generally available, used by or for persons with disability: for participation; to protect, support, train, measure or substitute for body functions/structures and activities; or to prevent impairments, activity limitations or participation restrictions'. Previously, such devices were designed to perform one particular function or address one specific disability. However, disabilities cannot easily be categorised, and even two people with the same disability can have different degrees of impairment. The focus has therefore shifted to a more personalised, user-centred approach – from 'low-tech' devices to advanced [assistive technologies](#) that include sophisticated ICT, software, cyber-physical and stem-cell applications.

The examples set out below illustrate some of the emerging trends. They are presented in five broad sub-categories: motor, vision, hearing, cognitive and communication disabilities.

### **Motor disabilities**

Motor disabilities, or mobility impairments, affect the upper and/or lower limbs. They include, for instance, cerebral palsy, spinal cord injuries (traumatic and non-traumatic), Parkinson's disease, multiple sclerosis, amyotrophic lateral sclerosis and varying degrees of paralysis, including locked-in syndrome.

An [estimated](#) 2.6 million people in the EU have mobility problems affecting their upper limbs, and approximately half of them require assistive technologies to perform

everyday tasks. The needs of people with severe motor disabilities can be addressed by means of [brain-computer interfaces](#) (BCI). A BCI is a system that translates brain signals into commands, which are then relayed to a device that carries out actions. BCIs are [either](#) invasive or non-invasive: invasive when electrodes are surgically implanted on or near the surface of the brain ([brain implants](#), [neuroprosthetics](#)); non-invasive when electrodes are placed on the scalp, usually held in place in a cap.

*Examples of non-invasive and invasive BCIs*

- A prototype [tongue-drive system](#) enables people with upper-level spinal cord injuries to navigate an electrically powered wheelchair by moving their tongue: the users wear a dental retainer embedded with sensors, which they control by means of a [tongue stud](#) containing tiny magnets.
- In a project funded by the US Defense Advanced Research Projects Agency, a precision-controlled [prosthetic arm](#) has been developed to restore functionality for people with upper-extremity amputations: electrodes detect electrical signals from the person's muscles and send them to a computer processor in the prosthesis, which translates them into a specific movement.
- Deep brain stimulation (DBS) is a type of [neurosurgery](#) used to treat some symptoms of Parkinson's disease, such as slowness of movement, stiffness and tremor. The [DBS system](#) consists of three components: the electrode, [implanted](#) in the brain; the extension, which is passed under the skin, connecting the electrode to the implantable pulse generator (IPG), usually placed around the chest area. When the device is switched on, the electrode delivers high-frequency stimulation to the targeted area in the brain, thereby changing some of the electrical signals that are responsible for the symptoms of Parkinson's disease.
- An ongoing small-scale project on gait rehabilitation has studied the use of a [mind-controlled exoskeleton](#) – a wearable robotic 'suit' that encases the limbs of people with lower extremity weakness, such as in the case of stroke or spinal cord injury. It works by converting brain signals into movement: the individual wears an electrode cap that allows the device to read brain activity patterns associated with the wearer's intentions to move. These are then translated into an electrical signal that moves the legs of the exoskeleton, allowing the person to walk. The device also feeds tactile information back to the wearer on how they are walking. Evidence from the study suggests that this feedback has partially reawakened the nervous systems of the participants by prompting nerve cells to reactivate and regrow. As a result, all of the people participating were found to regain sensations and the ability to move previously paralysed limbs.
- In a recent [experiment](#), researchers used a brain implant to enable a quadriplegic man to control a robot arm with fluid fine-motor movements. The team placed the implant in the [action-planning part](#) of the brain (the posterior parietal cortex) for the first time, and not in the area of the brain responsible for the *mechanism* of movement (the motor cortex). This allowed the man to steer the robotic arm so smoothly that he could pick up a bottle of beer and drink from it.

### **Stephen Hawking: mind over matter**

At age 21, the famous British scientist and author (now 73) was diagnosed with a slow-progressing form of amyotrophic lateral sclerosis and given two years to live. Yet, in spite of a disease that has gradually paralysed him over the decades, leaving him wheelchair-bound and dependent on a computerised voice system, he went on to [become](#) a world-renowned researcher and 'one of the most brilliant theoretical physicists since Einstein'.

### Vision disabilities

Vision impairments range from 'low vision' – a [term](#) grouping together moderate and severe visual impairment as per International Classification of Diseases (ICD) – to blindness. Visual impairment can be the result of an injury to the eye or a number of eye-related conditions, such as age-related macular degeneration, glaucoma and diabetic retinopathy. It can also be hereditary or caused by brain and nerve disorders.

*Examples of a wearable device, a stem-cell application and a neuroprosthetic*

- A [glove](#)-shaped wearable communication device is currently being developed for people who are deaf and blind. It translates 'Lorm', a hand-touch sign language used by the deaf-blind to communicate, into text messages and emails, and vice versa.
- A [small-scale study](#) involving patients with two types of eye diseases – age-related macular degeneration, the most common cause of vision loss in people over 60 years of age, and Stargardt's macular dystrophy, a rarer congenital disease – has provided the first evidence that [stem-cell transplants](#) from human embryos may be a safe and potentially effective therapy to help improve the sight of the nearly blind.
- Researchers are now constructing novel visual prostheses ('bionic eyes') that aim to restore sight for blind people or people with profound vision loss. The devices work by stimulating neurons in the retina or in the optic nerve.<sup>4</sup> First [results](#) have shown that the implants may enable blind patients to recognise objects and even perform reading tasks.

### Hearing disabilities

Hearing loss, or deafness, can be congenital. It can also result from disease (e.g. ear infections and meningitis), trauma, the side-effects of certain medicines, long-term exposure to loud noise, and ageing.

A person's ability to hear can be [improved](#) by hearing aids and – for deaf or profoundly hearing-impaired people who cannot use ordinary hearing aids – [ear implants](#). The most commonly used type of ear implant is the cochlear implant, an electronic [device](#) that transforms acoustic information into an electrical signal, which is then delivered directly to the auditory nerve. It consists of an internal part made up of a transmitter surgically implanted into the bone surrounding the ear (temporal bone), with an [electrode array](#) positioned in the [cochlea](#), and an external part – a microphone and speech processor. Approximately [324 000](#) people worldwide have received cochlear implants (data as of December 2012).

*Example of a neuroprosthetic used for gene therapy*

- [Scientists](#) have for the first time used cochlear implants for gene therapy: the electrical pulses delivered from the implant were utilised to deliver a solution of DNA molecules close to the implanted electrodes. These cells then produced neutrophins (proteins important for the development and function of neurons), thereby triggering the regeneration of auditory nerves. The new technique, which has so far only been tested in guinea pigs, is [thought](#) to have important implications far beyond hearing disorders.

### Cognitive disabilities

Cognitive disabilities [encompass](#) various conditions affecting intellectual or cognitive ability, such as Down syndrome, traumatic brain injury, autism and dementia. Examples may also include less severe conditions such as dyslexia, attention deficit disorder and other learning disabilities that involve problem-solving, mathematical comprehension, reading, linguistic and verbal comprehension.

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### *Example of a cyber-physical application*

- [Researchers](#) are using humanoid [robots](#), such as NAO or ZENO, to help children with autism improve social skills. Autistic children typically find human interaction overwhelming, and engaging with these interactive 'social' robots may prove to be a valuable learning tool.

### **Communication disabilities**

Speech impairments may range from mild to severe and [refer](#) to an impaired ability to produce speech sounds. They include articulation disorders (omissions or distortions of sounds), fluency disorders (atypical flow or rhythm) and voice disorders (abnormal pitch, volume, vocal quality or duration). Speech disabilities are caused by, or associated with, other disorders or disabilities, including amyotrophic lateral sclerosis, cerebral palsy, stroke, brain damage, Parkinson's disease, autism and Down syndrome.

### *Examples of applications (apps)*

- A free [app](#) allows people who cannot speak to display some basic concepts to other people by means of 'yes' and 'no' buttons and scrollable lists of statements.
- A free [app](#) for people who have difficulty speaking utilises the audio output of the phone to speak words, phrases and sentences.
- A prototype [app](#) enables people with speech and language disorders to communicate by translating unintelligible pronunciation into understandable speech.

### **Towards breakthroughs in cross-cutting fields**

Some advances have shown potential benefits across categories: apps,<sup>5</sup> for instance, may not only help the blind and deaf, but also individuals with autism or learning disabilities. Similarly, stem-cell therapy may be used to repair sight and hearing, but also for neurodegenerative conditions; deep brain stimulation may apply to Parkinson's and Alzheimer's diseases; and brain-computer interfaces may serve visual and acoustic needs.

## **EU action and programmes**

The EU framework for implementing the UNCRPD is the [European Disability Strategy 2010-20](#), adopted in 2010. It takes into account the experience of the [Disability Action Plan](#) (2004-10). The Strategy is accompanied by a [list of actions](#) for the 2010-15 period, among them actions to 'support research on new technologies addressing assistive technology'. The European Commission has funded several research projects on the development of assistive technologies, through various programmes. Below is a selection of recent and/or ongoing projects under the EU's Seventh Framework Programme (FP7):

- [ABCIT](#) (Advancing Binaural Cochlear Implant Technology): an ongoing project that started in 2012 and is co-funded by the EU with €4 million. The aim is to design a novel cochlear implant that allows users to experience more normal binaural (two-ear) listening.
- [ASSISTID](#) (Assistive Technologies in Autism and Intellectual Disability): an ongoing project that started in 2014, co-funded by the EU with €3.52 million. It trains experienced researchers in assistive technologies and behavioural sciences as applied to people with autism and intellectual disabilities.
- [AsTeRICS](#) (Assistive technology rapid integration and construction set): a project that ran from 2010 to 2012 and was funded with an EU contribution of €2.65 million. It proposed IT-based solutions to enable people with reduced upper-limb motor capabilities to access brain-computer interfaces at the desktop as well as on mobile

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phones or smart home devices. The project has since led to commercial production.

- **[MINDWALKER](#)**: a project that ran from 2010 to 2013 and was co-funded with an EU contribution of €2.75 million. Its aim was to design a system empowering lower-limb disabled people with walking abilities to perform their daily activities in an autonomous way (i.e. a 'mind-controlled exoskeleton' – see description above).
- **[SIGNLEARNSPEAK](#)**: an ongoing project that started in 2011, funded with an EU contribution of €246 000. It examines the relationship between linguistic and non-linguistic cognitive processes in deaf children's vocabulary development, with the aim to support language learning. It started in 2011 and is ongoing.

### European Parliament: events on assistive technologies for the disabled

On 7 March 2013, the European Parliament hosted the international [EC:GC2](#) Assistive Technologies (AT) Conference chaired by Marian Harkin, MEP. It comprised a [symposium](#) and workshops. Among the main [outcomes](#) was the creation of an inter-disciplinary global AT consortium to advance assistive technologies for people with autism and intellectual disabilities. On 23 June 2015, the Parliament's STOA Panel has organised the [workshop](#) 'Robots: Enabling the disabled or disabling the abled?', chaired by Ádám Kósa, MEP.

### Main references

[World report on disability](#), World Health Organization (WHO), 2011.

Gloria L. Krahn et al., [Persons with disabilities as an unrecognized health disparity population](#), *Am J Public Health*. 2015; 105:S198–S206.

### Endnotes

- <sup>1</sup> Adapted from [disabled-world.com](#), [How to use the ICE](#), [MedlinePlus](#), [MedicineNet.com](#), [NIH](#) website, [Chapter 3 – General health care](#) of the WHO World report on disability.
- <sup>2</sup> Prevalence estimates from public health surveys may differ since disability can be defined and categorised in different ways. Here, it is [defined](#) as 'self-reported limitation in the activities of everyday life'.
- <sup>3</sup> Data derived from the [EU statistics on income and living conditions \(EU-SILC\)](#).
- <sup>4</sup> Different approaches to placing the visual implants are being investigated: subretinal (between the retina and the [retinal pigment epithelium](#) (RPE); epiretinal (on the surface of the retina); suprachoroidal (between the choroid and the [sclera](#)); intrascleral (between the layers of the sclera).
- <sup>5</sup> The apps are taken from [myhealthapps.net](#), a website compiling free and commercial user-reviewed healthcare apps. Detailed information is provided for each app, including the name of the developer.

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