

# Assistive technology: Impact on education, employment, and independence of individuals with physical disabilities

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**Abstract.** The purpose of this manuscript is to discuss how assistive technology impacts individuals with disabilities in relation to their education, employment, and ability to live independently. Appropriately selected and utilized assistive technology is imperative for individuals to approach an even par with their non-disabled peers. This paper specifically addresses a number of key questions: How important is assistive technology (AT) to the success of individuals with disabilities in education, employment, and achieving independence? If AT is important, in what ways is it important? What essential need(s) are met by the use of AT in education, employment, and independence? What remain as unresolved issues and questions regarding the use of AT by individuals with disabilities as they pursue postsecondary education, meaningful careers, and living independently? This review notes that AT is a foundational support that produces multiple and life-altering benefits. While we know much about the impact of AT on the lives of individuals with disabilities, many unanswered issues and questions remain.

**Keywords:** Assistive technology, independence, education, employment, physical disability

## 1. Introduction

The research questions being addressed here are the following: How important is assistive technology (AT) to the success of individuals with disabilities in education, employment, and achieving independence? If AT is important, in what ways is it important? What essential need(s) are met by the use of AT in education, employment, and independence? What remain as unresolved issues and questions regarding the use of AT by individuals with disabilities as they pursue post-

secondary education, meaningful careers, and living independently?

We are interested in these questions because of our focus on providing effective assistance to individuals with disabilities in achieving in postsecondary education and careers in science, technology, engineering and mathematics, and in other fields. In addition, we have a significant history in the research, design, and utilization of AT. Our research and that of other investigators has shown that for AT to be selected and utilized optimally, a number of conditions must be right. For example, the assistive technology must be affordable, reliable, maintainable, and of sufficient design quality that the AT device will enable the intended assistance. The purpose of this paper is not to address these issues per se. Instead, we are interested in attempting to deter-

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mine the impact of AT on education, employment, and independence, without the confounding effects from these issues. The results should be useful in addressing the potential value or significance of assistive technology. We have chosen to use a literature and research analysis approach to answer the above questions, using a process adapted from Goldsmith, Bankhead, and Austoker's work on synthesizing qualitative research and information [24].

This literature and research synthesis will start with examining the growing prevalence of physical disability in America as well as both traditional and newer definitions of independence. The article then moves to a discussion of assistive technology. The impact of AT on the education, employment, and independence of individuals with physical disabilities will then be explored. The last section highlights some of the unresolved issues surrounding assistive technology for persons with physical disabilities.

## 2. Disability and aging in America

It is well established that disability is becoming a common experience in the lives of many Americans. Older individuals are living much longer than their counterparts of just a few decades ago. And while older individuals in general are healthier than ever before, they are experiencing relatively high rates of disability – 50% for those 65 or older and 75% for those age 80 and above [5,57,60]. Additional co morbid conditions increase a person's risk for a new disability; for example, in one study, individuals with four or more conditions at baseline were almost three times as likely to have lost mobility at follow-up [25].

In addition, individuals with disabilities are experiencing the highest rates of survival ever recorded [36, 40,59], such as individuals with spinal cord injury [18, 22,39,64]. For example, in 1987, individuals who experienced a spinal cord injury at the age of 20 were expected to live until the age of 40 to 53 years, while those injured at age 20 in 1995 were expected to live until the age of 55 to 65 years [28].

These two groups, those who age and become disabled and those with disabilities who become older, make up approximately 40 to 50 million people in the United States [20]. These numbers are expected to rise as many medical and technological advances continue to extend the life expectancy and health of many older individuals, while simultaneously the baby boom generation gets older and experiences more disability.

If one considers people who now have disabilities (at least one in seven Americans), people who are likely to develop disabilities in the future, and people who are or who will be affected by the disabilities of family members or others close to them, then disability affects today or will affect tomorrow the lives of most Americans. Clearly, disability is not a minority issue [28, p. 1].

Hence, America has a large population of individuals who currently need or will need in the relatively near future, assistance in living with a chronic disability. Sheets and Liebig [60, p. 145] cautioned service providers “demographic shifts have created a growing intersection between the older and disabled populations, giving them a shared stake in improving access to supportive environments” which includes assistive technology. This intersection has been called a convergence of “those living with and aging into disability” [10, p. 67].

Disability, itself, is a notion that is not always quantifiable and precise, and which varies from day to day and situation to situation [58,70]. Disability, then, is not just a physical or inherent attribute, but a result of interactions between people and their physical and social environments, including a complicated mix of social, cultural, political, climatic, topographic, architectural, and technological components [1,4,9,20,43, 69,70]. This latter observation is certainly appropriate when discussing the complex contexts and interplays of disability and assistive technology's impact on independence, education, and employment.

## 3. Assistive technology

In 1993, the National Council on Disability (NCD) released one of the first studies on assistive technologies for individuals with disabilities that proclaimed:

- About 76% of children who received AT were able to remain in a regular classroom, and about 45% were able to reduce school-related services.
- About 62% of working-age persons were able to reduce dependency on their family members, and 58% were able to reduce dependence on paid assistance.
- About 80% of older persons were able to reduce their dependence on others, and about half were able to avoid entering a nursing home.
- About 92% of employed persons reported that AT helped them to work faster or better, 83% indi-

cated that they earned more money, and 67% reported that AT had helped them to obtain employment [48, p. 1165].

In a more recent effort, the National Organization on Disability/Harris [45] survey found that nearly half of individuals with disabilities use assistive technologies specific to their disabilities. In addition, these same individuals rely on many mainstream technologies such as cordless telephones and on-line banking. Russell, Hendershot, LeClere, Howie, and Adler [53] found that nearly 7.4 million individuals used mobility devices, such as canes, walkers, and wheelchairs, while over 4.5 million used anatomical devices, such as leg braces and artificial limbs, and nearly 4.5 million used hearing devices. The investigators reported that use of AT devices had increased dramatically over the previous decade and one can assume this trend has continued in the decade since this study.

From these data, it would appear that AT is beneficial to a majority of individuals needing such assistance. Finlayson and Hammel [21] reminded us: "AT is not a panacea, but it does offer people opportunities to participate in life in ways that might not have been otherwise possible" (p. 109). When AT is appropriately matched to the individual with aspects of the environment, needs and preferences of the individual, and functions and features of the technology considered, assistive technology has great capacity to aid the individual in gaining increased independence, access to postsecondary education, and success in meaningful employment [52,54,55,58]. Indeed the potential benefits of AT are much more likely to be realized when the person-technology fit is a good one [16,17,33,34, 52,55,66].

The Technology Related Assistance for Individuals with Disabilities Act of 1988 as amended in 1994 and again in 2004 (Public Law 108-364 or the Assistive Technology Act, ATA) [8] has played an important role in providing necessary technology and devices to individuals with need. The ATA defined assistive technology devices as "any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities." This definition encompasses any device or item that helps an individual with a disability to complete tasks of daily living, and to participate in education, the workforce, and community life [48, 58]. Assistive technology devices may include durable medical equipment (DME), mobility devices (such as wheelchairs, canes, or walkers), prosthetics and or-

thotics, environmental controls, home modifications, and seeing, listening, and communication devices.

While the ATA and its reauthorizations have done much to improve the AT landscape for many individuals, much work remains. According to the law authorizing the ATA [8],

Despite the success of the Federal-State partnership in providing access to assistive technology devices and assistive technology services, there is a continued need to provide information about the availability of assistive technology, advances in improving accessibility and functionality of assistive technology, and appropriate methods to secure and utilize assistive technology in order to maximize the independence and participation of individuals with disabilities in society.

AT is meant to improve functional independence by circumventing environmental barriers, maximizing personal independence, and increasing activity participation. This, in turn, then affords greater opportunity for societal participation and integration, including in institutions of higher education and the workforce [15, 29,50].

AT devices are designed to *enable* persons with disabilities (users) to achieve utmost level of functioning in specific life roles. Therefore, the fundamental yardstick of AT impact is the user's *change in functioning* in activities involving the assistive devices. . . *Quantity of functioning* reflects the user's participation in a wide range of activities in different contexts or the consistency with which the user is able to perform specific activities. . . the *quality of functioning* is the ease and comfort with which a user accomplishes an activity using a device [7, p. 235].

For these reasons, the use of AT has dramatically increased in the US – at much higher rates than should be expected from the aging of the population alone – due to its availability and the functional limitations of a greater number of individuals [30,60]. However, Carlson, Ehrlich, Berland, and Bailey [21] reported that up to 60% of persons with disabilities received little or no information about AT in general or about how to obtain AT and cost has been reported as one of the major barriers to obtaining or upgrading AT [26,45].

#### 4. Assistive technology and higher education

The National Organization on Disability [45] noted that individuals with disabilities are less likely than

their non-disabled peers to complete college. While approximately 25% of individuals without disabilities complete college educations, only 13% of persons with mild and 2% of persons with severe disabilities complete similar degrees. Christ and Stodden [14] reported that almost 17 percent of all individual enrolled in higher education in the US self-identified as having a disability, indicating a growing need to address a number of access issues in postsecondary education. While students with disabilities are faring better than ever before, they are still not faring equally with their non-disabled counterparts: "While enrollment of students with disabilities in postsecondary education is increasing significantly, few such students are progressing and completing their program of studies at a level and within the time period of their non-disabled peers" [63, p. 196].

It is well-documented that higher education greatly enhances an individual's ability to secure meaningful employment and greater earnings – and this becomes notably true for individuals with disabilities [44,49,61, 62,70,72]. Zwerling et al. [72] reported that individuals with disabilities who were more educated fared much better in the working world than persons with disabilities with less education. As noted by Christ and Stodden [14, p. 24], "Research has shown that successful postsecondary education for students with disabilities leads to a more productive and fulfilling life, financial success, and improved vocational options."

However, as noted by a number of researchers [27, 46], there is little serious discourse on many college campuses about inclusion of individuals with disabilities in postsecondary education beyond "a minimalist approach" [62, p. 119] to physical access, such as ramps and curb cuts. A wide variety of programmatic, financial, social, and policy barriers preclude individuals with disabilities from being equals on campus due to the enormous time, energy, and resources it takes to identify, negotiate, and resolve problems with inaccessible classrooms, laboratories, and living spaces, inappropriate assessment techniques and support services, and less-than-positive attitudes of faculty and students. Lack of or inaccessible assistive technology (especially information technology) is one of the prime barriers within high education institutions for individuals with physical disabilities [27,46].

This is quite surprising, since some researchers [50, 62,63], proposed that the ubiquitous use of computers and other forms of assistive/information technology will greatly enhance and nearly equalize the ability of individuals with disabilities – especially severe disabilities – to attend and graduate from postsecondary institutions.

Stodden, Whelley, Chang, and Harding [63] reported on a 1998 national study of 650 postsecondary disability support coordinators. They found that testing accommodations were the most likely service to be offered and AT evaluations of students to be the least likely to be offered. They stressed

It is important to remember how important assistive technology is for students who use it. Students with disabilities in a national focus group considered assistive technology to be a "right, not a 'support'" . . . Despite the importance that students with disabilities appear to place upon assistive technology, fifteen to twenty-eight percent of the responding postsecondary programs did not offer such services at all. (p. 196)

Ofesh et al. [49] surveyed 163 disability service providers in higher education institutions and reported that the most frequent AT accommodations for students with disabilities included voice recognition systems, reading machines, FM systems, and text enlargement systems. They also found that voice recognition systems and reading machines were used by students with a wide variety of disabilities, from visual impairments to learning disabilities, to mobility impairments. Their finding supported the common notion that AT may often be used by others than for which it is originally designed, and when made available, success in higher education is more likely.

Stodden, Roberts, Picklesimer, Jackson, and Chang [62] reported combined results from data collected in 1998 and again in 2001 from disability support coordinators, AT professionals, or their designated counterparts. In reporting their findings concerning AT, the investigators reported that while a wide variety of institutions were offering AT supports to students with disabilities, "It is also apparent that this is a relatively new area of activity, and lack of clarity and direction among postsecondary education personnel as to what is required and/or needed by persons with disabilities is a continuing issue" (p. 118). They noted that while institutions were providing more universal technology access to all students, most were providing very minimal AT supports and accommodations for students with disabilities. They also noted that AT evaluations for students' use was the least likely service to be offered.

Christ and Stodden [14] used the same data set as the previously cited study above and noted that among all accommodations and services provided by US postsecondary disability support offices, assistive technology was the lowest of four grouped areas (including learning and studying strategies, assistive technology,

accommodations such as class relocation, and vocational work support). In addition, these two authors noted that “AT evaluations for students” was the least provided support both in its category and overall.

Sharpe, Johnson, Izzo, and Murray [59] took a different route and interviewed 139 graduates with disabilities, recruited from 20 postsecondary institutions across the nation. They revealed that while degree of frequency between high school use and postsecondary use were similar, research participants were more likely to claim AT devices were used at the postsecondary level. The researchers also noted that as the cost of the device increased, the reported frequency of use, that is, the number of students using it, decreased. The overwhelming majority of students reporting they first learned to use AT in postsecondary institutions was high (48%) as was the percent of students who were self-taught on their AT devices (74%). Only three percent were taught how to use AT by disability support service personnel, and 84 percent claimed they were self-taught or had help from a family member. Overall, the investigators concluded that their sample were fairly self-reliant and relied on a number of family and friends to fill the service or accommodation gaps not met by postsecondary institutions.

A number of findings can be summarized from these studies:

- Greater numbers of individuals with disabilities are matriculating to and graduating from postsecondary institutions than ever before, although still not on parity with their non-disabled counterparts.
- Postsecondary degrees are important to future earning power and lifestyle.
- Postsecondary institutions are not providing adequate AT services and expertise to students with disabilities.
- Assistive technology can be powerful tools to help equalize learning environments for students with disabilities.
- Evaluation of assistive technology needs was the service least likely to be provided to students with disabilities at postsecondary institutions, although AT is more prevalent in postsecondary than secondary schools.
- When AT devices are provided, a wide variety of disabilities/needs can be met.
- Students with disabilities attending higher education institutions are more likely to be knowledgeable about AT from personal sources (such as themselves or family members) than from disability service providers.

Many implications can be drawn from these findings, but one becomes very clear: If students with disabilities who need AT are to succeed in postsecondary education, they need to be well-schooled about their own needs and the necessary equipment because it is unlikely that this service will be received from postsecondary disability support providers. Again, being able to independently manage their own AT needs while seeking a degree may be a prerequisite to the success of students with disabilities. The next section will discuss the relationships between assistive technology and employment for individuals with physical disabilities.

## 5. Assistive technology and employment

NOD [45] found that of all working age (18–64) persons with disabilities, only 35% were employed full-or part-time, compared to 78% of working age individuals without disabilities. In addition to this gap of 43 percentage points, NOD reported that people with disabilities were twice as likely to be unemployed, and of those individuals with disabilities who were unemployed clearly 73% preferred to be working. Not surprisingly, people with the most severe disabilities are much less likely to be employed than those with slight disabilities or those without disabilities. These statistics are unfortunate, as for most individuals; employment is “fundamental to the physical and psychological health and well-being of people living in contemporary societies” [13, p. 257]. Indeed, Lidal, Huynh, and Biering-Sorensen [40] noted that the World Health Organization promoted the importance of productive work within its newest functional classification model in 2001 and reported on research that productive employment is associated with greater self-esteem, life satisfaction, and sense of well-being.

Having and using the right AT device may mean the difference between being locked in poverty and having the opportunity to work and earn a living [11,19,31,32,56,71]. Chan et al. [13] suggested that service providers perform extensive and comprehensive needs assessments to determine AT and other employment-related needs, while others have suggested that this assessment not only be conducted in “real-life” instead of clinical settings but not be performed at all until the job and employment setting is known [31,32,65]. Chan et al. also cautioned that instead of focusing exclusively on successful outcomes of clients, service providers should focus on maximizing the probability of successful outcomes by providing more intensive services

for those with poorer predicted employment outcomes, such as those with more severe disabilities.

Pell et al. [50] studied 71 Australians with spinal cord injuries (30 paraplegics and 41 quadriplegics) and found that 56% of these individuals were employed either full- or part-time. The investigators reported that most respondents were in information-based jobs, with 49 of 65 respondents using computers in their current occupations. For this sample, gender, level of computer skill, and level of education were the most significant predictors of employment status (i.e., being employed full- or part-time and being unemployed). Age and use of AT software were not significant predictors of employment status. The study's authors indicated "level of education and the ability to use computers effectively are most important, because people with disabilities can improve their achievement in these areas following the onset of the disability" (p. 337). To ensure productive employment, they emphasized individuals with disabilities, in order to become more employable, should learn basic computer skills, such as word processing and spreadsheets as well as be guided to careers and professions with a high degree of computer interaction.

Over 1,900 individuals who lived in California comprised the research sample of Yeager et al. [71] in a study of the relationship between AT and employment. Of the 1,507 working age respondents, 61% reported a mobility limitation and 15% reported a physical limitation, such as a chronic illness. Twenty-five percent of the entire sample (including a variety of disabilities) had a college degree, another 38% had attended but not graduated from college, and 20% had a high school diploma. Only 20% of the sample was employed, with only 6% working full-time. Individuals unable to walk reported the lowest employment rates of all disability groups at 12%. A majority of all employed respondents (54.2%) used some form of AT, accessibility features (such as ramps), or services (such as job coaches). Individuals with mobility impairments reported using wheelchairs, all of the accessibility features, and telephone headsets the most. For all respondents, computer technology was deemed the most important AT; followed by power or manual wheelchairs, and adapted personal vehicles. Nearly two-thirds of all respondents reported benefits from using AT at work, primarily through increased productivity, self-esteem, better attendance, and more paid work hours. AT was most often provided by employers (41.5%), by the individual (38.5%), by vocational rehabilitation (26.2%), by insurance (20%), or by donations of used equipment

(8.5%). One of their most interesting findings was that unemployed individuals did not see lack of AT devices as a barrier to work, while employed individuals, who had considerably greater education, viewed AT as one of their most valued assets – perhaps indicating that unemployed individuals were unfamiliar with technologies that might enable them to work.

Inge et al. [31] conducted research on the job placement of 21 individuals with severe physical disabilities and reported that the vast majority of workplace AT was considered low-tech. While 7% of the AT accommodations had no cost attached, 88% cost between one dollar and \$500 each. The one exception was an individual who needed a computer with speech recognition software. They concluded that, "once employed, this group of [individuals with severe physical disabilities] was very successful in achieving independence within the workplace." The fact that the majority of the technology identified and put into place was obtained commercially and was of low cost is evidence that individuals can be supported successfully with minimal costs to the businesses.

Driscoll et al. [19] interviewed five individuals with spinal cord injuries, three employers, and two co-workers and determined that AT is more successfully integrated into the workplace when (a) individuals with disabilities, employers and co-workers are all actively involved in the selection and implementation of AT, (b) all parties have positive, proactive attitudes toward AT use and people with disabilities, (c) service providers ensure adequate training on types and availability of devices, (d) service providers ensure adequate follow-up and problem resolution in a timely manner, and (e) some degree of flexibility for job tasks is provided in the workplace.

The Job Accommodation Network (JAN) provided Gamble, Dowler, and Orslene [23] access to 145 inquiries of AT workplace access by rehabilitation professionals in 2004. Within the 145 cases, five disability categories were represented, and those with severe motor disability were most prevalent. The most suggested workplace AT for these individuals was speech recognition software, recommended in eight cases. These authors noted that while selecting and using the right AT is a highly individualized process, it is undeniably effective in employment settings.

In addition, Kaye [35] noted that people who reported an inability to work due to a disability are ten times more likely to report a need for assistance with self-care activities, such as bathing, transferring, toileting, dressing, and eating. Noll, Owens, Smith, and

Schwanke [47] concluded, from their research study with vocational rehabilitation (VR) counselors, that AT has become an increasing effective service for VR to improve the employability and career advancement of individuals with disabilities.

These studies bear the following insights:

- People with disabilities are less likely than their non-disabled counterparts to be working.
- For those individuals with disabilities who are working, AT is an important feature of their jobs.
- For those individuals with disabilities who are not working, AT is viewed by them as a lower priority.
- Computer technology is viewed by individuals with disabilities as an important workplace AT.
- Most workplace AT used by individuals with disabilities is relatively low-tech and low-cost.
- Success of AT in the workplace depends on workers and employers adopting positive attitudes, that encompass flexibility and problem solving skills.

## 6. Assistive technology and independent living

Scherer and Glueckauf [55] emphasized that the ability to perform a variety of activities – either natively or augmented by AT – is very important to participating fully in life situations such as education, employment, and community life.

By enabling a person to perform desired tasks, ATs offer the potential to provide a sense of autonomy as well as reconnection to the community. By accommodating a person's weaknesses and supporting his or her strengths, ATs can reduce psychological as well as physical stress, thus leading to an enhanced subjective quality of life and self-esteem [55, p. 133].

Several authors have studied the gaps between functional ability and the inability to perform activities of daily living (ADLs) and instrumental activities of daily living (IADLs) and the accomplishment of such tasks. Some of these have used national databases and some have focused on the interplay between AT and personal assistance in promoting independent, community living.

Kaye et al. [36] calculated that the number of community-dwelling residents needing help with ADLs has increased from 2.6 million in 1989 to 4.1 million in 2004, a remarkable 54.2% jump. Carlson, Ehrlich, Berland, and Bailey. [12] reported that 8.3 million individuals with disabilities needed AT to perform ba-

sic ADLs, while 15.4 million reporting using assistive (primarily medical) devices such as glucose monitors, wheelchairs, etc. Sheets and Liebig [60] projected similar numbers, citing 15 million Americans with disabilities who are currently using AT devices to overcome functional limitations and perform activities of daily living.

Sheets and Liebig [60] noted that of the 15 million individuals with disabilities using AT, 6.4 million use ambulatory aids (canes, crutches, walkers, etc.) and 2.2 million use wheelchairs. As individuals age, their needs for AT increase as well. These authors noted that approximately 25% of individuals over the age of 50 report a number of ADLs that are not being compensated for by AT. They reasoned that many preventable secondary conditions and functional losses are being incurred due to a number of social and economic barriers to using available AT, with further losses to independent living.

Carlson, Ehrlich, Berland, and Bailey [12] drew data from the Disability Followback Survey that paralleled the National Health Interview Survey (NHIS) and reported on the results of telephone interviews with 269 persons with disabilities. Their findings included the following: (a) 42% of individuals felt that AT devices or services decreased their need for personal assistance, (b) 52% felt that better designed products and environmental access features reduced their need for AT, and (c) around 90% each felt that AT access laws or program policies were better than 10 years ago, more people were aware of the need for AT, and it is easier to get funding to purchase AT.

A number of research projects have also examined the interplay between AT and personal assistance (PA), especially for individuals with more severe physical disabilities. Guralnik [25] suggested that the definition of a severe disability include those individuals who need help with three or more of the six ADLs. It is most often that these individuals use both AT and PA, and yet have greater unmet needs resulting in greater residual disability [51]. For example, one study found that less than 50% of people with low-level quadriplegia and only 20% of those with high-level quadriplegia are using AT devices that have the potential to increase their quality of life, independence, and employability [51].

Verbrugge, Rennert, and Madans [68] used data from the National Health and Nutrition Examination Survey (NHANES 1) and its follow-up, the NHANES 1 Epidemiologic Follow-up Study (NHEFS). They found that individuals with severe disabilities were more likely to use assistance and were more likely to use per-

sonal assistance. They noted this was largely due to individuals with severe disabilities needing more lower extremity assistance which required bi-lateral help not available from equipment, whereas those with lesser disabilities who needed upper-extremity assistance could often use an alternate hand or a piece of equipment.

Verbrugge and Sevak [69], using the NHIS, reported that more severe disability was highly correlated with greater assistance use (both PA and AT). They found that severity of need was correlated with improvement, but not total resolution of the original functional limitation, especially for those with severe disabilities. These authors also stated that PA only was more likely to be used for dressing (94%), eating (89%), transferring (65%), and bathing (55%); while AT was preferred for toileting (26%) and for inside tasks (42%). Similarly, they found that for individuals with severe disabilities, recent technical improvements in AT have meant greater gains in independence, resulting in fewer unmet needs compared to past experiences. "People with severe functional problems do indeed have a large zone for gain [with the use of AT], whereas those with mild ones have a small [er] zone" [69, p. S375].

This was similar to results reported by Agree [1] that, even after controlling for underlying physical impairment, persons over 70 who rely solely on PAs are 1.5 times more and those who rely on both AT and PA are three times more likely to have residual disability, than those who rely on AT alone. She also reported, similar to Verbrugge et al. [68], that those who use AT only report less residual disability than those who use PAs, and the former group represents those individuals with less severe disability. As impairment increases, the ability of AT alone to ameliorate the residual disability is reduced.

Likewise, Agree and Freedman [2] commented that since few studies examine both PA and AT use, efficiency, and effectiveness within a single framework, little is known about which is more effective. They also drew data from the NHIS and found that for older adults, AT use was more common than PA use, especially for those with lesser disability, and users of AT not only had reported less disability but greater fatigue, pain, and time to task completion. They also found that individuals who used both AT and PA experienced greater degrees of difficulty; that is those with greater disability show greater needs that require the use of both AT and PA. Similarly, Meng et al. [42] and Strobel and McDonough [65] found that AT might serve as either a substitute for or supplement to PAs, depending

on the user's needs, limitations, and tasks to be performed. However, Verbrugge and Boynton [67] reported that users of AT reported greater feelings of confidence, level of control, and independence than those who relied more heavily on personal assistance.

Hoenig et al. [30] used the Long Term Care Study of 1994, a national database of nationally representative Medicare beneficiaries aged 65 and older. Their sample of 2,638 individuals demonstrated that AT often was substituted for PA in dealing with aspects of disability. Like others [68, cf. 1], these authors concluded that persons relying on technology assistance felt less residual disability than those relying on personal assistance, particularly those with arthritis, a mild/moderate physical impairment, or lower-extremity disability. They were clear about one thing: "People who did not use technology to cope with disability reported more dependency on others" (p. 336). They remarked that using technology help offset induced disability, increase physical activity, and allow self-care tasks to be performed more efficiently.

Using the second phase of the NHIS Disability Supplement study, Agree, Freedman, Cornman, Wolf, and Marcotte [3] captured data on 4,006 individuals 65 and older and reported that AT use does not necessarily replace personal assistance, but may, in fact, supplement it in a number of ways, for some groups. These researchers reported that AT might substitute for personal care for individuals who were unmarried, had at least some college education, and had no cognitive impairment. The relationships between use of AT, informal care, and formal care, however, are complex and non-linear. "Ultimately such [AT] devices may improve the quality of life of older persons and promote independence; however, their ability to substitute for more expensive formal care is not yet established" (p. S279).

The result of these studies can be summarized as follows:

- The use of AT by persons with physical disabilities is increasing dramatically.
- Individuals with milder disabilities can often mitigate their disability through AT use.
- Individuals with more severe disabilities use both AT and PA, using the latter for many tasks not achievable through AT alone.
- Many individuals may still experience some residual disability even after AT and PA use.
- The relationships between severity of disability, use of AT, use of PA, and residual disability and unmet need are complex and multifaceted.

- Even though these relationships are difficult to disaggregate, assistive technology has a significant impact on the ability of a person with a disability to live as independently as possible.

Most individuals with disabilities choose AT over PAs when possible because AT is designed for a specific task, is customizable to the individual, and maintains the individuals' self-sufficiency, whereas PA is less standardized and is not always readily available when needed. AT heightens their self-confidence, level of control, and independence – which are all important to individuals in order to reduce functional declines and hasten functional recoveries when possible [29,67–69]. In fact Verbrugge et al. [68, p. 890] explained:

A person maintains autonomy and self-sufficiency when using equipment; these qualities are relinquished when the person uses personal assistance. This suggests a hierarchy of preference: people try equipment first, if possible, and turn to human assistance when equipment fails or is unavailable. . . The distinctive findings point toward perceptions and emotions [of the users].

Meeting the ADL and IADL needs of individuals with disabilities is important in light of the consequences of these needs being or remaining unmet. For the majority of individuals, unmet ADL and IADL needs resulted in less independence as well as adverse consequences, such as secondary conditions like poor hygiene, decubitus ulcers, and urinary tract infections [38] and eventual loss of opportunities such as attending postsecondary education and gaining useful employment. Human help is not always the best solution to unmet needs. Assistive technology and environmental modification are often preferred, when and where possible, as they capture the intent of improving empowerment and self-determination, while potentially lowering learned dependency and overall expense [29,58,67–69].

## **7. Unresolved issues in AT for individuals with physical disabilities**

This literature and research review points to a number of findings about AT yet also uncovers a number of unresolved issues and needed answers. It is abundantly clear from this review that AT is vital in helping individuals with physical disabilities succeed in postsecondary education, attain viable careers, and to living independently. AT, along with personal assistance for

some, plays a decisive role in closing the gap between functional limitations and the potential to participate fully in community life. It is clear that

- Greater numbers of individuals with disabilities are pursuing postsecondary education; although fewer individuals with severe physical disabilities are doing so. Few individuals with disabilities attending postsecondary education report feeling confident that they are aware of potential assistive devices for their use, but these same individuals are not likely to be evaluated for AT need by postsecondary professionals, thus indicating a significant gap in service provision which is likely to result in poorer education outcomes.
- Workplace technology is important for individuals with disabilities and is usually low-cost and low-tech, with the exception of some computer technology. However, the success of employees with disabilities using technology is often still dependent on the attitudes and policies of the employers.
- Individuals with disabilities often offset or compensate for functional limitations through use of assistive technology, and in some cases, personal assistance. The degree of AT and PA use depends on a variety of factors, such as severity of functional limitations, environmental factors, and the task at hand. Assistive technology and personal assistance often counterbalance one another: as use of one goes up, the use of the other goes down. AT is often seen as more “liberating” because the person maintains greater control over devices than people.

These observations lead us to a variety of unresolved issues and questions:

- If AT is important to success in secondary and postsecondary education, for what reasons do people with disabilities remain uninformed about devices that may benefit them?
- Likewise, for what reasons do postsecondary service providers and other professionals not routinely perform AT evaluations on incoming students with disabilities?
- How can employers become more educated about the assistive technology needs of employees with disabilities and be encouraged to adopt positive and flexible attitudes?
- What are the relationships between functional limitations, assistive technology, and personal assistance that most impact the ability to perform ADLs and IADLs, achieve success in education and em-

ployment, and integrate into community activities, and enjoy a high quality of life?

## 8. Summary

The purpose of this manuscript was to explore the relationships between assistive technology and individuals with disabilities in relation to their education, employment, and ability to live independently. It is clear in all three areas that appropriately chosen and implemented assistive technology is imperative for individuals to approach an even par with their non-disabled peers. The challenge to society is recognizing that AT is of primary significance in affording Americans with disabilities the highest degree of independence possible, in attaining higher education degrees, successful careers, and fruitful lives. This includes individuals with the most severe physical disabilities, despite the fact that this might mean more intensive services and workplace supports [31]. As has been noted from this review, AT is a foundational support that produces multiple and life-changing benefits. While we know much about the impact of AT on the lives of individuals with disabilities, many unanswered issues and questions remain.

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