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Scoping review of economic evaluations of assistive technology globally

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ABSTRACT

The paper presents a scoping review of existing economic evaluations of assistive technology (AT). The study methodology utilized a PRISMA flow approach with final included studies that met an adapted PICOS framework. Types of economic evaluations employed, study type and rigor and domains of AT impact were considered and analyzed. The economic evaluations in this study included 13 CBA, 9 CMA, 18 CEAs and 10 CUA. The majority of studies (32 studies in total) mentioned or recorded that AT investment, access and/or usage had impacts on the domain of both informal and formal health care. Specifically, care costs, time, and resources were affected. Our study has found that current AT economic evaluations are limited. This study advocates for a wider use of robust alternative evaluation and appraisal methodologies that can highlight AT value and which would subsequently provide further evidence that may make governments more willing to invest in and shape AT markets.

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KEYWORDS
assistive technology; cost-saving; evaluation; value

Background

Economic evaluations are a significant and widely used form of assessment that are taken up by various sectors within the health field. The importance of understanding and capturing economic value for any intervention or device within the field of health is essential and for this reason, economic evaluations of assistive technology (AT) have used monetary value and market worth to assess the value to the provider (Deruyter, 1995; Galvin & Scherer, 1996; M.J. Fuhrer, 2001; Smith, 1996). Economic evaluations are a type of comparative analysis of alternative health-care strategies or programs in terms of costs and consequences (Drummond et al., 1997). They should consider both cost side and an outcome and benefit side. Within the general health-care field, such cost assessments are problematic, as noted by M. J. Fuhrer (2001), as the economic perspective of cost can greatly vary depending on the perspective taken, i.e., from the vantage points of patients, insurers, providers, or greater societal perspectives. Within the field of AT, public costs have tried to take into account the perspectives of patients, AT programs, family members, taxpayers, employers, and insurers (Andrich et al., 1998; MF Drummond et al., 1993; M Drummond et al., 1997; Goldman et al., 1996).

Economic evaluations are considered an integral part of the planning process of any health program. While in most fields of medicine decisions on medical interventions are evidence-based through direct comparison between benefits and costs, the provision of AT has been an exception. Part of this can be explained by the complexity of AT outcomes (Gelderblom & de Witte, 2002). This has been especially highlighted and stressed for interventions designed to address the complex needs of AT users. Due to the complex health and social problems associated with AT users, economic evaluations should also be able to consider such complexity. Further, comparisons between different AT devices, even in instances within the same device classification, can be exceedingly difficult due to the diversity of how the practitioner matches the technology to individual needs, what materials are deployed at what cost, and how that product is delivered and works within the user's environment.

Economic evaluations – as well as more general evidence assessments of AT impact on the user, the community, and overall society – are few and far between. Like any other device or intervention that aims to benefit a population or specific user, AT also should have within its field a mix of assessment tools that can capture its benefit. The tenants of evidence-based practices (EBP) have been championed in the literature by numerous health professionals, occupational therapists, physical therapists and other practitioners linked to AT (Holm, 2000; Manns & Darrah, 2006; Marcus J. Fuhrer, 2007). Specifically, Holm (2000) writes that patient outcomes alone are no longer sufficient to justify services, but rather there is a strong call for EBP. As a result "[occupational therapists] have an obligation to improve our research competencies, to develop the habit of using those competencies in everyday practice, and to advance the evidence base of occupational therapy in the new millennium" (Holm, 2000, p. 584). Similarly, Manns and Darrah (2006) write how physical therapy physicians and researchers must find ways of enhancing EBP, so that it can be used optimally as part of clinical decision making.

Yet, while AT practitioners are proponents of having and being able to refer to a solid evidence base, quality research on the impacts of AT on outcomes and AT value is extremely limited (Marcus J. Fuhrer, 2007). Despite the wide range of technologies available on the market, there is little hard

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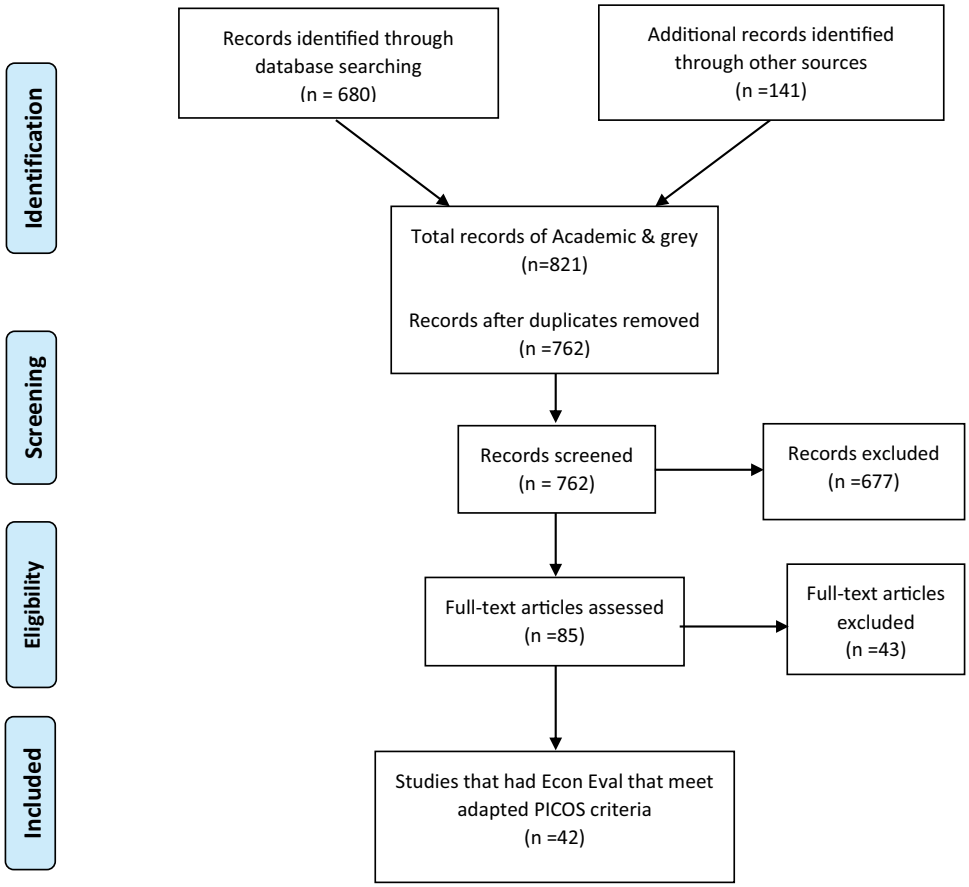

Figure 1. PRISMA search criteria. Adapted from Stovold, E., Beecher, D., Foxlee, R. et al. 2014.

evidence related to the success of AT systems in terms of how effectively they provide support for the individuals who use them and at what cost (Jacobs et al., 2003). Without a wider breadth of concrete evidence, which would demonstrate and capture the full extent of AT effectiveness and efficacy, financial support toward AT access and delivery will continue to be minimal and exclude a variety of AT options. Health-care services rely on evidence-based approaches to justify budgetary decisions, as highlighted by Marcus J. Fuhrer (2007), who gave the example that Medicare adjusted its payment guidelines to ensure that financially covered mobility AT devices (such as wheelchairs, crutches, canes, and prosthetic devices) met certain quality and outcome-based standards. If payers of health-care services rely on narrowly scoped evidence-based approaches to justify budgetary decisions, this may have implications on AT diversity and availability. This is especially true in the AT field where the plethora of devices and uncertainty of preferences by experts reign (Marcus J. Fuhrer, 2007). Likely because of the expansiveness of the field of devices and lack of consensus, there is a greater need for studies to be able to provide credible, comprehensive and meaningful evidence of the impact and value of AT. Accordingly, it is essential to look into the existing body of evidence to understand how AT impacts and value are currently framed. Through the aggregation and analysis of AT evaluation studies, this research captures the evidence landscape of AT and comments on how AT is valued within the research and policy community. The objective of economic evaluation is to identify, measure, and value what society forgoes when it funds an intervention (the opportunity cost) and what it gains (the benefit). Economic evaluation provides an important evidence base for decision-making in the health-care sector, aiding policy makers in the allocation of societal resources.

Aim of the scoping review

The aim of this scoping review is to capture the breadth and diversity of economic evaluations, appraisals, and measurements that are used to assign and define AT value. The focus of the search is to locate studies that assign an economic value with particular focus on capturing and assessing studies that use one of the following approaches: cost-benefit analysis, cost-effectiveness analysis, cost-minimization analysis, or cost-utility analysis. Consideration is given to any study that meets defined and standardized economic evaluation criteria as well as studies that use alternative evaluation approaches. The evaluation assessments include studies that analyze the impacts of AT by considering the value the enabling device has on the individual, family, community, labor force, as well as health and social care systems. AT value can also be captured upstream and include value produced as a result of a state's investment into AT production, manufacturing and distribution facilities. This type of search seeks to illustrate where AT value stands within the literature capture. A need to collate and systematically

review the existing cost-effectiveness and return on investment evidence serves as the impetus for the WHO AT background papers.

Capturing the strengths and weaknesses of "gold standard" economic evaluation framework

Evaluation frameworks are important as in many ways they structure and define the value of particular devices and interventions. The "mainstream" approach to evaluation is derived from neoclassical economic theory, in particular microeconomic theory and welfare economics (Dequech, 2007; Kattel et al., 2018; Kattel, 2020; Nelson & Winter, 1974). Dequech delineates neoclassical, heterodox, mainstream and orthodox economics. Based on Dequech's research, neoclassical economics is characterized by the combination of (1) the emphasis on rationality in the form of utility maximization, (2) the emphasis on equilibrium or equilibria, and (3) the neglect of strong kinds of uncertainty and particularly of fundamental uncertainty (Dequech, 2007). While Dequech (2007) finds that mainstream economics is temporally very general, neoclassical economics is the core thread within the mainstream approach as evident by its presence in the curriculum of prestigious economic departments and as a result of its placement within the economic literature. The influence of neoclassical economic thinking is apparent within policy evaluations and appraisals as techniques of static ex-ante cost-benefit analysis (CBA) reign dominant (Kattel, 2020, p. 6).

Gold standard economic research protocols focus on efficiencies and cost-effectiveness. The most highly valued analyses include CBA and cost-effectiveness analysis (CEA). CBA-type analyses are concerned with allocative or distributive efficiency, which involves making the best use of (fixed) resources at a fixed point in time. These appraising techniques, while they are currently held up as the highest golden standard of evaluation, are acknowledged to be limited as they rely on the assumption that the broad environment remains unchanged as a result of the intervention. They poorly handle dynamic interactions and can only capture marginal changes when conditions are thought to remain stable. Classic return on investment (ROI) schemes and cost-effectiveness scales are blunt instruments in which research funding has historically relied on in order to justify the usefulness and value of an intervention or device.

Instead of trying to have the AT landscape emulate other fields and only look at the robustness of rigid and supposedly neutral gold standard economic evaluations, this study follows the suggestion of Harris and Sprigle (2003) as cited in Schraner et al. (2008) to pay particular attention not just to methods, but the perspective employed by economists. Economists when choosing to show benefits of a device or program, apply a particular lens and perspective in which the AT assessment will be understood. Based on Can Feminist (1995), but reinterpreted by Schraner et al. (2008), there is concern that within the field of AT, health economists will "only engage with the work of medical practitioners who are mainly interested in body functions and structures, and as long as the scrutiny of the economists' work is limited to questions of methods, economists continue to limit themselves to analyzing a small part of what is or ought to be of interest to health economists" (Schraner et al., 2008, p. 923).

Given the critical insight about economic evaluations, this study considers how AT value is constructed by paying attention to the rigor and robustness of the evaluation studies, the types of evaluation methodologies employed, and the lens/perspective utilized. Further, this research associates itself with those in the AT community that wish to consider a concept of AT value that includes the impact of AT technological innovation through to how AT can enable human capabilities.

Studies that demonstrate AT value may be especially important for policy decision-making in lower-resourced settings, such as low-middle income countries (LMICs) whereby governments may feel even more compelled to justify spending and investment decisions if the mind-set is one of limited funds and resources. Currently in many LMICs, production of AT is low, and where access is possible, costs are excessive (WHO 2014; Schüler et al., 2013). While production of, and investment into, AT is low, there is an opportunity to grow this industry domestically as countries, such as Brazil, Cambodia, Egypt, and India have done over the past decade (WHO 2014). Part of this movement may be due to governments slowly recognizing that when the narrative of AT value switches from simply considering purchase cost to the entirety of value that can be found within the AT ecosystem, AT value is positive and potentially robust. For instance, in-country production of AT devices in Brazil has resulted in a reduction of AT costs by 30% as compared to importing such devices (Marasinghe et al., 2015). The potential for how comprehensive system-wide economic evaluations may alter the narrative of AT from being a costly investment in LMICs to a human-enabling device that has great economic potential within a system necessitates a review of existing economic evaluations.

Recognizing the interest in a more comprehensive assessment of how to best value AT by the research, policy, user, and advocacy communities, the discussion of the following results entails considering where AT economic evaluations stand currently and how they might be better transformed to reflect the value understood but not captured by the AT community. It also suggests ways of making the "invisible value" of AT innovation evident.

Methods

Identification and search strategy

The methodology for this study entailed conducting a scoping review that dove into academic literature and gray literature. AT devices examined in the literature were determined by the WHO AT priority list.[1] The literature search was conducted in English, Norwegian and Swedish. Nordic partners were brought in to capture AT evaluation studies published in Scandinavian languages as this region is known to produce

[1]WHO. (2021) Priority Assistive Products List. Improving access to assistive technology for everyone, everywhere. "WHO_EMP_PHI_2016.01_eng.Pdf". https://apps.who.int/iris/bitstream/handle/10665/207694/WHO_EMP_PHI_2016.01_eng.pdf?sequence=1.

interesting and novel methods of evaluation with regards to AT. A PRISMA-compliant search of the literature was conducted. The search comprised two steps as per the guidelines provided in the Cochrane Collaboration Handbook on Systematic Reviews of Interventions.[2] A preliminary search was conducted which identified original articles in the following electronic databases: Econlit, PubMed Clinical Queries, EBSCO Host, and Scopus. A full search was also undertaken in CINAHL, Embase, Global Health, Medline, PsychInfo, and Social Work abstracts.

The gray literature was based on searching through the websites of known NGOs that focus on AT, government bodies dedicated to AT, as well as private and industry partners that conduct relevant work in AT. Studies that were found on such websites (which were determined and selected based on familiarity with the AT landscape of the researchers) were pooled for further examination. The gray literature search (Figure 1) was not restricted to a specific search string. Rather, starting from the initially identified organizations and organizational websites, there was an additive snowballing search strategy for the gray literature to collect studies that otherwise would have been difficult to capture.

Eligibility criteria

The literature search was compliant with the PRISMA search criteria and included all articles from the date range of January 1990–January 2020. The academic search string used a combination of evaluative terminology including; cost-benefit analysis, return on investment, cost-effectiveness analysis, cost-utility analysis, and social return on investment. The search string also consisted of words related to evaluation, assessment, measurement, value and impact. These words were selected because they were analogous to assessment and evaluation. In terms of capturing assistive technology, the research strategy first conducted a general search of assistive technology through terms, such as: assistive products, technologies, and devices. For the academic search, the study then incorporated the specific assistive products as defined by the WHO product priority list into the search string along with the selected evaluative terminology. For the gray literature search, a similar approach of crafting an initial search string of an evaluation term and an assistive technology term was also implemented within the specific organizational websites. However, because of the snowballing approach of case study gathering, the researchers did not search for each one of the specific assistive products on the WHO priority lists for the gray literature search.

Both academic and gray texts were included based on their titles featuring some combination of an evaluation term and either a broad term of assistive technology, or a specific assistive product. The articles were uploaded to a reference software and duplicates removed. Thereafter, articles were screened for further eligibility based on the full text and whether the article appeared to be about measuring the value of AT through an economic lens. Consideration of economic evaluations studies were based on the PICOS criteria, a study assessment framework which looks into the parameters; Patients, Intervention, Comparator, Outcomes, Study Design. However, the criteria were extended to include alternative economic approaches that also try to capture AT value. A PICOS process was chosen as it is used in evidence-based practice to frame and answer health and health care-oriented questions. PICOS is a well-established framework in systematic reviews to ensure comprehensive and bias-free searches, and inclusion of relevant literature (Higgins & Green, 2011). Studies that met final inclusion PICOS criteria, as defined in Table 1, were assessed in the final analysis. Articles were also further categorized based on whether a "gold" standard economic measurement and study protocol was used, versus those studies that used additional alternative or comprehensive techniques to capture AT value. These two evaluation groups were overall analyzed equally and together. As it was also important to understand the fields in which the AT evaluation literature were sourced from, the disciplinary fields were also noted.

Table 1. Inclusion criteria and table suggested inputs.

Date	Year of Publication January 1990–January 2020
Author	
Title	
Country	
Population	Populations or individuals using AT, AT device comparisons, AT production or service delivery studies
Intervention	Any intervention involving AT usage that evaluates some kind of economic or financial impacts of AT access and usage
Comparator	Can be a pre/posttest design, prospective control, reflexive within study panel
Outcomes	Outcomes include the possible impacts and effects of the AT beyond what is already assessed in the economic evaluation, as well as factors included in the calculation. Possible examples that will be categorized under outcomes include how AT usage and access results in outcomes such as; enhanced quality of life, access to jobs, reduced stigma, decreases in care needs, social impacts
Economic Evaluation	Eligible criteria include all standardized and recognized economic evaluations such as; Cost-Effectiveness Analysis (CEA), Cost-Utility Analysis (CUA), Cost-Benefit Analysis (CBA), Social-Return on Investment (SROI). Additionally other studies outside the previously stated list of standardized "gold" economic measurement tools were included if such studies used a substantiated technique to capture AT value.
Key Finding	Key findings entail recording the AT value and whether economic value derived and/or reported was positive, uncertain or negative

Domains of AT impact through the use, access or industry interaction

Information from the studies was extracted concerning domains of AT impact as well. It is important to capture the outcomes and AT impact domains as traditionally these studies will take note of these arenas of where AT had impact, but they will not be reported as part of the main study findings or considered important compared to the single number of cost savings reported. This is essential for an area like AT that has a diversity and range of technologies, populations, and outcomes and thus single cost-effectiveness numbers are rarely comparable and thus hold little meaning and transferability.

Domains of AT impact entail consideration of how AT interfaces with either a user, family, healthcare, or industry (along

[2]Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.1 (updated September 2020). Cochrane, 2020. Available from www.training.cochrane.org/handbook.

Table 2. The number of studies according to specific AT type and location.

	Device									
Location	In homes Assistive Technology Systems for frail and elderly	Hearing aids	Wheelchairs (manual and powered)	Prosthetic device	Eye-care (spectacles)	Vehicle modifications	Canes, crutches, Walkers/ mobility devices	Location device (GPS)	Technical learning and/or time management support (cognitive disability AT)	Total AT Types
Sweden	1	1	3				1	2	2	10
UK	5	1	1	1						8
USA	1	1	1	2			1			6
Sub-Saharan Africa		2			1					3
Australia				1		1				2
Canada	1			1						2
Italy			2							2
South East Asia		2								2
Norway	2									2
Netherlands				1						1
Lithuania	1									1
Denmark	1									1
Ireland	1									1
Tajikistan			1							1
Bangladesh		1								1
Korea	1									1
Rwanda					1					1
Germany				1						1
Finland	1									1
Zambia					1					
All Locations	15	8	8	7	3	1	1	2	2	

with other entities). The domains of AT impact can be measured at different conceptual levels ranging from functional performance to quality of life (Gelderblom & de Witte, 2002). This study goes further to expand beyond commonly known domains of AT impacts to include how AT investment may lead to increased employment opportunities for communities through AT manufacturing, or an enhanced feeling of independence and safety. The study also pays attention to how larger domain categories can be measured in very different ways such that the domain of health may be assessed through specifically validated surveys as disability-adjusted life-years (DALY),[3] or quality-adjusted life-year (QALY),[4] as well as assessed by biomarkers, mobility status, or through a self-reported health questionnaire (Jacobs et al., 2003). Recording and detailing the domains of AT impacts and outcomes will help to shed light on the manifold ways AT add value beyond simply what is currently costed.

Results

The results of the initial search located 680 studies, with an additional 141 articles identified from the gray literature. After the preliminary screening of titles and abstracts, 677 articles were removed. A total of 85 articles remained with 42 studies eventually meeting adapted PICO criteria for inclusion. The studies came from a diverse range of countries. The main locations in which the studies and evaluations were conducted were Sweden (10), the UK (8), and the US (6). Swedish studies were likely more dominant because of the inclusion of Scandinavian language study search. For studies that used a mix of locations, each specific location noted in the study was recorded in the table 2 below.

It was also found that the journal fields and policy domains were predominantly situated in medicine and health, disability studies, followed by engineering and computer science, psychology and social science. A few studies were sourced from the field of economics.

The economic evaluations were generally of weak to moderate quality, as many encountered several methodological limitations either dealing with small sample sizes (often times only up to eight people being studied), or if the study was able to use information from a large pool of people, the experimental design was based on assumptive models that had little AT-specific data. There were a variety of study types, though randomized control trials and quasi-experimental pre-post intervention designs were the most dominant. Study types included prospective cohort, RCT, survey design, and several others detailed in Table 3. The data was primarily collected through interviews and surveys. Study size varied considerably from four individual interviews to a full panel study of 37,544 sampled participants.

Economic evaluations methods types and value framing

The economic evaluations employed within the selected studies included 13 CBAs, 18 CEAs, 10 CUAs and 9 CMAs (Table 4). Studies that used a mix of cost evaluation instruments would fall into more than one costing category. For instances some studies could both be listed as cost-effectiveness as well as cost-

[3]Measure of overall disease burden. Developed in 1990s as a way of comparing the overall health and life expectancy of different countries.
[4]Unlike DALYS, QALYS only measure the benefit without and without medical intervention and do not measure total burden. QALY tend to be used more often as an individual verses a societal measure.

Table 3. Study design types.

Study	Study Design Type
1	Large national panel data set with a control group
3	Retrospective study with reflexive comparator between study individuals
4, 13	Prospective observational study with interviews and follow up between intervention and control
19	Country case comparisons
21, 57, 81	Prospective cohort case control study
22, 45, 53, 56, 68, 75, 76, 84	Pre and post intervention/test design (may include further follow up or quasi experimental design)
29, 34, 55	RCT between intervention and control -(inclusive of one cluster-randomized control for delivery models)
31, 67	General population survey of AT value assessed through WTP
44	Retrospective case control study
54	Discrete choice experiment questionnaire
59, 71, 72, 73	Retroactive Secondary data analysis that compared those who had AT or undergone intervention with known or modeled system costs
64	Prospective semi-structured interviews small sample size
69, 77, 78, 79 80, 82, 83, 85	Speculative modeling of AT delivery costs and cost savings
74	Systematic Review of RCTS
69, 70, 71	Lifetime population modeling

Table 4. Economic evaluation employed within studies.

Health Economic Evaluation Method	Study	Total numbers of studies
Cost Benefit (inclusive of SROI)	1, 2, 3, 19, 31, 45, 53, 64, 67, 69, 72, 83, 85	13
Cost Effectiveness	3, 13, 16, 22, 29, 34, 38, 44, 46, 55, 59, 68, 69, 70, 71, 72, 73, 74	18
Cost Utility	1,3, 21, 22, 46, 54, 75, 76, 81, 84	10
Cost Minimization	12, 22, 56, 57, 77, 78, 79, 80, 82,	9

benefit study if these evaluation assessments were both deployed in the study design. Upon closer inspection of the economic evaluations and how the studies were framed to convey the value of AT, it was found that generally the economic impact of AT was mainly based on costs saved, compared to profit/value added, or cost recovered. These studies, which were predominantly cost-effectiveness or cost-minimization studies, found that AT usage costs when compared to either standard care costs based on historical, modeled, or recently collected data, were more cost-effective.

Overall, costing studies can be broken down into four categories of value framing. These categories of value are: 1) AT usage resulted in a positive economic benefit; 2) The usage of AT resulted in cost savings in other domains; 3) Prolonged AT usage resulted in a recuperation of initial cost 4); Investment in AT negatively impacts cost outcomes (Table 5).

Specifically AT access and usage were linked to costs saved for the health and social care systems. AT cost-effectiveness was presented in terms of how much the ability to access and use an AT saved health and social institutions compared to the "traditional" normal treatment option that usually relied on resources provided by health or social care services. ATs were more cost-effective compared to normal treatment experiences, i.e., compared to costs taken on by health and social

Table 5. Types of AT value cost/profit framing.

Types of AT value cost/profit framing	Study	Total Number of Studies
1. Investment in AT adds Positive Value and Benefit	1, 21,22, 31, 54, 64, 65, 69, 70, 72, 73, 81, 75, 76, 84	11
2. Investment in AT Reduces coston Health and Social Care Systems	4, 5,12,15, 19, 22, 34, 44,53, 55, 56,57, 59, 68, 71, 73, 74, 77, 78, 79, 80, 82	17
3. Initial Investment cost of AT will be Recuperated over time and will eventually add value	5,12, 67, 69, 72, 83, 85	5
4. Investment in AT negatively impacts costs	19	1

care for supplying a personal aid. Within the research, reduction or elimination of care was based on either models which looked at the impact of reduced or total reduction of care spending or time according to available data, or was based on evidence directly collected from the study. Few studies tried to look at the social benefit and value added of AT (table 6).

Domains of AT impact through the use, access or industry interaction

Domains of AT impact and subsequent outcomes, as defined and described in the last portion of the methods section, were included directly in the economic evaluation assessment and modeling. Thus, they would be represented in the final figure of how an AT demonstrated cost-benefit or cost-effectiveness, but many times these outcomes and impacts of AT were separately recorded and not necessarily added into the direct cost model.

The majority of studies (32 studies in total), mentioned or recorded that AT investment, access, and/or usage had impacts on the domain of both informal and formal healthcare. Specifically, care costs, time, and resources were affected. Care costs included both system-level care costs, such as reduction of the number of nurses needed, reduced hospital admissions, decreased nursing hours, as well as informal care costs if a family member could instead work or tend to other activities instead of needing to assist as they would when the user did not utilize the AT fully. After care cost, outcomes that were found to be important included an assessment of independence (though this was often interlinked with a care cost measurement), and some form of quality of life measurement as well as satisfaction with the technology. Of these studies that discussed satisfaction and quality of life, many specifically used the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) (Demers et al., 1996)[5] and QALY as recognized and comparable instruments. Outcomes of AT impact that were less often cited in the collection of studies examined included; stigma reduction, impacts on education and work participation, effects on transportation costs, and implications on social quality of life.

[5]The Quebec User Evaluation of Satisfaction with Assistive Technology evaluates a patient's satisfaction with various assistive technologies. It assess activities of daily living by capturing patient reported outcomes.

Table 6. Domains of AT Interaction that Impact or Produce Value.

	Domains of AT Interaction that Impact or Produce Value							
	USER		INFORMAL-CARE (primary care giver or family)		INSTITUTIONAL HEALTH/ SOCIAL CARE (Formal)		INDUSTRY, LABOR & ECONOMY WIDE EFFECTS	
AT Impact Value	Impacts of AT	Studies	Impacts of AT	Studies	Impacts of AT	Studies	Impacts of AT	Studies
Non-Market Value	*satisfaction *quality of life *functional status *Independence *pain levels/absence of illness *adverse events *social participation *Security/Confidence *Job participation *Educational participation *Psychosocial impacts *Improved mental health *Prolonged at home living *Stigma reduction	1, 3, 4, 12, 19, 21, 29, 34, 44, 46, 53, 55, 57, 64, 68, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 82, 83, 84, 85	*Reduced care giver burden/ stress *Community awareness of AT and Disability	5,29, 56, 59, 64, 77, 79, 80	*Enhanced AT capabilities and capacities	55, 70, 71	*Job participation	83, 85
Market defined value Determined by: cost, time, resources added or saved	***Out-of-pocket expenses for**; Health care, transportation, food, accommodation ***Increased access to**; educational and job opportunities that have impact on income and market participation *Smart Home adaptations of market value	3, 4, 5, 13, 19, 21, 29, 34, 44, 46, 53, 55, 57, 64, 68, 70, 71, 72, 73, 74, 83, 85	*Time-freed to earn income *Resources saved for home carer	3, 5, 19, 59, 64, 73, 77, 79, 80, 83	***Institutional or Societal Costs and time saved on**; Hospital admissions, Attendants, Day-Center or clinic services, Permanent care home feed, Referrals, Equipment costs, Logistical planning, Worker salaries	3, 5, 12, 13, 19, 21, 29, 34, 44, 54, 55, 56, 57, 59, 68, 69, 70, 71, 72, 73, 74, 77, 78, 79, 80, 82, 83	***AT industry investment leads to**; Community based employment in local AT research, development and production/ distribution facilities and networks *Fewer funds going to external stakeholders and increased investment in national economy	69

The economic evaluations undertaken by these studies were focused particularly on assessing how AT access and usage reduced the burden on either the social or health-care system, and improved individual user life. Many articles used the phrase "social cost." A few studies also took into account the impact which AT usage had on family members. One study expanded beyond the user, caretaker, and health/social care system and considered AT costs as related to modifications in the user's home or physical environment and the cost of materials and construction to adapt homes to be AT friendly, as well as overarching implementation costs (12, 59). The impact that AT had on employment was also occasionally brought up. Employment effects either included a potential increase in labor productivity through the usage of the specific AT (83, 85), but also how the AT impacted labor dynamics of personal care takers that were able to use newly-found time to increase or partake in the job market instead of caring for the AT user. At times, a larger societal perspective was taken, which tried to gauge value of AT of those who may not necessarily use an AT or be part of the AT ecosystem. This was captured through an AT willingness to pay (WTP) indicator (19, 31, 67). Service delivery of AT and costs associated also came up in the literature, such as the cost of purchasing and procuring the AT, maintenance of the device, or assistance needed to fix the device. One study even considered the particular mode of delivery within a low-income setting between a community-based approach versus a center-based approach and how differences in delivery models impacted facility, transportation, and food costs associated with running the center-based approach (55).

Discussion

This study found the economic evaluation mechanisms that are currently used to consider the "worth" of AT devices are of mixed quality, though they do resoundingly attempt to demonstrate that AT has value because of its ability to reduce costs to the general healthcare system. Through this preliminary investigation into the literature this paper considered the types and span of evaluation techniques present. While the studies all provided useful evidence in support of the positive value of AT, most studies framed this value only in terms of cost savings for the social and health-care systems, rather than AT value in its own right. For instance, Al-Oraibi et al. (2012) assessed the cost of a particular AT by demonstrating how an AT intervention led to a reduced number of poor health outcomes, and subsequently reduced health-care costs. Some other studies have also taken this approach when evaluating the benefit of AT, by demonstrating cost-saving outcomes when AT is utilized through a pre/postintervention study, or by analyzing large data sets, which captured resource flow once the AT was introduced and how that could lead to reduced hospital

admissions or fewer care hours (Lansley et al., 2004; Mann et al., 1999)

This study has considered the rigor of existing AT economic evaluations, the perspective the evaluations employed, the kind of methods utilized, and whether the evaluations took note either through the costing instrument or recorded observationally the impacts of AT on different domains. Two of these components, a comprehensive evaluation and the perspective the evaluation employs, are supported by the work of Schraner et al. (2008) who highlighted that the two most essential factors to consider are the perspective of the economic evaluation and whether it took into account the entire AT system. Within Schraner et al.'s structure of what is important in terms of estimating costs, an estimation of the quantity of resources used and those related to the value assigned to each unit of resource measured are highlighted. For AT analysis the two most important factors to consider in an economic evaluation between Schraner's and Harris and Sprigle's inputs are to ensure that the economic evaluation takes into account the entire system surrounding the AT and to identify the viewpoint/perspective the evaluation takes (Schraner 2008; Harris & Sprigle, 2003). For instance, AT costs must consider not just the device but the cost of the caregivers. The lens of how AT costs should be considered include how AT impacts everyone from medical staff, family carers, AT providers and funding institutions, government health authorities, and especially the AT user themselves.

Of the evaluative techniques used, those that do show some promise take on a more comprehensive perspective of AT value and prioritize the user perspective. The SIVA Cost Analysis Instrument (SCAI),[6] for instance, is aimed at helping clinicians and clients estimate the economic aspects of an individual AT program, especially when comparing the costs involved when different options are available. SCAI is a tool that demonstrates a degree of complex thinking when it comes to assessing AT economic impact. SCAI estimates cost by monetizing and valuating four categories: Investment (cost of purchasing and installing equipment), maintenance (upkeep of device), services (other services that are needed for the AT solution), and assistance (amount of human assistance needed) (Andrich, 2002). Traditional offshoots of WTP have also been used to determine the value of AT within society. While WTP as an instrument in itself is limited, the study objective of wishing to gather a larger perspective on the value of AT beyond the confinements of only looking at the AT user is noteworthy. In this instance, a study in Korea utilized the principle of WTP to capture how much a population values AT. This number was then multiplied by the number of households to provide an indicator of what a national budget could be placed at according to the society's WTP for AT (Shin et al., 2016). Through this general population lens, this study was able to show that even non-users considered AT as valuable and in need of government financial support and investment.

Further efforts of capturing costs of AT include consideration of AT service delivery and maintenance. Brodin and Persson (1995) used a function of Estimated Costs per Year to assess the cost of a wheelchair when installment, interest, maintenance, energy, spare parts, transport, and assistance were taken into account. This demonstrates the various costs associated with AT for the user as well as the system beyond simply considering one-time initial user costs.

Another factor that ought to be considered when reviewing available evidence of cost-effective assessments within AT is global applicability. Considering the global applicability of a study is important as AT studies conducted in a high-income country setting will lack transferability if emphasis is placed on costs saved because of social and health-care reductions. A model based on how the provision of an AT will result in fewer hospital admissions, or a decrease in house aid hours and, therefore, will reduce the cost to the government as compared to providing an AT, may not be a strong argument for countries that do not have the same health and social care infrastructures that already supply such social and care nets. Under such a framework of health and care resource cost reduction, in these settings without either the applicable data of how AT will alleviate institutional health system cost or a comparable health and social care system, the relevance that AT will reduce cost on the health and social care system may not have the same poignancy. Rather, presenting AT in terms of costs saved for such country settings when investment in AT is already negligible, may not encourage investment if the cost reduction models are based on inappropriate health and social care assumptions. One must steer away from defaulting to the existing regiment of looking at AT access as a cost-alleviating measurement for health and care services.

Instead, one study taken from the gray literature that provides a way forward for LMICs was the WHO Economic Assessment of Alternative Options: Provision of Wheelchair in Tajikistan (WHO 2019). This report models not just how in-country wheelchair assembly is often cheaper than importing fully assembled products, but rather proposes how the creation and production of an entire AT resource chain can provide numerous employment opportunities that will readily recover initial investment cost. Consideration of the AT innovation chain from initial production to user experience and how the AT enables human capability ought to be the framing going forward to accurately capture how AT may bring about economic, individual, and societal growth.

Economic evaluations methods types and value framing

Thus, this scoping study provides an initial snapshot of the assessment, evaluation, and evidence landscape surrounding AT. Through this study, and by capturing the evaluation, assessment, and evidence practices surrounding AT, the authors hope that the reader has a better understanding of how AT is currently evaluated, and therefore valued based on particular assessment practices and assumptions. This paper proposes that the current assessment framework of AT needs to be broadened whilst considering how to ensure the greatest levels of comparability and quality. Further, this research advocates against using simple models of ROI and CBA as they fail to capture greater system AT value.

[6]Andrich, Renzo (2002). "The SCAI Instrument: Measuring Costs of Individual Assistive Technology Programmes": 95– 99.

Reflecting on our study's findings, we propose to measure the public value of AT with particular focus and consideration of how AT impacts the innovation ecosystem, the overall community, and how best to go about shaping the AT market. This approach will help to further enhance conversations concerning how best to prioritize and make decisions that will be translatable and useful beyond a research and evidence base. Through its public value orientation, the approach will help governments to decide what actions should be taken based on which decision pathway will most likely enable multiple direct and indirect beneficial consequential effects on such important sectors as the economy, healthcare, and innovation. It is important to understand the impact and type of value generated in an innovation ecosystem as well as how AT can positively impact and enable user capabilities.

Further, the implications of advocating for and embracing alternative economic evaluations with AT within LMICs would enable an evidence environment in which the individual user as well as the service delivery system are able to make better-informed decisions on the choice of AT available as well as better-informed decisions on the range of AT offered. By reorienting how to assess AT, this will serve as an important catalyst for awareness of AT value and wider economic impact and enhance investment in AT provision, innovation, procurement, and distribution in a positive direction especially within LMICs.

Limitations of the study

The findings are constrained by the search strategy and the databases in which the search strategies were conducted. The AT devices that were considered were determined by the AT Priority device list and may not have included certain devices such as robotics which enable human capability but are not one of the selected Priority devices. While some of the databases tend to focus solely on health-related impacts (such as Pub Med and Clinical queries) which may skew the results to include more health-focused output, the other search engines and even the more heavily saturated "health"-oriented search databases did pull in journal articles that considered the impacts of assistive technology on other sectors such as housing, education, and job participation. The general search string which consisted of an assistive technology term (either general assistive technology or the specific AT device selected from the priority list), and an evaluative term (such as cost-benefit analysis) should have pulled in the majority of relevant publications to give a fairly representative sample of journal articles that seek to assess the economic value of AT devices. However, the authors are aware that such a search strategy may not be comprehensive enough to fully capture the entirety of the AT literature, especially when it comes to particular AT devices or very unique evaluation methods. In particular a more robust gray literature search should be conducted in the future to capture gray literature outside the few select locations scouted and chosen.

Conclusion

The goal of this paper was to demonstrate the multifaceted techniques and methods that are currently being used to capture AT value globally. Through this process it has become clear that within this literature there is evidence that AT offers value, but the studies conducted are only of moderate evidence strength and further the methodologies and tools employed to capture value are found wanting. The paper has synthesized and analyzed existing AT evaluation techniques and has highlighted some of the most common types of methods used to assess value along with capturing what are the most common perspectives in which AT value is understood. AT value is often understood in terms of how access and utilization of AT alleviate the cost and burden of the care network, whether this is through reductions in time family carers are required to assist users, or decreases in care costs through reduced time and resources expended.

This paper advocates both for a wider user of alternative evaluation and appraisal methodologies, as well as a synthesis of a mixture of different techniques. We recognize the CBA, CUA and CEA will not be abandoned, but rather they should be complemented by other measurements that embrace value which are difficult to monetize, such as wellbeing or AT innovation ecosystems. By promoting such alternative forms of evaluation this study hopes to provide a path forward for LMICs who currently have difficulty in prioritizing AT due to financial constraints and lack understanding of the manifold impacts of AT. Through a wider breadth of AT evaluations within the research domain, a more robust evidence base will enhance global awareness of AT value and its need to be prioritized.

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References

Al-Oraibi, S., Fordham, R., & Lambert, R. (2012). Impact and economic assessment of assistive technology in care homes in Norfolk, UK. *Journal of Assistive Technologies*, *6*(3). https://doi.org/10.1108/17549451211261317

Andrich, R. (2002). The SCAI instrument: Measurement costs of individual assistive technology programmes. *Technology and Disability*, *14*(3), 95–99. https://doi.org/10.3233/TAD-2002-14303

Andrich, R., Ferrario, M., & Moi, M. (1998). A model of cost-outcome analysis for assistive technology. *Disability & Rehabilitation*, *20*(1), 1–24. https://doi.org/10.3109/09638289809166850

Brodin, H., & Persson, J. (1995). Cost-utility analysis of assistive technologies in the European commission's tide program. *International Journal of Technology Assessment in Health Care*, *11*(2), 276–283. https://doi.org/10.1017/S0266462300006899

Harding,S. (1995). Thought make economics more objective? *Feminist Economics*, *1*(1), 7–32. https://doi.org/10.1080/714042212

Demers, L., Weiss-Lambrou, R., & Ska, B. (1996). Development of the Quebec user evaluation of satisfaction with assistive technology (QUEST). *Assistive Technology*, *8*(1), 2–13. https://doi.org/10.1080/10400435.1996.10132268

Dequech, D. (2007). Neoclassical, mainstream, orthodox, and heterodox economics. *Journal of Post Keynesian Economics*, *30*(2), 279–302. https://doi.org/10.2753/PKE0160-3477300207

Deruyter, F. (1995). Evaluating outcomes in assistive technology: Do we understand the commitment? *Assistive Technology*, *7*(1), 3–8. https://doi.org/10.1080/10400435.1995.10132246

Drummond, M., O'Brien, B., Stoddart, G., & Torrance, G. (1997). *Methods for the economic evaluation of health care programmes* (2nd ed.). Oxford University Publication.

Drummond, M. F., Brandt, A., Luce, B. R., & Rovira, J. (1993). Standardizing economic evaluation methodologies in health care. *International Journal of Technology Assessment in Health Care*, *9*(1), 26–36. https://doi.org/10.1017/S0266462300003007

Fuhrer, M. J. (2001). Assistive technology outcomes research: Challenges met and yet unmet. *American Journal of Physical Medicine and Rehabilitation*, *80*(7), 528–535. https://doi.org/10.1097/00002060-200107000-00013

Fuhrer, M. J. (2007). Assessing the efficacy effectiveness, and cost-effectiveness of assistive technology interventions for enhancing mobility. *Disability and Rehabilitation. Assistive Technology*, *2*(3), 149–158. https://doi.org/10.1080/17483100701374355

Galvin, J. C., & Scherer, M. J. (1996). *Evaluating, selecting and using appropriate assistive technology*. Aspen Publishers, Inc.

Gelderblom, G. J., & de Witte, L. P. (2002, January). The assessment of assistive technology outcomes, effects and costs. *Technology and Disability*, *14*(3), 91–94. https://doi.org/10.3233/TAD-2002-14302

Goldman, L., Garber, A., Grover, S., & Hlatky, M. (1996). Cost effectiveness of assessment and management of risk factors. *Journal of the American College of Cardiology*, *27*, 1020–1030.

Harris, F., & Sprigle, S. (2003). Cost analyses in assistive technology research. *Assistive Technology*, *15*(1), 16–27. https://doi.org/10.1080/10400435.2003.10131886

Higgins, J. P., & Green, S. (2011). *Cochrane handbook for systematic reviews of interventions*. John Wiley & Sons.

Holm, M. B. (2000). Our mandate for the new millennium: Evidence-based practice. *American Journal of Occupational Therapy*, *2000*(54), 575–585. https://doi.org/10.5014/ajot.54.6.575

Jacobs, P., Hailey, D., & Jones, A. (2003). Economic evaluation for assistive technology policy decisions. *Journal of Disability Policy Studies*, *14*(2), 120–126. https://doi.org/10.1177/10442073030140021001

Kattel, R. (2020). *Alternative policy evaluation frameworks and tools*. Department for Business, Energy & Industrial Strategy.

Kattel, R., Mazzucato, M., Ryan-Collins, J., & Sharpe, S. (2018). *The economics of change: Policy appraisal for missions, market shaping and public purpose*. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2018-06).

Lansley, P., McCreadie, C., & Tinker, A. (2004). Can adapting the homes of older people and providing assistive technology pay its way? *Age and Ageing*, *33*(6), 571-6. https://doi.org/10.1093/ageing/afh190

Mann, W. C., Ottenbacher, K. J., Fraas, L., Tomita, M., & Granger, C. V. (1999). Effectiveness of assistive technology and environmental interventions in maintaining independence and reducing home care costs for the frail elderly: A randomized controlled trial. *Archives of Family Medicine*, *8*(3), 210-7. https://doi.org/10.1001/archfami.8.3.210

Manns, P. J., & Darrah, J. (2006). Linking research and clinical practice in physical therapy: Strategies for integration. *Physiotherapy*, *92*(2), 88–94. https://doi.org/10.1016/j.physio.2005.09.006

Marasinghe, K. M., Lapitan, J. M., & Ross, A. (2015). Assistive technologies for ageing populations in six low-income and middle-income countries: A systematic review. *BMJ Innovations*, *1*(4), 4. https://doi.org/10.1136/bmjinnov-2015-000065

Nelson, R., & Winter, S. (1974). Neoclassical vs evolutionary theories of economic growth: Critique and prospectus. *The Economic Journal*, *84* (336), 886–905. https://doi.org/10.2307/2230572

Schraner, I., de Jonge, D., Layton, N., Bringolf, J., & Molenda, A. (2008). Using the ICF in economic analyses of assistive technology systems: Methodological implications of a user standpoint. *Disability and Rehabilitation*, *30*(12–13), 916–926. https://doi.org/10.1080/09638280701800293

Schüler, E., Salton, B. P., Sonza, A. P., Façanha, A. R., Cainelli, R., Gatto, J., Kunzler, L., & Araújo, M. D. C. C. (2013). Production of low cost assistive technology. *Proceedings of the Fifth International Conference on Management of Emergent Digital EcoSystems*, 297–301. MEDES '13. Association for Computing Machinery.

Shin, J., Kim, Y., Nam, H., & Cho, Y. (2016). Economic evaluation of healthcare technology improving the quality of social life: The case of assistive technology for the disabled and elderly. *Journal of Applied Economics*, *48* (15), 1361–1371. https://doi.org/10.1080/00036846.2015.1100254

Smith, R. O. (1996). Measuring the outcomes of assistive technology: Challenge and innovation. *Assistive Technology*, *8*(2), 71–81. https://doi.org/10.1080/10400435.1996.10132277

Stovold, E., Beecher, D., Foxlee, R., & Noel-Storr, A. (2014). Study flow diagrams in Cochrane systematic review updates: An adapted PRISMA flow diagram. *Systematic Reviews*, *3*(1), 54. https://doi.org/10.1186/2046-4053-3-54

WHO. (2019). *Provision of wheelchairs in Tajikistan: Economic assessment of alternative options*. https://apps.who.int/iris/bitstream/handle/10665/312049/9789289054041-eng.pdf?sequence=1&isAllowed=y&ua=1

World Health Organization. (2014). *Opening the gate for assistive health technology: Shifting the paradigm. Secondary Opening the gate for assistive health technology: Shifting the paradigm*. http://www.aaate.net/sites/default/files/gate_concept_note_for_circulation.pdf

Appendix. Studies included in economic evaluation assessment and review

Scoping Review References

Brent 2019 (USA) [1]
Brent, R. J. (2019) 'A Cost-Benefit Analysis of Hearing Aids, Including the Benefits of Reducing the Symptoms of Dementia'. *Applied Economics* 51, no. 28: 3091–3103.

Andrich et al., 1998 (Europe) [3]
Andrich R, Ferrario M, and Moi M. (1998) 'A Model of Cost-Outcome Analysis for Assistive Technology.' *Disability & Rehabilitation* 20, no. 1: 1–24.

Salatino et al., 2016 (Italy) [4]
Salatino C, Andrich R., Converti M, and Saruggia M. (2016) 'An Observational Study of Powered Wheelchair Provision in Italy'. *Assistive Technology: The Official Journal of RESNA* 28, no. 1: 41–52.

Andrich & Caracciolo 2007 (Italy/Europe) [5]
Andrich, R. Caracciolo A. (2007) 'Analysing the Cost of Individual Assistive Technology Programmes'. *Disability and Rehabilitation. Assistive Technology* 2, no. 4: 207–34.

Lansley et al., 2004 (England and Scotland) [12]
Lansley P, McCreadie C, and Tinker A. (2004) 'Can Adapting the Homes of Older People and Providing Assistive Technology Pay Its Way?' *Age and Ageing* 33, no. 6: 571–76.

Allen 2001 (USA) [13]
Allen, S. M. (2001) 'Canes, Crutches and Home Care Services: The Interplay of Human and Technological Assistance'. *Policy Brief (Center for Home Care Policy and Research (U.S.))*, no. 4: 1–6.

Duff & Dolphin 2007 (England, Ireland, Finland, Norway) [19]
Duff, P., and Dolphin C. (2007) 'Cost-Benefit Analysis of Assistive Technology to Support Independence for People with Dementia - Part 2: Results from Employing the ENABLE Cost-Benefit Model in Practice'. *Technology and Disability* 19, no. 2–3: 79–90.

Monksfield et al., 2011 (UK) [21]
Monksfield P, Jowett S, Reid A, and Proops D. (2011) 'Cost-Effectiveness Analysis of the Bone-Anchored Hearing Device'. *Otology & Neurotology : Official Publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology* 32, no. 8: 1192–97.

Hagberg et al., 2017 (Sweden) [22]
Hagberg L, Hermansson L, Fredriksson C, and Pettersson I. (2017) 'Cost-Effectiveness of Powered Mobility Devices for Elderly People with Disability'. *Disability and Rehabilitation. Assistive Technology* 12, no. 2: 115–20.

Leroi et al. 2013 (UK) [29]
Leroi I et al. (2013) 'Does Telecare Prolong Community Living in Dementia? A Study Protocol for a Pragmatic, Randomised Controlled Trial'. *Trials* 14: 349.

Shin et al., 2016 (Korea) [31]
Shin J., Kim Y, Nam H, and Cho Y. (2016) 'Economic Evaluation of Healthcare Technology Improving the Quality of Social Life: The Case

of Assistive Technology for the Disabled and Elderly'. *Applied Economics* 48, no. 15: 1361–71.

Mann et al., 1999 (USA) [34]
Mann W. C., Ottenbacher K.J., Fraas L, Tomita M, and Granger C.V. (1999) 'Effectiveness of Assistive Technology and Environmental Interventions in Maintaining Independence and Reducing Home Care Costs for the Frail Elderly. A Randomized Controlled Trial'. *Archives of Family Medicine* 8, no. 3: 210–17.

Cooper et al., 1999 (USA) [38]
Cooper R. A., Boninger M. L., and Rentschler A. (1999) 'Evaluation of Selected Ultralight Manual Wheelchairs Using ANSI/RESNA Standards'. *Archives of Physical Medicine and Rehabilitation* 80, no. 4: 462–67.

Al-Oraibi et al., 2012 (UK) [44]
Al-Oraibi S, Fordham R, and Lambert R. (2012) 'Impact and Economic Assessment of Assistive Technology in Care Homes in Norfolk, UK'. *Journal of Assistive Technologies*, 7 September.

Desideri 2016 (Italy) [45]
Desideri L et al. (2016) 'Implementing a Routine Outcome Assessment Procedure to Evaluate the Quality of Assistive Technology Service Delivery for Children with Physical or Multiple Disabilities: Perceived Effectiveness, Social Cost, and User Satisfaction'. *Assistive Technology: The Official Journal of RESNA* 28, no. 1: 30–40.

Noben et al., 2017 (Netherlands) [46]
Noben C, Evers S, van Genabeek J, Nijhuis F, and de Rijk A. (2017) 'Improving a Web-Based Employability Intervention for Work-Disabled Employees: Results of a Pilot Economic Evaluation'. *Disability and Rehabilitation. Assistive Technology* 12, no. 3 : 280–89.

Samuelsson & Wressle 2014 (Sweden) [53]
Samuelsson K, and Wressle E (2014). 'Powered Wheelchairs and Scooters for Outdoor Mobility: A Pilot Study on Costs and Benefits'. *Disability and Rehabilitation. Assistive Technology* 9, no. 4: 330–34.

Bray et al., 2016 (UK) [54]
Bray N, Yeo ST, Noyes J, Harris N, and Edwards RT. (2016) 'Prioritising Wheelchair Services for Children: A Pilot Discrete Choice Experiment to Understand How Child Wheelchair Users and Their Parents Prioritise Different Attributes of Wheelchair Services'. *Pilot and Feasibility Studies* 2 (2016): 32.

Ekman & Borg 2017 (Bangladesh) [55]
Ekman B, and Borg J. (2017) 'Provision of Hearing Aids to Children in Bangladesh: Costs and Cost-Effectiveness of a Community-Based and a Centre-Based Approach'. *Disability and Rehabilitation. Assistive Technology* 12, no. 6: 625–30.

Vincent et al. 2006 (Canada) [56]
Vincent C et al. (2006) 'Public Telesurveillance Service for Frail Elderly Living at Home, Outcomes and Cost Evolution: A Quasi Experimental Design with Two Follow-Ups'. *Health and Quality of Life Outcomes* 4: 41.

Creasey et al., 2000 (USA) [57]
Creasey G. H., et al. (2000) 'Reduction of Costs of Disability Using Neuroprostheses'. *Assistive Technology: The Official Journal of RESNA* 12, no. 1 (2000): 67–75. https://doi.org/10.1080/10400435.2000.10132010.

Aanesen et al., 2011 (global) [59]
Aanesen, M., Lotherington A, and F. Olsen. (2011) 'Smarter Elder Care? A Cost-Effectiveness Analysis of Implementing Technology in Elder Care'. *Health Informatics Journal* 17, no. 3: 161–72.

Hutchinson et al., 2020 (Australia) [64]
Hutchinson C, et al. (2020) 'Using Social Return on Investment Analysis to Calculate the Social Impact of Modified Vehicles for People with Disability'. *Australian Occupational Therapy Journal.*

Schulz et al., 2014 (USA) [67]
Schulz R et al. (2014) 'Willingness to Pay for Quality of Life Technologies to Enhance Independent Functioning among Baby Boomers and the Elderly Adults'. *The Gerontologist* 54, no. 3: 363–74.

Riikonen et al., 2010 (Finland) [68]
Riikonen M T, Mäkelä K., Perälä S. (2010). Safety and monitoring technologies for the homes of people with dementia. Gerontechnology 9(1)

WHO 2017 (Tajikistan) [69]
WHO (2017). Provision of Wheelchairs in Tajikistan: Economics Assessment of Alternative Options. World Health Organization Regional Office for Europe.

Baltussen & Smith. 2009 (sub-Saharan Africa and South East Asia) [70]
Baltussen, R., and Smith. A (2009) 'Cost-Effectiveness of Selected Interventions for Hearing Impairment in Africa and Asia: A Mathematical Modelling Approach'. *International Journal of Audiology* 48, no. 3 (1 January 2009): 144–58. https://doi.org/10.1080/14992020802538081.

Baltussen & Smith. 2012 (sub-Saharan Africa and South East Asia) [71]
Baltussen, R., and A. Smith. (2012) 'Cost Effectiveness of Strategies to Combat Vision and Hearing Loss in Sub-Saharan Africa and South East Asia: Mathematical Modelling Study'. *BMJ* 344, no. Mar02 1: e615–e615.

Croock Associates 2015 (Rwanda) [72]
Croock Associates (2015). Primary Eye Care Services in Rwanda: Benefits and Costs. Commissioned by Vision for a Nation Foundation.

WHO 2017 (global) [73]
WHO (2017). Global costs of unaddressed hearing loss and cost-effectiveness of interventions. WHO Global Report.

Healy 2018 (Australia, Canada, Germany, Netherlands, UK, USA) [74]
Healy A, Farmer S, Pandyan A, and Chockalingam N (2018) 'A Systematic Review of Randomised Controlled Trials Assessing Effectiveness of Prosthetic and Orthotic Interventions'. *PloS One* 13, no. 3.

Persson et al., 2008 (Sweden) [75]
Persson J, Aelinger S, Husberg M (2008) Kostnader och effekter vid förskrivning av hörapparat. CMT Rapport (5)

Persson et al., 2007 (Sweden) [76]
Persson J, Husberg M, Hellbom G, Fries A. (2007) Kostnader och effekter vid förskrivning av rollatorer (3)

Aanesen 2009 (Norway) [77]
Aanesen M (2009) LothNy teknologi i pleie og omsorg: en kost – nytteanalyse av smarthusteknologi og videokonsultasjoner. Norut Rapport 5

Socialstyrelsen 2013 (Denmark) [78]
Socialstyrelsen. (2013) Smarthometeknologi. https://socialstyrelsen.dk/filer/tvaergaende/hjaelpemidler-og-velfaerdsteknologi/smarthome-analyse.pdf

Dahlberg 2013 (Sweden) [79]
Dahlberg (2013). Nyttokostnadsanalys vid införande av välfärdsteknologi– exemplet Posifon. Hjälpmedelsinstitutet.

Hannerz 2013 (Sweden) [80]
Hannerz (2013). Utvärdering av projekt Förskrivning av larm i Östersund- ekonomi och process. https://docplayer.se/3797329-Utvardering-av-projekt-forskrivning-av-larm-i-ostersund-ekonomi-och-process-ostersund-2013-01-03.html

Griffiths 2014 (Zambia) [81]
Griffiths, UK (2014) 'Cost-Effectiveness of Eye Care Services in Zambia'. *Cost Effectiveness and Resource Allocation* 12, no. 1: 6.

Dahlberg 2012 (Sweden) [82]
Dahlberg Å (2012), Nyttokostnadsanalys vid införande av välfärdsteknologi – exemplet ippi. Hjälpmedelsinstitutet.

Dahlberg 2010 (Sweden) [83]
Dahlberg Å (2010), Kostnadsnyttobedömning av hjälpmedel till personer med psykisk funktionsnedsättning, Hjälpmedelsinstitutet.

Lund 2010 (Sweden) [84]

Lundmark 2013 (Sweden) [85]
Lundmark EN, Nilsson I, Wadeskog A (2013) Teknikstöd i skolan – Socioekonomisk analys av unga, skolmisslyckanden och arbetsmarknaden. Hjalpmedelsinstitutet

First author & year of publication (country)[ref table #]	Study, or sample type	Domains of AT Impact	EE type & perspective	Key study findings & methodological insights
Brent 2019 (USA) [1]	37,544 participants sampled between September 2005 and March 2017: full panel study from Alzheimer's coordinating centres	Reduction of dementia symptoms; direct benefits of device	CBA, direct utility benefits	Total benefits, mainly coming from the direct benefits, were extremely large relative to the costs, with benefit-cost ratios over 30.
Andrich et al 1998 (Europe) [3]	retrospective study evaluates in-depth assessment of 7 individuals with a walking/ mobility disability throughout Europe	socio-economic impact; user benefits (QALY); family/individual/society costs	HTA cost effectiveness and cost utility (cost utility SIVA/CAI Costs considered entail social, direct, marginal, and operating costs	prototype cost-outcome instrument designed for use in clinical practice in the provision of assistive technology to individual cases
Salatino et al 2016 (Italy) [4]	Observational Study of 79 powered wheelchair users verses those not provided with any wheelchair	AT satisfaction (QUEST); PIADS (Psychosocial Impact of Assistive Devices Scale)	QUEST (Quebec User Evaluation of Satisfaction with Assistive Technology), PIADS (Psychosocial Impact of Assistive Devices Scale), FABS/M (Facilitators and Barriers Survey/Mobility), and SCAI (Siva Cost Analysis Instrument):	provision of a powered wheelchair generated considerable savings in social costs for most users: an average of about $38,000 per person over a projected 5-year period was estimated
Andrich & Caracciolo 2007 (Italy/ Europe) [5]	survey of 31 individual AT programmes carried out over a number of years focused mainly on wheelchair related AT	Social cost (SCAI); assistance burden reduction	Siva Cost Assessment Instrument (SCAI) social cost: i.e., the difference between the social cost of the intervention (the sum of all of the human, material, and financial costs incurred) and the social cost of non-intervention (the cost that would have been incurred if no powered wheelchair had been provided). Siva Cost Analysis Instrument (SCAI) to measure additional social cost	Considerable savings detected in social costs were in the range 150,000 euros over 5 years: second major finding is the marked variation in the social costs of different individual cases where similar AT solutions were implemented
Lansley et al 2004 (England and Scotland) [12]	Examined impact AT modifications within 82 properties of those with a disability	independence; reduction of formal care services	Costs of adaptation level within home vs annual care cost	Cost of AT adaptations are recouped within average life expectancy
Allen 2001 (USA) [13]	observational study of 9,230 respondents to the adult disability (mobility focused) supplement Follow back survey (1994-1995);	Reduction of care hours and costs; reduction out of pocket expense	cost-effectiveness for individual and system level:: Cost data based on (inclusive of personal care attendant, services from centre for independent living, day activity centre services, and transportation services)	Use of canes and crutches reduced formal and informal hours of care received per week. Use of canes and crutches associated with lower-out of pocket costs for formal helping services Wheelchairs and walkers did not show same substitution effect with human assistance need
Duff & Dolphin 2007 (England, Ireland, Finland, Norway) [19]	5 country comparison from assessment trials as part of ENABLE study (quant and qual)	cost of time caring (user/family/institutional level); productivity loss of carers; hospitalisation costs; usefulness of AT; satisfaction of AT	Cost-benefit analysis and WTP	Savings could be made in relation to reduced caregiver burden. People were WTP for these services (81%), but actual cost of devices was far higher than perceived
Monksfield et al 2011 (UK) [21]	Prospective cohort case control analysis of 70 patients	QALY, standard care institutional costs	ICER	AT device has an ICER of 17,610 per QALY gained

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Hagberg et al. 2017 (Sweden) [22]	Pre/post intervention of 45 persons 65+ who have not used a PMD previously in Sweden	QALY, time savings	QALY, costs-effectiveness, time savings costs	Powered wheelchairs maybe cost-effective with initial cost dropping from 1395in first year to 592 second year, decrease in transportation costs and in relative's time use. Very limited increase in quality of life (0.041)… Cost per gained QALY were 12400-14700 US/QALY if value of time saved not considered; ((600-2900)) if considered
Leroi et al. 2013 (UK) [29]	RCT over 104 weeks of 500 participants living in community settings with dementia or cognitive impairment who had been referred to social services	caregiver burden; health related quality of life; number and severity of adverse events	cost-effectiveness analyses will measure costs associated with not being in care home, the second type will measure costs for whole 2 year period of care home and hospital stays	Trial in progress: speculative AT is shown to help people with dementia remain independent and improve their health-related quality of life, as well as being cost-effective
Shin et al. 2016 (Korea) [31]	400 person WTP for AT survey		Spike model of Contingent valuation method (CVM) utilises WTP	household's willingness-to-pay (WTP) for AT is US $4.26 per year through government-levied tax; although many people express zero WTP for the development of these technologies, people with higher household savings, levels of education and levels of charity donations have a higher WTP for AT
Mann et al. 1999 (USA) [34]	RCT : 52 treatment group: received AT and environmental interventions;52 control: usual care services	functional status; Craig handicap assessment; health care costs	Comparison of treatment and control groups on factors related to cost	Results indicate rate of decline can be slowed, and institutional and certain in-home personnel costs reduced through a systematic approach to providing AT and Els.
Cooper et al. 1999 (USA) [38]	Standards testing and cost-effectiveness analysis of four wheelchair models from different manufacturers (12 wheelchairs total)	wheelchair performance	cost effectiveness	Fatigue life and value of the ultralight manual wheelchairs were significantly higher than those previously reported for lightweight manual wheelchairs. Ultralight wheelchairs may be of higher quality than lightweight manual wheelchairs. Clinicians and consumers should select ultralight manual wheelchair to meet mobility needs.
Al-Oraibi et al. 2012 (UK) [44]	retrospective case-control study design was therefore used to collect data about the incidence of falls before and after AT systems were installed in two local authority (LA) managed Care Homes	# of Adverse events; # health care admissions and referrals; costs of avoided health care services	mean healthcare cost per incident: overall total cost of care linked to recorded incidents	installed AT system in residential care homes reduced the number of falls and health care cost in homes with a lower proportion of residents with advanced dementia than those with a higher proportion of residents with advanced dementia. Significant reduction (independent means t-test p=0.015) by more than 50 per cent from £95.90 per incident before the introduction of the new AT system to £45 per incident

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Desideri 2016 (Italy) [45]	quasi-experimental 3-months follow-up of 45 children aged 3-17 years using a pre-test /post-test design aimed at evaluating outcomes of assistive technology (AT) interventions targeting children with physical and multiple disabilities	Satisfaction; social cost; maintenance efforts; care/assistance resources	SCAI cost effectiveness employed to compare social cost generated by AT solution against the social cost generated with the help of human assistance alone. Uses national labour contracts for health and social care workers	SCAI showed more resources spent for AT intervention compared to human assistance without technological supports. For AT interventions, social cost ranged from €1.405 to €15.122 after 1 year of AT use, from €2.361 to €29.794 after two years, and from €3.317 to €44.466 after 3 years. For the same intervention without the AT solution, social cost ranged from €1.872 to € 9.750 in year 1, from €3.744 to €19.500 in year 2, and from €5.616 to €29.250 in year 3. It must be noted that, from data shown in Table 3, the estimated spent resources for using an AT solution exceed those estimated for human assistance alone in four cases in year 1, in three cases in year 2, and in two cases in year 3. Negative cost savings indicate that the AT solutions do not eliminate or even reduce the need for assistance. On the contrary, in certain cases the introduction of an AT solution may require more resources.
Noben et al. 2017	(Netherlands) [46]	compared web-based employability intervention (n=29) vs control (n=34) with regular trade union support amongst those with work-related health problems	Employability impacted by work-related health problems; QALY	cost-effectiveness and cost-utility analysis
Sixty-three participants were a-select allocated to either the intervention (n = 29) or the control (n = 34) group. Uptake regarding the intervention elements ranged between 3% and 70%. Cost-	effectiveness and cost-utility analyses resulted in negative effects although higher total costs. Incremental effects were marginal (work ability -0.51; QALY -0.01).			
Samuelsson & Wressle 2014 (Sweden) [53]	24 participants with functional limitations pilot prospective study with before after AT design with a baseline questionnaire and then 4 month after delivery of service	Social participation and life satisfaction; occupational performance; delivery method costs; safety and self esteem	Before/after AT intervention cost which calculated cost savings of not needing health/ care assistance	Assistance in outdoor mobility decreased significantly upon intervention, with an estimated cost of 122.4 euros per month. Overall with reduction of personal assistance there was a societal savings of 6227 euros per year per each user

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Bray et al. 2016 (UK) [54]	11 disabled children(aged 11 to 18) and 30 parents of children were administered discrete choice experiment via questionnaire to explore wheelchair services attributes	AT training; delivery time; Wheelchair attributes	calculate hypothetical marginal rate of substitution values for different configurations of wheelchair services using cost denominator	Comprehensiveness of wheelchair assessment and wheelchair delivery time significantly ($P < 0.05$) affected service preferences of children (β-coefficients = 1.43 [95 % bootstrapped CI = 1.42 to 2.08] and −0.92 [95 % bootstrapped CI = −1.41 to −0.84], respectively) and parents (β-coefficients = 1.53 [95 % bootstrapped CI = 1.45 to 2.16] and −1.37 [95 % bootstrapped CI = −1.99 to −1.31], respectively). Parents were willing to Contribute more financially to receive preferred services. Greatest importance on holistic wheelchair assessments encompassing more than health
Ekman & Borg 2017	(Bangladesh) [55]	Prospective, cluster-randomized controlled trial of two alternative delivery models of hearing aids to children in Bangladesh: a centre-based and a community-based model; 65 participants from five clusters in the centre-based group and 77 participants from six clusters in the community-based group (between 12 and 18 years).	DALY averted; health effects; Provider cost items include staff (audiometric technician, administrator and community worker), capital costs and equipment, facility costs, and running costs (utilities). Costs to the patient and the caregiver include time costs (lost schooling or work) and direct costs (travel, food, accommodation, and user charges	Cost-effectiveness study based on DALYS averted. Costing approach of the study follows that of Drummond et al. [21] and similar guidelines.)
Using	a community-based approach to deliver hearing aids to children in a resource constrained environment is a cost-effective alternative to the traditional centre-based approach. The total cost per participant in the community-based model was BDT 6,333 (USD 79) compared with BDT 13,718 (USD 172) for the centre-based model. Both delivery models are found to be cost-effective with an estimated cost per DALY averted of BDT 17,611 (USD 220) for the community-based model and BDT 36,775 (USD 460) for the centre-based model.			
Vincent et al. 2006 (Canada) [56]	38 elderly patients and 38 caregivers participated in quasi experimental design over 9 month period measured before and after intervention outcomes	Hospital stay reduction; reduced care-giver burden; cost of health and social public health services	Cost effectiveness- compared cost of health care system resources averted vs cost of AT intervention	Total cost of health and social public services used per client dropped by 17% after the first 3 months and by 39% in the second 3 months. Registering older adults at a tele surveillance centre staffed by nurses costs the health care system less than services provided without a tele surveillance system. Corresponds to Tinker's Estimate that in England it would cost the public system less to offer vulnerable adults an AT service

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Creasey et al. 2000 (USA) [57]	two studies based on in-depth interviews of 4 subjects 1) bladder/bowel care prosthesis vs usual care with attendant 2)Hand grasp prosthesis vs usual care data	Life time costs; reduction of complications; autonomy levels	Cost effectiveness- compared cost of health care system resources averted vs cost of AT intervention	Over 30 year lifetime hand grasp can save a total of $88, 487 due to a reduction in attendant time. For bladder and bowel neuroprosthesis for a period of 35 years an average cost savings of $322,000 during the life of the patient. Can improve control of bladder but can also pay for itself within 5 years and thereafter save costs. Hand grasp provides improved independence and can save costs over lifetime by decreasing need for personal assistance
Aanesen et al. 2011 (global) [59]	experience data from previous studies and from the actual use of the technologies, derived the net costs of the implementation of the technologies and related the costs to the assumed effects	time and resource savings for the home care providers; time savings for relatives; resource savings for hospitals	Cost effectiveness- compared cost of health care system resources, time savings of relatives and reduction of home care providers averted vs cost of AT intervention	Smart house technology is cost-effective, even if only relatives gain from it. Video visits, which have higher implementation costs, demand effects on both relatives and health care providers in order to be a cost-effective tool in home care.
Hutchinson et al. 2020 (Australia) [64]	8 semi-structured interviews from consumers 15 semi-structured interviews with other stakeholders concerning interventions SROI	Thirteen outcomes were identified, 11 related to consumers, including educational and employment opportunity, increased confidence and self-esteem, increased access to health services, and improved mental health and wellbeing. Two additional outcomes identified were reduced burden on caregivers and increased community awareness	SROI of AT modification: A co-investment model was adopted to estimate social return on investment and payback period for funder and consumer	Social return on investment ratios was positive for funder and consumer investment in all five scenarios. Social return on investment calculations based on co-investment ranged from $17.32 for every $1 invested (Scenario 1) to $2.78 for every $1 invested (Scenario 5). Consumers' payback periods were between 5.4 and 7.1 months, and funders between 3.5 weeks and 2 years 8.4 months.
Schulz et al. 2014 (USA) [67]	Nationally representative web survey of 416 baby boomers aged 45–64, and 114 older adults aged 65 plus (total n = 530). AT use not a precondition	Awareness of AT benefits for general population	Monthly WTP for in home AT	Those willing to pay something were on average willing to pay a maximum of $40.30 and $45.00 per month for kitchen and personal care technology assistance, respectively. Respondents concerned about privacy or who were currently using assistive technology were less willing to pay. Respondents with higher incomes, who were Hispanic, or who perceived a higher likelihood of needing help in the future were more willing to pay.
Riikonen et al. 2010 (Finland) [68]	29 different technologies were tested in the homes of 25 persons living at home with Alzheimer's	Prolonged at home living; less health and care resources; fewer adverse events and incidents	Cost effectiveness- compared cost of health care system resources averted vs cost of AT intervention	Devices were used on average for 7.5 months and the cost of devices installed varied from 30 to 2,100 Euros (average cost was 600). On average technology installed evaluated to have increased 'home time' of elderly persons by an average of 8 months, indicative of clear postponement of need for institutional care which contrasts to 3,000 a month for institutional care
WHO 2017 (Tajikistan) [69]	Comparison study of wheelchair service delivery cost based on estimated or available secondary data	Increased employment opportunities; creation of a sustainable industry that could lead to economic growth; reduced national expenses that go to external partners	Cost-benefit analysis that compares purchase price of wheelchairs and cost of services, maintenance, and replacement to understand which of the 4 models of AT production, and distribution (wheelchair service delivery model) most cost effective and beneficial to economy	Cost-benefit analysis demonstrated that in country production and assemblage of wheelchairs brought about the greatest net benefit for labor force and economy

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Baltussen & Smith 2009 (sub-Saharan Africa and South East Asia) [70]	mathematical models to compare and look into screening strategies for hearing impairment and delivery of hearing aids cost based on nationally available data	DALYs averted; reduced or recuperated care costs; resource investment in patient facility, central planning, admin functions supervision and training; media; maintenance; supplies; salaries; cost of visits, cost of hearing aids	Average cost-effectiveness ratios (ACERs) calculated for screening and delivery strategy by combining the information on the total costs with information on the total health effects in terms of DALYs averted	Findings showed that in both regions, screening strategies for hearing impairment and delivery of hearing aids cost between I$1000 and I$1600 per DALY, with passive screening being the most efficient intervention. Active screening at schools and in the community are somewhat less cost-effective.
Baltussen et Smith 2012 (sub-Saharan Africa and South East Asia) [71]	mathematical models to compare and look into screening strategies for hearing impairment and delivery of hearing aids cost based on nationally available data	DALYs averted; reduced or recuperated care costs; resource investment in patient facility, central planning, admin functions supervision and training; media; maintenance; supplies; salaries; cost of visits, cost of hearing aids	Average cost-effectiveness ratios (ACERs) calculated for screening and delivery strategy by combining the information on the total costs with information on the total health effects in terms of DALYs averted	Cost effective interventions to control hearing and vision impairment, with the cost per DALY averted <$Int285 in both regions. Screening of both schoolchildren (annually) and adults (every five years) for hearing loss costs around $Int1000 per DALY averted. These interventions can be considered highly cost effective.
Croock Associates 2015 (Rwanda) [72]	Retrospective study based on available data of those that received eye programme interventions vs modelling of system and productivity if no treatment	Enhanced educational opportunities; job uptake; quality of life; increased health and safety; community health care workers; distribution costs	a. The loss in productivity, opportunity and employment without AT impairment, b. Cost of accidents and injuries through poor vision, c. Costs in terms of quality of life, d. Economic deadweight loss	Productivity loss to the national economy as a result of URE is 60 million. Productivity gains envisaged for patients tested and provided with glasses at 10% where the 2013 GDP per capita is US $639. Overall cost is small in relation to potential productivity gains that could be generated through provision of eyeglasses
WHO 2017 (global) [73]	Retrospective data analysis study from GBD data demonstrating treatment effects and modelling for non-treatment cost outcomes	Labour uptake; formal and informal care costs; user employment; general productivity and societal participation	Cost-effectiveness of AT usage compared to societal costs incurred by healthcare and education	Use of hearing aids is shown to be cost-effective, especially use is continuous and accompanied by audiological rehabilitation. Cochlear implants are shown to be most cost-effective when fitted unilaterally and at an early age. However, even when implants are fitted later in life, or provided in both ears, the benefits exceed the costs incurred. Although no studies were found that assessed the cost–effectiveness of captioning services and sign language interpretation, evidence suggests that these interventions are effective in making information accessible to deaf and hard of hearing people.
Healy 2018 (Australia, Canada, Germany, Netherlands, UK, USA) [74]	Systematic lit review of cost effectiveness of prosthetics	Pain levels; quality of life; functional improvement; walking speed; functional reach; physiological assessments; activity and participation	Incremental cost-effectiveness ratios (ICERs), bootstrapping analysis and cost effectiveness acceptability curves: studies reviewed focused on Cost effectiveness- compared cost of health care system resources averted vs cost of AT intervention	RCT studies demonstrated that prostheses, despite initial cost, overall reduced costs through fewer hospital or care interactions. dearth of cost-effectiveness assessments and those studies that do exist highlight the potential cost saving in healthcare that can be achieved when services implemented correctly
Persson et al. 2008 (Sweden) [75]	Pre-post analysis, crossover with comparison of digital and analogue hearing aids first time hearing aid users (n=156)	Quality of life (HUI3 (Health Utilities Index Mark 3), EQ-5D)	Cost-utility analysis, Provider perspective	SEK 80000/QALY (EQ-5D), SEK 17300/QALY (HUI3), randomised cross-over study

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Persson et al. 2007 (Sweden) [76]	Pre-post analysis of rollator use in first time users (n=205)	Quality of life (EQ-5D)	Cost-utility analysis, Provider perspective	SEK 24000/QALY (EQ-5D)
Aanesen 2009 (Norway) [77]	Assumption-based model of smart home technology (security and fire alarms, door and fall sensors) for elderly living at home reducing nursing care services compared with hypothetical scenario without AT	Reduction in care hours. Possibility to live at home longer for users. Potential time savings and reduced worrying for next-of-kins.	Cost-minimisation analysis, Societal perspective	Positive net benefit
Socialstyrelsen 2013 (Denmark) [78]	Assumption-based model of smart house technology for individuals with disabilities living at home reducing nursing care services compared with hypothetical scenario without AT	Reduction in care hours. Dignity and fulfilment due to increased self-management of everyday tasks	Cost-minimisation analysis, Provider perspective (with discussion on non-tangible consequences for users and next-of kind)	Positive net benefit
Dahlberg 2013 (Sweden) [79]	Study of AT location device (mobile phone with GPS function) for individuals with dementia (n=36) living at home reducing nursing care services compared with hypothetical scenario without AT	Reduction in care hours. Independence (users may go for walks on their own without accompanying person, less worry for next-of-kind. Potential reduction in search actions for individuals with dementia getting lost.	Cost-minimisation analysis, Provider perspective. (with discussion on non-tangible consequences for users and next-of kind)	Positive net benefit
Hannerz 2013 (Sweden) [80]	Study of AT passive alarm devices (watch/clip with GPS, door alarm) for individuals with dementia living at home (n=11) reducing nursing care services compared with hypothetical scenario without AT	Reduction in care hours. Possibility to live at home longer for users. Potential time savings and reduced worrying for next-of-kins.	Cost-minimisation analysis, Societal.Per case estimations (with discussion on non-tangible consequences for users and next-of kind)	Positive net benefit in 7 out of 11 cases
Griffiths 2014 (Zambia) [81]	Prospective cohort study of 170 cataract and 113 refractive error/presbyopia patients over 10 months with follow up	Quality of Life; cost incurred by health care sector and patients; transport costs; visual acuity	Cost-utility analysis which evaluated incremental costs per QALY gained from intervention	Incremental costs per Quality Adjusted Life Years gained were US$ 375 for refractive error correction. The probabilities of the incremental cost-effectiveness ratios being below the Zambian gross national income per capita were 95% for both cataract surgery and refractive error correction.
Dahlberg 2012 (Sweden) [82]	Assumption-based model of video communication device through TV for elderly with care needs (qualitative data collection from users (n=11), care personnel and policymakers	Reduction in care hours. Improved information from the care services for users. Possibilities for virtual communication with relatives and friends.	Cost-minimisation analysis, Provider perspective (with discussion on non-tangible consequences for users and next-of kind)	Positive net benefit
Dahlberg 2010 (Sweden) [83]	Assumption-based model of time management devices for individuals with cognitive disabilities	Increased independence, self-esteem, better possibilities to get and upheld a job	Cost-benefit analysis, Societal perspective	Positive net benefit with cut-off after 1.5 years of use
Lund 2010 (Sweden) [84]	Study of a range of AT devices (hearing aid, rollator, manual and electrical wheelchairs) in individuals with physical disabilities (n=269)	Quality of live (PIRS (Problem Impact Rating Scale), EQ-5D)	Cost-utility analysis, Provider perspective	Hearing aid: SEK 52090/QALY (EQ-5D); Rollator: SEK 30759/QALY (EQ-5D); Manual wheelchair: SEK 70355/QALY (EQ-5D); Electrical wheelchair: SEK 317333/QALY (EQ-5D)
Lundmark 2013 (Sweden) [85]	Assumption-based model of learning support devices for students with cognitive disabilities	Increased independence, self-esteem, better possibilities to get and upheld a job	Cost-benefit analysis, Societal perspective	Positive net benefit, working life perspective