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RESEARCH ARTICLE



## Outcomes of assistive technology use by sex and gender; a scoping review

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### ABSTRACT

**Purpose:** This paper synthesises evidence on the influence of sex and gender on assistive technology (AT) outcomes, recognising AT as a tool for enabling participatory rights.

**Materials and Methods:** Employing a narrative synthesis informed by the socio-ecological model, we undertook a scoping review of sixty-six papers, identifying twenty-two with significant sex or gender associations.

**Results and Conclusions:** Findings revealed that gender bias in AT design correlated with diminished individual-level outcomes for women. Ableist stereotypes, exemplified by the neglect of disabled mothers' needs, were evident. Furthermore, inaccessible built environments amplified gendered ableism. To mitigate design bias, a greater emphasis on physiological sex differences and their impact on AT use is crucial. Attending to sex and gender dynamics in AT design and provision is essential for maximising benefits across genders. Future research and synthesis should incorporate other health determinants to provide a more comprehensive understanding of AT outcomes. Ultimately, addressing these factors is vital for equitable AT access and utilisation.

### ARTICLE HISTORY

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### KEYWORDS

Assistive technology; social determinants; gender bias; sex bias; health inequalities; gender; disability; health outcomes

### ► IMPLICATIONS FOR REHABILITATION

- Assistive products were viewed as vital for enabling public and social participation, including increasing sense of safety, among women. However, quantitative findings suggesting that assistive product use enhanced social participation among only men, underscore importance of addressing stigma at the intersections of gender and disability which impact disabled women's experience of socialising.
- Aesthetics of devices were evidenced to play a role within mental health outcomes associated with AT use, suggesting that where aesthetics are better suited towards user's preferences in terms of (gender) expression, this may lessen potential negative impacts on well-being, related to stigma of device use.
- Greater gender sensitivity in rehabilitation and skills interventions are warranted, including wheelchair skills, taking into account findings related to lesser gain of functional outcomes, greater injury and greater co-morbidities associated with assistive product use among women.
- Interdisciplinary obstetrics care for pregnant persons with disabilities may support relational bonds between carers and infants, as well as procuring necessary adaptations to products, furniture and home environments to support pregnancy and parenting.
- Increasing access to assistive products alone should not be seen as silver bullet towards rectifying historic inequities in access to economic opportunities for disabled women.

### Lived experience Commentary by Mary adeturinmo,<sup>1</sup> MRes, member of the Snowdon Trust's<sup>2</sup> Disabled Leaders' Network

Differentiating the different actors within the AT eco-system is a solid start for this paper. A human-centred, inclusive design approach to ATs may enable designers to understand users' nuanced needs, which, in turn, helps them to create products and services that individuals with disabilities would value. The additional

discussion of the financial cost of ATs enabled me to consider how I accessed them. Some can be subsidised to support people in their education and work, which is not an option for everyone. If one considers the gender pay gap for women, then research into the intersection of gender, disability and purchasing power could be explored further, as well as whether the high cost of some ATs could be a considerable barrier. Strong suggestions have been made, emphasising better training for staff prescribing ATs. This resonated

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with me because prescribers can act as gatekeepers or facilitators of equitable societal integration.

### **Lived experience commentary by anonymous member of the Snowdon Trust's<sup>3</sup> Disabled Leaders' Network**

The scoping review sets out a range of factors affecting assistive technology use, which have sometimes facilitated and limited my own choices in deciding which technologies I use or choose not to use. Whilst the piece rightly identifies a range of health determinants, the analytic analysis and breakdown sometimes proliferates crude binaries and categorisations, which fail to consider the multiple forms of oppression as well as complicated layers of identity and experience. Whilst this may be due to the nature of data collection and layout of existing scholarship, I was interested in finding out more about how Deaf and disabled folk understood the contested nature of assistive technology, why they used such technologies and the ways in which it acted as both a mechanism for inclusion as a means of masking or 'fitting in'. I enjoyed the authors' discussion of the built and physical environment but felt as though the social model of disability was a strong framework missing in the piece. In addition, important conceptual frameworks such as DeafSpace (a design philosophy that reiterates how Deaf people live in a rich sensory world, with a strong cultural identity centred around the spatial environment, sign languages and shared life experiences) would be integral to the discussion, yet left out from the dialogue.

### **Introduction and related work**

Beyond benefits to health and functioning, assistive technology (AT) is a means of enabling users to exercise their rights to participation and engagement in key realms of life [1]. The World Health Organization defines AT as "the application of organized knowledge and skills related to assistive products,<sup>3</sup> including systems and services"<sup>4</sup>. Wheelchairs, crutches, prosthetics, eyeglasses, hearing aids, fall monitors, grab-rails and even mobile phones (where used to support functioning) are all examples of assistive products. The absence of AT can exacerbate cycles of exclusion and isolation and entrench existing inequalities in resource distribution faced by persons with disabilities or other users of AT. With increased scholarship in AT, the importance of measuring outcomes associated with AT has been reaffirmed by actors such as The Global Alliance of Assistive Technology Organizations (GAATO) [2,3]. GAATO reiterates that appropriate outcome and impact

measurement is integral to designing policies for universal access that are grounded in evidence [4].

Researchers have reportedly found it difficult to measure outcomes related to assistive technology, especially in ways that truly reflect user needs [5]. Where Bell et al. point to the diversity in prioritisation of outcomes based on stakeholders' positioning in the AT ecosystem [5], others such as clinicians (be they occupational therapists, physiotherapists, speech and language therapists, etc.) tend to focus on evaluating its effectiveness on functional gains and designers tend to value usability, affordability and scalability [5]. Users, on the other hand, will inevitably place prominence on enhancement in capabilities and, by association, well-being [6–10]. As enunciated by Scherer et al. from a user perspective, AT "is only as valuable as what the person gains from using it, the benefits of use compared to the expenditures of procuring it, time learning to use it, fatigue in using it, an embarrassment of using it, and so on" [11]. In other works, they provide a structured way to analyse and understand how gender influences the experience of disability and the effectiveness of rehabilitation interventions, including the use of assistive technology [12]. This framework acknowledges individual and societal characteristics impacting gender effects in disability and AT.

User goals are key, but the lack of delivery systems can create hurdles for assistive products [13]. Like eyeglasses, which are often purchased privately, will require a prior eye test. Bell et al. remind us that measurement "must therefore consider outcomes associated not only with the assistive products themselves, but also those associated with the broader systems and services used to deliver them to the people who need them" [5]. To address the measurement challenges this entails, they go on to call for the adoption of "a holistic model" grounded in, and harnessing the 5Ps framework of the WHO Global Cooperation on Assistive Technology initiative. This encompasses people, policy, products, provision and personnel. AT interventions integrate multiple components, target numerous stakeholders and behaviours and often span across levels [14]. There is, therefore, value in viewing AT interventions as complex interventions under the Medical Research Council and adapting methodologies for evaluation to this end [15].

A fundamental principle in evaluating complex interventions is the explicit acknowledgement and systematic examination of context, with a particular emphasis on elucidating the dynamic interplay between interventions and their surrounding environments. As highlighted, "context is critical because AT is rarely used in isolation" from one's broader

environment [6]. The role of gender norms is a largely unexplored in assistive technology research. Gaps in understanding persist despite evidence that women are less likely to access AT in comparison to men [3,16], all the while reporting a higher prevalence of disability [17]. For the purposes of this review, gender and sex are defined in line with the Sex and Gender Equity in Research Guidelines<sup>5</sup> [18]. A recent scoping review concerning gender and access to AT (*in submission*) found that though women used assistive products more than men, they also reported larger unmet needs.

At the level of **people** (referring to AT users and their families, friends and local networks), gendered barriers to AT use included internalisation of stigma [19–21], perceptions [22], social isolation [23], lack of knowledge, familiarity, trust and skills and inequitable distributions of domestic work [19]. Negative body or self-image related to gender norms also impacted upon willingness to adopt AT [24]. The lack of capacity to source or pay for assistive products aligned with user's aesthetic goals, as linked to gender expression, emerged as a key barrier to use [19,25]. It is thus called for to understand how gender norms may influence outcomes of AT use and, if necessary, propose solutions to ensure users can benefit from AT. Users' willingness to adopt AT was also found to hinge on complex trade-offs balancing perceived benefits with heightened visibility and the risks this can incur, particularly for disabled women [25–28]. It is therefore also warranted to investigate how concerns surrounding visibility and potential ramifications for stigma impact outcomes associated with AT use across genders.

Barriers at the **policy** level included access to resources, including lack of accessibility in the built and physical environments. Meanwhile, barriers to use of AT the level of **products, provision** and **personnel** encompassed a lack of capacity to access products corresponding to users' gender expression [19,24,25], gender and sex biases in product design [29,30], lack of patient-centred care provision [24,31], maintenance and repair processes [32] and lack of awareness of gendered facets surrounding AT use/availability/adaptations [24]. These barriers are inextricably connected to broader legacies of sex and gender bias, which have been well documented in domains from (medical) research, product design and architecture to health service provision [33–39]. Less is known, in comparison, about how biases surrounding physiological differences, as evidenced in the design of assistive products, shape outcomes of use through implications, including potential injury [40].

Finally, inaccessibility of the built and physical environments constituted barriers to AT, impacting

disproportionality upon women [30]. This, coupled with existing contention surrounding the participation of (disabled) women and girls in public spaces, necessitates an examination of how outcomes of AT use are impacted [27,41–45]. This suggests that beyond the 5Ps model, a holistic model should include factors such as the built environment and their impact on AT use outcomes. Much research on the interactions of AT and the built environment focuses on specific products, such as wheelchairs [46]. Recently, research on inclusive infrastructure and public spaces has increasingly adopted a holistic perspective, examining the interplay between AT use and built environment design. Specifically, these studies investigate how inclusive design principles can serve as a tool to enhance the experience of the built environment for AT users [47]. As it is also well established that inclusion in the built environment is influenced by gender, the intersection of these two research areas merits further study [48–50].

### Rationale

The objective of this review is to explore how sex and gender influence outcomes for users of AT. In doing so, we hope to elucidate areas where either further research or attention to dynamics of sex and gender in the design and provision of assistive products are needed, such that maximal benefits of using AT can be gained across genders. To the authors' knowledge, this shall represent the first scoping review to systematically identify and synthesise evidence concerning outcomes of AT use by sex and gender. A scoping review is appropriate given the broad interest in the proposed subject matter and relative novelty/sparseness of the evidence base, combined with the overarching aim to identify gaps [51].

### Research questions

How do gender and sex shape outcomes of AT use across individual, relational, community and institutional levels?

### Positionality

The authorship team encompasses experts in gender, disability, inclusive design and assistive technology. Said expertise reflects both the academic and lived experience of disability, as well as that of the use of assistive products in daily life. The lived experiences of authors are thus embedded in the interpretation of results and consequent discussion. We approach this

research with an understanding of sex and gender as social determinants of health and thereby hypothesise that sex and gender impact outcomes of AT use. Commitment to co-production is further embedded through the commissioning of a Lived Experience Commentary (LEC) on our review. A LEC is a response to an academic paper from the perspective(s) of those with lived experience of the subject being examined.

## Methods

The Johanna Briggs Institute (JBI) methodology for scoping reviews [52], which builds upon methodology previously elaborated by Arksey and O'Malley [53], guided the conduct of this review. The PRISMA Extension for Scoping Reviews (PRISMA-ScR) [54] guides the sequence and content of reporting. A 'lived experience commentary' was provided by a group of experts by experience, drawn voluntarily from The Disabled Leaders Network<sup>6</sup> findings [55]. Including a lived experience commentary underscores the authors' commitment to enhancing co-production with persons with disabilities within research on AT.

## Protocol and registration

A review protocol was developed and registered on Open Science Foundations (<https://doi.org/10.17605/OSF.IO/SVNDM>). The current review was conducted with another scoping review focusing on gendered barriers and facilitators to AT. The registered protocol presents both reviews as integrated.

## Eligibility criteria

To be eligible for inclusion within the review, papers were required to have samples of users of AT, or potential users<sup>7</sup>, of any sex or gender, provided results reported were disaggregated to enable analysis. Studies comprised of all women and girls samples were included, whereas studies containing only men and boys were excluded. This was because this review was initially conducted as part of a different review (*in submission*) which aimed to identify barriers and facilitators to assistive technology for women and girls. This is acknowledged as a limitation. Participants among samples could be cis-gender, transgender, or among other gender minorities<sup>8</sup> including, but not limited to non-binary/gender non-conforming, two-spirit, Hijra etc [56]. No studies were excluded based on how sex and/or gender were recorded (e.g., self-identification, clinician-reported, perception of enumerators), or

reported. Excluded from the scoping review were studies whose results were not disaggregated by sex and/or gender.

Studies measuring outcomes from the perspectives of caregivers, or family members, of AT users, as 'proxies' for AT users were only included where AT user's capacity to engage with study protocols were limited e.g., where the primary group under research were children, or those deemed unable to consent). Studies whose samples were entirely caregivers, or family members, or service providers were not eligible for inclusion.

## Information sources

Only peer-reviewed literature was considered for inclusion. Grey literature, opinion papers, chapters of books not reporting original empirical data and conference proceedings were all ineligible. Finally, studies published before 2000, identified based on previous systematic reviews of AT [57], were excluded.

## Search strategy

A pilot search was conducted in OVID to identify articles relevant to gender and AT. Sample studies meeting inclusion criteria were selected to help identify search terms and refine eligibility criteria. The titles and abstracts of these sample studies, the index terms used to describe them and those from previous systematic reviews on AT, were utilised to develop a comprehensive search strategy [27,28] (see [Appendix A](#)). The searches for this review and a scoping review on gendered barriers and facilitators to AT conducted in tandem were combined into one. Hence, the final search strategy combined terms related to AT (concept one) with terms related to gender (concept two) and use/acceptance/access/outcomes (concept three). Searches were performed separately and adapted to each database. Seven databases, namely, Medline, Embase, CINAHL, PsycINFO, Web of Science (WoS), Cochrane Database (CENTRAL) and Institute of Electrical and Electronics Engineers (IEEE) were searched for this review.

After testing, title and abstract screening was conducted. An initial sample was undertaken by multiple authors, shared and discussed with the research team. Once consensus was reached, the remaining papers were screened by the first author. Studies judged to potentially meet inclusion criteria were retrieved for full-text screening, performed by two authors. Where a study was judged ineligible, the reasons for



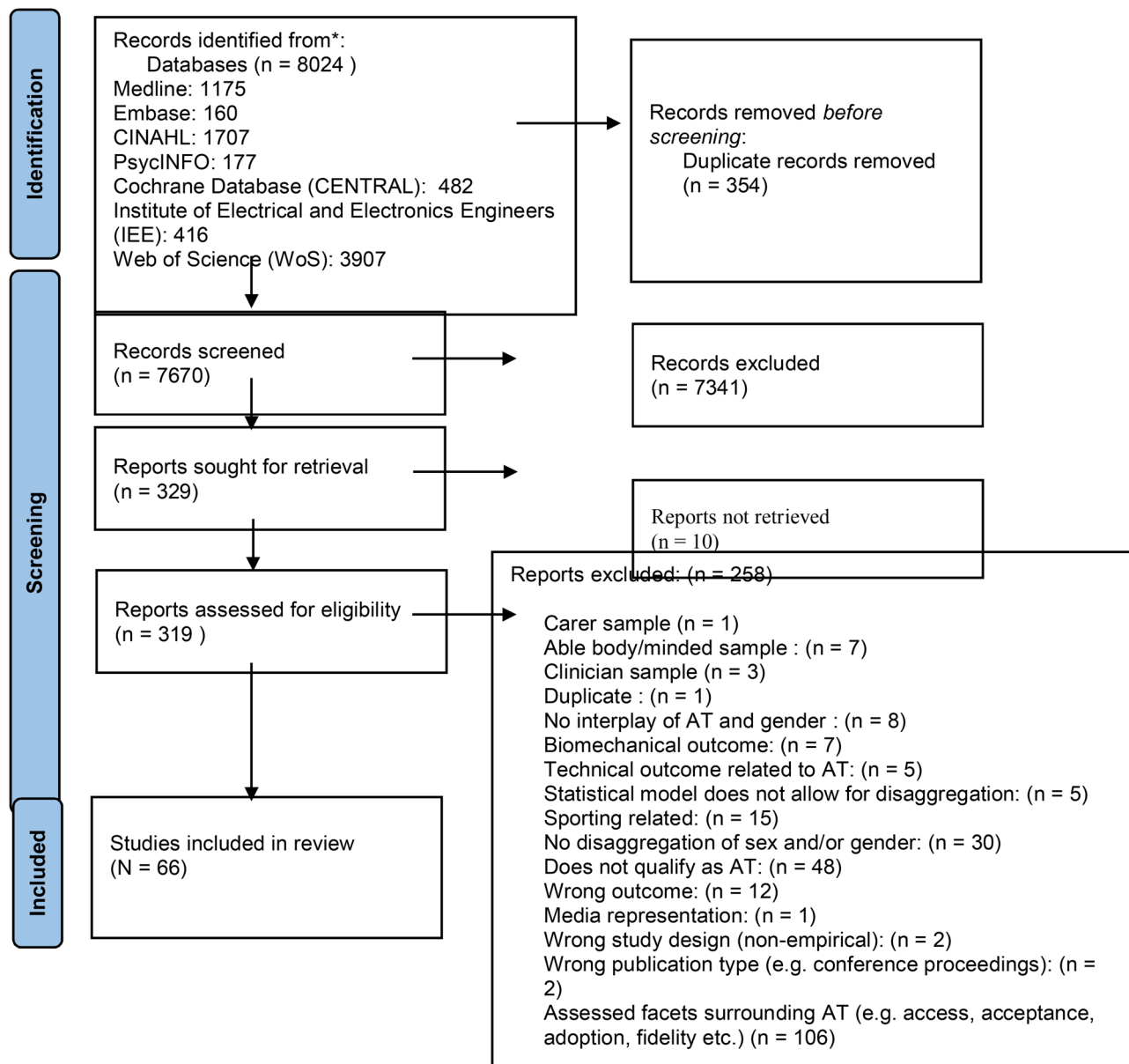


Figure 1. Identification of studies via databases.

exclusion were recorded, as seen in Figure 1. Any discrepancies in the authors' judgements were discussed until agreement was found. Results from search and screening are detailed within the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR) flow diagram [54].

### Data charting process

A data extraction tool was developed by authors within Excel. Relevant adaptations were made following testing among 10% of included studies, as well as iteratively throughout data extraction. For example, additions were made to extract data related to the

involvement of caregivers and/or family members, as well as to document nationally representative studies.

### Data items

This scoping review employed a systematic data extraction process across all eligible studies. Extracted information encompassed publication details (year, title, authors), methodological design (study design, country/region, settings, follow-up, control group, sample size, national representativeness) and participant demographics (inclusion/exclusion criteria, age, sex/gender, ethnicity, sexual orientation, socioeconomic status, disability types, disability measurement/definition).

Furthermore, the review documented the operationalisation of sex and gender concepts within each study. Data regarding AT included AT types, measurements and definitions. Both narrative and numerical outcomes were extracted, alongside author interpretations. The extraction form also captured details on outcome measurement and instrumentation.

## Results

A narrative synthesis was performed, accompanied by relevant tables. The narrative synthesis aims to answer the posed research question. Within the narrative synthesis, outcomes were analysed and sorted by individual, relational, communal and organisational/institutional level findings. This was explored as a framework to assess the impact of any intervention; it's crucial to consider outcomes across multiple levels for a comprehensive understanding. Individual outcomes focus on the direct effects on the person involved, while relational outcomes examine changes in their interactions with others. Moving beyond immediate relationships, communal outcomes explore broader impacts on groups or communities. Finally, institutional outcomes address systemic changes within organisations or society. This multi-layered approach provides a holistic understanding of the full spectrum of effects.

### Selection of sources of evidence

Searching was undertaken during November-December of 2023. A total of 8024 full-text records were identified through the database search. Deduplication removed 354 records, leaving 7670 records for title and abstract screening. Title and abstract screening was conducted within the software *Rayyan*. The title and abstract screening phase resulted in the exclusion of 7341 records. This left 329 records to be recovered for full-text screening, ten of which could not be retrieved. Full-text screening was therefore conducted on 319 records, resulting in a total of 66 papers meeting the criteria for inclusion. Details on the screening are reported within the PRISMA-Flow Diagram below (Figure 1).<sup>9</sup>

### Characteristics of sources of evidence

Quantitative studies constituted the majority of the included corpus ( $n=48$ ), with an observational design used within 42% of these studies and 30% using an interventional design. A cross-sectional design ( $n=20$ ) was the most frequently used design of quantitative

studies, followed by retrospective studies ( $n=8$ ). A qualitative or mixed-methods design was used in only 19.6% and 7.5% of studies, respectively. The largest number of studies were conducted within high-income settings ( $n=48$ ), followed by middle-income ( $n=12$ ). Sample sizes ranged from one at the lower end (within case studies) to a high of 10,022. Two studies constituted nationally representative samples were conducted in Denmark and Korea. Table 1 presents a full overview of the characteristics of studies included within the review ( $N=66$ ).

Regarding the operationalisation and measurement of sex and gender within studies, only one paper out of 66 reported a definition of either sex or gender. Only six articles specified whether they measured and reported on sex or gender. One of the four papers captured and specified how gender was operationalised, in this case as binary, i.e., male or female. The remaining papers did not state how the construct of gender was operationalised.

While the review's objective was to examine the literature on sex and gender regarding AT use, data on ethnicity was also extracted for sub-group

**Table 1.** Overview of characteristics of included papers ( $N=66$ ).

Variable		<i>n</i> of papers reporting	% of papers reporting
Study design [general]	Qualitative	13	19.6%
	Quantitative	48	72.7%
	Mixed-methods	5	7.5%
Study design [specific]	Observational	28	42.4%
	Case study	3	4.5%
	Case-control	2	3%
Region	Cross-sectional	20	20.3%
	Prospective	5	7.5%
	Retrospective	8	12.1%
	Intervention	20	30.5%
	Americas	26	39.4%
	Africa	4	6%
	Europe	27	41%
	South-East Asia	3	4.5%
Country/region income level <sup>a</sup>	Western Pacific	6	9.1%
	Low-income economies	2	3%
	Lower-middle income economies	4	6%
	Upper-middle income economies	12	18.1%
	High income	48	72.7%
Sample size	1–30	24	36.3%
	31–50	7	10.6%
	50–100	9	13.6%
	101–500	19	28.7%
	1001–5000	4	6.1%
	5000–10,000	2	3%
Year of publication	10,000–100,000	1	1.5%
	2000–2005	5	7.5%
	2006–2010	4	6%
	2011–2015	20	30.3%
	2016–2020	20	30.3%
	2021–2023	17	25.7%

Note: <sup>a</sup>Based on World Bank Classification, as of July 2021.

analysis. Data concerning ethnicity, however, was only reported within 13.6% of all studies. This is relevant for future efforts to synthesise evidence surrounding ethnicity as a social determinant relevant to AT outcomes.

Physical disabilities ( $n=47$ ) were the most common form of disability focused on within studies, followed by sensory disabilities ( $n=13$ ) then cognitive ( $n=3$ ). The remaining three studies discussed multiple forms of disability. Only 16.6% of all studies included either a definition of disability or the condition under scrutiny. Full details concerning the characteristics of disabilities discussed within the included studies are presented in [Table B1](#), [Appendix B](#).

Assistive products for mobility/dexterity were the most studied category ( $n=45$ ). This was followed by sensory products ( $n=12$ ), products spanning multiple categories ( $n=5$ ) and finally, cognition-related assistive products ( $n=4$ ). Prosthetics ( $n=17$ ) was the most represented specific product in any category, followed by wheelchairs ( $n=12$ ). In almost 90% of studies, the products discussed were among the WHO's Priority Assistive Products List (APL). Robotics (either social or physical assistive robots), virtual assistant-connected eyewear, a tactile mouse, a meal preparation instrument, a grabbing device, a micro switch, incontinence underwear and a tactile walking surface made up the remainder of products not listed within the APL. A detailed overview of the categories of AT represented, as well as the use of definitions within studies included in the review, is available in [Table C1](#), [Appendix C](#).

### Synthesis of results

The reviewed studies spanned many countries, incomes, disabilities and age groups, using varied research designs and sample sizes, some of which were nationally representative. This breadth enhances the capacity to generalise the findings. Synthesis of results examining gender in relation to outcomes of AT use are presented using the socio-ecological model [58]. This is done in order of individual, relational, communal and institutional levels [59,60]. The socio-ecological model, employed to analyse health and social phenomena, comprises four key levels: the individual, encompassing biological and personal factors; the relational, focusing on immediate social networks; the communal, examining health-related social settings; and the institutional, addressing broader societal influences on equity. [Table C1](#) presents an overview of the papers included in the review.

## Outcomes of at use by sex and/or gender

### Individual level outcomes

Forty-six studies examined outcomes of AT use at the individual level, with 10 examining mental health and 14 physical, 6 (health-related) quality of life, 16 functional and 2 developmental outcomes ([Table 2](#)).

### Mental health

The impact of assistive technology (AT) on mental health was explored across several studies, revealing diverse findings. Research on specific mental health outcomes included anxiety, depression, general psychosocial impact and self-confidence. For instance, studies by Brayda [62] and Mortensen [65] examined anxiety and depression, with Mortensen finding no association between sex and these conditions, while Brayda reported a reduction in anxiety for both male and female users of a tactile mouse (TAMO). Similarly, Long [64] and Elnitsky [31] highlighted positive effects on psychosocial well-being and self-confidence, specifically in relation to absorbent underwear and wheelchair use, respectively. Bliss [61] corroborated this by noting that the confidence of wearing absorbent products was unaffected by sex.

Further, several studies focused on self-esteem and self-efficacy. Uchenwoke [66] found no gender-based differences in these areas among mobility aid users, while others [63] explored both concepts concurrently. Finally, general mental well-being was addressed in studies by Orellano-Colon [19] and Williams [24], providing a broader perspective on the psychological

**Table 2.** Overview of outcomes of assistive technology use represented within included papers ( $N=66$ ) papers span multiple outcomes.

Level	Outcome	<i>n</i> of studies reporting	Authors
Individual	Mental health	10	[24,31, 61–68]
	Physical health	14	[69–82]
	Health related quality of life (QoL)	6	[61,66, 83–86]
	Functioning	16	[87–101]
	Childhood development	2	[102,103]
Relational	Relational communication	3	[104–106]
	Experiences of birthing/parenting	4	[26,107–109]
Communal	Navigation of home environment	2	[79,110]
	Social and public participation	16	[23,24, 30,61, 63,65, 66,74, 105,111–117]
Institutional	Academic performance	1	[118]
	Navigation of built and physical environments	8	[19,30, 65,78, 79,105, 107,115]
	Economic and political participation	5	[79,105, 113,119,120]



impact of AT. Taken together, these studies suggest a complex interplay between AT use, mental health and gender, with some findings highlighting positive impacts and others suggesting no significant gender-related differences.

These findings complement the qualitative exploration into the benefits of electronic memory aids on self-esteem and self-efficacy among women with traumatic brain injury, in Dry's [63] Canadian sample:

Since my injury, I don't feel like a whole person, this [Palm Pilot] makes me feel, helps me to feel like a real, functioning person again, I, I may not know what I'm doing, but nobody else knows that.

By contrast, Wang [67] found that device usage (in this case reading glasses, hearing aids, crutches, walkers and wheelchairs=) was more likely to worsen symptoms of depression among women than men. This finding may be attributed to increased exposure to stigma associated with device use, cited within studies by Orellanno-Collon [68] and Williams [24]. Hispanic men within Orellanno's sample discussed the negative impact of (internalised) stigma, heightened by perceived failings to adhere to masculine norms surrounding virility, productiveness and capacity for emotional well-being. Gendered norms, as well as their extension into constructions of sexuality, were again invoked by women, though not men, trialling therapeutic footwear in Williams' [24] U.K. sample. Women described a perceived loss of femininity, with ripple effects upon expressions of sexuality.

### Quality of life

Quality of life, among AT users was assessed within six studies, of which four compared outcomes by gender. Research examining the impact of assistive technology on quality of life reveals inconsistent gender-related outcomes. Uchenwoke [66] and Joanovic [84] found limited overall gender influence on quality of life among mobility aid and hearing aid users, respectively, although variations emerged in specific sub-domains like energy/fatigue and sensory abilities. Conversely, Benavent [83] and Saglam [85] identified significant gender disparities, particularly highlighting reduced quality of life in specific sub-domains for women using prosthetics and microprocessor-controlled devices. Specifically, women reported poorer perceptions of appearance [83] and physical quality of life [85].

Studies focused on medical devices also yielded varied results. Bliss [61] demonstrated that a prototype device addressing urinary leakage improved psychosocial well-being in women but did not significantly

impact the overall quality of life within the short study duration. Toro's research indicated that wheelchair provision enhanced the quality of life for both genders, though it lacked a comparative analysis of gender-specific improvements.

Collectively, these studies suggest that while some assistive technologies may not significantly alter the overall quality of life based on gender, they can influence specific sub-domains. Furthermore, gender-specific experiences and perceptions, particularly among women, warrant further investigation to tailor interventions and optimise outcomes.

### Physical health

Fourteen studies examined health-related outcomes associated with AT use. Nine of these studies examined differences by gender and/or sex, all of which identified significant differences between men and women sampled.

Persistent gender disparities in health outcomes and experiences were reported related to physical health, particularly concerning women. While Boninger [71] found no overall gender difference in shoulder injuries among manual wheelchair users, women exhibited greater radial force, potentially contributing to more severe MRI findings. This aligns with Wessels [82] and Ata [69], who reported significantly higher rates of shoulder pain and injury, along with range of motion deficits, in female wheelchair users. Boninger et al. [71] attributed these discrepancies to potential sex biases in wheelchair design, education and setup, emphasising the need for tailored clinical interventions for women.

Further evidence of gendered health disparities emerges from studies on prosthetics and general AT use. De Laat [72] documented higher comorbidity rates in women with lower-limb prostheses, while Hsieh [76] found women in residential care homes less responsive to wheelchair skills interventions in terms of postural improvement. Fitter [73] reported higher self-reported pain among women using the Baxter social assistive robot, and Hoevenaars [75] found lower adherence to aerobic exercise guidelines among female wheelchair users with spinal cord injuries. Magnusson [80] and a 2014 study [79] highlighted differing perceptions of health and pain experiences between men and women using prosthetics and orthotics in Sierra Leone, with women reporting more pain and irritation.

Critically, studies by Greenhalgh [74] and Iezzoni [121] highlighted the impact of sex biases in wheelchair design on women's experiences. Greenhalgh's veteran sample reported significant pain and discomfort, while Iezzoni's pregnant wheelchair users faced mobility limitations and

injury risks due to design inadequacies. These women often resorted to self-devised solutions to mitigate complications, underscoring the need for inclusive design processes and tailored clinical support. Collectively, these findings underscore the urgent need to address gender-specific considerations in AT design, prescription and rehabilitation to ensure equitable outcomes.

### **Functional outcomes**

Functional outcomes associated with AT use were examined within sixteen studies, fourteen of which examined differences by gender and/or sex, while the remaining examined outcomes among women only. Seven studies found no significant differences in functional outcomes of AT use by sex and/or gender. A very small effect size was found in relation to rehabilitation with hearing aids, with men demonstrating slightly elevated success, although this was not considered clinically relevant by the authors.

Differences by gender and/or sex were found with respect to walking with a lower-limb prosthetic [90,92], self-reported mobility [97] preconditions for successful prosthetic mobility following fitting [95], mobility with the use of mobility devices, older age [99] cognitive burden and effectiveness associated with a tactile surface [89]. Two studies examining rehabilitation outcomes also found gender differences, with opposing results. That is, while Fajardo [91] found that men were more likely than women to fail prosthetic rehabilitation, Knezevic [96] found that men recovered greater functionality than women following rehabilitation for lower-limb prostheses.

## **CHILDHOOD DEVELOPMENTAL OUTCOMES**

Two papers examined developmental outcomes associated with a microswitch and powerchair intervention among girls with Rett syndrome and muscular atrophy in Italy and the U.S. respectively [102,103]. Both demonstrated effectiveness in leading to positive childhood developmental changes (such as choice making, communication, cognition, and social interaction) among participants.

### **Relational level outcomes**

Seven studies examined outcomes of AT use at the relational level, of which four discussed experiences of birthing or mothering as an AT user. The others examined communication-related issues related to the use of social assistive robots and hearing aids.

### **Experiences of birthing and mothering**

Qualitative studies exploring the experiences of wheelchair-using mothers reveal a complex interplay between AT, healthcare support and societal perceptions of motherhood. Dos Santos [26] highlighted the crucial role of adapted furniture and skilled nursing in prenatal care, particularly in preventing falls and ensuring safe child positioning. This concern was echoed in McKeever [107] and Prilleltelsy [108], which documented maternal anxieties related to inadequate AT and the risk of falls. The need for adapted cribs, changing tables and breastfeeding devices was also emphasised [109].

However, excessive healthcare monitoring and a perceived focus on maternal deficits rather than AT accessibility induced anxiety and challenged mothers' sense of legitimacy [107,109]. A lack of nursing staff awareness regarding AT adaptation was also noted, forcing women to innovate independently.

McKeever [107] further explored the theme of contested motherhood, highlighting the labour-intensive self-innovation required due to inaccessible baby furniture. Studies by McKeever [107] and Prilleltelsy [108] revealed mixed child reactions to maternal wheelchair use, with early joy contrasting with later stigma. Prilleltelsy [108] documented instances of internalised stigma and resilient norm-defiance in children linked to the normalisation of wheelchair use within the home. These findings underscore the urgent need for accessible AT, informed healthcare practices and broader societal shifts to support the maternal experiences of wheelchair users.

### **Relational communication**

Obayashi [98], in a case series within a Japanese residential care setting, demonstrated that social assistive robots facilitated enhanced communication among female residents, both with carers and peers. Regarding hearing aids, quantitative findings indicated a more pronounced positive effect in female participants than males [104]. This was posited to stem from women's potentially greater communicative adaptability and the heightened social significance they ascribe to communication. Supporting this, a qualitative investigation involving Canadian women [105] revealed that hearing aids contributed to improved social support and forming intimate relationships. Collectively, these studies suggest that AT can significantly impact communication and social interaction, with potentially nuanced gender-specific outcomes.

### **Communal level outcomes**

Eighteen studies examined communal-level outcomes associated with AT, the majority ( $n=16$ ) focused on social participation and the remaining ( $n=2$ ) on navigation of home environments.

#### **Navigation of home environment**

Magnusson [79] found women with lower-limb prosthetics in Sierra Leone had more trouble navigating their homes than men. Meanwhile, Kenyon [110] showed a woman with cerebral palsy improved her power mobility and home navigation after a 12-week powerchair training program.

#### **Social and public participation**

Studies present varied findings on the impact of AT on social participation. Uchenwoke [66] found no gender differences in social participation among Nigerian mobility aid users. Sakakibara [116] linked confidence to participation in Canadian wheelchair users, with men showing a stronger correlation. Park [114] observed no association between device use and informal participation in Korean adults but noted a negative correlation between device use and formal participation in men attributed to cultural and masculinity-related factors. Mortensen [65] found no gender differences in confidence related to social navigation among Canadian mobility aid users.

Stuckey [117] found prosthetics enabled social participation for Bangladeshi women, with one prioritising aesthetics for public integration but removing it for domestic efficiency. Conversely, Tomsone et al. [23] reported mobility device absence restricted Latvian women's autonomy and social engagement. Bliss [61] found no statistical gender difference in incontinence product confidence, yet qualitative data revealed women viewed them as crucial for public participation. Cantin [111] proposed a communication device would enhance social participation, particularly for deaf-blind women. These studies highlight the complex and varied roles assistive technology plays in women's social inclusion.

Petterson [122] found powerchair inaccessibility fostered social isolation for both genders, with women citing exclusion from gendered social spaces, such as shopping centres and unwanted device interference in public spaces. Both Petterson [122] and Greenhalgh [74] noted women's erasure in public, with others ignoring them or addressing companions directly. Women also felt their gender and wheelchair use diminished their credibility. Gaetes Reyes [30] attributed this

invisibility to the "dys-appearance" of disabled female bodies, linked to the ageing (female body), wheelchair stigma and ableist notions equating mobility with intelligence, reinforcing their marginalisation as "non-citizens".

Pal's [113] mixed methods study of mobile-device use among low-vision adults in Bangalore indicated that women had a lesser tendency to switch mobile plans and changing phones, compared to men. This was attributed to a perception of reliability, where women indicated relying on phones to enhance safety in public spaces. Qualitative inquiry also found that using mobile phones as assisted products disrupted the sense of isolation felt by women with low vision through facilitating greater social and public engagement. Similarly, women in Nguyen's [112] intervention study of an-agent-assisted low-vision AT were found to use calls for social, shopping and the arts at greater rates than men.

Dry et al. [63] found women with traumatic brain injury prioritised electronic memory aids for social connection over functional memory gains. Similarly, Lockey et al. [105] reported women viewed hearing aids as crucial for social participation. However, women also valued their ability to disengage from amplified sound and strategically shifted communication responsibility to others, supplementing their assistive technology use. These findings underscore the importance of AT as a facilitator (among many others) of social participation in the lives of disabled women.

### **Institutional level outcomes**

Thirteen studies discussed outcomes of AT use at the institutional level, with five focusing on economic and political participation, eight on navigation of the physical and environments and one on satisfaction with academic performance (Table 2).

#### **Academic performance**

Only one study included measures related to academic performance among users of AT. Namely, Malcom's [118] retrospective analysis of Canadian students accessing AT through a university centre found that gender did not have a significant association with satisfaction and perception of academic performance.

#### **Economic and political participation**

Five studies explored economic/political participation, with three analysing gender differences. Christensen [120] found that workplace hearing aids significantly reduced disability benefit reliance for Danish women,

which was attributed to their communication-dependent roles. Pal's [113] qualitative data revealed smartphones aided low-vision men in fulfilling perceived economic roles in Bangalore. Lockey [105] highlighted the role of hearing aids in achieving vocational goals for women, with these goals also motivating aid use. These studies suggest assistive technology's economic impact is gendered and influenced by cultural and occupational contexts.

Van Leeuwen's [119] prospective study among adults in the Netherlands found an association between employment and uptake of hearing aids among men, though not women. The authors speculated that this might relate to differences in forms of employment, though not examined. Finally, women users reported greater difficulties voting compared to men, with 21% more female than male prosthetic and orthotic users reporting not voting in the previous general election, although this could be explained by factors beyond AT usage, such as political education.

### ***Navigation of built and physical environment***

Eight studies examined the interaction of gender, AT and navigation of physical or built environments. Mortensen [65] found Canadian women using mobility aids reported lower confidence in navigating physical environments than men, potentially due to lower manual wheelchair skills. Magnusson [123] reported women using lower-limb prosthetics/orthotics faced greater walking challenges on uneven terrain. Orellano-Colón et al. [19] found built environment concerns influenced assistive device use decisions significantly more among Puerto Rican women from low-income communities. These findings consistently indicate that environmental barriers disproportionately affect women's confidence and device usability.

Both McKeever [107] and Iezzoni [121] discussed the inadequacies of the built-environment fit out in relation to the parenting experiences of Canadian mothers using mobility aids, which were seen to reproduce false dichotomies surrounding motherhood and disability. Within the latter, this related specifically to the inaccessibility of obstetric services, particularly the lack of wheelchair-adapted weighing scales, height-adjustable examination tables, or lack of transfer devices. The observed practice deviates from established standards, potentially resulting in significant adverse consequences. For example, inaccurate weight measurements may compromise the precision of anaesthesia dosage calculations. In some instances, participants reported they were forced to forgo examination entirely, rely on caregivers to assist in transfers

and sustain injuries due to being dropped during manual transfers. Manual transfers engendered fear and humiliation, including due to unwanted physical contact, exposure and invasion of privacy. Participants also reported receiving unsolicited help in the transfer process, disregarding patient autonomy. Authors advocated for enhanced education of obstetricians regarding ethical and legal responsibilities to provide accessible care.

Petterson [122] similarly problematised the built environment as both a mirror and reflection of ableism, which is often presented as narrow conceptions of disabled bodies (in public space). Where efforts towards inclusion in the built environment were issued, these were seen to predominately cater to the male, athletic, manual-wheelchair users, to the detriment of female or power-based wheeled mobility users. Petterson [122] noted Swedish "accessible" spaces often prioritised manual wheelchair dimensions, disadvantaging power-chair users. Women, unlike men, also expressed public safety concerns. Gaete-Reyes [30] reinforced this, highlighting how navigating able-bodied spaces, compounded by gendered and ageist biases, creates a significant psychological burden for women.

Gaete-Reyes [30] challenged ableist rubrics and belonging, using Actor Network Theory to examine citizenship among UK wheelchair users. Participants reported an inversion of blame for transport disruptions attributed to inadequate infrastructure, highlighting the perceived lesser importance of their mobility. Petterson [122] echoed these concerns, noting biased wheelchair and architectural designs. Ramps, for example, were seen to favour athletic upper body movements, reinforcing a "charity model" of disability. This model construes accessibility provisions as incentives, not state-mandated human rights (Gaete-Reyes). Both studies underscore the systemic exclusion embedded within design and infrastructure, impacting disabled women's sense of citizenship and belonging.

Participant accounts illuminated challenges posed by inaccessible environments, where spatial occupation and public participation often necessitate compromising bodily integrity, such as navigating roadways to circumvent damaged or sensorially disruptive pavements. These narratives underscored the critical role of sensory experiences within the built environment.

### **Discussion**

This paper examined the complex relationship between gender and AT outcomes and use, drawing from a synthesis of existing research. It employs a socio-ecological model framework, recognising that individual



experiences are shaped by multiple interacting levels, including individual, relational, community and societal factors. This model is crucial for understanding how gender, as a social construct, influences AT outcomes beyond mere biological differences.

The socio-ecological model posits that health and well-being are influenced by a dynamic interplay of personal, social and environmental factors. In the context of AT, this means considering not only individual user characteristics but also the social norms, community resources and policy environments that shape access, usability and impact. This review highlights how gendered power dynamics, design biases and societal expectations intersect with disability, leading to disparities in AT experiences.

### Association of gender and AT

Assistive products were consistently identified as crucial for women's public and social engagement, particularly in fostering a sense of safety. However, a notable discrepancy emerged between qualitative and quantitative findings. While women perceived these products as essential for social interaction, statistical analyses indicated that only men experienced enhanced social participation. This highlights the critical need to address the intersecting stigmas of gender and disability, which profoundly affect women's social experiences.

Twenty-two out of thirty-eight analyses demonstrated associations between sex/gender and assistive technology (AT) outcomes. This review aimed to go beyond mere statistical correlation, seeking to understand the nuanced role of gender as a social determinant of AT outcomes, aligning with the WHO's definition of non-medical factors impacting health.

The thematic synthesis, illustrated in [Figure 2](#), revealed gender's pervasive influence across multiple domains. These included individual health-related outcomes, the societal impact of design bias, social and participation-related outcomes and economic/political participation. Design biases were found to negatively affect individual experiences, while social participation demonstrated gender-based disparities. Economic and political participation, reflecting relational and institutional levels, underscore the broader communal significance of AT. This approach allowed for a deeper exploration of gender's role in shaping AT outcomes, moving beyond simple statistical associations. This work builds on others [\[12,21\]](#) who have similarly explored the relationship between women and disability through the use of an organising framework. This similarly considers the physical and social participation to consider the person as a whole and not limited to their functional abilities.

### Health outcomes

The impact of AT on mental health at the individual level presented a mixed picture. While some studies found no association, others highlighted positive effects. Electronic memory aids improved self-esteem and self-efficacy in women with traumatic brain injury, linked to enhanced social interaction [\[63\]](#). However, the influence of hegemonic masculinity norms, known barriers to AT adoption, may explain the counterintuitive finding of increased depression among AT users [\[124\]](#). Furthermore, product aesthetics emerged as a significant factor, with women prosthetic users reporting poorer body image and quality of life [\[83\]](#), underscoring the importance of gender-sensitive design.

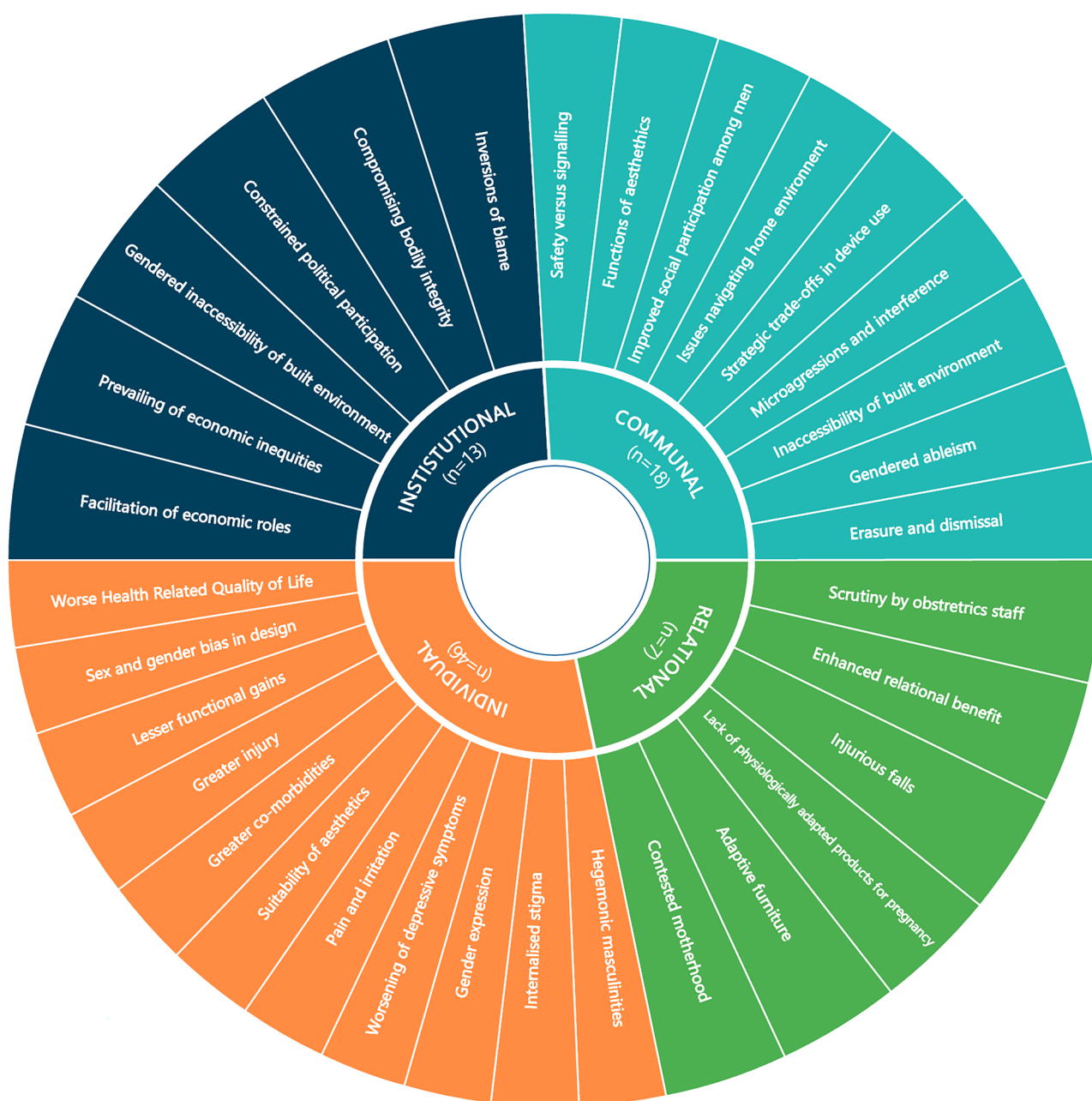
Regarding physical health outcomes, sex biases in device design may account for disparities in prosthetic outcomes, with women reporting lower quality of life, greater comorbidities and poorer functional recovery despite higher rehabilitation completion rates [\[72,83,95\]](#). Wheelchair use revealed significant gendered differences, with women exhibiting greater radial force exertion, range-of-motion deficits and shoulder injuries [\[69,71,82\]](#). These findings highlight the urgent need for improved gender-sensitivity in wheelchair skills interventions. The cognitive burden associated with tactile walking surfaces was also higher for women, possibly due to inadequate training [\[89\]](#).

Qualitative data further corroborated these design-related issues [\[74\]](#), attributing pain and discomfort to sex biases in wheelchair design. Additionally, the lack of pregnancy-compatible wheelchairs resulted in mobility limitations and safety risks [\[121\]](#). This evidence suggests that more research is needed to look into gender-related design flaws that affect many types of assistive technologies; this includes investigating whether or not design flaws may explain why women seem to have a harder time navigating around their homes than men [\[79\]](#).

### Design bias

Greater attention to physiological differences among sexes, as well as their implications in use, is needed to eradicate bias within the design of assistive products. Lessening sex and gender biases can also be worked towards by enhancing the diversity of end-users involved in design processes. Aligning to principles of user-centred/inclusive design is welcomed. However, this should not come at the expense of foregrounding what Hamraie [\[125\]](#) critiques as a 'post-disability' ideology. 'Post-disability ideology' includes, as referred to by the author, discourses pedestalling design as a means





**Figure 2.** Representation of themes relevant to findings on outcomes of AT use by sex and gender.

to ‘design-out’ disability [126,127]. Design processes must include users with a range of functional capacities, comorbidities, gender identities and expressions, anatomies, ages and desired outcomes of use.

### Social participation and AT

At the relational and community levels, observed disparities in hearing aid efficacy between genders suggest that social and communicative factors may play a crucial role. Specifically, the hypothesis posits that female hearing aid users may experience greater positive effects due to their potentially enhanced ability to

navigate communication challenges. This interpretation aligns with the established importance of effective communication within social environments for women, indicating that the benefits of assistive technology are not solely determined by device functionality but are also mediated by socio-cultural gender roles and expectations. This highlights the necessity of considering gender-specific social dynamics when assessing and implementing assistive technologies, particularly those related to communication [104]. Social participation was seen as a key motivator for hearing aids, though participants also reported contentment with the capacity to embrace the

non-amplified world, seen as a unique attribute of hearing impairments compared to hearing populations [105]. Emphasis on social participation also corresponds to findings that women report greater quality of life scores in subdomains of intimacy, social participation and sensory abilities when using hearing aids [84] and state that lack of access to mobility devices limits both their autonomy and social participation [23]. Similarly, prosthetics were viewed as vital for enabling public and social participation among women, emphasising the aesthetic function of 'blending in' [117].

While these results support the benefits of AT for enhancing relational communication, social participation and navigation of social environments, several studies found enhanced benefit impacted only men, compared to women using assistive devices. This trend was noted among mobility aid users, wheelchair users and denture users. Potential explanations for the difference in benefits by gender may relate to reported frustration at exclusion from gendered forms of socialising due to inaccessible environments [122], lack of compatibility of devices with preferred gender expressions, the persistence of gendered microaggressions such as unwanted touching of assistive products or unsolicited 'help' with assistive products [74,122], or erasure and dismissal of women using (powered) mobility devices [30,74,122]. The latter was seen to reflect ableist conceptions of mobility with intelligence, as tied to constructions of the (economic) 'productivity.'

The erasure of disabled mothers' needs, through a lack of wheelchair-adapted baby furniture and assistive device add-ons, reflects pervasive ableist stereotypes [107,108]. Mothers often innovate independently, underscoring the necessity for adapted resources and nursing support to foster maternal bonding and care [107,109]. Obstetric staff training is crucial to dismantle these biases, which manifest in intrusive healthcare practices.

Design standards for baby furniture and medical devices must be reassessed to ensure inclusivity. Discrepancies in manufacturing standards across medical and commercial sectors can compromise the quality and accessibility of parenting experiences for wheelchair users. This disparity can hinder independence during the transition from hospital to home, impacting crucial bonding and caregiving activities. Addressing these design and training deficiencies is essential to promote equitable parenting experiences for disabled mothers.

'Accessibility' of the built environment was seen as catering to male-bodied, athletic, manual-wheelchair

users [122]. Meanwhile, women wheelchair users recounted an inversion of blame, deflected back to the disabled body, due to 'disruptions' in transport schedules caused by poorly maintained or inadequate accessibility infrastructure, such as bus or train ramps. Participants saw this as reflective of the relegation of the needs among wheelchair users in relation to ambulant passengers [30]. Inaccessible environments produced quandaries in terms of capacity to occupy space or participate in public, with both often hinging on compromising bodily integrity by disabled persons, such as traversing roads to avoid broken or uneven pavements [30]. Both individualised solutions towards increased mobility, such as taxi credits and dependence on support from transit professionals or fellow commuters (to compensate for faulty equipment), were viewed as reinforcing charity-based models of disability, as opposed to the promotion of rights-based inclusion.

Aligned with the above, awareness campaigns should consider targeting stigma at the intersection of ableism and (cis)sexism. These should showcase a range of AT users, forms of disability and gender expressions beyond the focus on para-athletes. Pedestalling of para-athletes within the cultural zeitgeist surrounding disability was evidenced within data presented to create unrealistic expectations surrounding user capacities, as well as reinforce hegemonic (disabled) masculinities.

### ***Economic and political participation***

Finally, mixed evidence emerged in relation to enhanced economic participation as a result of assistive product use [119]. While there was evidence to speak to the benefit of assistive products in the fulfilment of vocational goals among men and women [128], two studies demonstrated associations between uptake of product use and employment among men and not women [119]. This may infer that increasing access to assistive products alone is not a silver bullet towards rectifying historic inequities in access to economic opportunities for disabled women. Neither, based on findings that women prosthetics and orthotic users encounter greater barriers to voting [80,113], is access to assistive products sufficient, as a standalone, to enhance political participation among disabled women.

In conclusion, we wish to reiterate the fundamental question proffered by Austin and Holloway and build on Amartya Sen's Tanner Lecture, "AT for what?" [1] where the authors call for consensus in situating AT, thereby making efforts to increase access within a

capabilities approach – i.e., as a means for users to choose and realise what they want to do and be and broader alignment with principles of disability justice. We echo said calls and wish to caution against narratives and systems conceiving of AT as a vehicle for the economic instrumentalisation of persons with disabilities. That is, AT should not be seen as a means to ends of rendering disability economically ‘viable,’ should this run contra to the capacities and goals of users themselves. This is salient given the extent to which persons and disproportionality women with disabilities, rely on precarious work, which is itself associated with poor health outcomes, including disablement [129]. Finally, neither should AT serve an agenda of assimilation but bolster the flourishing expression of human differences in communication, mobility, cognition and tactile and sensory experiences.

## Implications

Implications relevant to research, policy and practice are described below.

### Research

Future research should prioritise several critical areas to enhance understanding and equity in AT access and outcomes. Firstly, it is imperative to investigate the lived experiences, unmet needs and multifaceted impacts of AT use within sexual and gender minority populations; a group often marginalised in AT research. Secondly, a comprehensive synthesis of AT outcomes is needed, explicitly considering intersectional social determinants of health, including ethnicity, socioeconomic status, education, citizenship and sexual orientation, to identify and address systemic disparities. The persistent absence of disaggregated data across sex, gender, ethnicity, socio-economic status and age in AT research is a critical limitation stemming from both methodological hurdles and systemic biases. Methodologically, incorporating these intersecting variables requires larger, more diverse samples and sophisticated analytical approaches to ensure statistical power and account for interaction effects. Inconsistent operationalisation of these constructs further hinders comparative analysis.

Systemic biases within the research ecosystem also contribute significantly to these omissions. Historically, dominant demographics have been the focus, leading to research questions, data collection methods and analytical frameworks that often overlook the diverse experiences of marginalised populations. Funding priorities and a lack of diverse representation within the research workforce can perpetuate this oversight.

A concerted effort is needed to develop inclusive methodologies, challenge systemic biases, prioritise intersectional approaches and allocate adequate resources. Addressing these data gaps is crucial for holistically understanding outcomes and developing equitable interventions.

Finally, the intersection of gender and disability inclusion within the built environment, especially in spaces for socialisation and leisure, demands investigation to ensure equitable access and participation for all individuals.

### Policy

To promote equity and improve outcomes for AT users, particularly those at the intersection of gender and disability, the following policy and practice recommendations are proposed. Firstly, policies must be developed to ensure equitable access to AT, including mobile devices, addressing gendered barriers and facilitators, as identified in recent research. Secondly, universal healthcare access, including comprehensive mental health services, should be guaranteed across all life stages.

Public awareness campaigns are essential to combat stigma related to ableism and sexism, featuring diverse AT users and disability representations beyond stereotypical portrayals. Funding for disabled culture and arts should be increased, emphasising community spaces and the participation of disabled women and gender minorities.

Workplace accessibility for disabled women must be improved, including reasonable accommodations, targeted training and leadership opportunities. The implementation of a universal basic income warrants consideration to empower persons with disabilities to exercise their rights without reliance on charity-based models.

Accessibility of built environments and transport systems should be enhanced, specifically addressing the needs of disabled women and girls. Healthcare settings, examinations and treatments, including sexual and reproductive care, must be made accessible to all AT users.

### Practice

To address the multifaceted challenges faced by AT users, particularly those related to gender and disability, several targeted interventions are necessary. Firstly, clinical counselling should be offered to help users navigate mental health challenges arising from stigma, gender expression and perceived changes in gender

roles. This counselling should focus on developing coping strategies, setting realistic goals and managing expectations.

Secondly, rehabilitation and skills interventions, including wheelchair skills training, must be made more gender-sensitive, addressing the documented disparities in functional outcomes and injury rates among women. Healthcare providers should receive gender and disability-adapted training to combat stereotypes, especially concerning disability and sexuality.

Home environment adaptations should be supported through multidisciplinary care teams, ensuring timely implementation. Interdisciplinary obstetrics care for pregnant persons with disabilities is crucial, encompassing relational support and adaptations to products and environments for pregnancy and parenting.

Finally, inclusive design, with an intersectional approach, must be integrated into the education and training of design professionals, both in higher education and through continuing professional development. This will ensure that design processes inherently consider the diverse factors leading to exclusion, such as disability and gender.

## Limitations

We outline some limitations of this scoping review. Evidence which may have met eligibility criteria may have been missed, given the inaccessibility of certain databases. Neither backward nor forward citation tracking was performed due to limited capacity among authorship, meaning further studies may have been missed. Lack of consideration of biomechanical or functional outcomes may have impacted a comprehensive understanding of the relevance of sex and gender in all relevant domains of AT use. Future synthesis of evidence surrounding AT outcomes should look towards the relevance of other known social determinants (in addition to sex and gender), such as socioeconomic status, ethnicity, education and immigration status.

Twenty-one studies excluded individuals with co-morbid disabilities, most commonly cognitive disabilities ( $n=14$ ) followed by mental health conditions ( $n=5$ ). People with developmental disabilities were likely further excluded due to criteria that limited participation for those with “difficulties understanding and expressing themselves in response to questionnaires” ( $n=6$ ). This restricts the generalisability of findings to women and other AT users with multiple disabilities. Similarly, the 6% of studies which restricted samples in institutional settings may have limited participation of those with more severe forms of disability, whose

outcomes of AT use may differ. The systematic exclusion from research participation raises health equity concerns, especially given the prevalence of disabling health conditions and the compounded challenges in accessing other forms of healthcare faced by women with multiple disabilities, institutionalised women, immigrant women and transgender women, among other gender minorities, Indigenous women and women living in institutions [109,111].

This review excluded work that had samples of only men and boys, as this research aimed to provide a focused and in-depth understanding of the unique outcomes of assistive technology as experienced by women and girls, acknowledging that their experiences are often distinct from those of men and boys. Notably, no studies reported the inclusion of genders beyond the male/female binary. Consequently, while transgender and gender non-binary individuals might be represented in data, the absence of detailed reporting on measurement restricts generalisability across different gender identities. The lack of sociodemographic and ethnicity data alongside gender limits this study's scope, obscuring intersectional inequalities. This limits the generalisability as findings may not reflect diverse populations. Policy recommendations risk inadequacy, failing to address nuanced needs. Targeted interventions become impossible, perpetuating disparities. Ethically, omitting this data reinforces biases and marginalises vulnerable groups. A comprehensive understanding of AT experiences requires intersectional data, ensuring equitable outcomes and inclusive policies.

## Conclusions

Associations between sex and/or gender with assistive technology outcomes were found in twenty-two out of thirty-eight papers. Greater attention is needed to the physiological differences among sexes and their implications for AT use to eradicate bias within the design of assistive products. Certain forms of AT were viewed as vital for enabling public and social participation among women, including as a means of ‘blending in’ or providing enhanced safety. However, several studies found enhanced benefits in social participation impacted only men, compared to women using assistive devices. Ableist stereotypes were also reflected through erasure of the needs of disabled mothers, underscoring the need for adapted AT and training of obstetrics staff. Given the evidence of an association between the uptake of assistive product use and employment did not impact women, increasing access to assistive products alone should not be seen as a

silver bullet towards rectifying historical inequities in access to economic opportunities for disabled women.

Awareness campaigns and participation initiatives should consider targeting stigma at the intersection of ableism and (cis)sexism. Further efforts to synthesise and generate evidence surrounding AT should consider the relevance of ethnicity, socioeconomic status, education and citizenship status, among other known determinants of health, on outcomes of AT use.

This work has highlighted that the outcomes of AT use are influenced by gender, reflecting the intersecting impacts of ableism and misogyny present in broader society. Consequently, we conclude that gender is a social determinant of AT outcomes, with women disproportionately affected. These findings underscore the necessity of incorporating gender analyses, as well as gathering additional evidence surrounding gender (with a focus on experiences of gender minorities) and other social determinants such as age and ethnicity. Such efforts are essential to refine global programme delivery and AT access through policy-making to ensure that individuals across the gender spectrum have the opportunity to lead lives they value.

## Notes

1. Equality, Diversity and Inclusion Researcher, Imperial College London.
2. Snowdon Trust, Unit 18, Oakhurst Business Park, Wilberforce Way, Southwater, Horsham, RH13 9RT.
3. Assistive products are defined by the WHO as “any external product (including devices, equipment, instruments or software), especially produced or generally available, the primary purpose of which is to maintain or improve an individual’s functioning and independence, and thereby promote their well-being. Assistive products are also used to prevent impairments and secondary health conditions.”
4. Assistive technology is understood as a subset of health technology.
5. The SAGER Guidelines understands sex as “a set of biological attributes in humans and animals that are associated with physical and physiological features including chromosomes, gene expression, hormone function and reproductive/sexual anatomy [1]. Sex is usually categorized as female or male, although there is variation in the biological attributes that constitute sex and how those attributes are expressed,” while gender speaks to “the socially constructed roles, behaviours and identities of female, male and gender-diverse people. [Gender] influences how people perceive themselves and each other, how they behave and interact and the distribution of power and resources in society. Gender is usually incorrectly conceptualized as a binary (female/male) factor. In reality, there is a spectrum of gender identities and expres-

sions defining how individuals identify themselves and express their gender.”

6. The Disabled Leaders Network “is a platform,” managed by the Snowdon Trust and The Global Disability Innovation Hub, bringing together “Snowdon Trust Scholarship winners and Alumni to build relationships with other exceptional disabled leaders, creating a hub of information, knowledge and support.”
7. Referring to “those who might benefit from using an assistive product for the same purposes as users but do not yet have access.”
8. Gender minorities refers to people whose “gender identity that differs from that commonly associated with their sex assigned at birth.”
9. From: Page et al. [130]

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## Appendix A

Example search, as executed in Medline, accessed through Ovid, November 2023.

1. Self-help devices/ or communication aids for disabled/ or wheelchairs/ or motorized mobility scooter/ or sensory aids/ or hearing aids/ or auditory brain stem implants/ or cochlear implants/
2. "Assistive technolog\*".mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]
3. Exp wheelchairs/ or "assistive product\*".mp.
4. "Assistive equipment".mp.
5. "Assistive device\*".mp.
6. "Self-help equipment".mp.
7. "Self-help technolog\*".mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]
8. "Assistive robot\*".mp.
9. Orthoses.mp. or Orthotic Devices/
10. Prosthesis.mp. or "Prostheses and Implants"/
11. "White cane\*".mp.
12. Orthopedic equipment/ or walkers/
13. "Rollators\*".mp.
14. "Incontinence product\*".mp. or Incontinence Pads/
15. "Brailier\*".mp.
16. "Deafblind communicator\*".mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]
17. "Braille display\*".mp.
18. "screen reader\*".mp.
19. "Closed captioning display\*".mp. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]
20. "Self-care device\*".mp.
21. "Self-care technolog\*".mp.
22. "Self-care aid\*".mp.
23. "Self-care equipment".mp.
24. "Self help aid\*".mp.
25. "Assistive aid\*".mp.
26. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25
27. Gender.mp.
28. Femininity/ or gender role/ or masculinity/
29. "Gender norm\*".mp.
30. "Gender stereotype\*".mp.
31. Female/ or wom\*n.mp.
32. Girl\*.mp.
33. 27 or 28 or 29 or 30 or 31 or 32
34. Disabled.mp. or disabled persons/
35. Disabilit\*.mp.
36. Limit 35 to no language specified
37. "Functional impairment\*".mp.
38. "Functional difficult\*".mp.
39. "Chronic condition\*".mp.
40. "Chronic illness\*".mp.
41. Handicap\*.mp.
42. "Hearing impairment\*".mp. or \*hearing disorders/
43. "Visual impairment\*".mp.
44. "Older person\*".mp.
45. "Elderly".mp. or \*aged/
46. 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45
47. Barrier\*.mp.
48. Facilitator\*.mp.
49. "Usage".mp.
50. Enabler\*.mp.
51. Access\*.mp.
52. Acceptance.mp.
53. Attitude\*.mp.
54. Perception\*.mp.
55. Preference\*.mp.
56. \*Treatment Outcome/ or outcome\*.mp.
57. Impact\*.mp.
58. \*Treatment Refusal/ or refusal.mp.

(Continued)

**Table 1.** Continued.

59.	Abandon*.mp.
60.	Adoption*.mp.
61.	Obstacle*.mp.
62.	47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61
63.	26 and 33 and 46 and 62
64.	Limit 63 to (humans and yr="2000–2024")
65.	Limit 64 to full text
66.	Limit 64 to English language
67.	Limit 66 to (female and full text and humans and yr="2000–current")
68.	Limit 66 to full text

## Appendix B

**Table B1.** Overview of characteristics of impairment represented within included papers ( $N=66$ ).

Variable		<i>n</i> of papers reporting
Forms of disability	Physical	47
	Spinal cord-injury	10
	Amputation or limb-difference	18
	Multiple sclerosis	2
	Cerebral palsy	6
	Surgery	3
	Spina bifida	3
	Post-polio syndrome	2
	Muscular dystrophy	1
	Muscular atrophy	1
	Arthritis	2
	Chronic pain	2
	Involuntary faecal or urinary leakage	2
	ALS	1
	Stroke	3
	Sensory	12
	Vision	5
	Hearing	5
	Vision and sensory	1
	Cognitive	3
	Brain injury	2
	Dementia	1
	General aging	1
	Multiple	4
Papers providing definition of disability [general or specific]		11

## Appendix C

**Table C1.** Overview of characteristics of assistive technology represented within included papers (*N*=66).

AT for	<i>n</i> of papers reporting	% of papers reporting	Types of AT	<i>n</i> of papers reporting
Physicality/mobility/dexterity	45	68.2%	Mobility aids (unspecified)	6
			Wheelchairs	13
			Manual wheelchairs	6
			Powerchairs	4
			Scooter	1
			Unspecified	5
			Insole/therapeutic footwear	1
			Orthotics	4
			Grabbing device	1
			Microswitch	1
			Prosthetics	17
			Lower limb	9
			Incontinence products	3
			Incontinence pads	2
			Incontinence underwear	1
			Therapeutic footwear	1
			Meal preparation instrument	1
Sensory/communication	12	18.2%	Hearing aids	7
			Tactile mouse	1
			Tactile walking surface	1
			Mobile devices	1
			Communication devices	1
			Virtual assistant connected eye wear	1
Cognition	4	6%	Robotics	4
			Social or physical assistive robots	4
Multiple	5	7.6%	Assistive products [general]	7
Papers providing definition of AT [general or specific]	11			
Papers concerning AT on WHO's priority assistive products list	58	87.9%		