




# Estimating need and coverage for five priority assistive products: a systematic review of global population-based research

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## ABSTRACT

**Introduction** To improve access to assistive products (APs) globally, data must be available to inform evidence-based decision-making, policy development and evaluation, and market-shaping interventions.

**Methods** This systematic review was undertaken to identify studies presenting population-based estimates of need and coverage for five APs (hearing aids, limb prostheses, wheelchairs, glasses and personal digital assistants) grouped by four functional domains (hearing, mobility, vision and cognition).

**Results** Data including 656 AP access indicators were extracted from 207 studies, most of which (n=199, 96%) were cross-sectional, either collecting primary (n=167) or using secondary (n=32) data. There was considerable heterogeneity in assessment approaches used and how AP indicators were reported; over half (n=110) used a combination of clinical and self-reported assessment data. Of 35 studies reporting AP use out of all people with functional difficulty in the corresponding functional domains, the proportions ranged from 4.5% to 47.0% for hearing aids, from 0.9% to 17.6% for mobility devices, and from 0.1% to 86.6% for near and distance glasses. Studies reporting AP need indicators demonstrated >60% unmet need for each of the five APs in most settings.

**Conclusion** Variation in definitions of indicators of AP access have likely led to overestimates/underestimates of need and coverage, particularly, where the relationship between functioning difficulty and the need for an AP is complex. This review demonstrates high unmet need for APs globally, due in part to disparate data across this sector, and emphasises the need to standardise AP data collection and reporting strategies to provide a comparable evidence base to improve access to APs.

## INTRODUCTION

Assistive technology (AT) includes assistive products (APs) and related services that can improve health and well-being, enable increased independence and foster participation for people with functional difficulties, including older adults and people with

## Key questions

### What is already known?

- ▶ Access to assistive technology (AT) is limited globally, especially in low/middle-income countries (LMICs), largely due to sparse, disparate data on assistive products (APs).
- ▶ Currently, there exists no dedicated repository of population-based AP research.
- ▶ As a result, many governments lack coherent information about unmet AP need, which can hinder development of evidence-based programmes and policies to address this gap.

### What are the new findings?

- ▶ The finding of high unmet need (>60%) for each of the five APs emphasises the need to secure political prioritisation and funding to expand access to AT globally.
- ▶ Vision is proportionately overrepresented in the literature, with 76% of studies reporting all or in part on glasses. 'AP use' was reported 195 times overall (30% of all 656 indicators), making it the most commonly reported AP indicator from this dataset.
- ▶ Discrepancies in how key terms related to AP access were defined likely led to overestimates/underestimates of need.

### What do the new findings imply?

- ▶ Synthesising disparate evidence and comparing across country contexts and functional domains provided a strong base to advocate for increasing access to APs, while identifying underrepresented regions, populations and APs.
- ▶ The evidence basis in LMICs is particularly sparse, demonstrating that knowledge gaps are widest, where AP access is the most limited.
- ▶ The development of a global minimum dataset on AP research is needed, as well as future research that disaggregates domain-specific and region-specific AP access by additional variables (eg, gender, income and education).

impairments or chronic health conditions.<sup>1</sup> This paper uses the umbrella term ‘functional difficulty’ (FD) to refer to all of these groups.

The WHO estimates 2.4 billion people globally have FD and over 1 billion need APs and related services.<sup>2</sup> This need is expected to rise as populations age, which forecasts an increase in years lived with FD.<sup>2</sup> Furthermore, in some low/middle-income countries (LMICs), higher prevalence of chronic and infectious disease and injury-related morbidity, coupled with a shortage of trained care workers, results in higher overall rates of FD and associated increased demand on healthcare, rehabilitation and AT service delivery systems.<sup>3</sup> The SARS-CoV-2 (COVID-19) pandemic has also resulted in increased FD prevalence due to disruptions of health/rehabilitation services and its direct impact on health and functioning.<sup>4</sup> This includes ‘long COVID-19’, where symptoms decreasing functional abilities persist, the full impact of which is yet to be fully realised.<sup>5,6</sup>

Despite AT’s critical relevance to all 17 sustainable development goals, the sector has not received equitable attention on the international agenda.<sup>7</sup> Data on AP need are essential to support decision-makers to secure political prioritisation, identify causes of delivery system bottlenecks, and implement interventions to address population-level AT access.<sup>8</sup> Information on this access is lacking, including estimates of use, unmet needs, and met needs, due in part to the complexity of assessing individuals for AP need.<sup>9</sup> Further, due to disparate patterns of data collection, analysis, and reporting, it’s often unclear what data are available and impactful data may go unused. An essential next step is, therefore, to centralise and collate available data indicating AP access and synthesise learnings across APs and functional domains to inform the sector overall.

Assistive product lists (APLs) (PAPs) are used to focus and coordinate efforts to expand AP access. Further specifying a list of priority assistive products (PAPs) at

the national level is encouraged in specific countries to ensure the list is contextual and based on their unique needs. The WHO Global Cooperation on Assistive Technology’s priority assistive product list presents a global list of 50 priority APs.<sup>10</sup> Of these, ATScale,<sup>11</sup> a Global Partnership for Assistive Technology, selected five priority APs corresponding to four functional domains: hearing aids (hearing), limb prostheses and wheelchairs (mobility), glasses (vision) and personal digital assistants (PDAs) (cognition).<sup>10</sup>

### Aims

To contribute to a global effort to increase the AT evidence base, we conducted a systematic review of studies, which generated population-based AP access indicators for the five priority ATScale APs. This review aims to (1) characterise existing population-level research producing AP access indicators and (2) present and synthesise indicators globally to support scaling up AT provision.

This review builds on the findings of an initial scoping review, commissioned by the WHO and published separately,<sup>9</sup> which primarily focused on the strengths, limitations and most effective contexts for different methods used for estimating AP supply and demand at market level in AT research. Results from these methodologies are explored in this systematic review.

### METHODS

The systematic search was conducted in March 2020 and included peer-reviewed articles and grey literature with findings on APs. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement was followed throughout review.<sup>12</sup>

### AP access indicators defined

Population-level AP access indicators are variably used and defined in the literature. [Table 1](#) shows the definitions used for the purposes of this review, developed by

**Table 1** AP access indicators definitions and calculations

AP access indicator	Working definition	Equation
Need	The proportion of a defined population who could benefit from using an appropriate AP, based on an AP assessment approach, including those already using the AP	Population who could benefit from an AP/defined population
Has AP	The proportion of a defined population who have an AP (obtained through purchase, loan, rent, donation or by other means)	Population who have APs/defined population
Use	The proportion of a defined population who use an AP	Population who use APs/defined population
Met need (population with full coverage)	The proportion of a population who need and use appropriate APs	Population who need and use appropriate APs/defined population
Undermet need (population with partial coverage)	The proportion of a population who need and use APs that are insufficient to maximise functioning	Population who use insufficient APs/defined population
Unmet need (population with no coverage)	The proportion of a population who need and do not use any APs	Population who need and do not use appropriate APs/defined population
Coverage	The proportion of a defined population who need and use an AP	Population who need and use APs/population who need APs

AP, assistive product.

drawing on authors' expertise and relevant background literature (table 1).<sup>9</sup> These terms are referred to as 'indicators' throughout this paper.

### Search strategy

Fifteen databases were searched for empirical and grey literature using a set search string specifying (1) a synonym for AP or the name of the actual AP, (2) an indicator and (3) a synonym for FD in the study's title/abstract (online supplemental appendices 1 and 2). Studies were exported to the Rayyan QCRI web application<sup>13</sup> to remove duplicates and screen abstracts.

### Eligibility criteria

Our search included studies published between 2000 and 2020, written originally in English, French, Portuguese, or Spanish, or providing a translation. Studies were eligible for inclusion if they met the following criteria during full text review:

- ▶ At least a portion of study data is collected since 1 January 2000.
- ▶ The study generated at least one indicator (table 1) for one of the five specified priority APs.<sup>10</sup>
- ▶ The study was a primary or secondary analysis of a representative, population-based sample.

### Review

After removing duplicates, all titles and abstracts were initially screened for any mention of AT or FD. Remaining abstracts were then reviewed by two authors, according to eligibility criteria.<sup>9</sup> In addition, eligible systematic reviews were cross-referenced; any relevant citations missing from our searches were added. All full texts were then reviewed by two authors. Conflicts at all stages were settled by a third reviewer.

### Data extraction and analysis

Data were extracted from full texts and entered into a data portal designed by authors to standardise data extraction for the following: study setting, population, design, assessment methodologies, impairment definitions used, and indicators, including numerator and denominator values (online supplemental appendix 3).

Indicators were included if (1) they were directly reported in the results of studies, meaning they aligned with our terms and definitions (table 1) or (2) they were indirectly reported, meaning it was possible to calculate them using clearly defined data provided in the articles (demonstrated in online supplemental appendix 4).

Given substantial variation in how indicators are presented and reported, not all results were directly comparable and a meta-analysis could not be conducted. Where studies present pooled estimates from previously published results (eg, reviews), the unique pooled indicator was extracted. To facilitate comparison across studies where possible, indicator denominators are denoted in our results tables with the following labels:

- ▶ Total population: the broader regional or national population from which the study sample was drawn.

This denominator is larger than the number of participants when study results are only presented as extrapolations.

- ▶ Total in analysis: all participants included in the study's analysis. This may be smaller than the number of total participants reported in a study, as some participants may not complete all components of the assessments.
- ▶ Total with FD: all study participants assessed to have the relevant impairment (eg, vision impairment) or functioning difficulty (eg, difficulty seeing). Some studies only include individuals with impairment/FD as participants or in the analysis.
- ▶ Total with need: all participants assessed to have need of the relevant AP. Some studies consider all participants with impairment/FD as needing an AP.
- ▶ Total with AP: all participants who already have an AP.

Most included vision AP studies reported on vision assessments done at 6m. Alternative definitions (eg, 20ft, log MAR) were converted to 6m using the NIDEK conversion chart.<sup>14</sup> For distance vision studies, prevalence estimates for uncorrected and undercorrected refractive error were also extracted, as these equate to unmet and undermet need for glasses, respectively. Results for 'refractive error' only (ie, without specifying uncorrected or undercorrected) were not extracted.

### Risk of bias in individual studies

The Critical Assessment Tool for Prevalence Studies from the Joanna Briggs Institute (JBI) was used to evaluate all included full texts.<sup>15</sup> We adapted this tool by adding a 10th criterion: 'The study describes its ethical approval, including how consent was obtained from participants'. We present each study's summary score and specific missing checklist criteria (online supplemental appendix 5).

This review was not registered with PROSPERO due to its relation to the scoping review,<sup>9</sup> which necessitated the extraction of some overlapping systematic review data during the scoping review process. PROSPERO does not register scoping reviews and will not register systematic reviews which have already begun data extraction.

### Role of the funding source

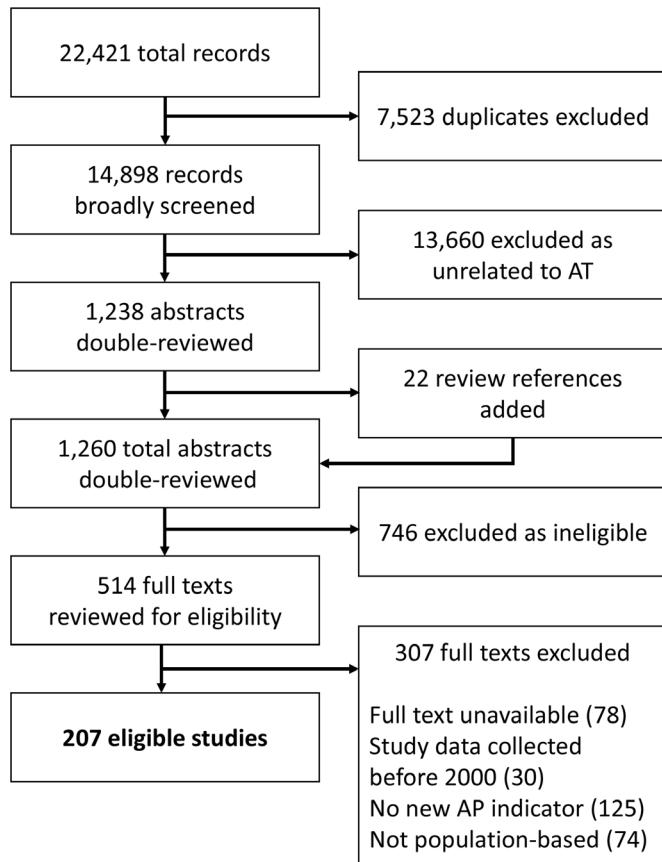
The funder of the study had no role in study design, data collection, data analysis, data interpretation or writing of the report.

### Patient and public involvement

Patients and the public were not involved in any way in this research.

## RESULTS

This section first details overall study selection and characteristics. Next, results including AP indicators are presented for each AP, grouped by functional domain.



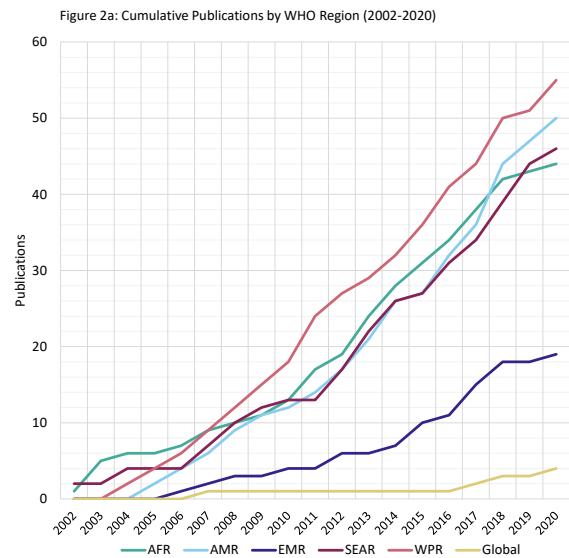
**Figure 1** Study selection. AP, assistive product; AT, assistive technology.

**Study selection**

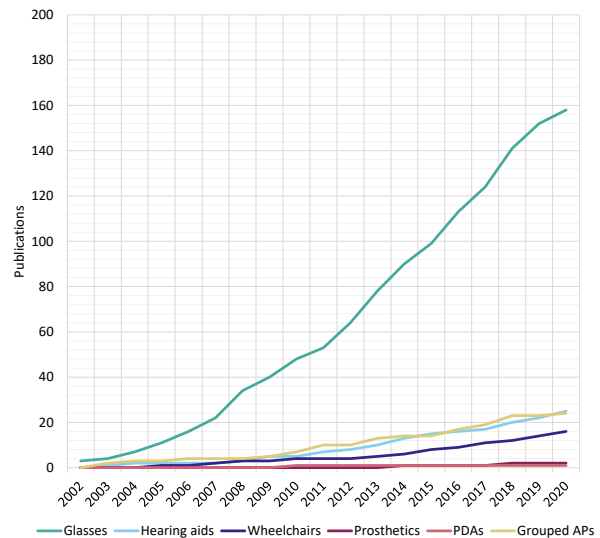
Of 14 898 unique records identified, 1238 abstracts mentioned AT and/or FD (JD). Ten per cent (n=1336) of discarded records were reviewed by a second author (CH, DB and SP) with 100% agreement. Seven reviews were identified at this stage and cross-referenced, adding 22 abstracts (JD, DB and ES). Of 1260 total abstracts, 514 met inclusion criteria, determined by two authors (JD, DB, VDR, SP, CH and ES). Following full-text review, 207 articles met inclusion criteria (with 96% inter-rater agreement) (JD, DB, VDR and ES). Studies excluded at this stage are listed in online supplemental appendix 6. **Figure 1** details the full review process. Corresponding authors were contacted for all articles missing full texts (initially n=85), resulting in seven additions (JD). All extracted data were double-checked (JD, AK, VDR, DB, ES, SP and CH).

**Included study characteristics**

All studies were published between 2002 and 2020. The cumulative frequency of studies published each year is shown by WHO region and AP type in **figure 2A,B**. The most represented region was the Western Pacific Region (WPR) (n=55, 27%), specifically China (n=29/55, 53%), followed by the Region of the Americas (AMR) (n=50, 24%), specifically the USA (n=27/50, 54%) and the Southeast Asian Region (SEAR) (n=46, 22%), specifically India (n=31/46, 67%).



**Figure 2a:** Cumulative Publications by WHO Region (2002-2020)



**Figure 2b:** Cumulative Publications by AP Type (2002-2020)

**Figure 2** Cumulative publication frequency by WHO Region (A) and AP type (B). AP, assistive product; PDAs, personal digital assistants.

**Figure 2B** demonstrates most studies (n=158, 76%) presented indicators for glasses, compared with the other APs.

In terms of study design, the vast majority were cross-sectional (n=199, 96%), using primary (n=167) and secondary data (n=32). Common assessment approaches included clinical (n=60), self-report (n=37), or a combination of both (n=110, 53%).

The youngest included age was zero (included in 27 studies) and 129 studies (62%) included no age maximum. Nineteen studies (9%) include most or all ages (<3 years to >84 years). Children <13 years are included in 91 studies overall (44%) and 20 exclusively (10%), while adults >64 years are included in 137 overall (66%) and 13 exclusively (6%).

The average JBI score among all 207 studies was 9.3/10, with 50% (n=104) achieving all 10 checklist

**Table 2** Hearing aid studies and indicators

Study design	Cohort	Cross-sectional	Mixed-methods	Secondary cross-sectional	–	–	–	Total
N	1	9	1	14	–	–	–	25
%	4%	36%	4%	56%	–	–	–	100%
Assessment approaches	Clinical only	Self-report only	Functional only	Clinical and self-report	Clinical and functional	Other combination	Secondary sources (multiple)	
N	2	4	0	14	2	2	1	25
%	8%	16%	0%	56%	8%	8%	4%	100%
Participants (N)*	<500	500–999	1000–4999	5000–9999	10 000–24 999	>25 000	Not available	
N	3	1	11	2	3	4	1	25
%	12%	4%	44%	8%	12%	16%	4%	100%
Age (years) included†	Under 15	<15 to 85+	15 to 85+	40 to 85+	65 to 85+	Over 85	–	
N	1	7	5	4	7	1	–	25
%	4%	28%	20%	28%	28%	4%	–	100%
JBI score	<7	7	8	9	10	–	–	
N	1	1	5	5	13	–	–	25
%	4%	4%	20%	20%	52%	–	–	100%
Functioning difficulty or impairment definition	Use of AP	Reported activity limitations	Clinical threshold	Combination	–	–	–	
N	3	5	14	3	–	–	–	25
%	12%	20%	56%	12%	–	–	–	100%
WHO Region	AFR	AMR	EMR	EUR	SEAR	WPR	Global	
N	3	10	1	8	3	8	1	34
%	9%	29%	3%	24%	9%	24%	3%	100%
AP access indicator	Total need	Met need	Unmet need	Undermet need	Coverage	Use	Has AP	
N	7	1	17	0	2	26	9	62
%	11%	2%	27%	0%	3%	42%	15%	100%
Indicator denominator	Total with/using AP	Total with need	Total with functioning difficulty	Total participants	Total population	–	–	
N	1	20	15	24	2	–	–	62
%	2%	32%	24%	39%	3%	–	–	100%

\*Participants (N) ranged from 379 to 455 200 for this domain.

†Age group boundaries varied considerably by study; studies are sorted into categories that most closely represent their included age boundaries.

AFR, African Region; AMR, Region of the Americas; AP, assistive product; EMR, Eastern Mediterranean Region; EUR, European Region; JBI, Joanna Briggs Institute; SEAR, Southeast Asian Region; WPR, Western Pacific Region.

items, and only one scoring below 7. By domain, the average JBI score ranged from 8.6 to 9.3. The most missed items were #2 (appropriate or well-described sampling of study participants) (n=30), #4 (study subjects and setting described in detail) (n=49) and our added #10 (consent and ethical approval detailed) (n=18) (online supplemental appendix 5).

### AP access indicators

Overall, 656 AP access indicators were extracted. High-level results are presented for each AP, grouped by functional domain (tables 2–5) with all indicators from each

study listed in online supplemental appendices 7–11. Studies reporting data, which could be disaggregated by comparable need indicators, are also included in figure 3A–E and online supplemental appendix 12.

### Hearing

In total, 25 studies (12%) provided 62 indicators on hearing aid access, detailed in table 2 and online supplemental appendix 7.<sup>16–40</sup> Nearly all were based on primary (n=10, 40%) or secondary analyses (n=14, 56%) of cross-sectional studies. The majority (n=18, 72%) used multiple assessment approaches, while self-report was exclusively used by 4 (16%) and clinical assessment by 2 (8%). All but one study<sup>38</sup> assumed all participants identified as

**Table 3** Mobility AP studies and indicators

Study design	Cohort	Cross-sectional	Mixed-methods	Secondary cross-sectional	–	–	–	Total
N	0	3	1	11	–	–	–	15
%	0%	20%	7%	73%	–	–	–	100%
Assessment approaches	Clinical only	Self-report only	Functional only	Clinical and self-report	Clinical and functional	Other combination	Secondary sources (multiple)	
N	1	9	0	4	0	1	0	15
%	7%	60%	0%	27%	0%	7%	0%	100%
Participants (N)*	<500	500–999	1000–4999	5000–9999	10000–24 999	>25000	Not available	
N	0	1	4	4	2	4	0	15
%	0%	7%	27%	27%	13%	27%	0%	100%
Age (years) included†	Under 15	<15 to 85+	15 to 85+	40 to 85+	60 to 85+	Over 85	–	
N	1	3	5	0	5	1	–	15
%	7%	20%	33%	33%	33%	7%	–	100%
JBI score	<7	7	8	9	10	–	–	
N	0	0	3	5	7	–	–	15
%	0%	0%	20%	33%	47%	–	–	100%
Mobility functioning difficulty or impairment definition	Use of AP	Reported activity limitations	Clinical threshold	Combination	–	–	–	
N	7	6	0	2	–	–	–	15
%	47%	40%	0%	13%	–	–	–	100%
WHO Region	AFR	AMR	EMR	EUR	SEAR	WPR	Global	
N	2	10	0	2	2	1	0	17
%	12%	59%	0%	12%	12%	6%	0%	100%
AP access indicator	Total need	Met need	Unmet need	Undermet need	Coverage	Use	Has AP	
N	3	0	6	1	2	26	4	42
%	7%	0%	14%	2%	5%	62%	10%	100%
Indicator denominator	Total with/using AP	Total with need	Total with functioning difficulty	Total participants	Total population	–	–	
N	3	2	12	19	6	–	–	42
%	7%	5%	29%	45%	14%	–	–	100%

\*Participants (N) ranged from 839 to 66410 for this domain.

†Age group boundaries varied considerably by study; studies are sorted into categories that most closely represent their included age boundaries. AFR, African Region; AMR, Region of the Americas; AP, assistive product; EMR, Eastern Mediterranean Region; EUR, European Region; JBI, Joanna Briggs Institute; SEAR, Southeast Asian Region; WPR, Western Pacific Region.

having a hearing difficulty also needed a hearing aid (ie, prevalence of hearing difficulty equals hearing aid need were the same). The proportion of participants with hearing difficulty who were using hearing aids ranged from 4.5%<sup>38</sup> to 47.5%,<sup>34</sup> although the definition of hearing difficulty varied between these studies (online supplemental appendix 7). Ten studies across 17 settings informed on total need. **Figure 3A** demonstrates high unmet need for hearing aids, with most settings (n=16, 89%) showing over 60% unmet need (ie, >60% of people assessed to need a hearing aid did not have one). All of

these studies reported unmet need, but only one also reported met need<sup>33</sup> while the others substituted AP use.

### Mobility

Fifteen studies (7%) reported 42 access indicators for mobility APs, including prosthetics, motorised and manual wheelchairs. Characteristics are included in **table 3** and all indicators in online supplemental appendix 8.<sup>17 22 25 27 30 40–49</sup> Most mobility AP studies (n=11, 73%) were secondary analyses of national-level surveys/censuses. Six studies relied entirely on

**Table 4** Near and distance glasses studies and indicators

Study design	Cohort	Cross-sectional	Mixed-methods	Secondary cross-sectional	-	-	-	-	-	Total
N	1	46	0	5	-	-	-	-	-	52
%	2%	88%	0%	10%	-	-	-	-	-	100%
Assessment approaches	Clinical only	Self-report only	Functional only	Clinical and self-report	Clinical and functional	Other combination	Secondary sources (multiple)	-	-	
N	18	2	0	30	0	0	2	-	-	52
%	35%	4%	0%	58%	0%	0%	4%	-	-	100%
Participants (N)*	<500	500–999	1000–4999	5000–9999	10 000–24 999	>25 000	Not available	-	-	
N	3	6	24	10	6	2	1	-	-	52
%	6%	12%	46%	19%	12%	4%	2%	-	-	100%
Age (years) Included†	Under 15	<15 to 85+	15 to 85+	40 to 85+	60 to 85+	Over 85	Other	-	-	
N	2	7	1	28	8	0	6	-	-	52
%	4%	13%	2%	15%	15%	0%	-	-	-	100%
JBI score	<7	7	8	9	10	-	-	-	-	
N	0	1	5	19	27	-	-	-	-	52
%	0%	2%	10%	37%	52%	-	-	-	-	100%
Vision functioning difficulty or impairment definition	Use of AP	Reported activity limitations	Clinical threshold	Combination	-	-	-	-	-	
N	1	0	44	7	-	-	-	-	-	52
%	2%	0%	85%	13%	-	-	-	-	-	100%
WHO Region	AFR	AMR	EMR	EUR	SEAR	WPR	Global	-	-	
N	20	23	4	11	27	17	2	-	-	104
%	19%	22%	4%	11%	26%	16%	2%	-	-	100%
AP access indicator	Total need	Met need	Unmet need	Undermet need	Coverage	Use	Has AP	Uncorrected RE	Undercorrected RE	
N	11	40	61	8	29	43	3	37	1	233
%	5%	17%	26%	3%	12%	18%	1%	16%	0%	100%
Indicator denominator	Total with/using AP	Total with need	Total with functioning difficulty	Total participants	Total population	Total with unmet need	-	-	-	
N	10	58	61	81	22	1	-	-	-	233
%	4%	25%	26%	35%	9%	0%	-	-	-	100%

\*Participants (N) ranged from 134 to 3 983 541 for this domain.

†Age group boundaries varied considerably by study; studies are sorted into categories that most closely represent their included age boundaries.

AFR, African Region; AMR, Region of the Americas; AP, assistive product; EMR, Eastern Mediterranean Region; EUR, European Region; JBI, Joanna Briggs Institute; RE, Refractive Error; SEAR, Southeast Asian Region; WPR, Western Pacific Region.

self-reported assessment of activity limitation and/or AP need and seven used self-reported AP use to approximate functioning difficulty or impairment prevalence. AP use was the most reported indicator (n=26/42, 62%). Among the total with mobility difficulty, use of any type of mobility AP ranged from 0.9% (both prosthetics and motorised wheelchairs)<sup>30</sup> to 17.6% (manual/unspecified wheelchairs) (online supplemental appendix 8).<sup>45</sup> Only one clinical impairment assessment study<sup>22</sup> presented AP indicators allowing disaggregation of total need, showing high unmet need (>65%) for manual wheelchairs in two settings among those who needed the AP (figure 3C).

## Vision

Vision results are presented in three categories: near/reading glasses (n=35), distance glasses (n=31) and bifocal/combined/unspecified ('grouped') glasses (n=124). High-level results for near and distance glasses are combined in table 4, with specific results for each type described separately in-text. All included studies and indicators are available for near and distance glasses in online supplemental appendix 9<sup>22 50–100</sup> and grouped glasses in online supplemental appendix 10.<sup>27 30 40 51–55 62–65 72 76 78 80 81 84 86 95 101–202</sup> Need indicators for grouped glasses are also visualised in online supplemental appendix 12.

**Table 5** Grouped and cognitive AP studies and indicators

Study design	Cohort	Cross-sectional	Mixed-methods	Secondary cross-sectional	–	–	–	Total
N	0	17	1	6	–	–	–	24
%	0%	71%	4%	25%	–	–	–	100%
Assessment approaches	Clinical only	Self-report only	Functional only	Clinical and self-report	Clinical and functional	Other combination	Secondary sources (multiple)	
N	1	21	0	1	0	1	0	24
%	4%	88%	0%	4%	0%	4%	0%	100%
Participants (N)*	<500	500–999	1000–4999	5000–9999	10 000–24 999	>25 000	Not available	
N	0	3	7	5	5	4	0	24
%	0%	13%	29%	21%	21%	17%	0%	100%
Age (years) included†	Under 15	<15 to 85+	15 to 85+	40 to 85+	60 to 85+	Over 85	Other	
N	0	16	5	0	2	0	1	24
%	0%	67%	21%	8%	8%	0%	4%	100%
JBI score	<7	7	8	9	10	–	–	
N	0	2	5	10	7	–	–	24
%	0%	8%	21%	42%	29%	–	–	100%
Functioning difficulty or impairment definition	Use of AP	Reported activity limitations	Clinical threshold	Combination	–	–	–	
N	3	21	0	0	–	–	–	24
%	13%	88%	0%	0%	–	–	–	100%
WHO Region	AFR	AMR	EMR	EUR	SEAR	WPR	Global	
N	14	7	1	0	2	1	0	25
%	56%	28%	4%	0%	8%	4%	0%	100%
AP access indicator	Total need	Met need	Unmet need	Undermet need	Coverage	Use	Has AP	
N	2	4	9	1	0	24	2	42
%	5%	10%	21%	2%	0%	57%	5%	100%
Indicator denominator	Total with/using AP	Total with need	Total with functioning difficulty	Total participants	Total population	–	–	
N	1	5	28	8	0	–	–	42
%	2%	12%	67%	19%	0%	–	–	100%

\*Participants (N) ranged from 505 to 393 949 for this domain.

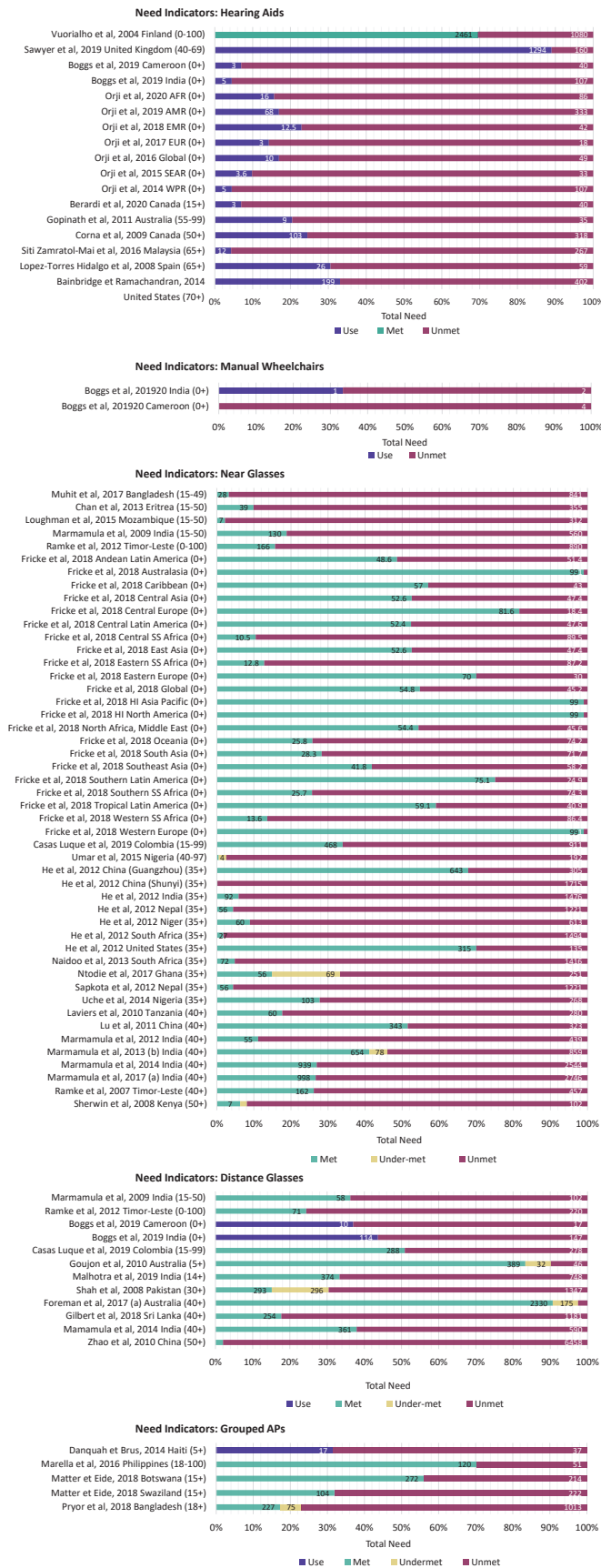
†Age group boundaries varied considerably by study; studies are sorted into categories that most closely represent their included age boundaries. AFR, African Region; AMR, Region of the Americas; AP, assistive product; EMR, Eastern Mediterranean Region; EUR, European Region; JBI, Joanna Briggs Institute; SEAR, Southeast Asian Region; WPR, Western Pacific Region.

Thirty-five studies (17%) provided 126 indicators for near glasses (table 4). Most were primary cross-sectional (n=32; 91%) and used a combination of clinical and self-reported assessment data (n=22; 63%), while 11 (31%) used clinical assessment data only. The most reported indicators were unmet (n=49; 38%) and met need (n=30; 24%). Near glasses use among individuals with vision difficulty ranged from 0.1%<sup>64</sup> to 89.5% (online supplemental appendix 9).<sup>83</sup> Twenty-one studies (60%) reported total need indicators,

with 17 showing unmet need for near glasses above 60% among those who needed the AP (figure 3C).

Thirty-one studies (14%) report 107 indicators for distance glasses (table 4). All studies are either primary (n=21, 81%) or secondary (n=5; 19%) analyses of cross-sectional surveys. Sixteen studies (53%) used both clinical and self-reported assessments, with 11 (37%) relying only on clinical assessment. The most reported indicator was uncorrected refractive error (n=35/107; 33%). Among those with





**Figure 3** Need indicators for hearing aids (A), manual wheelchairs (B), near glasses (C), distance glasses (D) and grouped APs (E). HI, High-Income; SS, Sub-Saharan.

difficulty seeing, use of distance glasses ranged from 0.4%<sup>64</sup> to 55.2%<sup>87</sup> (online supplemental appendix 9). Eleven studies provided total need indicators across 12 settings, the majority (n=8/12; 67%) of which reported an unmet need for distance glasses of >60% among those who needed the AP (figure 3D).

### Grouped APs and cognitive

Twenty-four studies (12%) presented 42 indicators for grouped APs, with one study also presenting a cognitive AP indicator for PDAs<sup>203</sup>; characteristics for all grouped AP studies are described in table 5 with all indicators included in online supplemental appendix 11.<sup>17 25 27 30 203-222</sup> Nearly all (n=21; 88%) used only self-reported activity limitations to identify impairment or FD. 'AP use' was the most commonly reported indicator in the grouped domain (n=24/42, 57%), with the proportion of participants with FD using any AP ranging from 2.8%<sup>217</sup> to 94.8% (online supplemental appendix 11).<sup>27</sup> In three of five studies presenting total need indicators, unmet need for APs was >60% among those who needed APs (figure 3E).

## DISCUSSION

AT is gaining recognition on the international global health agenda, as evidenced in this systematic review by the increasing frequency of publications from 2000 to 2020. However, many data gaps have not been addressed. During this period, 76% (n=158) of the 207 articles reported all or in part on glasses, with fewer articles available for the other APs, emphasising data gaps in hearing, mobility and especially cognitive functional domains. Older adults (65+ years) were more often included in studies than children under 12 years, and <25% of studies focused exclusively on young children, making it challenging to identify disparities in AP need based on age. This review also highlights the heterogeneity in study design and reporting that has led to a lack of standardisation in population-based AP data collection efforts and limits comparability between settings. Total need indicators were reported from 84 study settings, the majority of which (n=57/84, 68%) reported unmet need >60% among all participants with AP need in each functional domain and in all country income contexts. Total need estimates were also commonly reported across all functional domains except mobility, though functional domains were not equally represented in these studies.

AP indicators were often used variably in the literature. The prevalence of FD was frequently equated to AP need, which can overestimate/underestimate true need and coverage.<sup>22</sup> This approach typically lacks a holistic assessment of AP need since it does not account for important data about an individual's personal factors, including their specific health needs, activities, participation and environmental contexts. All but one mobility study<sup>22</sup> made this assumption and relied solely on self-reported assessments, which can be limited by participants' poor awareness of APs or underlying causes for FD, further

misestimating need.<sup>9 22</sup> 'Has AP' or 'use' were also used to approximate 'met need' for an AP; all hearing aid studies indicating need reported 'use' in lieu of met need (excepting one<sup>18</sup>). This substitution limits understanding of AP need in multiple ways: in the literature, the 'use' indicator has included the use of APs that are appropriate ('met need') and APs that might be broken and/or inappropriate ('undermet need'), which obfuscates remaining need. Denominators used when calculating indicators also varied considerably, encompassing individuals with need, functioning difficulty, included in the study, or extrapolated to the total population. Though the latter can provide useful measures for drawing international comparisons and evaluating trends over time, the variation in denominators overall limits comparability across studies. Each has its use in a comprehensive evidence basis, but more comparable methodology and reporting are needed to improve understanding of population-level need.

Self-reported assessments were typically employed in functional domains where a large sample size was needed and/or the relationship between the individual's need and a specific AP is complex (eg, mobility or cognition), or multiple APs were considered (eg, grouped APs). Subsequently, clinical impairment and/or functional assessment for all participants was often not feasible. For example, most of the reviewed mobility studies were secondary data analyses, with over half using censuses or national health studies (n=10/15; 67%), while mobility studies that collected primary data tended to have very low numbers of individuals assessed as needing or already using the AP, ranging from 0<sup>22</sup> to 186<sup>40</sup> individuals. Additionally, most studies reporting on grouped APs relied exclusively on self-reported assessment data (n=21/24; 88%). Clinical impairment assessments produce more standardised, comparable data, yet do not always capture personal factors, which are also necessary to holistically evaluate need. This demonstrates the importance of employing multiple types of data in recommending appropriate AT.<sup>9</sup>

While some established datasets based on universal care<sup>18</sup>/centralised health record systems<sup>46 223</sup> collect potentially impactful population-level data on AP users, these data do not necessarily include everyone. Relying exclusively on these data would miss individuals obtaining their APs by other means, such as private purchase or through the non-government sector. This missing data gap will be even more pronounced where government-led AT provision is more limited. Primary cross-sectional surveys can be helpful to address this gap, yet these surveys can be resource intensive, lack comparability and generalisability, and may not produce timely data needed by AT stakeholders. Our literature presents >150 studies from LMICs, which generate valuable learnings across the sector overall. However, when narrowing to AP-specific or country-specific data, the evidence base drastically decreases, showing the limitations of relying exclusively on few cross-sectional surveys

and demonstrates that the largest knowledge gaps are in areas where access to APs is lowest.

Collating this critical body of work to extract sector-wide learnings has been broached, in parts, by other reviews commissioned by the Lancet Global Health,<sup>224</sup> the WHO,<sup>3 9 225</sup> and development-focused institutes/governmental departments.<sup>226 227</sup> The WHO papers cited heterogeneous approaches to assessment,<sup>3 9 225</sup> severity of FD for inclusion,<sup>9 225</sup> and sampling source demographics,<sup>3 9 225</sup> as main challenges to interpreting results across publications, which mirrored our data extraction and presentation experience. Population-level data are overall extremely limited, and findings on need must be interpreted with caution. Appropriate research methods must also be used for this sector—RCTs are often unsuitable for AT interventions,<sup>3</sup> and based on available data, different approaches may be more effective than others.<sup>9</sup> Key gaps in the AT sector described in this discussion are emphasised when considering other AT reviews. Crucial research into effectiveness and follow-up of AT interventions is limited.<sup>3 9 225–227</sup> Our review similarly found this, as most primary and secondary studies were cross-sectional and did not incorporate any follow-up data collection. Limited awareness of AT demand and effectiveness was a commonly cited barrier to expanding AT production and access.<sup>226 227</sup> Often, available data go unused<sup>226</sup> or are not collected alongside quality-of-life indicators.<sup>226</sup> Furthermore, standardised impact measurement approaches are also needed.<sup>3 9 226</sup> Regarding all types of information relevant to AT, including need indicators, supply and demand data, and product designs, more substantial diffusion is hindered by the fragmented nature of available information.<sup>226</sup>

We have four main recommendations following our comprehensive review. First, considering the methodological and reporting variation between studies, we recommend establishing a global minimum AP dataset allowing researchers to address specific questions and compare evidence. This dataset should include the following: (1) standardised measures to determine individual need for an AP; (2) standardised APs (eg, APLs);<sup>10 228</sup> (3) standardised AP access indicators (as presented in this review) and (4) standardised approaches to measuring them. Second, we recommend the collection and use of data that holistically considers an individual's personal and environmental factors when assessing their capacity to benefit from an AP. As more holistic measurement methodology is developed, it is critical that it is tested and adapted for diverse contexts, especially LMICs. Third, modules collecting data to inform AP indicators should be included in established population surveys to maximise existing data collection methods and enable more nuanced secondary analyses. This can be supported by working with national statistics offices in both high and LMIC countries. Finally, differentiation should be made between the total using an AP, and within that value, the total with met need. This can highlight undermet needs among AP users, which provides further data about the

setting and/or population for which specific APs are not fully appropriate. To begin to collate this dataset, a global AT data portal<sup>229</sup> accompanying this review will make all extracted study data available and more accessible. This portal will also serve as a place to host future data, employing features to map evidence and provide context across disciplines to support knowledge sharing in this sector.

Our large-scale review captured >200 studies and benefited from including five APs across four functional domains, with a broadly inclusive search string and list of article sources. Data extraction criteria were developed to accommodate substantial variation in results reporting, so as much relevant data as possible could be considered, allowing us to extract >650 indicators. Through data extraction, we identified study settings, impairment/FD thresholds and denominators (among other factors) to ensure our comparisons and conclusions are appropriate.

However, this review has several limitations. Given the breadth of literature, we searched terms for FD rather than listing specific health conditions (online supplemental appendix 2), as there is no established list of conditions within each domain/relevant to each AP. Studies may have been missed that focused on specific health conditions without mentioning FD or APs in the title/abstract. This likely occurred for the mobility and cognitive domains, given these are less well defined in terms of which conditions could relate to certain APs. This also means we could not explore the variation in need for APs within a functional domain by certain conditions or pathologies. We also limited the review to five specific APs, while the WHO APL includes 50. Furthermore, a meta-analysis of indicators and exploration into their disaggregation by demographic factors (eg, sex, income, and education) was precluded from the remit of this review due to wide variation in methods/reporting. Finally, some vision studies also reported visual acuity measures, but extracting indicators based on these measures required clinical judgements and assumptions outside the remit of this review. Overall, future domain-specific research is recommended to address each of these limitations, including additional cognitive APs, with appropriate detail to identify sub-population-level disparities in AP access.

## CONCLUSION

This review highlights high unmet AP need across different settings, demonstrating the need to prioritise and expand access to AT globally. It also highlighted key AP research gaps in available literature, including lack of standardised and comparable data collection and reporting methods, particularly in LMICs. These gaps must be addressed so data collection efforts can identify areas with high need and inform, monitor, and evaluate AP service planning and delivery. Improving global access to these life-changing products is essential to each sustainable development goal and our accompanying

data portal<sup>229</sup> will ensure this review is used to its fullest potential in support of this aim.

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