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Assistive technology access in longitudinal datasets: a global review

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Abstract

Functional limitations become more prevalent as populations age, emphasising an increasingly urgent need for assistive technology (AT). Critical to meeting this need trajectory is understanding AT access in older ages. Yet few publications examine this from a longitudinal perspective.

This review aims to identify and collate what data exist globally, seeking all population-based cohorts and repeated cross-sectional surveys through the Maelstrom Research Catalogue (searched May 10, 2022) and the Disability Data Report (published 2022), respectively. Datasets incorporating functional limitations modules and question(s) dedicated to AT, with a wave of data collection since 2009, were included.

Of 81 cohorts and 202 surveys identified, 47 and 62 meet inclusion criteria, respectively. Over 40% of cohorts were drawn from high-income countries which have already experienced significant population ageing. Cohorts often exclude participants based on pre-existing support needs. For surveys, Africa is the most represented region (40%). Globally, 73% of waves were conducted since 2016. 'Use' is the most collected AT access indicator (69% of cohorts and 85% of surveys). Glasses (78%) and hearing aids (77%) are the most represented AT. While gaps in data coverage and representation are significant, collating existing datasets highlights current opportunities for analyses and methods for improving data collection across the sector.

Keywords
assistive technology; longitudinal data; ageing; functional limitations

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Introduction

The World Health Organization (WHO) estimates that the global average life expectancy has increased from 66.8 to 73.4 years, between 2000-2019 [1]. This increase in longevity comes with unique and urgent concerns, as populations (and the individuals who comprise them) experience ageing differently. The 2015 World Report on Ageing and Health stresses a need to understand drivers of variation in healthy ageing [2, 3] or the development and maintenance of functional ability that enables wellbeing in older age [4]. An increase in the average life expectancy is often driven by better survival at all ages and does not always indicate improved health at older ages, emphasising the importance of distinguishing years lived in good health from all years lived [5, 6]. Ageing populations tend to demonstrate an increase in the prevalence of functional limitations, both physical and cognitive, which impact physical and emotional health and societal participation [7–9]. There is an increasing need for assistance and support in these populations, which emphasises the growing role of assistive technology (AT) access in an ageing/aged world [10–13]. Yet limited data and low political prioritisation of AT have prevented a thorough understanding of the trajectory of this need. This review aims to collate all datasets currently or explicitly planned to be longitudinal and include dedicated questions on AT indicators to establish a global minimum dataset to facilitate research on AT access.

Assistive technology is defined by the WHO as "an umbrella term covering the systems and services related to the delivery of assistive products and services. Assistive products maintain or improve an individual's functioning and independence, thereby promoting their well-being," [14] and their global relevance was highlighted with the 2022 publication of the Global Report on AT [13]. However, which specific products and services are available and accessible through national provision infrastructure vary substantially between (and often within) countries [15–18]. The WHO promotes the development of national priority assistive product lists (APLs) which clearly define the most relevant AT for a specific country context, based on the unique needs of its population [19, 20]. Measuring and monitoring access to AT in a population is critical to support healthy longevity.

Systematic [21] and scoping reviews [18, 22] have identified that most research publications on AT access are single-wave cross-sectional studies, which lack follow-up and inhibit the exploration of trends in this sector. Only ten studies were identified in a large systematic review that had any longitudinal/follow-up consideration, comprising <5% of all 207 included studies [21]. However, a wealth of standardised longitudinal data do exist in the forms of repeated cross-sectional administrative surveys and population cohort studies, where questions on AT are incorporated. Yet the vast majority of these data have not been utilised in longitudinal analyses.

Forecasting AT access with longitudinal data can describe inequities between and within countries, defined by key demographic, geographic, and health variables [23, 24]. AT access serves as an aggregated health indicator and describes a population's capacity to initially and repeatedly access products and services needed to support different areas of individual functioning. A longitudinal perspective allows the identification of disparities in healthy ageing and bottlenecks in provision at multiple positions on the continuum of care. Despite this critical relevance to healthy ageing and potential to produce nuanced forecasts that are valuable for provision planning, these data have not been used to study AT access in this capacity. An essential first step to improve data use in this sector is to identify what data are available, for which countries, and what characterises their strengths and limitations for producing evidence needed to expand AT access. An additional output of this research will be a dedicated section of the AT2030 data portal [25], constituting a baseline repository of longitudinal datasets that include AT, which can be updated as new datasets emerge or are identified through methods outside this review.

Methods

Two types of population-based datasets were sought for this review: repeated cross-sectional surveys and cohorts. To support the comparability of datasets generated by these studies, only those approaching disability through functional assessments were used. As there is no systematic way of searching for all potential data sources, this paper maintains the remit of a scoping review.

For the purposes of this review, assistive products are focused on and defined using the WHO's list of 50 priority assistive products [20]. These data may include unspecified assistive products that are grouped, products defined inseparably with their essential services, or a single product alone, as long as it is clear that either of these three options includes one product found on the priority list. However, PDAs (e.g. smartphones) or services (e.g. physical therapy) are not included if represented in isolation.

We further assume AT access can be indicated in parts by needing, having, using, or being dis/satisfied with an assistive product. Self-reported need for an AP approximates a measure of demand that, when considered in line with the other outcomes, can indicate where access is limited (e.g. reporting need for an AP while also reporting not having it indicates unmet need for the AP [26]. These indicators of access are in line with those used by the WHO's rapid assistive technology assessment survey, launched in 2020, that maps population-level access to AT in terms of need, demand, supply, and satisfaction with AT [27].

Eligibility

For inclusion in this study, cohorts and surveys had to meet the following criteria:

1. Incorporate a functional limitation module, characterised as one or more questions asking a participant to estimate their level of difficulty in a certain functional domain or corresponding activity (e.g. seeing, hearing, mobility, self-care, communication, and remembering).

2. Collect data on one or more AT access indicator(s) [21]—use, has, need, unmet/met/under-met need—for specific or aggregate external APs from the WHO priority list [20]. This does not include internal APs like dentures, contact lenses, or pacemakers.

3. If cross-sectional, at least one wave must have already been conducted or be explicitly planned, from 2009. If cohort, the study must be ongoing or have concluded from 2009.

A routine survey may change the questionnaire it uses over the years as modules are updated. For this reason, the questionnaire used for each wave of a survey was reviewed individually. If at any point (from 2009) a survey used a questionnaire that met our criteria, the survey would be included in this review, and the year(s) an appropriate questionnaire was used would be recorded.

Search strategy

Cohort studies incorporating functioning modules were identified through the Maelstrom Research Catalogue [28, 29] as all cohort or registry studies collecting data on both 'Use of assistive devices' and 'Functional limitations,' which are variables available under the information area 'Perception of health, quality of life, development and functional limitations' in the Catalogue's advanced search tool.

Cross-sectional surveys incorporating functioning modules were identified from the 2022 Disability Data Initiative report, full details of which are publicly available [30]. In brief, all surveys in this report were identified through the following sources:

1. the International Household Survey Network (IHSN) microdata catalogue;
2. the World Bank microdata library catalogue;
3. the International Labor Organization (ILO) survey catalogue;
4. the repository of census questionnaires maintained by the United Nations Statistics Division;
5. government websites

Data extraction

Key characteristics were extracted from either the Maelstrom Catalogue for cohort studies or individual questionnaire(s) for cross-sectional surveys, in terms of study design, assessment questions or participant inclusion/exclusion criteria (where relevant), and AT indicators. Results are presented for individual cohorts and surveys.

Results

Cohort studies

The search was conducted on 10th May, 2022, and yielded 81 cohorts, of which 47 meet inclusion criteria. Two are based on specific disease registers (see Table 1).

To report results by country, cohorts are double-counted where population-based samples were taken in multiple countries (n = 58). Ten samples (10/58, 17%) are from the United States, with eight (14%) from Canada, five (9%) each from the United Kingdom, Australia, and Sweden, and four (7%) from Japan. No cohorts include populations in South America or the Middle East.

Of 47 cohorts, 44 either provide a min/max age for enrolment or state there is no min/max requirement. The minimum age is under 18 for five studies (5/44, 11%), and between 18–30 for nine studies (20%). Thirty-eight (84%) have a maximum age of 65 or older; 22 (49%) have no age maximum. Five are women-only and one is men-only. Five studies also mention a language requirement for enrolment. Of 15 cohorts with inclusion/exclusion criteria beyond age and location, 12 (12/15, 80%) exclude persons due to a pre-existing health limitation or diagnoses, and four (27%) exclude institutionalised persons, meaning those who are incarcerated or residing in long-term care facilities.

Thirty-three cohorts (69%) only collect data on 'Use' of APs, making it the most represented indicator. Four (8%) collect data on over 20 specific APs. Six (13%) ask which functions/activities of daily living an individual uses APs to support, rather than what types of APs are used, meaning individual APs are not disaggregable. Thirty-three surveys (69%) collect indicators specifically for glasses, 32 (67%) for hearing aids, and 21 (44%) for wheelchairs, and nine (19%) for prosthetics, meaning the rest of the collected data can be disaggregated for these individual APs, compared to three (6%) that only collect indicators for grouped APs. Fifteen (31%) only ask about glasses, hearing aids, and/or wheelchairs, but no other APs.

Cross-sectional surveys

Two hundred and eighty questionnaires, representing waves from 202 unique surveys, were reviewed. Eighty-five of these questionnaires (corresponding to 62 surveys) met inclusion criteria (see Table 2).

Twenty-five surveys (25/62, 40%) are set in the WHO African Region, most commonly South Africa (n = 4). Eleven (18%) are set in the Region of the Americas and the Western Pacific Region, with two each in Brazil, Mongolia, and the Philippines. Eight (13%) are set in the European Region, with no countries represented more than once. In the Southeast Asian Region, four surveys were identified with two from Bangladesh. Three are set in the Eastern Mediterranean Region, with two from Palestine.

Overall, 23 waves (23/85, 27%) were conducted from 2009-2015, and 62 (73%) from 2016–2021. All data collected in these surveys was self-reported, given by the participant or a proxy respondent in the same household, and include individuals at nearly all ages.

Fifty-three surveys (53/62, 85%) collect data on 'Use' of APs. Four surveys (6%) specifically ask participants what APs they think they need, all of which are surveys dedicated to disability and functioning, and three of which collect these data for over 20 individual APs. Fifty-three surveys (53/62, 85%) collect data that can be disaggregated for glasses, 52 (84%) for hearing aids, 15 (24%) for wheelchairs, and eight (13%) for prosthetics. Eight also collect data for grouped APs that cannot be separated out by type, though these groupings can be disaggregated by functional domain for two surveys.

Table 1: Cohort studies

WHO region	Country	Name	Start date	Latest wave end date	Initial cohort population enrolment criteria	Participants (n)	Age Low	Age High	AT Indicators	PAPs*	Other AT
AFR	Central African Republic, Congo	Epidemiology of Dementia in Central Africa	2013-07	2014-09	Participants aged 65 years old and over, from the rural area Nola in the Central African Republic. Exclusion criteria: The presence of severe disease with short-term high risk of death.	12099	65	No max	Use, Frequency of use, Improvement with use, Reason for improvement	G	None
AFR, AMR, EUR, SEAR, WPR	Ghana, South Africa, Mexico, Russia, India, China	WHO Study on Global Ageing and Adult Health	2002	2010	As the focus of SAGE is older adults, a much larger sample of respondents aged 50 years and older were selected with a smaller comparative sample of respondents aged 18–49 years. Institutionalized people and respondents who can't answer the questions because of poor physical health or poor cognition were excluded. Proxy respondents were identified for respondents who were unable to respond themselves.	63437	18	No max	Use	H, W	Visual aids, walking aids
AMR	Canada	3D Study - Design, Develop, Discover	2011-12	2021-08	The population is composed of 8 to 14 weeks pregnant women from the general population between 18 and 47 years of age, who are fluent in French or English, who were attending prenatal clinics (ultrasound, midwife and/or doctor's clinics) during the first trimester of pregnancy and who plan to deliver in a study hospital. Exclusion Criteria: Multiple pregnancies, intention to donate or bank cord blood, intravenous drug users, or if the woman has any one or more of the following conditions: HIV+ status, renal disease with altered renal function, any collagen vascular disease requiring active treatment (e.g. lupus, scleroderma), epilepsy, cardiovascular disease, serious pulmonary disease, cancer, or severe hematologic disorder.	8365	18	47	Use	G, H, W	Braces/orthotics, walker, Gavage feeding, stander, adapted seat, other
AMR	Canada	Canadian Longitudinal Study on Aging	2011	2018	This population is composed of a representative sample of Canadians aged 45 to 85 years who consented to a telephone interview.	51338	45	85	Use	G, H, P, W	>20
AMR	Canada	CARTaGENE	2012–12	2015–02	Participants were excluded if they were not registered in the FIPA files, if they resided outside the selected regions, lived in First Nations Reserves or long-term health care facilities or were in prison.	43046	40	69	Use	G	None
AMR	Canada	Fraéle, une étude longitudinale de ses expressions (Frailty, a longitudinal study of its expressions)	2010-02	2013	Older adults aged 65 years and older. Participants were drawn from the Régie de l'assurance-maladie du Québec (RAMQ)	1643	65	No max	Use	P, W	Other'
AMR	Canada	GESTation and Environment	2017-09	2023-03	The population is composed of pregnant women who were enrolled at less than 20 weeks of pregnancy, at their first prenatal care visit at the University Hospital Center of Sherbrooke. A second sample of women was recruited at delivery. & Children of the women in the GESTE study. Born between February 2008 and July 2009.	1561	18	No max	Use	G	None
AMR	Canada, United States	North American Registry for Care and Research in Multiple Sclerosis	2016-05	Missing; >2019	The population consists of individuals aged 18 to 65 years old who have relapsing or progressive multiple sclerosis, with a clear date of onset within 15 years.	712	18	65	Use	G, W	>20
AMR	Canada, United States	North American Research Committee on Multiple Sclerosis Registry	2008-04	Missing; >2016	The population is composed of people 18 years or older, who have been diagnosed with multiple sclerosis.	41000	18	No max	Use	G, W	>20
AMR	Canada, United States	Nurses' Health Study	1976	2015-05	The participants are women only, registered nurses, aged 30 to 55 years and married at the time of recruitment in 1976, and who lived in the 11 most populous states (California, Connecticut, Florida, Maryland, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania and Texas). Both premenopausal and postmenopausal women (mainly Caucasian) who had no history of cancer were included in the study population.	276146	30	55	Use	W	Cane/Walker
AMR	United States	Health and Retirement Study	1992	2013	The HRS sub-sample consists of people who were born in 1931 through 1941 and were household residents of the conterminous U.S. in the spring 1992, and their spouses or partners who could be of any age. Institutionalized persons (prisons, jails, nursing homes, long-term or dependent care facilities) are excluded from the initial survey population. Respondents are followed as they transition to nursing homes.	15497	51	No max	Use	None	Grouped (by function)
AMR	United States	Long Beach Longitudinal Study	1994-01	2012-09	Representative sample of person 30 years of age or older residing in Long Beach, or in nearby cities within Los Angeles, Riverside, San Bernadino, and Orange counties.	2125	30	No max	Use	G, H	None
AMR	United States	Mayo Clinic Study of Aging	2004-10	2016-04	Olmsted County residents aged 70 to 89 years on October 1st 2004, were randomly selected from an enumeration of the County population using an age and sex stratified sampling scheme. Persons with a confirmed diagnosis of dementia were initially excluded, but since 2014 are now being recruited where possible. Persons who are terminally ill and unable to provide information, or are in hospice are not included.	4600	70	89	Use	None	Grouped (by function)
AMR	United States	National Longitudinal Study of Youth 1979	1979	2013-09	A cross-sectional sample of 6,111 individuals, designed to represent the noninstitutionalized civilian segment of young people living in the United States in 1979 and born January 1, 1957, through December 31, 1964.	12686	14	21	Use, Frequency of use	G, H	Other'
AMR	United States	Oregon Brain Aging Study	1989-03	2013-12	Free of most co-morbid illnesses (full criteria available at https://www.maelstrom-research.org/study/obas)	305	55	No max	Use, Improvement with use	G, H	Walking aid
AMR	United States	Religious Order Study	1994	2013-12	Members of religious order communities of the Catholic church. No dementia diagnosed before baseline. Agree to annual follow-up and donation of brain, spinal cord, muscle and nerve upon death.	1200	65	No max	Use, Frequency of use	G, H	None
AMR	United States	Wisconsin Longitudinal Study	1957	2011	The population consists of a random sample of all Wisconsin high school graduates in 1957, born between 1938 and 1940.	22334	14	18	Use	G, H, W	Grouped (by function), 'Other'

Continued.

Table 1: Continued

WHO region	Country	Name	Start date	Latest wave end date	Initial cohort population enrolment criteria	Participants (n)	Age Low	Age High	AT Indicators	PAPs*	Other AT
AMR, WPR	United States, Japan	Midlife in the U.S.	1995	2009-05	Respondents were drawn from a nationally representative random-digit-dial sample of non-institutionalized, English-speaking adults, aged 25-74, selected from working telephone banks in the coterminous United States. As a refinement to Midlife Development in the United States (MIDUS 2), 2004-2006, a sample of African Americans from Milwaukee was included to examine health issues in minority populations. MIDJA population consist of Noninstitutionalized Japanese-speaking adults living in one of the 23 wards of Tokyo from April 2008-September 2008.	8727	25	74	Use	G, H, W	None
EURO	Germany	German Ageing Survey	2002	2011	The German Ageing Survey (DEAS) is a nationwide representative cross-sectional and longitudinal survey of the German population aged over 40.	14713	40	85	Use	G, H, P, W	Incontinence pads, cane/walking stick, walker/rollator, other
EURO	Germany	Longitudinal Urban Cohort Ageing Study	2000	2018-06	The population is composed of independently living community-dwelling persons, aged 60 years and older, without need of nursing care (German long-term care insurance) or cognitive impairment. At baseline, participants must not suffer from cognitive impairment or a terminal disease and not be in need of professional nursing care, or human assistance with daily activities. The GPs excluded those patients with (a) a need of human assistance with basic activities of daily living (ADL) or needing professional nursing care (according to the German long-term care insurance system); (b) cognitive impairment (equivalent to a Mini Mental Status score $\leq$24; (c) terminal disease; and/or (d) inability to understand German	3326	60	No max	Use	None	Grouped (by function)
EURO	Greece	Hellenic Longitudinal Investigation of Aging and Diet	2011	2016	The population consists of men and women aged 65 years and over; residents from the city of Larissa in the province of Thessaly, and from Marousi, a suburban city of Athens, Greece.	1943	65	No max	Use	W	Walker, quad cane, other cane, other
EURO	Ireland	Irish Longitudinal Study on Ageing	2009-10	2013-01	Eligible respondents for this study include individuals aged 50 and over and their spouses or partners of any age.	8500	50	No max	Use	G	Grouped (by function)
EURO	Netherlands	LifeLines	2007	2013	The study population consists of a representative sample of the population of the northern provinces of the Netherlands, covering three generations. Based on the age of the participant, he or she is included in the children's cohort (0–18 years), the adult cohort (18–65 years) or the elderly cohort (>65 years). Severe psychiatric or physical illness are excluded.	165000	No min	No max	Use	G, H	None
EURO	Poland, Spain	Collaborative Research on Ageing in Europe	2011	2016-02	The population consisted of individuals from Poland and Spain ages 18 and older.	10800	18	No max	Use	G, H	None
EURO	Sweden	Betula Study	1998-09	2014-07	When participants entered the study, they were excluded if they had a severe visual or auditory disability, intellectual disability, dementia or a native language other than Swedish.	4425	35	80	Use, Timing of use	H	None
EURO	Sweden	LifeGene Project	2009-09	2016-12	Index participants recruited to the study are Swedish men and women, aged 18 to 50 years at the time of recruitment. These participants in turn may invite family members. Adults of any age may volunteer. Hence the age range is 0-95.	100000	0	95	Use	H	Diaper, ear protection
EURO	Sweden	Swedish National Study and Care in Blekinge	2001	2018	The SNAC-B population consists of a random sample of individuals living both at home and in institutions.	1817	60	No max	Use	H, P, W	Grouped (by function)
EURO	Sweden	Swedish National study on Aging and Care - Good Aging in SkÃ¥ne	2001	2017	The GÅS-SNAC-S population consists of a random sample individuals of all ages living both at home and in institutions, in five municipalities in Skåne county: Malmö, Eslöv, Hässleholm, Osby and Ystad, covering urban and rural areas during a 3-year period (February 2001- June 2004).	5804	60	81	Use	P, W	Other'
EURO	Sweden	The Gothenburg H70 Birth Cohort Studies	2015	2019	The population consisted of a representative sample of 70-year-old men and women born between July 1901 and June 1902 and living in Göteborg in 1971-72.	9209	70	70	Use	G, H, W	Walking aid
EURO	Switzerland	Lausanne Cohort 65+	2004	2020	The population is composed of non-institutionalized males and females aged 65 to 70 in 2004 (birth year 1934 to 1938).	4731	65	70	Use, Replacement gaps	G, H, W, P	Walking aid
EURO	Switzerland	Swiss Clinical Quality Management in Rheumatic Diseases	1997	2022	Clinical diagnosis or suspicion of rheumatoid arthritis; ankylosing spondylitis (AS) or other forms of spondyloarthritis (SpA) with predominantly axial disease according to the opinion of the treating rheumatologist; psoriatic arthritis (PsA) diagnosed by the treating rheumatologist; undifferentiated inflammatory arthritis (UA) diagnosed by the treating rheumatologist; giant cell arteritis (GCA) diagnosed by the treating rheumatologist; polymyalgia rheumatica (PMR) diagnosed by the treating rheumatologist.	20096	Not provided	Not provided	Use	P, W	Walker, Special chair, raised toilet seat, jar opener, long-handled appliances for reaching, bathtub seat, other

Continued.

Table 1: Continued

WHO region	Country	Name	Start date	Latest wave end date	Initial cohort population enrolment criteria	Participants (n)	Age Low	Age High	AT Indicators	PAPs*	Other AT
EURO	United Kingdom	Avon Longitudinal Study of Parents and Children	1999-09	2017-09	The population consists of all pregnant women residents in the old administrative county of Avon, in the South West of England, with an expected date of delivery between 1 April 1991 and 31 December 1992.	42710	Not provided	Not provided	Use, Problems with use, Parental use	G, H	Brace
EURO	United Kingdom	Caerphilly Cohort Study of Older Men	1979	2011	The population consist of men aged 45-59 years living in and around the town of Caerphilly, South Wales.	2959	45	59	Use	H, W	Walking aid
EURO	United Kingdom	English Longitudinal Study of Ageing	1998-01	2013	The survey sample is drawn from respondents to the Health Survey for England (HSE) – a study conducted jointly by the Department of Epidemiology and Public Health, UCL, and the National Centre for Social Research, on behalf of the Department of Health.	12099	50	100	Use, Has	G, H, W	>20
EURO	United Kingdom	Lothian Birth Cohort 1936	2004	2013-11	A sub-sample of the Scottish Mental Survey 1947. The mean age of the participants was 70 years old at wave 1, 73 years old at wave 2 and 76 years old at wave 3.	1091	Not provided	Not provided	Need, Use	G, H	None
EURO	United Kingdom	UK Biobank: a large-scale prospective epidemiological resource	2006	2013-06	The population consisted of individuals from all around the UK between 40 and 69 at the time of recruitment who lived within the vicinity of the assessment centres.	503316	40	69	Use, Timing of use, Reason for use	G, H	None
SEAR	Indonesia	Atma Jaya Cognitive and Aging Research	2011	2019	Not provided	860	60	No max	Use	G, H	Walker
WPR	Australia	Australian Longitudinal Study of Ageing	1992-09	2014-05	The primary sample of the older old adults (70 and older) was randomly drawn from the database of the South Australian Electoral Roll. Persons in the older age groups as well as males were deliberately over sampled to compensate for the higher mortality that could be expected over the study period. In addition, spouses of primary respondents (aged 65 and over) and other household members aged 70 and over were asked to participate.	2087	65	No max	Use, timing of use	G, H, W	Mobile scooter, magnifying glass, cane, walker, frame, other
WPR	Australia	Older Australian Twins Study	2007	2013	The participants are identical and non-identical twin pairs, aged 65 years and older and living in New South Wales, Queensland and Victoria.	623	65	No max	Use, Usability (adequate for all purposes)	G, H, W, P	Other'
WPR	Australia	Personality and Total Health through life	1999	2016	At the start of the study, this cohort was aged 20-24 years (birth years 1975-79).	7485	20	No max	Use	G, H	None
WPR	Australia	Sydney Centenarian Study	2009-01	2016-12	The population is composed of individuals aged 95 years and older who were not suffering from a terminal illness, and resided in Randwick, Waverley, Woollahra, Botany Bay, Kogarah, Rockdale, and Marrickville at the time of recruitment.	345	95	No max	Use	H	Other'
WPR	Australia	Sydney Memory and Aging Study	2005-09	2009-12	The participants were aged 70 to 90 years and living in the community of Kingsford-Smith and Wentworth, New South Wales. Participants had to speak and write English sufficiently well to complete a psychometric assessment and were able to consent to participate. The participants were excluded if they had a previous diagnosis of dementia, psychotic symptoms or a diagnosis of schizophrenia or bipolar disorder, multiple sclerosis, motor neuron disease, developmental disability, progressive malignancy, or if they had medical or psychological conditions that may have prevented them from completing assessments. Participants were excluded if they had a MMSE score of less than 24 at study entry or if they received a diagnosis of dementia after comprehensive assessment.	1037	70	90	Use	G, H, W, P	Other'
WPR	China	The China Health and Retirement Longitudinal Study	2011-06	2014-03	Nationally representative sample of Chinese residents ages 45 and older and their spouses.	17708	45	No max	Use	G, H	Walking stick, travel device, toilet series, auxiliary
WPR	Japan	Japanese Study of Aging and Retirement	2007-01	2011-07	The individuals in the baseline sample of JSTAR are aged between 50 and 75 and live in five municipalities mainly in the eastern area of Japan. The cities are Takikawa city in Hokkaido, Sendai city in the Tohoku area, Adachi ward which is a special city in the centre of the Tokyo metropolis, Kanazawa city in the Hokuriku area and Shirakawa town in a mountainous town in the Chubu area.	7268	50	75	Use, Frequency of use	G, H	None
WPR	Japan	Keys to Optimal Cognitive Aging	2007-11	2012-12	Community-dwelling elderly aged 80 and older who were functionally independent, recruited from those who participated in local senior center activities at least once.	197	80	93	Use	G, H	None
WPR	Japan	Tokyo Centenarian Study	2000-06	2002-05	The Tokyo Centenarian Study population is composed of Japanese centenarians living in the 23 wards of metropolitan Tokyo.	513	100	No max	Use	G, H	None
WPR	New Zealand	Dunedin Multidisciplinary Health and Development Study	1975	2012	Study participants were born between April 1st 1972 and March 30 1973 at the Queen Mary Maternity Centre in Dunedin who were still living in the greater Dunedin metropolitan area three years later.	1037	3	3	Need	G	None

*Priority assistive products (PAPs) include: Glasses (G), hearing aids (H), prosthetics (P), personal digital assistants (PDA), wheelchairs (W).

Discussion

Collating these datasets and comparing study designs and world regions highlights critical data gaps, opportunities for analyses that are possible with existing data, and key opportunities to improve data collection across the sector. These steps are critical to generate evidence, demonstrate need, mobilise political will, and ultimately expand access to AT.

A significant limitation is the representativeness of population cohorts, especially when seeking to understand AT access on a global scale. Most cohort data are from high-income, English-speaking countries that have already aged considerably (27/58, 47%), which restricts their international relevance and highlights the need for cohorts from diverse contexts when studying inequities in healthy ageing trajectories. Almost 75% (34/47) focused all or in part on participants over 65, which restricts investigations of how health at younger ages affects healthy longevity. Utilising these cohorts to represent disabilities in a population is also complex, given how often participants are specifically excluded for pre-existing conditions, use of assistance, or residence in long-term health facilities. Further, only three cohorts and no surveys collected data on the timing of use (when a person began using AT in their lifetime). These gaps prevent the exploration of disparities in AT access between people ageing with a disability and people acquiring disability as a result of ageing. Unlike most surveys which include functioning modules for all ages over five, the Multiple Indicator Cluster Surveys (MICS) focus on women aged 18-50, affecting their relevance to ageing studies. In both cohort studies and cross-sectional surveys, vision and hearing are proportionately overrepresented compared to other functional domains. Subsequently, less is known about APs that are useful for functional limitations with lower prevalence. This limited awareness can obfuscate the true demand for these APs in a population, which hinders efforts to expand access to them. Though national-level surveys are routinely conducted, waves of data collection are often separated by multi-year gaps. Further, 73% of surveys have also only incorporated AT modules in waves conducted in the last six years. Though more waves are explicitly planned, very few presently exist that can be used to establish trends or understand how AT access at younger ages in the past has affected the current population.

Despite these fundamental gaps, these datasets hold great potential to inform on AT access in a population. Current AT data collection methods allow the identification of clusters of need, and with capacity for longitudinal analyses, past trends can be studied, and forecasts can be developed to support policy planning and better understand the significance of AT access to healthy ageing trajectories. For example, where the single AT indicator 'Use' is collected, we can learn the number of people with a functional limitation who have had access to an AP across a range of ages, and whether they still experience difficulty even when using the AP communicates who is experiencing under-met need. This information is also useful to AT innovators, who need to identify and learn about the populations for whom certain APs are not reaching their potential. Unmet or under-met needs may be more common at certain age groups, geographies, functional domains, or associated with pre-existing health conditions. Adding data on satisfaction is another opportunity to differentiate between people who use the AP because it works for them, or who use it only because it is better than nothing. Not having AT despite experiencing functional difficulties indicates to policymakers that there is a bottleneck in provision, which could be due to market-level factors, like the cost or availability of the AP, or challenges for individuals who need it when accessing essential health care services. With a longitudinal approach, changing states of AT access can also be examined and factors influencing when an individual transitions from having an unmet to a met need for AT can be identified. Where these data can be disaggregated by key demographic and health variables, a more comprehensive and dynamic understanding of an ageing/aged country's national-level AT needs and opportunities can take shape.

As evidenced by this review, these analyses are possible in many cases but not for all populations that have been surveyed or included in cohorts, demonstrating where and how data collection can be improved. Many studies only collect data that can be disaggregated for glasses and/or hearing aids, limiting our capacity to study other APs and their relationship to functional difficulties outside of vision and hearing. Many countries of all income contexts are also missing data on all but one or two APs. Data in this sector could be improved by adding or expanding existing AT modules in existing multi-wave surveys or setting up population-based cohorts where data are particularly scarce or non-existent. Collection methods can be bolstered by incorporating questions on multiple specific APs when asking about functioning and activities of daily living. Indeed, cross-sectional data meeting our criteria will be expanded if the MICS program and broader demographic and health surveys (DHS) continue to include the functioning modules with dedicated questions on APs. Improving data collection and data sharing across this sector overall supports the development of global reports, such as those on Assistive Technology [13] and Ageing [31] which inform policy and operational planning for countries and regions as they prepare for the dynamic support needs of a growing aged population. To support these efforts, we will incorporate the findings of this review into the AT2030 data portal, which can be updated with new waves and sources to provide an up-to-date view of available data across this sector.

Limitations

This scoping review contributes new data sources to a global minimum dataset on AT access. Though both sources of AT data are comprehensive, some relevant cohorts and surveys may have been missed.

We also limited our inclusion criteria to studies utilising functioning modules. It is possible AT questions may also be included in surveys that assess disability in binary or alternative terms, or even surveys that do not consider disability at all. However, based on the infrequent inclusion of AT-specific questions even in dedicated functioning modules, we understand these cases to be exceptions.

Commercial and health-record data providing insight on AT access may also be available, though these sources were not included in the remit of this review due to difficulty searching and accessing them systematically.

Table 2: Cross-sectional surveys

WHO Region	Country	Name	Questionnaires (n)	Year(s) of Questionnaire(s)	Functioning module*	AT Access Indicator(s)	PAPs†	Other AT
AFR	Algeria	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AFR	Central African Republic	Multiple Indicator Cluster Survey 6 (MICS6)	1	2018-19	WGSS	Use	G, H	None
AFR	Chad	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AFR	Guinea-Bissau	Multiple Indicator Cluster Survey 6 (MICS6)	1	2018-19	WGSS	Use	G, H	None
AFR	Lesotho	Continuous Multipurpose Household Survey/ Household Budget Survey	1	2017	WGSS	Have	G, H	None
AFR	Lesotho	Population and Housing Census	1	2016	WGSS	Use	G, H, W	Walking stick/frame/Crutches, White cane
AFR	Malawi	Integrated Household Survey (IHS)	2	2010, 2019	WGSS	Use	Grouped	N/A
AFR	Malawi	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AFR	Malawi	Population Census	1	2018	(3)	Use	G, H	None
AFR	Mali	Demographic and Health Survey (DHS)	1	2018	WGSS	Use	G, H	None
AFR	Nigeria	Demographic and Health Survey (DHS)	1	2018	WGSS	Use	G, H	None
AFR	Nigeria	General Household Survey Panel (GHSP)	3	2010, 2012, 2018	WGSS	Have	Grouped	N/A
AFR	Rwanda	Demographic and Health Survey (DHS)	1	2019-2020	WGSS	Use, Difficulty without use	G, H	None
AFR	Sao Tome and Principe	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AFR	Senegal	Demographic and Health Survey (DHS)	2	2018, 2019	WGSS	Use, Difficulty without use	G, H	None
AFR	South Africa	General Household Survey (GHS)	13	Yearly from 2009-2021	WGSS	Use	G, H, W	Walking stick/frame, Other
AFR	South Africa	Governance Public Safety and Justice Survey	1	2018-19	WGSS	Use	G, H, W	Walking stick/frame, 'Other'
AFR	South Africa	National Household Travel Survey (NHTS)	1	2013	(3)	Use	G, H, W	Walking stick/walking frome, Crutches, 'Other'
AFR	South Africa	Population and Housing Census	1	2011	(3)	Use	G, H, W	Walkingstick/frame
AFR	Tanzania	National Panel Survey (NPS)	2	2010, 2014	WGSS	Have	Grouped	N/A
AFR	Uganda	Demographic and Health Survey (DHS)	1	2016	WGSS	Use	G, H	None
AFR	Uganda	Functional Difficulties Survey	1	2017	WGSS	Use, Difficulty without use, Need	G, H, P, W	Walking aid
AFR	Uganda	National Household Survey	1	2009	WGSS	Have	Grouped	N/A
AFR	Uganda	National Panel Survey (NPS)	2	2009, 2010	WGSS	Use	Grouped	N/A
AFR	Zimbabwe	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AMR	Bolivia	Encuesto Nacional de Hogares	1	2019	(3)	Have	Grouped	N/A
AMR	Brazil	Brazilian Longitudinal Study of Aging (ELSI)	1	2015-2016	(2) (3)	Use	G, H	None
AMR	Brazil	Pesquisa Nacional de Saude	1	2019	(3)	Use	G, H, P, W	>20, 'Other'
AMR	Canada	Survey on Disability	1	2017	(3) (4) (5)	Use, Unmet need, Reason for unmet need	G, H, P, W	>20, 'Other'
AMR	Colombia	Encuesta Nacional de Calidad de Vida (ENCV)	2	2017, 2020	(3)	Use	Grouped (by functional domain)	N/A
AMR	Cuba	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AMR	Haiti	Demographic and Health Survey (DHS)	1	2016	WGSS	Use	G, H	None
AMR	Honduras	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
AMR	Jamaica	Population Census	1	2011	(3)	Use	Grouped	N/A
AMR	Mexico	Encuesta Nacional de los Hogares (ENH)	2	2016, 2017	(4) (5)	Use	G, H	None
AMR	United States	National Health Interview Survey (NHIS)	4	2018, 2019, 2020, 2021	(3)	Use, Frequency of use	G, H, P, W	Cane/walker, 'equipment to get around'
EMR	Afghanistan	Model Disability Survey (MDS)	1	2019	WGSS	Use, Problems using, Reason for not using, Unmet need	G, H, P, W	>20
EMR	Palestine	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019-20	WGSS	Use	G, H	None
EMR	Palestine	Expenditure and Consumption Survey (ECS)	1	2009	(3) (4)	Have	G, H, W	None
EUR	Belarus	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
EUR	Bosnia/ Herzegovina	Household Budget Survey	1	2015	(2) (3)	Have	G, H, P, PDA, W	Grouped
EUR	Cyprus	European Health Interview Survey	1	2019	(3) (4) (5)	Use	G, H	N/A
EUR	Kosovo	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019-20	WGSS	Use	G, H	None
EUR	Malta	European Health Interview Survey	1	2019-20	(3) (4) (5)	Use	G, H	N/A
EUR	Moldova	Population Census	1	2014	WGSS	Have	Grouped (by functional domain)	N/A
EUR	North Macedonia	Multiple Indicator Cluster Survey 6 (MICS6)	1	2018-19	WGSS	Use	G, H	None
EUR	Turkmenistan	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
SEAR	Bangladesh	Household Income and Expenditure Survey (HIES)	2	2010, 2016	WGSS	Have	G, H	Crutches, Grouped
SEAR	Bangladesh	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
SEAR	Nepal	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
SEAR	Pakistan	Demographic and Health Survey (DHS)	1	2017	WGSS	Use	G, H	None
WPR	Australia	Survey of Disability, Ageing and Carers	1	2012	(1) (3)	Use, Improvement with use	G, H, W	15-20, Other
WPR	Kiribati	Multiple Indicator Cluster Survey 6 (MICS6)	1	2018-19	WGSS	Use	G, H	None
WPR	Mongolia	Multiple Indicator Cluster Survey 6 (MICS6)	1	2018-19	WGSS	Use	G, H	None
WPR	Mongolia	Women's Health and Life Experiences Survey	1	2017	(1)	Use	G, H	Walking aid
WPR	Philippines	Model Functioning Survey	1	2016	WGSS	Use, Need, Unmet need	G, H, P, PDA, W	>20
WPR	Philippines	Model Functioning Survey	1	2016	(2) (3)	Use, Need, Unmet need	G, H, P, PDA, W	>20
WPR	Samoa	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019-20	WGSS	Use	G, H	None
WPR	Thailand	National Disability Survey	1	2017	WGES	Use	G, H	None
WPR	Timor Leste	Demographic and Health Survey (DHS)	1	2016	WGSS	Use	G	None
WPR	Tonga	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019	WGSS	Use	G, H	None
WPR	Tuvalu	Multiple Indicator Cluster Survey 6 (MICS6)	1	2019-20	WGSS	Use	G, H	None

* Functioning modules included the Washington Group Short Set (WGSS), Washington Group Extended Set (WGES), and variations on the WGSS indicated as follows: (1) Yes/No answer; (2) Answer scale is different from that in the WGSS; (3) Wording of questions is different from the WGSS; (4) Does not have the self-care domain; (5) Does not have the communication domain.

† Priority assistive products (PAPs) include: Glasses (G), hearing aids (H), prosthetics (P), personal digital assistants (PDA), wheelchairs (W).

Conclusion

Longitudinal data on AT access are a critical component for planning policy and provision that will support aged/ageing populations. By collating a global dataset indicating what kind of data are available and where, we have identified current data gaps, opportunities to learn from existing data, and recommendations for improving data collection going forward.

Contribution statement

Authors contributed as follows:

Conceptualization, J.D., C.H., S.H.; Methodology, J.D., S.M., S.H; Validation, J.D.; Formal Analysis, J.D.; Investigation, J.D.; Resources, J.D., C.H., S.H.; Data Curation, J.D., S.H.; Writing – Original Draft Preparation, J.D.; Writing – Review & Editing, J.D., S.M., C.H., S.H.; Supervision, C.H., S.H.; Project Administration, C.H.; Funding Acquisition, C.H.

Data sharing

All data collected for this study have been included and will also be made available at at2030.org by April 2023.

Conflict of interests

Authors have no conflicts of interest to declare.

Ethics statement

Ethical approval was not required for this study, as all data is publicly available.

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