Factors influencing hearing aid use, benefit and satisfaction in adults: A systematic review of the past decade

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ABSTRACT

Objective: This systematic review examined the audiological and non-audiological factors that influence hearing aid use, benefit and satisfaction in adults based on studies published during the last decade (2010 and 2023).

Design: Studies were identified by using PRISMA guidelines for systematic searches on five platforms (Web of Science, Scopus, PubMed, EBSCOhost including CINAHL and Academic Search Complete). The National Institute of Health Quality assessment tool and the Oxford Centre for Evidence Based Medicine tool were used for quality assessment and grading of level of evidence.

Results: Forty-Five articles were included in the review. A total of 100 significant factors influencing hearing aid use (n=46), benefit (n=17) and satisfaction (n=37) were identified. Clear determinants of hearing aid use, benefit and satisfaction included hearing sensitivity, self-reported hearing difficulty, speech perception, attitude and beliefs. 38 cross-sectional studies in this review were graded level 4, 5 cohort studies rated level 3 and 2 randomized control trials rated level 2.

Conclusion: Factors associated with hearing aid outcomes identified in the past decade support previous evidence. New factors like social networks and service-delivery models, have also been identified. These factors require further investigations through high quality studies to further strengthen existing evidence.

KEYWORDS

Hearing aid, Hearing aid outcome, Use, Benefit, Satisfaction, Systematic review

INTRODUCTION

Most people with hearing loss (71.3%) are adults, who present with a mild to moderate degree of hearing loss which can be managed successfully with hearing aids (World Health Organization, 2021). Hearing aids have been shown to be effective in improving hearing, communication, and quality of life (Ferguson et al., 2019). The effectiveness of hearing aids on the treatment of hearing loss can be evaluated by considering patient outcomes. These outcomes can be based on health indicators such as improvements in communication, decreased anxiety, depression, and improved quality of life or specifically based on hearing and/or hearing aids. Clinically it is common to measure patient outcomes in terms of hearing aid use, benefit and satisfaction. Moreover, these outcomes can be measured using objective (e.g., hearing aid use through data logging), behavioral (e.g., hearing aid benefit measures through speech testing with and without hearing aids) and/or self-reported (i.e., standardized measures such as International Outcome Inventory for Hearing Aids; IOI-HA) measures.

The three constructs of hearing aid outcomes (i.e. use, benefit and satisfaction) are closely related and have been well defined in the audiological literature (Humes, 1999). Hearing aid use refers to how many hours a day a hearing aid owner uses their hearing aid/s (Solheim et al., 2012) whereas hearing aid benefit is defined as improvements in hearing function and communication ability as a result of hearing aid performance (Cox & Alexander, 1992). Hearing aid satisfaction refers to positive emotional experience as a result of the user's evaluation of their hearing aid performance (Wong et al., 2003). While they can be defined separately, these constructs are related and influenced by one another. For instance, hearing aid use is a good indicator or factor

of hearing aid performance. Wang et al. (2021) and Houmoller et al. (2022) revealed a positive association between daily hearing aid usage time and hearing aid benefit. Furthermore, Korkmaz at al. (2016), Singh at al. (2015) and Wang et al. (2021) showed a positive association between daily hearing aid use time and hearing aid satisfaction. However, among those who use hearing aids, the amplification or gain provided by hearing aids does not guarantee satisfaction (Wong et al., 2003).

The above defined constructs or domains of hearing aid outcomes are largely influenced by various factors. Efforts have been made by researchers to synthesize available evidence to identify different factors influencing hearing aid use, benefit and satisfaction. For example, a review of 39 peer-reviewed articles by Knudsen et al. (2010) identified 31 factors that were studied in relation to the four outcome domains of help-seeking behavior for hearing loss, hearing-aid uptake, hearing-aid use, and satisfaction. These factors can be grouped into categories of personal factors (e.g., source of motivation, expectation, attitude), demographic factors (e.g., age, sex) and external factors (e.g., cost, counseling), with self-reported hearing problem as a strong predictor variable for all the four outcome domains.

Another systematic review of 22 articles by Ng and Loke (2015) identified five audiological factors (i.e., self-perceived hearing problems, severity of hearing loss, type of hearing aids, background noise acceptance, and insertion gain) and six non-audiological factors (i.e. expectation, demographics, group consultation, support from significant others, self-perceived benefit, and hearing aid satisfaction) as determinants of hearing aid adoption and use. A recent systematic

review focusing on a population of people living with dementia and age related hearing loss by Hoopet et al. (2022) identified factors such as degree of hearing loss, hearing aid handling proficiency, positive experiential consequences, degree of hearing aid comfort or fit, person-environment interactions and social reinforcement as factors influencing hearing aid use within this community.

It is noteworthy that the first two reviews (Knudsen et al., 2010; Ng and Loke, 2015) were conducted over a decade ago. Moreover, these reviews identified most factors which were explored in a limited number of studies (e.g., cost, hearing aid features, fitting counseling, handling of hearing aids and satisfaction with hearing aids, income level and education). In addition, no conclusion was reached for several factors (e.g., source of motivation, attitudes towards hearing aids and counseling) due to mixed evidence. The most recent review by Hooper et al. (2022) focused only on a specific population of people living with dementia and age related hearing loss, excluding young and middle-aged adults without dementia making the review limited in its scope.

During the last decade, several studies have been published that explore new factors influencing hearing aid use, benefit and satisfaction in adults, e.g., mental health, service delivery model and social networks which were not included in the previous reviews. A study by Giuliani (2021) showed a negative association between neurological disorders that contributes to mental health and infrequent hearing aid use. Another recent study by Nixon et al. (2021) showed a positive association between high cognition and increased hearing aid use. These new studies that have

examined a range of additional factors related to hearing aid outcomes that have been published in this decade warrant an updated review in this area. This systematic review, therefore, aims to examine audiological and non-audiological factors that influence hearing aid use, benefit and satisfaction in adults based on the studies published during the last decade (2010 and 2023).

METHOD

Research Design

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021) was used in conducting and reporting this review. The review protocol was registered on the International Prospective Register of Systematic Reviews (CRD42022298403).

Search Strategy

The following databases were utilized: (i) Web of Science (ii) Scopus, (iii) PubMed, (iv) EBSCOhost including CINAHL, and (v) Academic Search Complete. The search was conducted using the following search terms: “hearing aid” or “hearing device” or “amplification” or hearing instrument” AND “use” or “usage” or “usage rate” or “non-use” or “rejection” or “refusal” or “utilization” or “benefit” or “advantage” or “gain” or “satisfaction” or “satisfy” or “contentment” or “fulfillment” or “success” or “outcome” or “post-fitting”. Two researchers (BM and MK) independently searched for relevant articles based on the inclusion criteria (see Table 1) which was developed using the Population Intervention Comparison Outcome Study Design Timeline

(PICOST) criteria. A secondary literature search was done during the process of writing the review to identify the latest articles.

Table 1: Inclusion and Exclusion Criteria

Characteristics	Inclusion	Exclusion
Population	Adult hearing aid users (18 years or older)	Non-hearing aid users, Infant and children below the age of 18 years
Intervention	Amplification with digital air-conduction hearing aid (i.e., bilateral or unilateral).	Amplification with surgically implanted hearing devices (e.g., cochlear implant, bone-anchored hearing aid).
Control	Any comparator	None
Outcomes	▪ Self-reported outcomes (e.g., self-reported hearing aid use, hearing aid benefit and/or satisfaction) ▪ Behavioral measures such as speech recognition (word and sentence) in quiet and/or noise ▪ Objective assessments such as hearing aid data log	No outcomes reported
Study Design	Quantitative studies with any design published in peer-reviewed journals	Unpublished studies, non-peer-reviewed publications, thesis/dissertations, animal studies, systematic reviews and qualitative studies. Qualitative studies were excluded from this review to be in line with the previous reviews for comparative data.
Timing	Peer-reviewed articles from 2010 onwards	Peer- reviewed articles from 2009 and earlier.
Language	English only	Articles written in any other language other than English

Table 2: Key characteristics of included articles (45)

Author	Year	Country	Study Design	Sampling	N	Age	Use	Benefit	Satisfaction	Level of Evidence	Quality rating
1. Arnold et al.	2019	United States	Cross-sectional (P)	Random	1898	60.3	✔			4	Fair
2. Aazh et al.	2015	United Kingdom	Cross-sectional	Purposive	1874	74	✔			4	Fair
3. Bennett et al.	2020	Australia	Cohort (P)	Convenience	413	71.14	✔	✔	✔	3	Fair
4. Dwarakanath et al.	2020	India	Cross sectional (p)	Purposive	42	71.6	✔	✔	✔	4	Fair
5. Dwarakanath et al.	2020	India	Cross sectional	Purposive	42	71.6	✔	✔	✔	4	Fair
6. Ferguson et al.	2016	United Kingdom	Cross-sectional (P)	Random	30	68.4	✔	✔	✔	4	Fair
7. Fuentes-López et al.	2017	Chile	Cross sectional	Probability (S)	4766	60	✔			4	Fair
8. Fuentes-López et al.	2019	Chile	Cross sectional (R)	Purposive	355	79.4	✔			4	Fair
9. Giuliania, NP.	2021	United States	Cross-sectional (R)	NR	196	73.8	✔			4	Fair
10. Helvik et al.	2016	Europe	Cross-sectional (R)	NR	10499	77.9 (F) 72.8 (M)	✔			4	Fair
11. Hickson et al.	2014	Singapore	Cross sectional (R)	NR	160	73	✔			4	Fair
12. Ho, E. C et al.	2018	Singapore	Cross sectional (R)	NR	1068	70	✔			4	Fair
13. Houmøller et al.	2021	Europe	Cohort (P)	Purposive	1961	66.1 (F) & 67 (M)	✔	✔	✔	3	Fair

14. Humes et al.	2017	United states	Randomized Double-Blind Placebo-Controlled Clinical Trial	Purposive	164	(AB; 69.9) (CD;68), and P (69.5)		✔	✔	2	Good
15. Moon et al.	2015	South Korea	Cross sectional (R)	Random	530	70.1	✔			4	Fair
16. Kaplan-Neeman et al.	2012	Israel	Cross sectional	Purposive	131	65.2 (users) & 66.2 (non-users).			✔	4	Fair
17. Kelly-Campbell & McMillan	2015	New Zealand	Cross sectional	Purposive	47	71.15			✔	4	Fair
18. Klyn et al.	2020	United states	Cross sectional (R)	Purposive	SHL= 8362; 2009A OHL=2412; 2009B OHL= 1240; 2010 OHL=1586.	SHL= 79; 2009a OHL=80; 2009b OHL = 80; 2010 OHL=78.	✔			4	Fair
19. Korkmaz et al.	2016	Turkey	Cross sectional (R)	Purposive	400	63.67			✔	4	Fair
20. Meister et al.	2015	Germany	Cross sectional (P)	Purposive	30	71.4		✔	✔	4	Fair

21. Narne et al.	2016	India	Cross sectional (R)	Purposive	255	23.53 (M) & 22.49 (F).		✔		4	
22. Nixon et al.	2021	Australia	Cohort (P)	Purposive	85	70.23	✔	✔		3	Fair
23. Saunders et al.	2016	United States	cross-sectional (P)	Purposive	160	69.3	✔	✔	✔	4	Fair
24. Singh et al.	2015	Canada	Cross-sectional (P)	Purposive	163	68.9			✔	4	Fair
25. Solheim et al.	2012	Norway	Cross sectional	Purposive	90	80.8	✔			4	Fair
26. Staehelin et al.	2011	Switzerland	Cross sectional	Purposive	8389	74	✔			4	Fair
27. Tognola et al.	2019	Italy	Cross sectional	Purposive	102	81.1		✔		4	Fair
28. Wang et al.	2021	China	Cross sectional	Purposive	235	55	✔	✔	✔	4	Fair
29. Wu et al.	2019	China	Cross sectional (P)	Purposive	73	77	✔	✔	✔	4	Fair
30. Meyer et al.	2014	Australia	Cross-sectional (R)	Purposive	123	72			✔	4	Fair
31. Turan et al.	2019	Turkey	Cross-sectional (P)	Purposive	301	49.11			✔	4	Fair
32. Naylor et al.	2015	Sweden	RCT Balanced Cross-over design	Purposive	24	72.3	✔	✔	✔	2	Good
33. Jilla et al.	2020	United States	Cross-Sectional (P)	Convenience	152	75	✔			4	Fair
34. Laakso et al	2022	Finland	Cohort study (P)	Purposive	144	55.6	✔		✔	3	Fair
35. Bisgaard & Ruf	2017	Germany, France and United King	Cross-sectional (R)	Purposive	132,028	65			✔	4	Fair
36. Kemker et al.	2012	United States	Cross-sectional (P)	Purposive	20	60-80	✓		✓	4	Fair

37. Sawyer et al.	2019	United Kingdom	Cross-sectional (P)	Purposive	18,730	40-69	✓			4	Fair
38. Jorbonyan et al.	2022	Iran	Cross-sectional (P)	Random	300	71.38	✓			4	Fair
39. Kim et al.	2022	South Korea	Cross-sectional (P)	Purposive	1148	71.3			✓	4	Fair
40. Dwarakanath & Manjula	2022	India	Cross-sectional (P)	Purposive	42	71.6	✓	✓		4	Fair
41. Chinnaraj et al.	2022	India	Cross-sectional (P)	Purposive	50	51-70		✓		4	Fair
42. Laakso et al.	2022	Finland	Cohort (P)	Purposive	144	23-66	✓		✓	3	Fair
43. Thai et al.	2022	United States	Cross-sectional (P)	Purposive	2060	73.9	✓			4	Fair
44. Taylor et al.	2023	United Kingdom	Cross-sectional (P)	Convenience	164 460	40-69	✓			4	Fair
45. Yi et al.	2022	United States	Cross-sectional (P)	Purposive	10 301		✓			4	Fair

Data Charting and Extraction

Results from the literature search were extracted to Rayyan software (https://www.rayyan.ai) for independent blinded eligibility screening. Study duplicates were identified and removed through the Rayyan software which was followed by a screen of titles and abstracts with full texts inspected when required. Studies passing the initial screening were read to determine eligibility independently by each of the two researchers (BM & MK). 29% of the conflicted decisions on the exclusion and inclusion of articles were recorded and resolved by the two researchers. Any disagreements between the two reviewers were resolved through discussion with a third researcher (VM). For each study, relevant data suggested by the PRISMA 2020 guidelines were extracted. Data extraction was conducted by the primary researcher (BM) on an Excel spreadsheet designed specifically for the purpose of this review. A second researcher (MK) cross-checked 20% of randomly selected articles to ensure reliability and consistency. Descriptive data including country, population, sample size, study design, mean age, biological sex ratios as well as information relevant to key outcomes were extracted.

Quality Assessment and Determination of Level of Evidence

The National Institute of Health (NIH) Quality Assessment Tool (National Institute of health, 2021) was used to assess the quality of the studies included. The ratings 0-4 indicated poor quality, 5-10 indicated fair quality and 11-14 indicated good quality (Biagias et al., 2021). The level of evidence for included studies was determined using the Oxford Centre for Evidence Based Medicine (CEBM) - Levels of Evidence tool, which classifies studies based on the research design. According to the CEBM tool, systematic reviews are categorized as high level 1 evidence while

case control studies are categorized as low level 5 (less evidence). Both quality assessment and level of evidence determination were done by a primary researcher (BM) and a second reviewer (MK) cross-checked 20% of randomly selected articles.

Data Synthesis

Due to the high heterogeneity of included studies, quantitative synthesis of results was not possible. Hence, the synthesis without meta-analysis (SWiM) reporting guidelines Campbell et al., 2020) was used to summarize the study findings. Vote counting based on the direction of effect was selected as the synthesis method (Campbell et al., 2020). The synthesis was conducted through full reading of the included articles and extraction of identified factors by the primary reviewer (BM). The results were reported as agreed on by all members of the research team (MK, VM, FMA, and DS).

RESULTS

Included Studies

A total of 1,111 peer-reviewed articles were identified through the search process (see Figure 1). After removing 376 duplicate articles, the remaining 735 articles were screened. Of these, 660 were excluded based on abstract screening and the full text of the remaining 73 were reviewed to determine eligibility. A total of 45 articles, including those identified manually after the initial electronic search were included in the review.

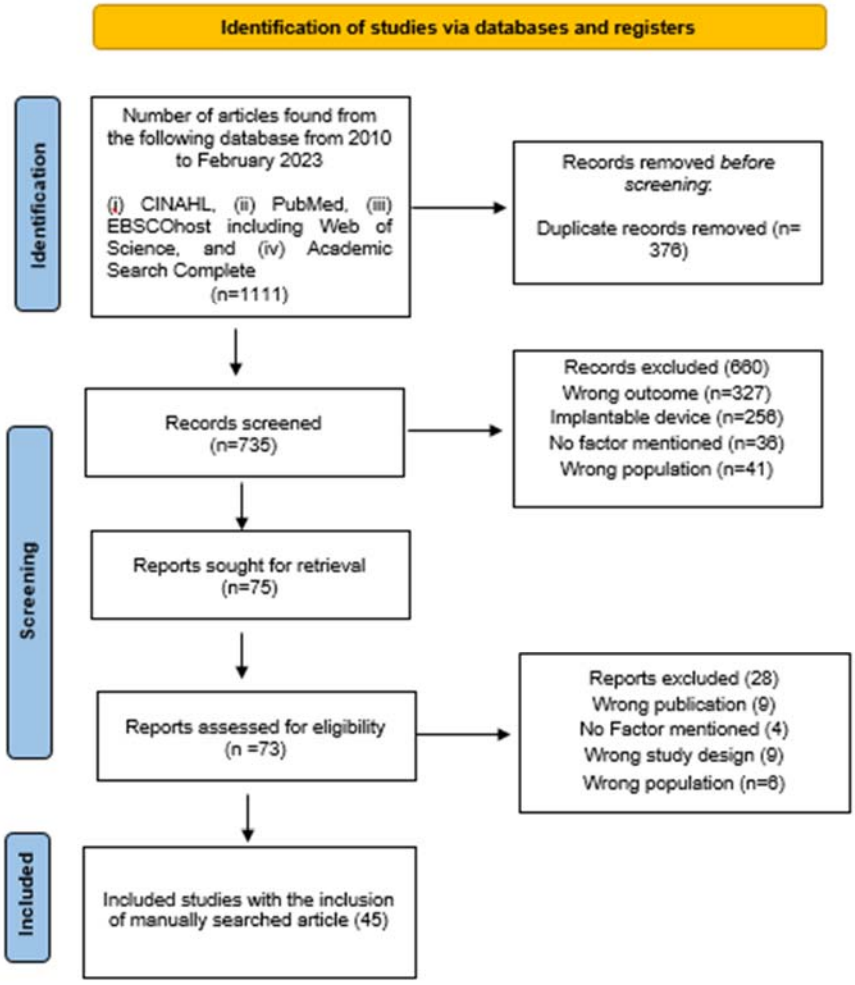

Figure 1. PRISMA flow diagram of the selection process.

Study Characteristics

Study design varied with five cohort studies (Bennett et al., 2020; Houmøller et al., 2021; Nixon et al., 2021), 38 cross sectional and two randomized control trials (Humes et al., 2017; Naylor et al., 2015). Sample sizes varied significantly across studies, ranging from 20 to 164 460 participants, with an average age of 67 (ranging from 49 to 81). Most of the included studies used non-standardized questionnaires and/or patient-reported outcome measures (PROMs) as a data

collection method (31/45), with two studies using telephonic interviews (Arnold et al., 2019; Kaplan-Neeman et al., 2012) and a single study using a structured interview (Fuentes-López et al., 2019). See Table 1.

Outcome Measures

The International Outcome Inventory for Hearing Aids (IOI-HA) was most commonly used (14/45) PROM to evaluate hearing aid outcomes, followed by the Satisfaction with Amplification in Daily Living (SADL; 5/45) (Ferguson et al., 2016; Kaplan-Neeman et al., 2012; Singh et al., 2015 & Jilla et al., 2015) and the Abbreviated Profile of Hearing Aid Benefit (APHAB; 3/45) (Humes et al., 2017; Nixon et al., 2021; Tognola et al., 2019). Data-logging was used in eight studies as an outcome measure for hearing aid use (Giuliania, 2021; Houmøller et al., 2021; Staehelin et al., 2011).

Factors Influencing Hearing Aid Use

Nineteen audiological and 37 non-audiological factors reported across studies on hearing aid use are illustrated in Tables 3 and 4, respectively. Among the studied factors, 46 were found to be significant determinants (i.e., positive or negative relation to hearing aid outcome) and 10 were not significant determinants (i.e., neutral association) of hearing aid use. Figure 2 represents the number of significant factors (either negatively or positively associated with hearing aid outcomes) per category.

Table 3: Audiological factors influencing hearing aid use

Factor	Number of Studies	Positive	Negative	No association
Hearing sensitivity				
Pure Tone Average (PTA)	13	10	-	3
Slope of the audiogram	1	-	-	1
Hearing loss Asymmetry	1	1	-	-
Speech perception				
WRS	2	2	-	-
SRT	1	1	-	-
Speech perception ability	2	2	-	-
Self-reported hearing disability				
Non-standardized self-reported hearing disability	5	4	-	1
Ear, Tinnitus, and balance				
Bothersome Tinnitus	3	3	-	-
TM perforation	2	2	-	-
Balance problems	1	1	-	-
Hearing aid acoustics and features				
Prevalence of hearing aid problems	1	-	1	-
Insertion gain	1	1	-	-
Price of Hearing aid	1	1	-	-
Digital vs Analog hearing aids	1	1	-	-
Hearing aid candidate factors				
Satisfaction and benefit with hearing aids.	3	2	-	1

First Fitting Age	1			1
Narratives on hearing aid fitting	1	1(D)	-	1(I)
Hearing Aid Handling skills	2	2	-	-
Previous hearing aid experience	1	-	-	1
Hearing aid fitting and follow-up				
Type of Hearing Aid Fitting (bil versus Uni)	6	3	-	3

Note: D=Prefer Group D (D=diagnostic narrative) I= prefer Group I (Interactive Group)

Audiological Factors Influencing Hearing Aid Use

Audiological factors within the categories of hearing sensitivity, speech perception, self-reported hearing difficulty, ear problems, tinnitus and balance problems were shown to be significantly associated with hearing aid use (Figure 2 & Table 3). Measures of hearing loss severity including pure-tone average (PTA) (Aazh et al., 2015; Arnold et al., 2019; Fuentes-López et al., 2017; Helvik et al., 2016; Ho et al., 2018), hearing loss asymmetry (Houmøller et al., 2021) and self-reported hearing difficulty (Helvik et al., 2016; Hickson, Meyer et al., 2014; Klyn et al., 2020) were shown to be positively associated with increased hearing aid use. Hearing aid users with higher speech perception abilities measured through self-reported speech perception ability, word recognition score (WRS) and speech recognition threshold (SRT) were shown to use hearing aids more frequently (Dwarakanath & Manjula, 2020b; Jorbonyan et al., 2022; Houmøller et al., 2021; Wang et al., 2021; Wu et al., 2019). Additionally, hearing aid users who presented with bothersome tinnitus, tympanic membrane perforation and balance problems were shown to be frequent hearing aid users (Giuliania, 2021; Houmøller et al., 2021; Moon et al., 2015).

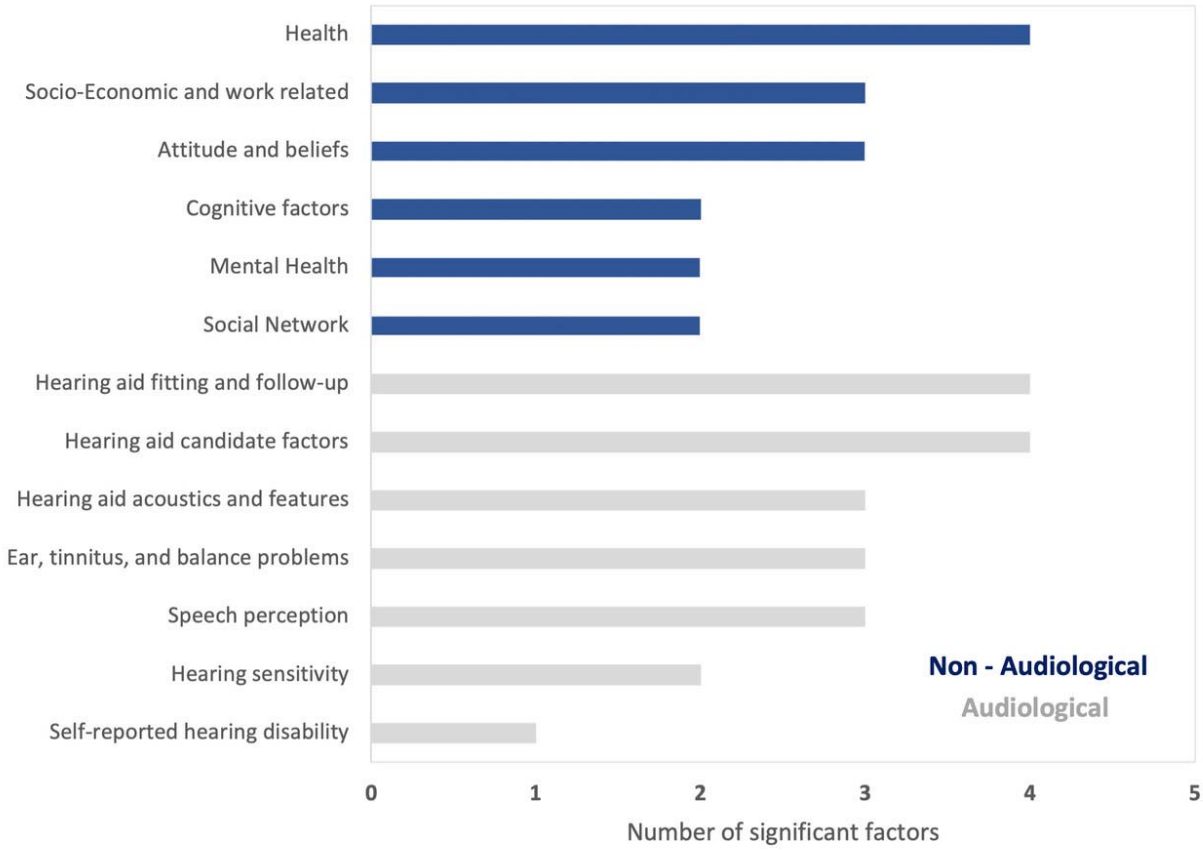

Figure 2. Number of Significant Factors Identified Within Studies that Influence Hearing Use for Each Category of Audiological and Non-audiological factors.

Several factors in categories of hearing aid acoustics and features, candidate factors, fitting and follow-up were significantly associated with use (see Figure 2). Within these categories, increasing hearing aid use was positively associated with digital vs analog hearing aids, conducting insertion gain, using more expensive hearing aids (Jorbonyan et al., 2022; Hickson et al., 2014; Wang et al., 2021), patients who adopt a diagnostic narrative on hearing aid fitting procedures (Naylor et al., 2015) and with better hearing aid handling skills (Nixon et al., 2021). Increasing prevalence/number of hearing aid problems was a negative predictor of hearing aid

use (Bennett et al., 2020). Other factors such as hearing aid satisfaction and benefit and bilateral hearing aid fittings had mixed results of positive and no significant associations with hearing aid use respectively (Aazh et al., 2015; Jorbonyan et al., 2022; Staehelin et al., 2011; Wang et al., 2021). Three studies reported different results of a neutral link between these factors and hearing aid use (Ho et al., 2018; Jilla et al., 2015; Wu et al., 2019).

Non-audiological Factors Influencing Hearing Aid Use

Several non-audiological factors were identified with positive and negative associations with hearing aid use across categories including demographics, social networks, psycho-social, mental health, cognitive factors, attitudes and beliefs, and socio-economic and work-related factors (Figure 2 & Table 4). A positive association was reported between men living with spouses and hearing aid use (Helvik et al., 2016). Three different studies showed mixed associations between female and male biological sex and increased and decreased hearing aid use (Houmøller et al., 2021; Klyn et al., 2020; Jorbonyan et al., 2022). In contradiction, one study shows a positive association between being male and hearing aid use (Staehelin et al., 2011). Race effects included a negative association between being non-Hispanic and hearing aid use and a positive association between being Hispanic and hearing aid use (Klyn et al., 2020; Sawyer et al., 2019).

Table 4: Non-audiological factors affecting hearing aid use

Factor	Number of studies	Positive	Negative	No Association
Demographics				
Age	13	2	7	4
Biological sex	8	2	2	4
Ethnicity	3		1 (black)	2
Race	2	2 (white)	1 (black)	-
Marital Status	1	-	-	1
Living Arrangements	1	1 (MLS)	-	1 (WLS)
Living status	1	1	-	-
Place of Residency	2	2	-	-
Social Network				
Social Support from others	2	2	-	-
Family time	1	1	-	-
Number of House Members	1	-	-	1
Psycho-social				
Personality	3	3	-	-
Perceived Need for of the hearing aid	1	1	-	-
Self-Efficacy	3	1	-	2
Accepted need	1	1	-	-
Social assessment and consciousness	1	-	-	1
Mental health				
Active Neurological disorders	1	-	1	-
Depressive mood	1	-	-	1
Amount of stress in life	1	1	-	-

Cognitive factors				
Working Memory	1	1	-	-
Cognition	1	1	-	-
Attitude and Beliefs				
Attitude	4	3	-	1
Beliefs	1	1	-	-
Motivation	1	1	-	-
Socio-Economic and work related				
Occupation an employment	2	1	-	1
Income	3	1	-	2
Knowledge	1	1	-	-
Education	5	5	-	-
Coping in work liife	1	1	-	-
Socio-economic status	1	-		1-
Social activities	1	-	-	1
Health				
Myopia	1	-	1	-
Astigmatism	1	1	-	-
Self-reported General Health Status	4	2	1	1
Health Literacy	2	1 (SHL)	-	1 (OHL)
Hospitalization	1	-	-	1
Medical aid	1	1	-	-

Note: MLS= Male Living with Spouse; WLS= Women living with spouse; SHL =Subjective Health Literacy, OHL = Objective health literacy. Social assessment = view on how people think about them) Consciousness (of their hearing loss and hearing aids)

Support from other people (Hickson et al., 2014), family time (Nixon et al., 2021), personality (Dwarakanath & Manjula, 2020a), perceived need (Arnold et al., 2019), accepted need (Solheim et al., 2012; (Solheim et al., 2012), cognition (Nixon et al., 2021), working memory (Dwarakanath & Manjula, 2020b; Nixon et al., 2021) were shown to have a positive influence on hearing aid use. Additionally, positive attitude towards hearing loss (Dwarakanath & Manjula, 2020a), positive attitude towards hearing aids and beliefs (Saunders, Frederick, Silverman, Nielsen, & Laplante-Lévesque, 2016) and motivation (Houmøller et al., 2021) were shown to be positive determinants of frequent hearing aid use. Adult hearing aid users with neurological disorders which contribute to mental health were shown to be infrequent hearing aid users in a single study (Giuliania, 2021).

Education (Helvik et al., 2016), coping in work life (Laakso et al., 2022), knowledge (Fuentes-López et al., 2017), self-reported health status (Fuentes-López et al., 2019), and subjective health literacy (Klyn et al., 2020) which were all reported to be positive determinants of frequent hearing aid use. Income was shown to have mixed results, with two studies (Fuentes-López et al., 2017; Moon et al., 2015) showing a non-significant association and a single study (Fuentes-López et al., 2019) showing a positive association. Additionally, vision impairments and hearing aid use showed varied results, with myopia negatively associated with hearing aid use, whereas astigmatism and having medical aid were positively associated with hearing aid use (Moon et al., 2015).

Table 5: Audiological factors affecting hearing aid benefit

Factor	Number of Studies	Positive	Negative	No Association
Hearing Sensitivity				
Pure Tone Average (PTA)	6	3	2	1
Asymmetry	1	-	-	1
Speech perception				
WRS	2	2	-	-
SRT	1	1	-	-
Speech Perception Ability	1	1	-	-
Auditory processing abilities				
Temporal processing	1	-	-	1
Auditory closure	1	-	-	1
Binaural Interaction	1	-	-	1
Auditory closure	1	-	1	-
Binaural integration	1	-	1	-
Ear, Tinnitus and Balance				
Tinnitus	1	-	-	1
Hearing aid acoustic and features				
Prevalence of Hearing aid problems	1	-	1	-
Price of Hearing aid	1	1	-	-
Hearing aid candidate factors				
Daily Use time	2	2	-	-
First Fitting age	1	-	-	1
Narratives on hearing aid fitting appointments	1	1 (I)	-	1(D)

Note: D=Prefer Group D (D=diagnostic narrative) I= prefer Group I (Interactive Group)

Factors Influencing Hearing Aid Benefit

Thirteen audiological factors (Table 5) and 10 non-audiological factors (Table 6) influencing hearing aid benefit were identified. Seventeen factors were found to be significant determinants of hearing aid benefit (17/23). Significant results will be discussed below while non-significant factors can be found in Tables 4 and 5. Significant audiological and non-audiological factors are shown in figure 3.

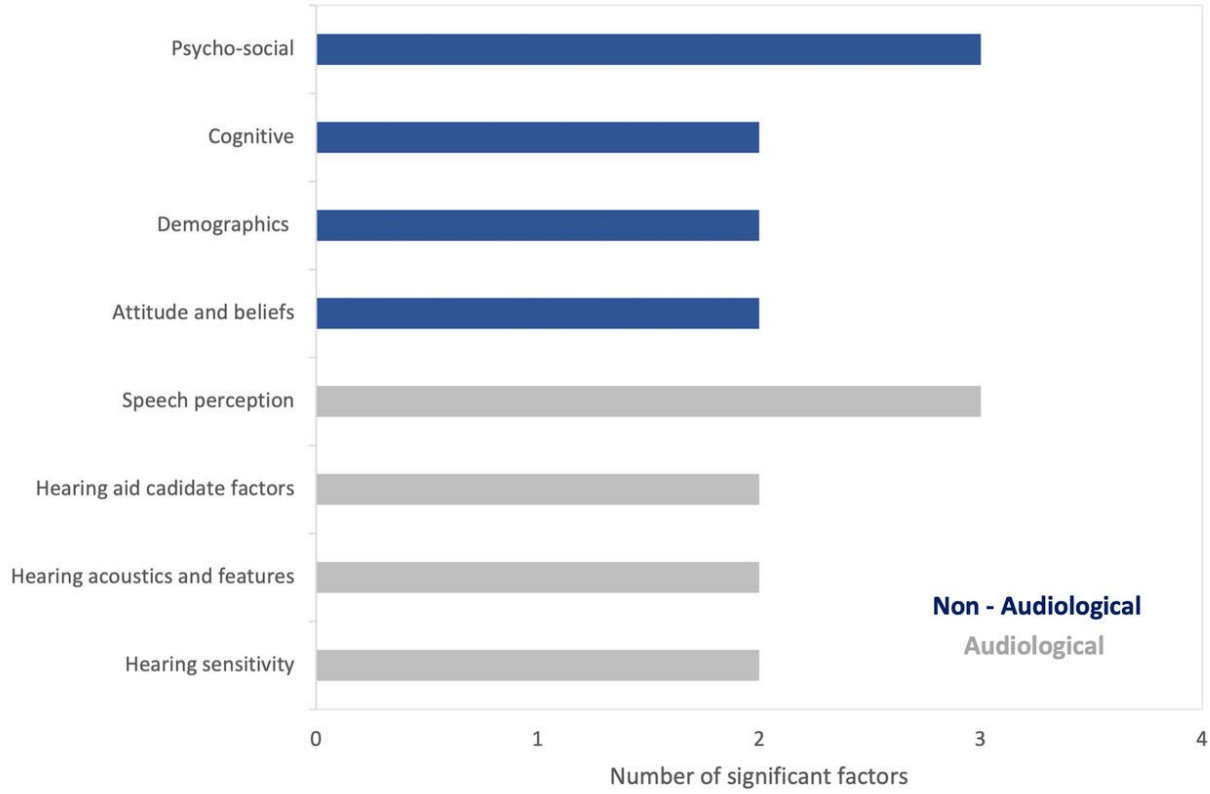

Figure 3. Number of Significant Factors Identified Within Studies that Influence Hearing Aid Benefit for Each Category of Audiological and Non-audiological Factors

Audiological Factors Influencing Hearing Aid Benefit

Hearing loss severity measured through PTA was shown to have mixed results of positive (Houmøller et al., 2021; Meister et al., 2015; Nixon et al., 2021) and negative associations with hearing aid benefit (Tognola et al., 2019; Wang et al., 2021). Hearing loss asymmetry was reported to be a negative determinant of hearing aid benefit (Houmøller et al., 2021). Better speech perception ability measured through a self-reported questionnaire, WRS and SRT were shown to be positively associated with increased hearing aid benefit (Dwarakanath & Manjula, 2020b; Houmøller et al., 2021; Wang et al., 2021; Wu et al., 2019). Difficulties in auditory processing abilities including auditory closure and binaural integration were shown to have a negative association with hearing aid benefit (Chinnaraj et al., 2022). Patients with bothersome tinnitus were shown to have less hearing aid benefit (Houmøller et al., 2021). Hearing aid acoustics and hearing aid related factors such as prevalence/number of hearing aid problems and cost of hearing aids were shown to have a negative and positive influence on hearing aid benefit, respectively (Bennett et al., 2020; Wang et al., 2021). Hearing aid candidate factors such as daily hearing aid usage time (Houmøller et al., 2021; Wang et al., 2021) and adoption of a diagnostic narrative on hearing aid fitting by hearing healthcare professionals (Naylor et al., 2015) were shown to be positive determinants of hearing aid benefit.

Table 6: non-audiological factors affecting hearing aid benefit

Factor	Number of Studies	Positive	Negative	No association
Demographics				
Age	4	1	2	1
Biological sex	2	2	-	-
Psycho-social				
Personality	2	2	-	-
Self-Efficacy	1	-	-	1
Expectations	1	1	-	-
Readiness to improve hearing	1	1	-	-
Cognitive factors				
Cognition	3	3	-	-
Working Memory	2	1	-	1
Attitude and Beliefs				
Attitude	4	4	-	-
Motivation	1	1	-	-

Non-audiological Factors Influencing Hearing Aid Benefit

Older age was shown to have positive (Meister et al., 2015) and negative (Tognola et al., 2019; Wang et al., 2021) associations with hearing aid benefit. In terms of biological sex, female hearing aid users reported improved hearing aid benefit (Houmøller et al., 2021) while contradictory findings by Narne et al. (2016) showed more hearing aid benefit among male hearing users.

Personality (Dwarakanath & Manjula, 2020a), readiness to improve hearing, expectations (Dwarakanath & Manjula, 2020a; Ferguson et al., 2016), cognition (Meister et al., 2015; Nixon et al., 2021; Tognola et al., 2019), working memory (Dwarakanath & Manjula, 2020b), attitude towards hearing loss and hearing aids (Dwarakanath & Manjula, 2020a; Nixon et al., 2021; Saunders et al., 2016) and motivation (Dwarakanath & Manjula, 2020a; Houmøller et al., 2021; Nixon et al., 2021; Saunders et al., 2016) were shown to be positive determinants of hearing aid benefit.

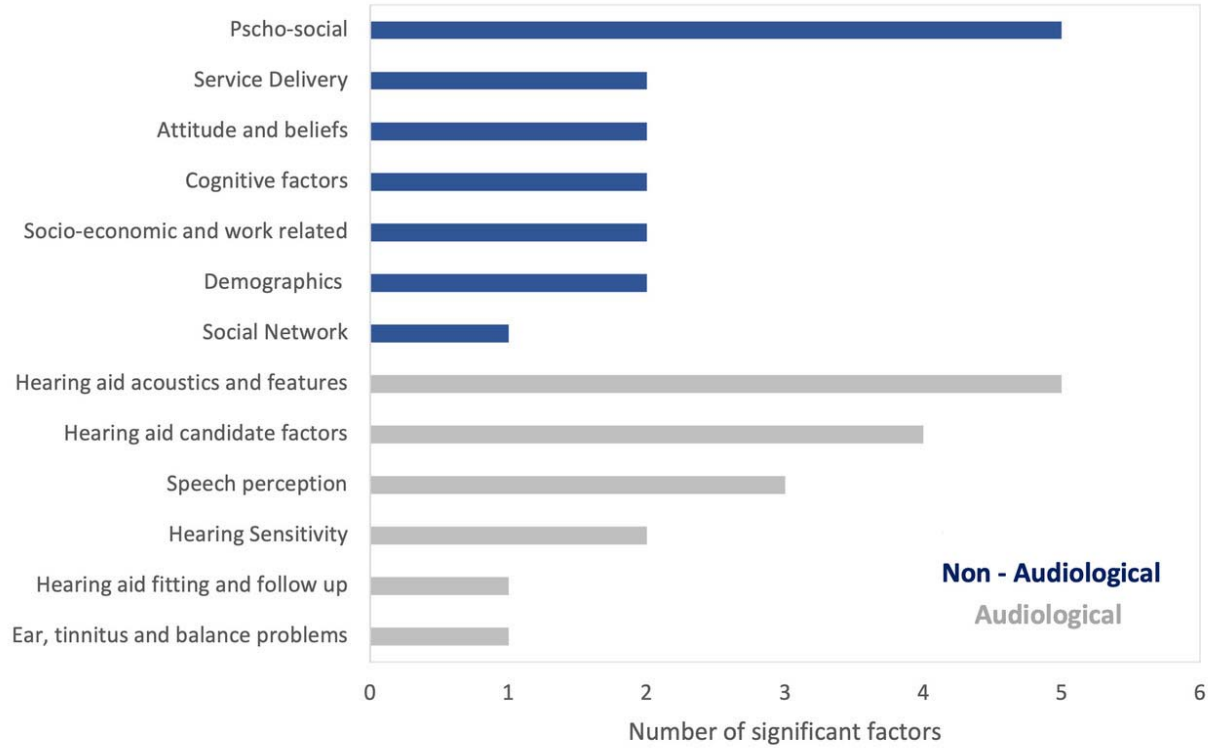

Figure 4. Number of Significant Factors Identified Within Studies that Influence Hearing Aid Satisfaction for Each Category of Audiological and Non-audiological Factors.

Factors Influencing Hearing Aid Satisfaction

Forty-five factors influencing hearing aid satisfaction were investigated in 17 studies. Among all studied factors, 37 factors (see Tables 7 and 8) were found to be significant determinants (37/45) of hearing aid satisfaction whereas eight factors were shown to have no significant association with hearing aid benefit (8/45). The number of significant factors per category is shown in Figure 4.

Audiological Factors Influencing Hearing Aid Satisfaction

Studies reporting an association between PTA and hearing aid satisfaction had mixed evidence of positive (Houmøller et al., 2021; Korkmaz et al., 2016; Meister et al., 2015) and negative associations with hearing aid satisfaction (Kaplan-Neeman et al., 2012; Turan et al., 2019; Wang et al., 2021). Hearing loss asymmetry was shown to be a negative determinant of hearing aid satisfaction (Houmøller et al., 2021). Hearing ability with hearing aids was shown to have a positive association with hearing aid satisfaction (Meyer et al., 2014). Speech perception ability measured through a self-reported questionnaire, WRS and SRT was shown to be a positive determinant of hearing aid satisfaction (Houmøller et al., 2021; Wang et al., 2021; Wu et al., 2019). Additionally, bothersome tinnitus was shown to be negatively associated with hearing aid satisfaction (Houmøller et al., 2021).

Table 7: Audiological factors influencing hearing aid satisfaction

Factor	Number of Studies	Positive	Negative	No association
Hearing Sensitivity				
Pure Tone Average	9	3	3	3
Asymmetry	1	-	1	-
Hearing ability with hearing aids	1	1	-	-
Speech perception				
WRS	2	2	-	-
SRS	1	1	-	-
Speech Perception Ability	1	1	-	-
Ear, Tinnitus and balance				
Tinnitus	1	-	1	-
Hearing aid acoustics and features				
ITE vs BTE hearing aid	1	1	-	-
Digital Technology	1	-	-	1
Hearing aid comfort	1	-	1	-
Hearing aid appearance	1	1	-	-
Price of hearing aid	2	2	-	-
Prevalence of hearing aid problems	2	-	2	-
Product performance	1	1	-	-
Product features	1	1	-	-
Hearing aid Candidate factors				
Duration of Hearing aids	1	-	-	1
Hearing ability with hearing aids	1	1	-	-
Site of hearing aid wear	1	-	-	1

First Fitting age	1	1	-	-
Narratives on hearing aid fitting appointments	1	1 (D)	-	1 (I)
Hearing Aid Usage	6	6	-	-
Experience with hearing aid use	2	-	-	2
Hearing aid handling skills	1	1	-	-
Hearing aid fitting and follow up				
Type of Hearing Aid Fitting (bil versus Uni)	6	5	-	1
Regular hearing aid follow up	1	1	-	-

Note: D=Prefer Group D (D=diagnostic narrative) I= prefer Group I (Interactive Group); WRS: Word Recognition Score; SRS: Speech Recognition Score.

Factors within categories of hearing aid acoustics and hearing aid related factors such as hearing aid candidate and hearing aid fitting and follow up included In the Ear (ITE) vs Behind the Ear (BTE), price of hearing aid (Wang et al., 2021), hearing aid product performance and features (Bisgaard & Ruf, 2017), adoption of diagnostic narrative on hearing aid fitting procedure by hearing healthcare professionals (Naylor et al., 2015), daily hearing aid use (Gurjit et al., 2015; Houmøller et al., 2021; Kaplan-Neeman et al., 2012; Korkmaz et al., 2016; Wang et al., 2021), hearing aid handling skills (Kemker et al., 2012), regular hearing aid follow-up (Kim et al., 2022) and bilateral hearing aid fitting (Kaplan-Neeman et al., 2012; Turan et al., 2019; Wang et al., 2021) were shown to be positive determinants of hearing aid satisfaction. Prevalence of hearing aid problems and lack of hearing aid comfort were shown to have a negative association with hearing aid satisfaction in 2 studies (Bennett et al., 2020; Meyer et al., 2014).

Non-audiological Factors Influencing Hearing Aid Satisfaction

Older age was shown to have mixed results of positive (Meister et al., 2015) and negative associations with hearing aid satisfaction (Kaplan-Neeman et al., 2012; Korkmaz et al., 2016; Laakso et al., 2022; Tognola et al., 2019; Turan et al., 2019; Wang et al., 2021). In terms of biological sex, Houmøller et al. (2021) reported a positive association between female and hearing aid satisfaction. Narne et al. (2016) and (Korkmaz et al., 2016) revealed a negative association between male and hearing aid satisfaction.

Non-audiological factors within categories of social network, socio-economic, work, and psycho-social had significant associations with hearing aid satisfaction. Social support (Gurjit et al., 2015), education (Korkmaz et al., 2016), self-efficacy, expectation (Kelly-Campbell & McMillan, 2015), readiness to improve hearing (Ferguson et al., 2016) and openness (Gurjit et al., 2015) were shown to have a positive association with hearing aid satisfaction in 3 studies (Dwarakanath & Manjula, 2020a; Ferguson et al., 2016; Kelly-Campbell & McMillan, 2015). Neuroticism was shown to have a negative association with hearing aid satisfaction (Gurjit et al., 2015). Non-audiological factors such as cognition (Meister et al., 2015; Nixon et al., 2021; Tognola et al., 2019), working memory (Dwarakanath & Manjula, 2020b), attitude (Dwarakanath & Manjula, 2020a; Nixon et al., 2021; Saunders et al., 2016), motivation (Houmøller et al., 2021) and confidence in healthcare practitioner (Gurjit et al., 2015) were shown to be positive determinants of hearing aid satisfaction. Additionally, Humes et al. (2017) reported a positive association between audiology best practice service delivery model as compared to direct-to-consumer model and hearing aid satisfaction.

Table 8: Non- Audiological factors influencing hearing aid satisfaction

Factor	Number of Studies	Positive	Negative	No association
Demographics				
Age	12	2	7	3
Biological sex	4	2 (both)	1 (male)	1
Living status	1	-	-	1
Quality of life measures	1	-	-	1
Social Network				
Social Support	1	1	-	-
Socio-Economic and work related				
Employment status	2	-	-	2
Education status	2	2	-	-
Psycho-social				
Personality	1	1	-	-
Self-Efficacy	2	1	-	1
Expectations	1	1	-	-
Readiness to improve hearing	1	1	-	-
Openness	1	1	-	-
Neuroticism	1	-	1	-
Cognitive factors				
Cognition	3	3	-	-
Working Memory	1	1	-	-
Attitude and Beliefs				
Attitude	3	3	-	-

Motivation	1	1	-	-
Service delivery				
Hearing healthcare practitioner	1	1	-	-
Service Delivery Model	1	1(AB)	-	-
Service Provision	1	1	-	-

Note: AB = Audiology best practice

Assessment of Quality and Level of Evidence

The NIH Quality Assessment Tool was used to assess the quality of the studies included. Of the 45 included, 43 had a rating between 5-10, indicating fair quality (43/45) while 2 were rated between 11-14, indicating good quality (2/45). The studies included in this review were evaluated using the Oxford CEBM Levels of Evidence scale. Under this tool, studies are graded into 4 grades of recommendations (A–D) and 5 levels of evidence (1–5). 38 cross-sectional studies included in this review were graded as level 4 (38/45), 5 cohort studies rated as level 3 (5/45) and 2 randomized control trials rated as level 2 (2/45).

DISCUSSION

This systematic review identified significant audiological and non-audiological factors influencing hearing aid use (46 factors), benefit (17 factors) and satisfaction (37 factors) from literature published during the last decade. Due to the high number of factors identified for each outcome variable, the discussion focuses on the prominent predictors across all three outcomes, those not reported in previous reviews, and factors with mixed inconclusive results.

Audiological Factors Influencing Hearing Aid Use, Benefit and Satisfaction

The most reported audiological factor influencing hearing aid use, benefit and satisfaction is the degree of hearing loss measured as PTA, demonstrating a clear positive association with hearing aid use and mixed inconclusive associations with benefit and satisfaction. For the outcome dimension of hearing aid use, a systematic review by Ng and Loke (2015) reported results of a clear positive association while a review of literature by Knudsen et al. (2010) showed contrasting results of non-significant association with hearing aid use. For the hearing aid dimension of satisfaction, Knudsen et al. (2010) showed similar mixed inconclusive results of positive and negative associations with hearing aid satisfaction.

Other audiological factors, which form part of the audiological profile including hearing loss asymmetry (Houmøller et al., 2021), speech perception ability (Wang et al., 2021; Wu et al., 2019), bothersome tinnitus (Houmøller et al., 2021) and tympanic membrane perforation (Moon et al., 2015), have limited evidence across hearing aid outcome dimensions of use, benefit and satisfaction. Some of these factors are important potential influencers of improved hearing aid outcomes. For instance, higher speech perception ability measured through SRT, WRS and self-reported questionnaire was positively associated with improved hearing aid use, benefit and satisfaction, placing an emphasis on the inclusion of speech assessments to inform benefit and satisfaction with hearing aids (Davidson et al., 2021).

Recent audiological factors related to the hearing aid across hearing aid use, benefit and satisfaction not reported in previous reviews include bothersome tinnitus, narratives or

perspectives of the hearing aid fitting process and prevalence of hearing aid problems. These recent factors are much more related to hearing aid features such as tinnitus management programs, mobile and virtual troubleshooting support. For instance, a scoping review by Jacquemin et al. (2021) showed that hearing aids could provide tinnitus relief. This explains the frequent use and improved satisfaction among hearing aid users with bothersome tinnitus (Lee et al., 2022). Another example is with the introduction of virtual forms of hearing aid support for hearing aid users such as multimedia educational programs, mobile applications and virtual access to hearing healthcare professionals (Ross, 2020). This hearing aid support irrespective of the method used has been shown to facilitate the journey through hearing aid adaptation and address the prevalence of hearing aid problems for users, improving use and benefit (Ferguson et al., 2016).

Another recent factor is the patient narrative effect on the hearing aid fitting procedure. The study by Naylor et al (2015) showed that patients who had a positive interactive narrative on the hearing aid fitting procedure reported improved hearing aid outcomes in terms of use, benefit and satisfaction as compared to those who were provided with a contrasting narrative (i.e., diagnostic). In this study, the hearing aid fitting process of a diagnostic narrative or character required that the participants should be passive, their opinions not sought, and the expert makes diagnostic measurements of their hearing and fits the hearing aid according to the audiogram. The interactive hearing aid fitting process was designed in a way that the participants should feel that they were involved in creating their own settings for the hearing aids (Naylor et al., 2015). The possible underlying factors in improved hearing aid outcomes include confidence in the

hearing health care professional (Singh et al., 2015) and indicate the importance of hearing health care professionals in the management of hearing loss throughout the whole journey.

Non-audiological Factors Influencing Hearing Aid Use, Benefit and Satisfaction

Age is a commonly explored demographic predictor of hearing aid outcome domains with mixed inconclusive results regarding hearing aid use, benefit and satisfaction. In contrast, a systematic review by Ng and Loke (2015) showed a clear positive association between the hearing aid outcome dimension of frequent hearing aid use and older age. Additionally, Knudsen et al. (2010) showed no significant association between age and hearing aid use. In comparison to mixed inconclusive results found by this study, Ng and Loke (2015) and Knudsen et al. (2010) showed clear results of positive and non-association with hearing aid use respectively. Biological sex is another prominently reported demographic predictor with mixed results of no association, positive association and negative association for hearing aid use and satisfaction. Knudsen et al. (2010) and Ng and Loke (2015) showed different results of a non-significant association and a clear female positive association with hearing aid use, respectively.

Apart from demographic factors, several other non-audiological factors within the patient's communication settings were found to be contributors towards hearing aid outcomes. For all studied hearing aid outcomes, this includes factors such as working memory and personality which were shown to have positive associations with improved hearing aid use, benefit and satisfaction. Knudsen et al. (2010) showed contrasting results of a non-significant association between personality and hearing aid use; but similar results of a positive association between

the personal image subscale of SADL and four personality traits of neuroticism, extraversion, agreeableness and consciousness. Recent non-audiological factors identified to contribute to hearing aid outcomes include social networks in the form of social support, neurological disorders which contribute to mental health and service delivery of audiology best practice and direct to consumer showed varying associations with hearing aid use and satisfaction. These factors have been explored in limited studies and have not been included in previous reviews (Knudsen et al., 2010; Ng & Loke, 2015). These recent factors, along with overall non-audiological factors within the patient's communication setting, should be considered in clinical practice, promoting individualized care to optimize hearing aid outcomes.

Non-audiological factors in Knudsen et al. (2010), such as pre-fitting attitudes towards hearing aids, motivation and pre-fitting attitude towards own hearing loss, were also studied in the past decade, strengthening the evidence for hearing aid satisfaction. Pre-fitting attitudes towards hearing aids, motivation and pre-fitting attitudes towards hearing loss showed positive associations with hearing aid satisfaction as reported by Knudsen et al. (2010). In this review, attitude towards hearing loss and hearing aids as well as motivation were reported to have a positive association with improved hearing aid satisfaction. The new and emerging evidence requires further exploration through studies of higher quality and higher level of evidence.

Future Research

Some factors reported in this review (e.g., mental health, service delivery model) are recent and were not captured by previous reviews (Knudsen et al., 2010; Ng and Loke, 2015). There

are also mixed inconclusive results on several factors (e.g., hearing sensitivity and age) and limited evidence for other factors (e.g., cost of hearing aid). This review therefore identifies the areas that require further investigations for these recently identified factors and those with mixed inconclusive results and limited evidence. Additionally, this review shows a need for studies of higher quality and higher level of evidence, which should be the focus in future studies in this area.

CONCLUSIONS

Identified factors consistent with previous reviews include self-reported hearing difficulty, cost of hearing aid and its maintenance for hearing aid use; and PTA, hearing aid appearance, age, pre-fitting expectations, satisfaction with the practitioner, self-motivation, pre-fitting attitudes towards hearing aids for hearing aid satisfaction. Recent factors influencing hearing use, benefit and satisfaction, which were not captured by previous reviews, include speech perception ability, bothersome tinnitus, neurological disorders that contribute to mental health, prevalence of hearing aid problems, narratives on hearing aid fitting procedures, service delivery model and social networks. These identified factors need further investigations through studies of high quality and high level of evidence to strengthen evidence on their influence on hearing aid outcomes. In clinical practice, the identified predictors of hearing aid use, benefit and satisfaction should be considered to optimize hearing aid outcomes.

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