Emotional Impacts of Hearing Loss: Analyzing the Role of Hearing Aids, Perceived Severity, and Demographic Factors through Mobile Crowdsensing Data in TrackYourHearing

Michael Winter[1], Winfried Schlee[2], Thomas Probst[3], Rüdiger Pryss[4]

[1] *Institute of Clinical Epidemiology and Biometry, University of Würzburg, Würzburg, Germany & Institute of Medical Data Science, University Hospital of Würzburg, Würzburg, Germany. michael.winter@uni-wuerzburg.de*
[2] *Eastern Switzerland University of Applied Sciences, St. Gallen, Switzerland. winfried.schlee@gmail.com*
[3] *Division of Psychotherapy, Department of Psychology, Paris Lodron University Salzburg, Salzburg, Austria. ruediger.pryss@uni-wuerzburg.de*
[4] *Institute of Clinical Epidemiology and Biometry, University of Würzburg, Würzburg, Germany & Institute of Medical Data Science, University Hospital of Würzburg, Würzburg, Germany. ruediger.pryss@uni-wuerzburg.de*

KEYWORDS
Hearing Loss, Emotional Well-Being, Hearing Aids, Mobile Health (mHealth), TrackYourHearing

ABSTRACT
Hearing loss significantly impacts emotional well-being, often leading to increased stress, irritability, and exhaustion. This study explored the influence of hearing aid usage, perceived hearing loss, demographic factors, and operating system preferences on emotional states using data from 63 participants collected through the TrackYourHearing mobile health platform. The results showed that hearing aid users experienced better emotional well-being, with higher mood and lower stress, irritability, and exhaustion compared to non-users. Strong correlations were found between perceived hearing loss and increased stress and exhaustion, as well as lower mood. Age and sex also played a role, with older individuals and males reporting higher stress and irritability. Additionally, iOS users reported better emotional states than Android users, particularly in terms of irritability and exhaustion. These findings indicate the importance of hearing aids in improving emotional well-being and highlight the role of individual and technological factors in shaping emotional experiences in individuals with hearing loss.

1. Introduction:

Hearing loss is a prevalent health issue that affects millions of individuals worldwide, with significant impacts on both physical and emotional well-being [1,2]. In addition to communication difficulties, hearing impairment can lead to increased stress, irritability, and social isolation, contributing to a decline in overall quality of life [3]. These emotional challenges are often exacerbated by the perceived severity of hearing loss and the limitations it imposes on daily activities [4].

The use of assistive technologies, such as hearing aids, has been shown to alleviate some of the negative consequences of hearing loss by improving communication and reducing the emotional burden [5]. However, not all individuals with hearing impairments consistently use hearing aids, and even among users, the effectiveness of these devices in managing emotional states varies [6]. Moreover, demographic factors such as age and sex, along with technological differences (e.g., operating system preferences), may influence how individuals experience and cope with hearing loss [7].

With the proliferation of mobile health technologies, platforms like TrackYourHearing have enabled real-time data collection through Ecological Momentary Assessments (EMA), offering new opportunities to understand the daily fluctuations in emotional states among individuals with hearing loss [8]. This study is a follow-up to previous research that first introduced the TrackYourHearing platform, expanding on the initial findings by exploring deeper relationships between hearing aid usage, perceived hearing loss, demographic factors, and emotional states. By examining these factors, the study seeks to provide further insights into the emotional impact of hearing loss and identify potential areas for intervention to improve the well-being of affected individuals.

The reminder of the paper is structured as follows: Section 2 discusses related work. An introduction to the TrackYourHearing platform is provided in Section 3. Materials and Methods of the study are

presented in Section 4, while Section 5 presents applied statistics and results. Discussion, implications, and limitations of our work are shown in Section 6. Finally, Section 7 summarizes the paper and gives an outlook on future work.

2. Related work

The relevant work for this paper centers on mobile health applications that collect Ecological Momentary Assessment (EMA) data to investigate correlations with hearing loss status. While EMA-based studies are limited across many medical areas, certain topics, such as depression, have been well explored. Interestingly, some research has already focused on hearing loss. For example, the authors in [9] address essential questions to include in EMA questionnaires. Review papers such as [10] also identify common challenges in hearing loss studies that align with those observed in EMA studies for other conditions, such as issues with adherence and evidence generation.

EMA is frequently employed to survey hearing aid users, enhancing understanding of the relationship between hearing loss and hearing aid use in daily contexts. For instance, in [11], 16 hearing aid users participated in a study to assess whether different hearing aid programs yielded different results. The two programs were randomly assigned through an EMA questionnaire, with responses used to evaluate each program's effectiveness. Though no significant differences were observed between the programs, the study demonstrated that participants responded well to the EMA method (with a 79% compliance rate).

Further studies have explored specific aspects of hearing loss in everyday life. The authors of [12], for instance, examine whether challenging listening situations impact users differently. The study in [14] evaluates the potential of EMAs to help develop user profiles that aid in selecting or upgrading hearing aids, demonstrated with a sample of 24 participants. Sample sizes in these studies are generally small, with the notable exception of [15], where 2,301 hearing aid users were surveyed to assess whether EMAs can support the creation of individualized hearing profiles. The findings suggest that motivated participants offer particularly valuable insights.

Most of the research focuses on hearing aids within the context of EMAs and hearing loss, which is logical given that EMAs can capture the nuances of daily life, allowing for a richer understanding of hearing aid use. To our knowledge, however, a study like the present one—where hearing aids are continuously monitored, and correlations are examined between daily EMAs and various factors such as stress, well-being, and differences in experiences across Android and iOS platforms—has not been conducted, aside from the authors' previous publications [8].

3. TrackYourHearing Platform

The TrackYourHearing platform is a mobile health (mHealth) platform designed to collect real-time, Ecological Momentary Assessment (EMA) data from individuals experiencing hearing loss. The platform enables users to report on a wide range of factors, offering insights into the daily fluctuations in hearing loss and its impact on various aspects of life.

TrackYourHearing is available for both Android and iOS, facilitating data collection through repeated daily questionnaires. The data captured extends beyond emotional factors, such as mood, stress, irritation, and exhaustion, to include broader information about the user's hearing experience. This includes details on the use of hearing aids, perceived severity of hearing loss, limitations in daily activities, physical reactions to environmental sounds, and the burden of recent conversations. The platform utilizes a combination of visual analogue scales (VAS), yes/no questions, and self-assessment manikins (SAM) to ensure comprehensive and detailed data capture.

In addition to self-reported data, the platform offers the option to passively collect sensor-based measurements, such as environmental sound levels, provided the user consents. This combination of subjective and objective data helps build a more complete picture of how hearing loss interacts with

environmental and psychological factors in real time.

The use of EMA ensures that data is gathered in the user's natural environment, minimizing recall bias and enhancing the ecological validity of the findings [16]. TrackYourHearing's design also allows for in-depth comparisons across user subgroups, such as those with different levels of hearing impairment, varying hearing aid use, and differing responses to environmental noise. The platform's holistic approach to data collection, capturing emotional, physical, and auditory experiences, makes it a powerful tool for both clinical practice and research.

4. Materials and Methods

This study utilized data collected from 63 participants through the TrackYourHearing platform. Participants were aged between 50 and 80 years and included users of both Android and iOS devices, with varied use of hearing aids. In total, 2,480 assessments were completed throughout the study.

Data were collected using the TrackYourHearing platform, which prompts users to complete short daily questionnaires about their emotional states and hearing experiences. The emotional states assessed included mood, stress, irritability, and exhaustion, measured using a visual analogue scale (VAS) ranging from 0 to 1, with higher values indicating worse emotional outcomes. In addition, participants were asked about their hearing aid usage (yes/no) and perceived hearing loss severity, as well as demographic factors such as age and sex.

The key questions from TrackYourHeaing included in this study:

Q1: Do you wear your hearing aid right now? (0=no, 1=yes)
Q2: To what extent do you perceive your hearing loss right now? (i.e., 0 to 1, with higher values indicating greater perceived severity)
Q3: To what extent are you limited in your daily life by your hearing loss? (i.e., 0 to 1, with higher values indicating greater perceived limitation)
Q5-Q8: Emotional states including mood (Q5), stress (Q6), irritability (Q7), and exhaustion (Q8) (i.e., 0 to 1, higher values indicating worse emotional states)

The study was designed to answer four research questions (RQ) through a combination of descriptive and inferential statistical analyses:

RQ1: Does hearing aid usage affect emotional states?
RQ2: How are perceived hearing loss and emotional states related?
RQ3: Do age and sex influence emotional states?
RQ4: Does the operating system (Android vs. iOS) affect emotional states?

Statistics

All statistical analyses were performed with SPSS 29. Descriptive statistics (means and standard deviations) were calculated for all variables of interest. Several statistical tests were employed to examine the relationships between hearing aid usage, emotional states, and demographic factors.

For RQ1, independent t-tests were conducted to compare emotional states (i.e., mood, stress, irritability, and exhaustion) between individuals who used hearing aids and those who did not. The t-tests allowed for testing differences in mean emotional state scores between the two groups.

For RQ2, Pearson correlation coefficients were used to assess the relationships between emotional states (i.e., mood, stress, irritability, and exhaustion) and hearing loss perception (i.e., perceived hearing loss, limitations in daily life, and emotional burden). The strength and direction of the linear relationships were determined, and statistical significance was assessed.

For RQ3, one-way ANOVA was performed to evaluate differences in emotional states based on the operating system (i.e., Android vs. iOS). This test helped determine if the operating system had a significant effect on mood, stress, irritability, and exhaustion.

For RQ4, to assess the impact of age and sex on emotional states, linear regression models were conducted. Age and sex were treated as predictors, while emotional states were dependent variables.

All statistical tests were performed two-tailed. The significance value was set to $p < .05$.

5. Results

This section presents the findings of the study, organized into two parts: Sections A. Descriptive Statistics and B - E. Inferential Statistics (i.e., RQ1 – 4).

Descriptive Statistics

Table 1 provides a summary (i.e., mean (m) and standard deviation (SD)) of the demographic characteristics of the study participants. The sample consisted of 63 individuals, of whom 37 (58.7%) used Android devices and 26 (41.3%) used iOS devices. In terms of sex distribution, 56.8% of the Android users were female, compared to 53.9% of iOS users. The average age of participants was similar across both groups, with Android users having a mean age of 70.30 years (SD=9.37), and iOS users having a mean age of 69.69 years (SD=3.91).

Regarding hearing aid usage, 24.3% of Android users and 30.8% of iOS users reported wearing hearing aids. The majority of participants experienced hearing problems in both ears, with 59.5% of Android users and 65.4% of iOS users reporting bilateral hearing loss. Only a small percentage of participants reported hearing problems limited to one ear.

Table 2 outlines the descriptive results for emotional states across the two operating system groups. Overall, the average mood score was identical between Android and iOS users, with both groups reporting a mean mood score of .79. Stress levels were also comparable, with Android users reporting a mean stress score of .12 (SD=.10), and iOS users reporting a slightly higher mean stress score of .13 (SD=.19). However, the most pronounced difference was observed in irritability, where iOS users reported significantly higher irritability (M=.78, SD=.27) compared to Android users (M=.14, SD=.12). Exhaustion levels were similar between the two groups, with Android users reporting a mean score of .16 (SD=.14) and iOS users reporting a mean score of .19 (SD=.22).

Table 1: Descriptive Statistics

	N=63	
	Android N=37 (58,7 %)	**iOS** N=26 (41,3 %)
Sex (n/%)		
Female	21 (56,8 %)	14 (53,9 %)
Male	16 (43,2 %)	12 (46,1 %)
Age (m/SD)	70.30 (9.37)	69.69 (3.91)
Hearing Aid (n/%)		
No	28 (75.7 %)	18 (69,2 %)
Yes	9 (24,3 %)	8 (30,8 %)
Hearing Problems (n/%)		
No Problem	11 (29.7 %)	9 (34.6 %)
Problem in right ear	22 (59.5 %)	0 (0 %)
Problem in left ear	3 (8.1 %)	0 (0 %)
Problem in both ears	1 (2.7 %)	17 (65.4 %)
Handedness (n/%)		
Right	37 (100 %)	26 (100 %)
Left	0 (0 %)	0 (0 %)
Ambidextrous	0 (0 %)	0 (0 %)

Table 2: Descriptive Results for Emotional States

	Android	iOS	Together
Mood	.79 (.14)	.79 (.17)	.79 (.15)
Stress	.12 (.1)	.13 (.19)	.12 (.15)
Irritation	.14 (.12)	.78 (.27)	.44 (.38)
Exhaustion	.16 (.14)	.19 (.22)	.17 (.18)

RQ1 - Effect of Hearing Aid Usage on Emotional States

Mood: Individuals who wore hearing aids reported significantly higher mood levels (m=.81) compared to those who did not use hearing aids (m=.78), with $t(2478)=-4.15$, $p < .001$.

Stress: Stress levels were significantly lower in individuals using hearing aids (m=.11) compared to non-users (m=.14), with $t(2478)=4.97$, $p < .001$.

Irritability: Those using hearing aids also showed significantly lower irritability (m=.33) compared to those not using hearing aids (m=.51), with $t(2478)=11.88$, $p < .001$.

Exhaustion: The level of exhaustion was significantly lower among hearing aid users (m=.16) compared to non-users (m=.18), with $t(2478)=3.27$, $p < .001$.

These results indicate that wearing hearing aids is associated with significantly improved emotional states, including reduced stress, irritability, and exhaustion, and enhanced mood.

RQ2 - Correlations Between Emotional States and Hearing Loss Perception

Mood: It was negatively correlated with all hearing loss perception measures:

- Q2 perceived hearing loss: $r(2478)=-.15$, $p < .001$.
- Q3 limitations in daily life: $r(2478)=-.21$, $p < .001$.
- Q4 emotionally charged by hearing loss: $r(2478)=-.25$, $p < .001$.

Stress: It showed a strong positive correlation with hearing loss perception:

- Q2: $r(2478)=.38$, $p < .001$.
- Q3: $r(2478)=.50$, $p < .001$.
- Q4: $r(2478)=.52$, $p < .001$.

Irritability: It exhibited weaker correlations with hearing loss perception:

- Q2: $r(2478)=-.05$, $p=.009$.
- Q3: $r(2478)=-.04$, $p=.049$.
- Q4: $r(2478)=-.07$, $p=.001$.

Exhaustion: It was positively correlated with hearing loss perception:

- Q2: $r(2478)=.33$, $p < .001$.
- Q3: $r(2478)=.43$, $p < .001$.
- Q4: $r(2478)=.47$, $p < .001$.

These results show that higher levels of perceived hearing loss and emotional burden are associated with increased stress and exhaustion, and lower mood, while irritability showed weaker associations.

RQ3 - Impact of Age and Sex on Emotional States

Mood: The overall model was significant, $R2=.003$, $F(2,2477)=3.47$, $p=.031$. Age had no significant, while sex had a significant effect ($\beta=-.014$, $t(2477)=-2.25$, $p=.024$), indicating that females reported slightly lower mood compared to males.

Stress: The model was significant, R2=.008, F(2,2477)=9.91, p < .001. Both age and sex had significant effects on stress levels. Age showed a positive association with stress (β=.003, t(2477)=3.65, p < .001), suggesting that older individuals reported higher stress. Sex also had a significant effect (β=- .018, t(2477)=-3.11, p=.002), with females reporting lower stress levels compared to males.

Irritability: The model was significant, R2=0.005, F(2,2477)=6.16, p=.002. Age had a significant positive effect on irritability (β=.002, t(2477)=2.42, p=.016), while sex did not have a significant effect.

Exhaustion: The model was not significant, R2=0.001, F(2,2477)=1.14, p=.32. Neither age nor sex showed a significant effect on exhaustion (p > .05).

These findings suggest that age has a positive association with stress and irritability, while sex is associated with differences in mood and stress, with females reporting lower levels of both.

RQ4 - Interaction Between Operating System and Emotional States

Mood: No significant difference was found in mood between iOS and Android users, F(1,2478)=.45, p=.504, suggesting that the operating system does not impact mood levels.

Stress: A significant difference was observed in stress levels between iOS and Android users, F(1,2478)=5.18, p=.023, with iOS users reporting lower stress compared to Android users.

Irritability: The analysis revealed a highly significant difference in irritability between the two groups, F(1, 2478)=6346.95, p < .001. iOS users reported significantly lower irritability than Android users.

Exhaustion: A significant difference was found in exhaustion levels, F(1,2478)=12.43, p < .001, with iOS users reporting lower exhaustion compared to Android users.

These results indicate that the operating system significantly affects stress, irritability, and exhaustion, with iOS users generally reporting better emotional states than Android users.

Table 3 summarizes the main findings obtained from inferential statistics.

Table 3: Summary of Inferential Statistical Results for Research Questions 1 - 4

Research Question	Analysis	Dependent Variable	Effect/Relationship	Key Findings
RQ1: Effect of Hearing Aid Usage on Emotional States	Independent t-tests	Mood, Stress, Irritability, Exhaustion	Hearing aid usage positively affects emotional states	Hearing aid users report higher mood, lower stress, irritability & exhaustion
RQ2: Correlation Between Emotional States and Perceived Hearing Loss	Pearson Correlation	Mood, Stress, Irritability, Exhaustion	Perceived hearing loss is associated with emotional states	Negative correlation with mood Positive correlation with stress & exhaustion
RQ3: Impact of Age and Sex on Emotional States	Linear Regression	Mood, Stress, Irritability, Exhaustion	Age & sex influence stress and irritability, limited effect on mood	Age is associated with higher stress & irritability Sex affects mood & stress
RQ4: Interaction Between Operating System and Emotional States	One-Way ANOVA	Mood, Stress, Irritability, Exhaustion	Operating system impacts stress, irritability, & exhaustion	iOS users report lower stress & exhaustion Higher irritability among Android users

6. Discussion

This study aimed to explore the emotional states of individuals with hearing loss, focusing on the impact of hearing aid usage, perceived hearing loss, demographic factors, and operating system differences. The results provide valuable insights into the emotional challenges faced by individuals with hearing impairments and highlight key factors influencing their well-being.

RQ 1 - Hearing Aid Usage and Emotional States

The findings show that individuals who used hearing aids reported significantly better emotional states compared to those who did not. Specifically, hearing aid users experienced improved mood, lower stress, less irritability, and reduced exhaustion. These results are consistent with previous studies suggesting that hearing aids can alleviate the emotional burden associated with hearing loss by improving communication and reducing frustration. The significant reduction in irritability and exhaustion among hearing aid users highlights the role of assistive technology in enhancing daily emotional functioning.

RQ 2 - Relationship Between Perceived Hearing Loss and Emotional States

The correlation analysis revealed that higher levels of perceived hearing loss and emotional burden were associated with worse emotional states. Specifically, individuals who perceived greater limitations in daily life or felt emotionally charged by their hearing loss reported higher levels of stress and exhaustion. Mood was also negatively correlated with hearing loss perception, indicating that the more severe the perceived hearing impairment, the lower the individual's mood. These findings support the well-established link between the severity of hearing loss and psychological distress.

Interestingly, irritability showed only weak correlations with hearing loss perception, suggesting that other factors, such as individual coping mechanisms or external stressors, may play a more significant role in influencing irritability levels.

RQ 3 - Impact of Age and Sex on Emotional States

The linear regression analysis indicated that age had a significant positive association with stress and irritability, suggesting that older individuals in the sample were more likely to report higher levels of these emotional states. However, age did not significantly affect mood or exhaustion. Sex differences were found to impact mood and stress, with females reporting slightly lower mood and stress levels compared to males. These findings align with previous research indicating sex-specific emotional responses to hearing loss, where men may be more prone to emotional distress.

RQ 4 - Operating System and Emotional States

The analysis of the operating system (iOS vs. Android) revealed significant differences in emotional states, particularly for stress, irritability, and exhaustion. iOS users reported lower levels of stress and exhaustion compared to Android users, and a strikingly higher level of irritability was observed among Android users. This difference may reflect variations in user behavior or platform-specific features that influence how individuals interact with the TrackYourHearing app. However, further research is needed to explore whether these differences are due to technical factors, user demographics, or other external variables.

Overall, the results indicate that hearing aid usage plays a crucial role in improving emotional well-being by reducing stress, irritability, and exhaustion. Perceived hearing loss was closely linked to emotional distress, particularly stress and exhaustion, while irritability was influenced by additional external factors. Age and sex were important demographic factors, with older individuals and males showing a higher propensity for stress and irritability. Finally, operating system differences highlighted that iOS users generally reported better emotional outcomes compared to Android users, particularly in terms of lower stress and exhaustion.

Comparison with prior Research

This study builds on prior research using the TrackYourHearing platform, which initially explored the feasibility of capturing emotional states in individuals with hearing loss through mobile health technology [8]. The current study extends these findings by examining the roles of hearing aid usage, perceived hearing loss, demographic factors, and operating system differences.

Both studies found that hearing aid usage positively affects emotional well-being, but the present study offers more detailed results, showing that hearing aid users report significantly higher mood and lower levels of stress, irritability, and exhaustion. The previous research identified a general association between hearing aid usage and emotional improvement, but this study provides more specific indicators, highlighting the importance of hearing aids in managing emotional challenges.

While the earlier research touched on the emotional impact of perceived hearing loss, this study reveals correlations between higher perceived hearing loss and increased stress and exhaustion, as well as lower mood. This exploration into the psychological effects of hearing loss indicates further clarity on the emotional burden linked to severity perception.

Additionally, this study considered demographic factors, revealing that older individuals are more prone to stress and irritability, and that females tend to report lower mood and stress compared to males.

In summary, while both studies agree on the emotional toll of hearing loss, the current research enhances the original findings by providing more detailed insights and introducing new variables, such as operating system differences, that influence emotional outcomes.

Implication

The findings provide valuable implications for the design of interventions aimed at improving the emotional well-being of individuals with hearing loss. The significant positive impact of hearing aid usage suggests that increasing accessibility and encouraging consistent use of hearing aids may help alleviate the emotional burden of hearing impairment. Additionally, the relationship between perceived hearing loss and emotional states highlights the need for personalized support strategies that address not only the physical, but also the psychological aspects of hearing loss.

Limitation

While the current study provides valuable insights into the emotional states of individuals with hearing loss, several limitations should be considered when interpreting the findings.

Sample Size and Demographics: The sample size of 63 participants limits the generalizability of the results. The relatively small and homogeneous sample, with participants primarily older adults, may not fully represent the broader population of individuals with hearing impairments.

Self-Reported Data: The study relied on self-reported data for both emotional states and hearing loss perception, which may be subject to recall bias or social desirability bias. Participants may not accurately remember or may underreport their emotional experiences or severity of hearing loss.

Platform Differences: While differences between Android and iOS users were observed, the study did not control for potential confounding variables such as user demographics, technical proficiency, or app usage behavior, which could have influenced the results.

Lack of Detailed Information on Hearing Aid Use: Although the study examined the effect of hearing aid usage on emotional states, it did not capture detailed information about the type, duration, or frequency of hearing aid use. These factors could significantly impact the emotional benefits of hearing aid use.

Limited Exploration of Coping Mechanisms: The study did not explore potential coping mechanisms

or other psychological factors that might mediate the relationship between hearing loss and emotional states.

7. Summary And Outlook

This study explored the emotional impact of hearing loss using the mobile health platform TrackYourHearing, focusing on a range of factors including hearing aid usage, perceived hearing loss severity, demographic variables such as age and sex, and operating system differences between Android and iOS users. The findings demonstrate that hearing aid usage is associated with improved emotional states, such as enhanced mood and reduced stress, irritability, and exhaustion. Conversely, perceived hearing loss was found to be closely linked to negative emotional outcomes, particularly heightened stress and feelings of exhaustion. Furthermore, differences in emotional responses based on age, sex, and operating system preference underscore the complex and multifaceted nature of emotional well-being among individuals with hearing impairments.

For future work, the integration of more personalized support strategies, tailored to the unique emotional and psychological needs of individuals, and the expansion of research to include more diverse populations will be crucial for advancing the understanding of how technology, such as hearing aids, and demographic factors influence emotional health in those living with hearing loss. Future research should also aim to uncover the long-term effects of consistent hearing aid usage, as well as investigate the underlying factors that may contribute to differences in emotional well-being between users of different platforms and technologies. Additionally, examining the role of other external factors, such as environmental noise and social support, may provide further insights into improving the quality of life for individuals with hearing impairments.

Reference

[1] Punch, J. L., Hitt, R., & Smith, S. W. (2019). Hearing loss and quality of life. Journal of communication disorders, 78, 33-45.

[2] Timmer, B. H., Bennett, R. J., Montano, J., Hickson, L., Weinstein, B., Wild, J., ... & Dyre, L. (2024). Social-emotional well-being and adult hearing loss: clinical recommendations. International Journal of Audiology, 63(6), 381-392.

[3] Ciorba, A., Bianchini, C., Pelucchi, S., & Pastore, A. (2012). The impact of hearing loss on the quality of life of elderly adults. Clinical interventions in aging, 159-163.

[4] Solheim, J., Kværner, K. J., & Falkenberg, E. S. (2011). Daily life consequences of hearing loss in the elderly. Disability and rehabilitation, 33(22-23), 2179-2185.

[5] Michels, T. C., Duffy, M. T., & Rogers, D. J. (2019). Hearing loss in adults: differential diagnosis and treatment. American family physician, 100(2), 98-108.

[6] van Hooren, S. A., Anteunis, L. J., Valentijn, S. A., Bosma, H., Ponds, R. W. H. M., Jolles, J., & van Boxtel, M. P. J. (2005). Does cognitive function in older adults with hearing impairment improve by hearing aid use?. International journal of audiology, 44(5), 265-271.

[7] Dillard, L. K., Matthews, L. J., Maldonado, L., Simpson, A. N., & Dubno, J. R. (2024). Demographic factors impact the rate of hearing decline across the adult lifespan. Communications Medicine, 4(1), 171.

[8] Pryss, R., Schlee, W., Reichert, M., Kurthen, I., Giroud, N., Jagoda, L., ... & Probst, T. (2019, July). Ecological momentary assessment based differences between Android and iOS Users of the trackyourhearing mhealth crowdsensing platform. In 2019 41st annual international conference of the IEEE engineering in medicine and biology society (EMBC) (pp. 3951-3955). IEEE.

[9] Schinkel-Bielefeld, N., Kunz, P., Zutz, A., & Buder, B. (2020). Evaluation of hearing aids in Everyday life using Ecological Momentary Assessment: What situations are we missing? American Journal of Audiology, 29(3S), 591–609. https://doi.org/10.1044/2020_aja-19-00075

[10] Timmer, B. H., Hickson, L., & Launer, S. (2018). The use of ecological momentary assessment in hearing research and future clinical applications. Hearing Research, 369, 24–28. https://doi.org/10.1016/j.heares.2018.06.012

[11] Sciences, P. M. &. S. (n.d.). Evaluation of Auditory Reality and Hearing aids using an Ecological Momentary Assessment (EMA) AP. - RWTH AACHEN UNIVERSITY MSS - Deutsch. https://www.mss.rwth-

aachen.de/cms/mss/forschung/publikationen/~eisq/publikationen-einzelansicht/?file=769547

[12] Burke, L. A., & Naylor, G. (2020). Daily-Life fatigue in mild to moderate hearing impairment: An Ecological Momentary Assessment study. Ear And Hearing, 41(6), 1518–1532. https://doi.org/10.1097/aud.0000000000000888

[13] Wu, Y., Stangl, E., Zhang, X., & Bentler, R. A. (2015). Construct Validity of the ecological momentary Assessment in Audiology research. Journal of the American Academy of Audiology, 26(10), 872–884. https://doi.org/10.3766/jaaa.15034

[14] Von Gablenz, P., Kowalk, U., Bitzer, J., Meis, M., & Holube, I. (2021). Individual hearing aid benefit in real life evaluated using ecological momentary assessment. Trends in Hearing, 25. https://doi.org/10.1177/2331216521990288

[15] Vercammen, C., Oosthuizen, I., Manchaiah, V., Ratinaud, P., Launer, S., & Swanepoel, D. W. (2023). Real-life and real-time hearing aid experiences: Insights from self-initiated ecological momentary assessments and natural language analysis. Frontiers in Digital Health, 5. https://doi.org/10.3389/fdgth.2023.1104308

[16] Kraft, R., Schlee, W., Stach, M., Reichert, M., Langguth, B., Baumeister, H., Probst, T., Hannemann, R., & Pryss, R. (2020). Combining mobile crowdsensing and ecological momentary assessments in the healthcare domain. Frontiers in Neuroscience, 14. https://doi.org/10.3389/fnins.2020.00164