



# Hearing Care Providers' Perspectives on the Utility of Datalogging Information

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1 **Title page**

2 **Title:** Hearing care providers' perspectives on the utility of datalogging information

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5

6 **Key words:** hearing aids, datalogging, mixed-methods

7

8

9 **Abstract**

10 **Purpose:** To learn how (a) datalogging information is being used in clinical practice by hearing  
11 care professionals (HCPs) in the US, and (b) HCPs' opinions about how information collected  
12 through the hearing aids could be broadened in clinical application.

13 **Methods:** A mixed methods approach was undertaken consisting of an online quantitative survey  
14 and qualitative structured telephone interviews. Survey data were analyzed using descriptives and  
15 chi-squared analyses. The interview data were transcribed and analyzed using inductive content  
16 analysis.

17 **Results.** In total, 154 HCPs completed the survey, of whom 10 also completed an interview.  
18 Survey data showed that most HCPs use datalogging for conventional applications, such as  
19 counseling and fine tuning during a hearing aid trial. Interview data highlighted four additional  
20 desirable datalogging features: (1) data about the sound environment; (2) details about operational  
21 aspects of hearing aid use; (3) data about use and non-use; and (4) automated diagnosis of a  
22 hearing aid malfunction. HCPs also envisaged using datalogging in novel ways, such as for  
23 demonstrating hearing aid value and supporting decision-making.

24 **Conclusions.** Today, datalogging is primarily used as a tool for counseling clients about hours and  
25 patterns of hearing aid use, and for troubleshooting and fine tuning. However, HCPs suggested  
26 novel and more ambitious uses of datalogging such as for sending alerts about non-use, for  
27 automated diagnosis of a hearing aid malfunction, and for helping the client in their decision-  
28 making. It remains to be seen whether in the future these will be implemented into clinical practice.

29

30

31

32 **Introduction.**

33 Datalogging is the automated recording and storing of data collected about hearing aid and  
34 cochlear implant use. It has been around since the 1990's when Mangold, Ringdahl and Eriksson-  
35 Mangold developed a hearing aid with a datalogging feature in order to understand patient usage  
36 patterns of a multimemory hearing aid (Mangold et al., 1993, Ringdahl, 1994). In the intervening  
37 time, datalogging has become a standard feature in almost all makes and models of hearing  
38 devices, and the information being logged is expanding. Standard datalogging records total use  
39 time, volume control usage and program usage. Some commercially-available hearing aids and  
40 cochlear implants now log parameters additional parameters such as the battery life, time spent  
41 streaming data, sound pressure level input (SPL), listening environment classification, directional  
42 microphone settings, and signal-to-noise ratio (SNR). However, due to data storage limitations this  
43 information is typically stored cumulatively over time, i.e., average use is computed from an ever-  
44 growing data log (Kuvadia & Camacho, 2017). On the other hand, experimental hearing aids  
45 connected via a smartphone to the internet have greater storage capacity, so they can log, on a  
46 time-stamped minute-by-minute basis, the SPL, noise floor level, signal modulation parameters,  
47 SNR of the listening environment in separate frequency bands, and can make sound environment  
48 classifications (Pontoppidan et al., 2018).

49 For research, datalogging has been used to compare self-reported hearing aid and cochlear  
50 implant use with that collected by the hearing devices, both in adults (Gaffney, 2008; Solheim &  
51 Hickson, 2017; Maki-Torkko, Sorri, & Laukli, 2001; Laplante-Lévesque, Nielsen, Jensen, & Naylor,  
52 2014) and in children (Gustafson, Ricketts, & Tharpe, 2017). Datalogging information has also  
53 been used to understand the relationship between device use patterns and outcome (Easwar,  
54 Sanfilippo, Papsin, & Gordon, 2018), predictors of device use (Walker et al., 2013; Wiseman &  
55 Warner-Czyz, 2018), and for describing listening environments encountered by device users  
56 (Easwar, Sanfilippo, Papsin, & Gordon, 2016; Cristofari et al., 2017; Humes, Rogers, Main, &  
57 Kinney, 2018; Gaffney, 2008). It has even been proposed that datalogging information combined

58 with other sources of clinical and real-world data, can be stored in a data repository and later used  
59 for evidence-based public health policy making (Dritsakis et al., 2018, Saunders et al., 2019). In  
60 sum, the above studies show that (a) adults, and the parents of children who use hearing device,  
61 tend to overestimate device usage - particularly when device use is irregular; (b) more consistent  
62 device usage results in better outcomes; (c) device usage is greater among children who are older,  
63 have poorer hearing, and who have a mother with a higher level of education, and among adult  
64 hearing aid users who have more severe hearing impairment and prior hearing aid experience; (d)  
65 device users are exposed to a variety of listening environments, but that adults are poor at  
66 classifying the sound environments they are exposed to; and (e) more hearing aid use is  
67 associated with exposure to higher sound and noise levels and more diverse sound environments.

68 Of course, data collected using datalogging should be interpreted with some degree of caution  
69 because the data are dependent on each manufacturers' algorithms for data collection, analysis  
70 and classification of the sound environment which likely vary in their accuracy. To illustrate,  
71 hearing aid usage time is usually computed cumulatively over time by measuring the number of  
72 hours that the hearing aid is turned on. Thus, if a client removes their hearing aid but does not  
73 open the battery door, the hours of usage logged will be an overestimation of actual use.

74 While publications clearly describe how datalogging information has been used for research, it is  
75 less clear how datalogging information is used in clinical practice. Back in 2007, Mueller discussed  
76 three possible ways the data could be used: (i) as a counseling tool on the day of fitting to make  
77 patients aware that the clinician has access to information about hearing aid use, (ii) as a  
78 counseling tool at the initial follow-up visit to facilitate discussion about overall use, and patterns of  
79 use of programs and volume control, and (iii) as a tool to assist with troubleshooting and fine tuning  
80 the hearing aids. To date, there appears to be just one published study that has investigated how  
81 hearing care providers (HCPs) use datalogging information in clinical practice (McMillan, Durai, &  
82 Searchfield, 2018). One hundred eight audiologists in New Zealand were surveyed. It was found  
83 that almost 90% reported datalogging information to be clinically useful. The information was used

84 by almost all survey respondents for counseling (94%), but many also used it for fine tuning the  
85 hearing aids and when working with individuals who were unable to provide accurate self-reports.  
86 The information most often looked at was hours of use, program and volume control use, and time  
87 spent in different listening environments. The information was most often accessed and used  
88 during the patient's first follow-up visit. The individuals surveyed in this study were all members of  
89 the New Zealand Audiology Society, each held a Master of Audiology degree or the equivalent,  
90 they were relatively young, with 67% of respondents being aged 25-45 yr., and 48% had less than  
91 ten years of experience practicing audiology. All adults in New Zealand with a permanent hearing  
92 loss and who could benefit are, at a minimum, eligible for a government subsidy for hearing aids,  
93 and some are eligible for government hearing aid funding scheme that covers the full cost of  
94 hearing aids (<https://www.enable.co.nz/services/hearing-aid-funding-and-subsidy/>).

95 We were interested in the opinions about datalogging held by a broader range of HCPs, including  
96 hearing aid dispensers, hearing instrument specialists and audiologists, who practiced in the US  
97 where there is almost no government funding for hearing aids for adults - beyond that provided for  
98 Veterans. The aim of the study was to learn (a) how datalogging information is being used in  
99 clinical practice in the US and (b) how HCPs think information collected through the hearing aids  
100 could be expanded to broaden its clinical application. To this end, we conducted a short survey,  
101 followed by telephone interviews with a subset of the sample surveyed.

102

### 103 **Methods.**

104 The study received approval from the Research Ethics Committee of the Capital Region of  
105 Denmark.

106 Participants. All participants were HCPs who were actively fitting amplification in the USA and  
107 whose contact information was stored in a database at Oticon USA. Recruitment took place in two  
108 stages. In stage 1, an invitation to complete the survey was sent to 84 HCPs. This version of the

109 survey included an invitation to participate in a follow-up phone interview. Thirty-one HCPs  
110 completed the survey and of these, ten self-selected to participate in a follow-up interview. In stage  
111 2, the survey was sent to an additional 500 HCPs. This version of a survey did not include an invite  
112 for a follow-up interview and differed in terms of 3 items (see below for details). An additional 123  
113 HCPs completed this second survey. The overall survey response rate was 26.4%.

#### 114 Test measures.

115 • **HCP Survey.** A short survey about use of datalogging information was developed and then  
116 input regarding content and phrasing was obtained from three audiologists. Changes were  
117 made based upon the input, resulting in Version 1 of the survey.

118 Version 1 of the survey consisted of 9 demographic and job-related items, and 3 items about  
119 use of datalogging information. Each of these datalogging items had a single follow-up  
120 question (total of 3) contingent upon the initial response.

121 Version 2 of the survey consisted of the same 9 demographic and job-related items, and the  
122 same 3 items about use of datalogging information. However, in this version there were 5  
123 possible follow-up questions contingent upon the initial response. The additional questions  
124 were added following input from colleagues.

125 The surveys were entered into the Qualtrics<sup>XM</sup> Survey Software which permits responses to be  
126 formatted for a single option response, multiple option responses, and free-text responses, as  
127 well as for a contingency pathway. Each of these formats were used in the surveys here. Both  
128 surveys can be found in Appendix 1.

129 • **HCP Interview.** A structured interview guide was developed to learn about participants'  
130 thoughts about use and collection of real-world data from clients and their hearing aids. It  
131 consisted open-ended questions with follow-up questions and prompts. See Appendix 2.

132 Participant payment. Participants did not receive payment for completing the survey. The ten HCPs  
133 who took part in the one-on-one phone interview received a \$50 gift card.

134

135 Procedures

136 Stage 1. Emails were sent to 84 HCPs. The body of the email message comprised an invitation to  
137 complete the survey by following the in-message link to the Qualtrics survey page. Beyond  
138 collecting email addresses of individuals who self-selected to be contacted for a follow-up  
139 interview, no personal health information or identifiable information were collected. Data were  
140 collected over a period of eleven days beginning on May 17<sup>th</sup>, 2019.

141 All HCPs who responded that they were willing participate in a one-on-one structured phone  
142 interview and who provided an email address were sent an email inviting them to schedule an  
143 interview. Of the 15 who initially volunteered to be interviewed, ten were successfully contacted  
144 and interviewed. All but one interview took place via skype for business. One individual happened  
145 to be visiting the test site and so was interviewed in person. Interviews took place between July  
146 10<sup>th</sup> and July 30<sup>th</sup>, 2019 with the first (G.S.) and third author (L.T.) Prior to starting all interviews, we  
147 asked permission to record the interview. All agreed to this. Electronic recordings of each interview  
148 were stored on a secure password-protected server for transcription.

149 Stage 2. Emails were sent to an additional 500 HCPs. The body of the message was identical to  
150 that in stage 1, except that no mention was made of a follow-up interview, and the in-message link  
151 took potential participants to Version 2 of the survey. Data were collected over an 8-day period,  
152 between July 10<sup>th</sup> and July 18<sup>th</sup>, 2019.

153

154 **Analyses.**

155 Survey data were downloaded from the Qualtrics software into an excel spreadsheet, which was  
156 then read into IBM SPSS Statistics for analyses. Analyses comprised of descriptive, crosstabs and  
157 chi-squared analysis.



158 Interview data were transcribed and analyzed using inductive content analysis as described by  
159 Erlingsson and Brysiewics (2017)., Content analysis was used to analyze the interview data  
160 because it is recommended when there is limited research or theory about a phenomenon (Hsieh  
161 and Shannon, 2005), which is the case with HCPs perceptions of datalogging. An inductive  
162 approach was used as findings were generated from the data, as opposed to being mapped to an  
163 existing theory or model (deductive). The analysis was completed by the second author (A.B.), who  
164 was not involved in the interviews. She was provided with the aims of the study and the transcripts.  
165 As outlined by Erlingsson and Brysiewics (2017), initially, transcripts were read and re-read,  
166 ensuring the second author (A.B) was familiar with the data. Notes were written down, identifying  
167 the main concepts relevant to this study. Then, relevant text was highlighted and broken into  
168 smaller sections, called meaning units. Meaning units were shortened or condensed, whilst  
169 ensuring that the core meaning was retained. Condensed meaning units were assigned a code or  
170 label and similar codes were grouped together, creating categories. Finally, two or more categories  
171 that were rich in latent meaning, referring to why or how, were grouped together to create themes.  
172 The final report, produced by the second author (A.B), was reviewed and agreed to by the first  
173 author (G.S) who had conducted all interviews. Thus, the qualitative findings were confirmed by the  
174 first and second author through two separate means.

175

## 176 **Results.**

### 177 **1. Survey Data**

178 Demographic information. Table 1 shows demographic information from the survey respondents  
179 and interviewees separately. Note, however, that the data from the 10 individuals who were  
180 interviewed is included in the survey respondent data. With the exception that there were a greater  
181 proportion of males among the interviewees than the survey respondents, the HCPs who were

182 interviewed were generally demographically similar to those who completed the surveys, thus their  
183 views can be expected to represent those of the larger group.

184 How often do HCPs use datalogging information? Of the 154 survey respondents, 49.4% ( $n=76$ )  
185 said they looked at datalogging information 'always or usually', 40.9% ( $n=63$ ) said they looked at it  
186 'sometimes', 8.4% ( $n=13$ ) said 'rarely', and 1.3% ( $n=2$ ) reported that they 'never' looked at  
187 datalogging information. Table 2 shows the reasons given for not using datalogging by the 78  
188 respondents who responded that they 'sometimes', 'rarely', or 'never' looked at datalogging  
189 information. Participants were permitted to choose more than one reason for not using datalogging  
190 information - hence there are more than 78 responses to this question.

191 When datalogging information is unused it is generally because it is not considered to have clinical  
192 utility. This is seen both from the closed set responses but also from the free text responses.

193 Are HCPs interested in receiving additional datalogging information? In general, respondents were  
194 interested in the possibility of receiving more detailed data logging information, such as how and  
195 when a client adjusts his/her hearing aids, or graphs of minute-by-minute use in different listening  
196 environments, as illustrated by the fact that 77.3% ( $n=119$ ) participants responded 'Yes, I am  
197 interested in this'. On the other hand, 16.9% ( $n=26$ ) responded 'unsure', 3.9% ( $n=6$ ) responded  
198 'Yes, but it is not practical for me', and 1.9% ( $n=3$ ) responded 'no'. When these latter 34  
199 participants were asked to further explain their thinking, most ( $n=29$ ) responded 'I am not sure how  
200 I would use the data in my clinical care', four cited technical concerns (unsure how to access the  
201 data, additional data might decrease battery life), four considered that currently available data is  
202 and should be sufficient for provision of clinical care, and one said (s)he has no time to add this to  
203 clinical care.

204 Is there value in providing data access to clients? More than half of the respondents (58.4%,  $n=90$ )  
205 said they would be interested in providing their clients with an app that allowed the client to see  
206 detailed information about his/her own hearing aid use, 29.2% ( $n=45$ ) were unsure about this,  
207 10.4% ( $n=16$ ) said they were not interested in this, and 1.9% ( $n=3$ ) felt it would be impractical.

208 Reasons given by those who said they were not interested are shown in Table 3. Once again,  
209 participants could give more than one reason, and once again the primary reasons could be  
210 classified as the information having little or no clinical utility.

211 When and how is datalogging used? The 123 participants who responded to version 2 of the  
212 survey answered two additional questions: 'When do you look at the datalogging information?' and  
213 'How do you use datalogging information in your clinical process?'. Participants were permitted to  
214 choose more than one response, so again there are more than 123 responses to each question.  
215 Over three quarters of respondents look at the datalogging information during a follow-up  
216 appointment (88.6%,  $n=109$ ), 17.1% ( $n=21$ ) look at it 'on a regular basis', 4.1% ( $n=5$ ) look at it prior  
217 to a follow-up appointment and 4.9% ( $n=6$ ) look at it at other times, such as when a problem  
218 arises, at each visit and if a client requests the information.

219 Table 4 shows how participants use datalogging information in clinical practice. The fact that  
220 participants use datalogging information in multiple ways shows that it can have many applications  
221 – in particular, for monitoring/confirming hearing aid use, for counseling, and as a basis for making  
222 hearing aid adjustments.

223 Chi-square analyses were used to determine whether there were any relationships between  
224 demographic variables (age, education level, years in practice, daily client load) and interest in use  
225 of datalogging information, interest in additional data and in providing client with access to data.  
226 There were no statistically significant relationships indicating that, among the population here,  
227 demographic variables are not determinants of use of datalogging.

228

## 229 **2. Interviews**

230 Responses from the interviewees are presented below in three sections, reflecting the questions  
231 asked in the interview: current perception and use of datalogging, future datalogging features, and  
232 future applications of datalogging. After each quote we provide information about the individual

233 from whom the quote was taken in terms of a coded identifier, the gender and the number of years  
234 they have practiced audiology.

235 Current perception and use of datalogging. Two themes emerged that represented the HCPs  
236 current use and attitude toward datalogging. An overview of the themes, categories and codes  
237 relating to current perception and use of datalogging is summarized in Table 5.

238 **(i) A positive attitude toward capabilities** *'The more information you can give us, the*  
239 *better we can do our job.'* (HCP 5, Male, 10+) (Coded identifier, gender, number of years'  
240 experience working as an HCP).

241 Broadly, HCPs had a positive attitude toward datalogging. They reported datalogging was  
242 'helpful' and 'useful' to them and discussed how datalogging could be expanded to enhance  
243 aspects of clinical care, such as for counseling and fine tuning, as further described below.  
244 Further reinforcing HCPs' positive attitude toward prospective datalogging capabilities were the  
245 comments made by three HCPs who acknowledged minimal current use of datalogging. All  
246 three were interested in learning how other HCPs use datalogging and exploring how they could  
247 use it in their clinic. For example, one HCP stated

248 *'I look forward to using it. I look forward to kind of experimenting with it and see how much I*  
249 *use it and when it will be the most useful.'* (HCP 8, Female, 10+).

250 **(ii) Application is limited to specific clients and purposes**

251 Although HCPs had a positive attitude toward datalogging in clinical care, many highlighted  
252 currently only using it to address the needs to specific clients and/or for a specific purpose. For  
253 example, one HCP explained 'I will be honest. I certainly, I don't think it is something that I  
254 would use for the majority of patients.' (HCP 8, Female, 10+). There was agreement among  
255 HCPs that 'checking' datalogging was most helpful for clients who were having difficulties with  
256 their hearing aid. HCPs often used datalogging to check clients hearing aid use, as well as use

257 of volume and programs. HCPs reported using this information for counselling or fine tuning the  
258 hearing aid, particularly during a hearing aid trial. For example, one HCP explained

259 *'... especially in their trial period and they say they're having trouble adjusting to the sound*  
260 *and I look at datalogging and they've only worn them for two hours a day, that tells me, that*  
261 *I need to counsel a little bit more about the importance of wearing the hearing aids all day*  
262 *every day for the first couple weeks, to let your brain adjust to the sound.'* [\(HCP 1, Female,](#)  
263 [0-1\).](#)

264 Future uses of datalogging information. Four desirable features for datalogging were described by  
265 HCPs: (1) data about the sound environment; (2) details about operational aspects of hearing aid  
266 use; (3) data about use and non-use; (4) automated diagnosis of a hearing aid malfunction. There  
267 is no table for this section because there are no latent themes in the responses.

268 **(i) Data about the sound environment 'I think the environmental data would be the**  
269 **biggest one that I would like to see in there.'** [\(HCP 2, Male, 6-10\)](#)

270 HCPs wanted more information on the sound environment relevant to client's lifestyle. For  
271 example, HCPs were interested in knowing how often clients were in different types of sound  
272 environment, such as noisy versus quiet. They wanted this information to be presented via a  
273 classification system or by having access to the signal-to-noise ratio. Several HCPs saw value  
274 in clients being able to take an auditory 'snapshot' or a sound recording of a challenging sound  
275 environment. For example, one HCP explained:

276 *'If there was a way of them marking, the patient to somehow subjectively say 'okay I need*  
277 *to; this is the place I'm having trouble' and so we, you know, take a snippet of that situation,*  
278 *and then we can sit down and analyse what was going on in that information, in that*  
279 *sample.'* [\(HCP 5, Male, 10+\)](#)

280 The overall benefit and use of more detailed information on the sound environment was  
281 considered helpful for aspects of fine tuning, counselling and troubleshooting, and for building a

282 better understanding of the client's needs. HCPs also considered this information helpful for  
283 clients who were 'vague' or had difficulty recalling their sound environments.

#### 284 **(ii) Details about operational aspects of hearing aid use**

285 HCPs wanted more detail about how their clients operate their hearing aids. They were  
286 interested in being able to monitor clients' use of each program, use of streaming, volume  
287 control changes and how they connected the hearing aids to their phone. HCPs were also  
288 interested in having data that would provide insight as to whether clients were incorrectly  
289 operating their hearing aids. They said they would use this type of information for counselling.

290 In particular, HCPs were interested in accessing information about battery use and life. They  
291 wanted this information for troubleshooting reports of battery life issues. Several HCPs  
292 explained that clients often unknowingly have streaming turned on, which considerably reduces  
293 the life of the battery.

294 *'... people might [sic] realize, may not think they're streaming, and they actually are*  
295 *streaming. They're turning on like the microphone or the end on the on the phone the*  
296 *phone mic or something like that and then say 'hey you don't realize it but your phone is*  
297 *actually connected streaming Bluetooth for, you know, six hours through the day.'* [\(HCP 2,](#)  
298 [Male, 6-10\)](#)

#### 299 **(iii) Data about hearing aid use and non-use**

300 HCPs reported that obtaining information about hearing aid use and non-use would enable  
301 them to be proactive in their client care. Being proactive was considered important for  
302 preventing client frustration, impressing clients, and minimizing hearing aid returns and/or  
303 nonuse<sup>4</sup>. HCPs explained that having earlier knowledge that an individual is not using their  
304 hearing aids would help them problem solve with clients. They said that it would be valuable to  
305 have this kind of information throughout the lifetime of the hearing aid, both during a hearing aid  
306 trial period and beyond, as illustrated by the following two statements made by different HCPs:

307 *'Great example, just this past week: I loaned out some demos to a guy and he came back*  
308 *and told me he only wore them one day, because he was afraid to wear them. He thought*  
309 *he might lose them or damage them. And if I found out, you know, two days later, that he*  
310 *hadn't been wearing them, I could have proactively called him and asked, you know, 'is*  
311 *something wrong? Why are you not wearing them?'* [\(HCP 4, Male, 10+\)](#)

312 *'Certainly, would want to know if usage changes for some reason or the other. Just last*  
313 *week, a patient said she had stopped using whatever hearing instruments about a month*  
314 *ago and then didn't make an appointment to come in for a month. That would be very good*  
315 *information.'* [\(HCP 7, Female, 10+\)](#)

#### 316 **(iv) Automated diagnosis of a hearing aid malfunction**

317 Although not a specific question in the structured interview guide, several HCPs brought up the  
318 considerable value of an automated diagnosis of a hearing aid malfunction, i.e. a hearing aid  
319 that could self-test for functional problems. Two HCPs described this feature as being like a  
320 'warning light in your car' prompting you that your fuel is low. HCPs reported that having a  
321 warning of a hearing aid malfunction would help reduce clients' frustration. They noted that  
322 often clients are unaware of a malfunctioning hearing aid and thus do not seek help in a timely  
323 manner. They suggested that being sent an alert about a malfunctioning receiver or microphone  
324 would be highly positive and advantageous and would allow them to provide proactive care. As  
325 one HCP explained:

326 *'That's going to really impress any patient, that if you call them and tell them you know*  
327 *we've discovered that your microphone is malfunctioning, we need you to come in so that*  
328 *we can take care of that. That's going to blow them away in terms of customer service.'*

329 [\(HCP 4, Male, 10+\)](#)

330

331 Similarly, some HCPs also saw value in being notified if a hearing aid were lost and also saw  
332 value in then being able to locate where the hearing aid was last used.

333 *'If a hearing aid was lost, if it separates from its partner, I would love that [notification].'*

334 [\(HCP 10, Female, 10+\)](#)

335 Associated with this, several HCPs reflected on the issue of client privacy if they were to be able  
336 to more closely monitor clients hearing aid use (or non-use). HCPs commonly resolved this  
337 concern by acknowledging that clients should be able to 'opt-in' or 'opt-out' of datalogging.

338 Future applications of datalogging. HCPs discussed aspects of applications of datalogging: (i)  
339 different levels of datalogging over time, (ii) the dubious value of client-initiated alerts, and (iii)  
340 demonstrating hearing aid value and supporting decision-making. [An overview of the themes,](#)  
341 [categories and codes relating to HCPs perspectives toward the future applications of datalogging](#)  
342 [is summarized in Table 6.](#)

343 **(i) Different levels of datalogging over time: *'It makes sense to change it obviously.'*** [\(HCP](#)  
344 [5, Male, 10+\)](#)

345 When HCPs discussed specific features and how datalogging could be expanded to assist them  
346 in clinical practice, it emerged that there was a difference in what they wanted from datalogging  
347 information relevant over time. For example, during a hearing aid trial period, HCPs wanted  
348 comprehensive information and reported they would like to access information related to  
349 different sound environment, operational aspects of the hearing aid and client's satisfaction, use  
350 and non-use. However, once the trial period was over, they were happy for datalogging  
351 information to be collected on an ongoing basis, but only wanted to be notified when the data  
352 indicated a change in usage or behavior – such as hearing aid malfunction, non-use of the  
353 hearing aids, or a change in the sound environment profiles. They also reported that it would be  
354 unnecessary to receive alerts about use and behavior changes after the hearing aid trial period  
355 was completed. As one HCP summed up:



356 *'I would probably want more kind of comprehensive, more specific information during the*  
357 *trial period, because that would really be used as a tool to give me information on how I can*  
358 *program the hearing aids or, you know, fine tune the hearing aids to give that client more*  
359 *benefit. Versus if it's an older device I would really just want to know, are they still using it?'*  
360 [\*\(HCP 1, Female, 0-1\)\*](#)

361 **(ii) The dubious value of client-initiated real time alerts *'Obviously the chance of it being***  
362 ***abused is quite high.'*** [\*\(HCP 5, Male, 10+\)\*](#)

363 HCPs were asked to reflect on the value of real-time client-initiated alerts, meaning the ability  
364 for the client to directly alert the HCP about a concern or problem. While most HCPs saw value  
365 in receiving an automated alert in specific situations – such as hearing aid malfunction or  
366 hearing aid non-use, they were dubious about having clients initiate these alerts. Several HCPs  
367 were concerned that some clients would *'abuse'* this feature and that they would therefore be  
368 *'bombed'* with client-initiated alerts. Other HCPs said that a client-initiated real time alert was  
369 not any different to the current situation in which a client sends an email or phones when an  
370 issue arises.

371 Furthermore, HCPs were generally against receiving information about a problem or concern  
372 directly in an alert. Instead, they wanted the detailed alert to go into the hearing aid software,  
373 with a notification being sent via email or SMS that there was alert to be investigated. As one  
374 HCP explained:

375 *'You know, a flash of a light and you have a notification. Then you got to log in to software*  
376 *to find out what the notification's about.'* [\*\(HCP 4, Male, 10+\)\*](#)

377 This approach was preferred by HCPs because it allowed them to control when they accessed  
378 the alerts.

379

380

381 **(iii) Demonstrating hearing aid value and supporting decision-making**

382 HCPs discussed using datalogging information to demonstrate the value of hearing aids to their  
383 clients. For example, HCPs reported that having datalogging information that could demonstrate  
384 the 'amount of work' a hearing aid is doing in different situations, could help a client see value in  
385 the cost of their hearing aids. As one HCP explained:

386 *'They're [hearing aid] extremely technical. And if they [client] can see, get a glimpse of how*  
387 *technical they are, even if they don't necessarily understand all of it, but they can see that*  
388 *there's a lot going on and I know how to run all of that, that adds value. It helps them. It*  
389 *helps them see value in the money that they paid.'* ([HCP 2, Male, 6-10](#))

390 Similarly, some HCPs saw the potential benefit of datalogging information to help objectively  
391 demonstrate to the client the level of hearing aid technology that is most suited to their need.  
392 Thus, this could be used to assist clients with decision-making about a hearing aid model. HCPs  
393 provided examples of how this could be used to justify the need for higher or lower level  
394 technology. As one HCP explained:

395 *'I think that if I have a client, for example, that is having, comes in and says, they're having*  
396 *a lot of trouble in certain situations and they may have a lower technology hearing aid, if I'm*  
397 *able to see that they're in noise, significantly more than they said they are, when I was*  
398 *giving my recommendation, that would help me determine that, maybe a higher level of*  
399 *technology with more help in background noise, would be more useful for that client.'* ([HCP](#)  
400 [1, Female, 0-1](#))

401  
402 **Discussion**

403 The aim of this study was first to learn how datalogging information is being used in clinical  
404 practice in the US by having practicing HCPs complete a short survey, and second, to dig deeper

405 into this by interviewing a subset of survey respondents to find out how they think datalogging and  
406 other data collected through real world use of hearing aids could be used in clinical practice.

407 Survey findings showed that most HCPs currently use datalogging, and that it is most commonly  
408 used during follow-up appointments. When it is not used, it is because the HCPs considered the  
409 information provided has little or no clinical utility, is not actionable, or if a client has no problems,  
410 no action is needed. Interview findings were consistent with survey findings in that most HCPs had  
411 a positive attitude toward datalogging, wanted more features from it and wanted more  
412 comprehensive information during the hearing aid trial compared to on an ongoing basis.

413 Furthermore, while the surveys and interviews showed that HCPs used datalogging information for  
414 conventional applications such as monitoring hearing aid use, counselling, and fine tuning the  
415 hearing aids, the HCPs who were interviewed identified novel uses for datalogging such as for  
416 tracking changes in hearing aid use, sending alerts about non-use, for automated diagnosis of a  
417 hearing aid malfunction, and for helping the client in their decision making. Both the survey and  
418 interviews indicated that HCPs were reluctant to give clients access to data and control of alerting  
419 capabilities. They reported that clients would not be interested and/or capable of understanding  
420 data logged information, and that some clients would 'abuse' the option for initiating alerts. On the  
421 other hand, HCPs were open to receiving automated alerts about hearing aid malfunction or non-  
422 use, as long as they had an element of control over these alters by having details about the  
423 problem stored in hearing aid software, rather than being provided in the alert itself. In this way  
424 they could look at the alert when they chose to do so. Overall then, the findings from our survey  
425 and interviews are in line with the findings of McMillan et al. (2018), illustrating that datalogging is  
426 used and considered valuable to HCPs in clinical practice.

427 HCPs who took part in the interviews discussed that they would like to expand some datalogging  
428 features so that it can be have benefits that extend beyond counselling and fine-tuning hearing  
429 aids. They wanted more detailed information on clients use of programs, use of volume control and  
430 their sound environment. Once again, this finding is consistent with that reported by McMillan et al.

431 (2018) who reported that program use, use of volume control and a sound 'snapshot' were useful  
432 datalogging information for HCPs to have during a hearing aid trial. In the present study, HCPs  
433 also mentioned the potential value of an objective sound 'snapshot', explaining this would be  
434 helpful for clients who have difficulty objectively recalling details. They also suggested that this  
435 information could be used to help clients understand which hearing aid level of technology is most  
436 suitable for them.

437 While the study design of McMillan et al. (2018) did not observe HCPs use of detailed datalogging  
438 information after the hearing aid trial period – because the observation period was limited to  
439 hearing aid fitting and follow-up appointments only – information from the present study suggests  
440 that HCPs want different information during a hearing aid trial as compared to later on. Although  
441 not stated aloud, this might be because they are willing to give more intensive and extensive  
442 support during the trial period than once a hearing aid has been purchased. On the other hand, the  
443 HCPs interviewed did not intend to stop monitoring datalogging information entirely, but they were  
444 more selective in the information they wanted to receive. First, HCPs said that automated alerts  
445 about a hearing aid malfunction and hearing aid non-use would be valuable. They explained that  
446 months can pass before they become aware of cessation or malfunction because many clients  
447 may not realize that their hearing aid is not performing optimally or may only tell the HCP to non-  
448 use during a scheduled appointment. Thus, having real-time alerts in these specific instances  
449 would allow HCPs to proactively contact clients, which HCPs perceived as demonstrating a high  
450 level of customer support and demonstrating their value to their clients. Second, HCPs said that  
451 having information relating to use of streaming and battery consumption would be highly beneficial  
452 because it is not uncommon for clients to raise concerns over 'short' battery life. The HCPs  
453 hypothesized this is because some clients unknowingly have streaming capabilities enabled. In  
454 such cases the HCPs said they would use the datalogging information to show the client that they  
455 were in streaming mode more often than they knew and could show them that streaming directly  
456 impacted battery life.

457 While HCPs wanted a real-time alert relating to hearing aid non-use or malfunction there were few  
458 other instances in which an alert was desired, and they were very wary of permitting clients to  
459 generate real-time alerts. In general, they commonly said that they preferred to schedule an  
460 appointment with the client once they were made aware of an issue rather than to use a remote  
461 care app to address the problem. The reluctance to use teleaudiology has been reported  
462 elsewhere (Singh, Pichora-Fuller, Malkowski, Boretzki, & Launer, 2014), although a recent  
463 systematic review suggests attitudes are changing (Ravi, Gunjawate, Yerraguntla, & Driscoll,  
464 2018).

465 While using a mixed-methods approach allowed for a better understanding of HCPs current use  
466 and future wants from datalogging than either purely quantitative or qualitative methods used on  
467 their own, a limitation of this study was the use of convenience sampling for both surveys and  
468 interviews and therefore self-selection bias may be present. More specifically, it is likely that the  
469 individuals who participated in the study had either strongly positive or strongly negative views  
470 about data logging that they wanted to share with the investigators. However, it is not possible to  
471 ascertain this from the study.

472

## 473 Conclusion

474 In conclusion, it seems that Mueller's 2007 suggestions that datalogging be used as a tool for  
475 counseling clients about hours and patterns of hearing aid use, and for troubleshooting and fine  
476 tuning, has come into practice. However, today's HCPs can envisage novel and more ambitious  
477 uses of datalogging such as for tracking changes in hearing aid use, sending alerts about non-use,  
478 for automated diagnosis of a hearing aid malfunction, and for helping the client in their decision-  
479 making. It remains to be seen whether the combination of technology and clinical interest will see  
480 these implemented into clinical practice in a few years' time.

481

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484

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Table 1. Demographic information from 154 survey respondents and 10 interviewees

		Survey respondents		Interviewees	
		<i>n</i>	%	<i>n</i>	%
<b>Age group (yr.)</b>	<b>20-30</b>	9	5.8	2	20
	<b>31-40</b>	37	24.0	2	20
	<b>41-50</b>	30	19.5	2	20
	<b>51-60</b>	39	25.3	1	10
	<b>61+</b>	39	25.3	3	30
<b>Gender</b>	<b>Female</b>	119	77.3	5	50
	<b>Male</b>	35	22.7	5	50
	<b>Diverse</b>	0	0.0	0	0
	<b>Undisclosed</b>	0	0.0	0	0
<b>Highest qualification</b>	<b>HS diploma</b>	9	5.8	2	20
	<b>Bachelor degree</b>	21	13.6	1	10
	<b>Master degree</b>	19	12.3	0	0
	<b>Doctorate (AuD/PhD)</b>	104	67.5	7	70
	<b>No response</b>	1	0.6	0	0
<b>Duration practicing audiology (yr.)</b>	<b>0-1</b>	4	2.6	2	20
	<b>2-5</b>	11	7.1	0	0
	<b>6-10</b>	18	11.7	1	10
	<b>&gt;10</b>	121	78.6	7	70
<b>Average daily client load (n)</b>	<b>1-3</b>	2	1.3	0	0
	<b>4-8</b>	66	42.9	5	50
	<b>9+</b>	86	55.8	5	50

**Table 2. Reasons given for using not datalogging information ( $n=89$  respondents).**

Response options	Respondents	
	n	% total
I do not have the time to add this to my clinical care	9	5.8
I am not sure how to make use of the data in my clinical care	15	9.7
The information I can access is not clinically useful	29	18.8
Other	36	23.4
<b>Free text 'other' responses</b>		
Unnecessary if patient is doing well/has no complaints/problems	14	
Information is not needed to accomplish clinical care/goals	9	
Forget to use it	7	
Only use it to confirm/determine hearing aid use	3	
Patient can provide the relevant information	3	

**Table 3. Reasons given for not being interested in providing data access to clients (n=64 respondents)**

Response options	Respondents	
	<i>n</i>	% total
I would not have the time to add this to my clinical care	13	8.4
My clinic does not have a good enough internet for me to help patient with this	1	0.6
I do not think my patients would be interested	35	22.7
I do not think my patients would be able to do this and/or they do not have the necessary equipment (smart cell phone etc.)	27	17.5
I have tried it already and it was problematic	5	3.2
Other	18	11.7
<b>Free text 'other' responses</b>		
More information may cause problems and confusion	7	
Patients won't see how they benefit from the information	5	
Will add clinical burden (training in use, dealing with issues raised)	2	
Does not change behavior	1	
Adds patient burden with little gain	1	
No reason provided	2	

**Table 4. Clinical uses of datalogging information (n=118 respondents)**

Response options	Respondents	
	n	% total
To monitor hearing aid usage	115	74.7
To discuss information with the patient	95	61.7
To adjust hearing aid settings	71	46.1
Confirm patient reported usage	95	61.7
Decide if patient needs a follow-up visit	22	14.3
Other	6	3.9
<b>Free text 'other' responses</b>		
To assess appropriate level of technology for patient	1	
To learn about hearing aid management (open battery door)	1	
To learn about hearing aid use patterns	2	
To counsel patient	2	

**Table 5 Summary of themes, categories and codes relating to current perception and use of datalogging**

Themes	Categories	Codes
Positive attitude toward future capabilities	Positive reaction	Helpful Useful Wanting more
	Open to learning	Limited use Unsure of application Interested
Application is limited to specific clients and purpose	Use with challenging clients	Difficult clients Clients with problems Clients that cannot recall details
	Counseling	Hearing aid use Program use Volume use Important during trial
	Fine tuning / programming	Client's lifestyle Listening environment

**Table 6 Summary of themes, categories and codes relating to perception toward future applications of datalogging**

Themes	Categories	Codes
Different levels of datalogging over time	Hearing aid trial	The sound environment Hearing aid operation Hearing aid satisfaction Use Non-use Comprehensive
	Ongoing / post hearing aid trial	Change of use Change of sound environment Hearing aid malfunction Non-use
The dubious value of real-time alerts	Valuable in specific context	Notification for hearing aid malfunction Notification for hearing aid non-use
	Concern over misuse of alerts	Clients abuse alerts HCPs bombarded with client-initiated alerts
	Maintaining control	Alert via email Alert in fitting software Check alert in own time Similar process to current
Demonstrating hearing aid value and supporting decision making	Demonstrating value	Justify cost Increasing client knowledge on hearing aid
	Recommending technology based on datalogging	Objectively demonstrate level of technology Justify better technology level Justify lower technology level Clients' needs

## HCP survey

Demographic questions omitted, item added in version 2 are in italicized font

**Today's hearing aids can log many aspects of hearing aid use, such as duration, type and sounds level of listening environment, what and when hearing aid adjustments are made, etc.**

Do you look at data logging information?

- Yes, always/usually
- Sometimes
- Rarely
- No

### QUESTION CONTINGENT ON ITEM ABOVE

When you choose not to look at datalogging information, why is this? Check all that apply.

- I do not have the time to add this to my clinical care
- I am not sure how to make use of the data in my clinical care
- The information I can access is not clinically useful
- Other (specify):

*When you look at datalogging information, how do you use it in your clinical process? Check all that apply.*

- To monitor hearing aid usage*
- To discuss information with the patient*
- To adjust hearing aid settings*
- Confirm patient reported usage*
- Decide if patient needs a follow-up visit*
- Other (specify)*

*When do you look at the datalogging information? Check all that apply.*

- On a regular basis*
- Prior to a follow-up visit*
- During a follow-up visit*
- Other (specify)*

If you could have more detailed data logging information such as how and a patient adjusts his/her hearing aids, or graphs of minute by minute use in different listening environments, etc., would you be interested?

- Yes, I am interested in this
- Yes, but it is not practical for me
- Not sure
- No



QUESTION CONTINGENT ON ITEM ABOVE

You indicated that more data logging information is not practical/would not be of interest to you. Why is this the case? Check all that apply.

- I would not have the time to add this to my clinical care
- I am not sure how I would use the data in my clinical care
- I am not sure how I would access the data
- My clinic does not have a good enough computer system
- Other: \_\_\_\_\_

If you could provide your patients with an app that allows them to have detailed information about their own hearing aid use would you be interested?

- Yes, I am interested in this
- Yes, but it is not practical for me
- Not sure
- No

QUESTION CONTINGENT ON ITEM ABOVE

You indicated that it is not practical/you would not want to provide your patients with an app. Why is this the case? Check all that apply.

- I would not have the time to add this to my clinical care
- My clinic does not have a good enough internet for me to help patient with this
- I do not think my patients would be interested
- I do not think my patients would be able to do this and/or they do not have the necessary equipment (smart cell phone etc.)
- I have tried it already and it was problematic
- Other (specify

If you have any additional comments to add please enter them here.

## Structured interview guide

We want to ask you some questions to do with tele-audiology. In particular, we want to know your thoughts about collecting data real time real world data from patients and their hearing aids - do you want this type of information? How might you use it? How would you like to receive it? Etc

What would you think if we told you that you could monitor your patients' hearing aid use, hearing aid settings, listening environments, subjective evaluations of listening and more?

Prompts: Would this information be helpful to you? How might you use the information? How would you like to receive the information? Is there any particular information you would like? Feel free to be creative. How often might you look at the information?

What would you think about getting this information during the 30-day trial period versus on an ongoing basis? Why?

Prompts: Is there a time point at which receiving input about a patient's hearing aids would no longer be of interest? When might that be? Why? Do you think the information you would like to see would change over time?

What kind of information would you like to know about a person's hearing aid use?

Prompts: Daily use, listening environments, program use, their opinions, nothing Why/Why not?

How would you use the information?

Prompts: For counseling patient, tracking business, learning for future, other, Tell me more...

How often would you like to receive information?

- i. If it came from an automated system?
- ii. If it came directly from patients?

Prompts: Real time, daily, when alert is triggered, on demand. Why/Why not?

In what form would you find the information most useful?

Prompts: Graphs, text, tables

What might you do with the information?

Prompts: Print it, add it to EHR, give it to patient, chart records, other?

It is possible to develop a system that automatically sends you a message say, if a patient stops using his/her hearing aid, or we could develop a system with which patients send you an alert only when they need assistance, or we could have system that has both possibilities. What would you think of this? Why?

What kind of alerts might you want to receive?

Prompts: Low wear-time, low satisfaction, device performance issue

How might you use the alert?

Prompts: automated response, phone patient, add f/u appointment

What would you think about being able to customize alerts from patient to patient? E.g. alert type and thresholds for alerts

What do you think your patients would think about your collecting this type information? Why?

What would you think about being able to compare a particular patient's data with that of other data? For example, we could show you how much time each day/week/month a particular individual is using their hearing aids relative to other similar people. Why? What comparisons might be of interest?

Prompts: Similar age groups/similar hearing loss/other? Why?

Do you think your thoughts are likely to differ from those of your colleagues? Why?

Do you have any other ideas to share? Is there anything else you would like to let us know about this topic?

Prompts: What? Why? How?