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**Contralateral acoustic hearing aid use in adult unilateral cochlear implant recipients:  
Current provision, practice, and clinical experience in the UK**

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## 1 **Abstract**

2 Objectives: The study surveyed practising cochlear implant audiologists with the aim of: (1)  
3 characterising UK clinical practice around the management and fitting of a contralateral  
4 hearing aid in adult unilateral cochlear implant users ('bimodal aiding'); (2) identifying  
5 factors that may limit the provision of bimodal aiding; and (3) ascertaining the views of  
6 audiologists on bimodal aiding.

7 Methods: An online survey was distributed to audiologists working at the 20 centres  
8 providing implantation services to adults in the UK.

9 Results: Responses were received from 19 of the 20 centres. The majority of centres  
10 reported evaluating hearing aids as part of the candidacy assessment for cochlear  
11 implantation. However, a majority also indicated that they do not take responsibility for the  
12 contralateral hearing aid following implantation, despite identifying few practical limiting  
13 factors. Bimodal aiding was viewed as more beneficial than wearing the implant alone, with  
14 most respondents actively encouraging bimodal listening where possible. Respondents  
15 reported that fitting bimodal devices to take account of each other's settings was potentially  
16 more beneficial than independently-fit devices, but such sympathetic fitting was not routine  
17 practice in any centre.

18 Discussion: The results highlight some potential inconsistencies in the provision of bimodal  
19 aiding across the UK as reported by practising audiologists. The views of audiologists about  
20 what is best practice appear to be at odds with the nature and structure of the services  
21 currently offered.

22 Conclusion: Stronger evidence that bimodal aiding can be beneficial for UK patients would  
23 be required in order for service providers to justify the routine provision of bimodal aiding  
24 and to inform guidelines to shape routine clinical practice.

25

26 **Key Words:** Cochlear Implants; Bimodal Aiding; Acoustic Hearing Aids; Clinical Practice of  
27 Bimodal Fitting; Binaural Hearing; Bimodal Benefits; Sympathetic Bimodal Fitting; Bimodal  
28 Listening.

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## 49 **Introduction**

50 Cochlear implantation was originally devised as a method for restoring a sensation of sound  
51 in bilateral sensorineural hearing impairment where the degree of loss was total or  
52 profound (Ramsden, 2013). A consensus statement from the US National Institutes of  
53 Health (NIH) in the late 1980s demonstrated that cochlear implantation was largely  
54 restricted to individuals who could derive no real benefit from acoustic hearing aids and no  
55 open set speech discrimination (Kohut et al., 1988). A subsequent NIH consensus statement  
56 acknowledged that listening performance of some adults with a severe-to-profound hearing  
57 impairment was poorer than that of adults with a more profound impairment but who used  
58 a cochlear implant (Gates *et al.*, 1995). As a result, a relaxation of candidacy criteria was  
59 recommended to include individuals with up to 30% open-set speech discrimination in their  
60 best aided condition in the US.

61

62 At approximately the same time in the UK, a national study group was evaluating outcomes  
63 following cochlear implantation in patients who either had no open-set speech  
64 discrimination before implantation (“traditional candidates”) or who had some measurable  
65 discrimination (“marginal hearing aid users”) (UKCISG, 2004a). The study group concluded  
66 that those patients who had some usable residual hearing pre-operatively (i.e. non-  
67 traditional candidates, or “marginal hearing aid users”) can have favourable odds of  
68 benefitting from cochlear implantation, particularly those with shorter durations of  
69 deafness, and therefore should be considered as candidates for the treatment.

70

71 In 2009, the National Institute for Health and Care Excellence (NICE) in the UK reviewed the  
72 evidence for the effectiveness and cost-effectiveness of cochlear implantation in adults

73 (NICE, 2009). As a result of their appraisal of the evidence, NICE recommended unilateral  
74 cochlear implantation for adults with a bilateral severe-to-profound sensorineural hearing  
75 impairment who derive “insufficient” benefit from acoustic hearing aids. Insufficient benefit  
76 was defined as an inability to report at least 50% of words on an open-set test of speech  
77 discrimination in quiet while in their best-aided condition. The effective result of these  
78 recommendations was an expansion of the eligibility criteria which led to an associated  
79 increase in the number of hearing impaired individuals that would be suitable for the  
80 treatment. When the NICE guidance was published, approximately 900 adults were  
81 implanted each year across 14 hospitals (NHS, 2012), a level of activity which had increased  
82 to 1161 by 2014 across 19 implanting centres (BCIG, 2015). As candidacy criteria in the UK  
83 now permit candidates to have measurable open-set speech perception but still restrict  
84 implantation to one ear (thus retaining the audiological status of the non-implanted ear),  
85 many implant recipients in the UK now have measurable residual hearing and potentially  
86 aidable thresholds in their non-implanted ear.

87

88 Bimodal aiding is the practice of providing and fitting an acoustic hearing aid (HA) in one ear  
89 and a cochlear implant (CI) in the other ear. Improvements in listening abilities from using  
90 both devices over using the CI alone (bimodal benefits) have been widely documented, and  
91 are thought to reflect the integration of low frequency acoustic cues from the HA with  
92 higher frequency cues from the CI (Gantz and Turner, 2003). Despite the fact that unilateral  
93 cochlear implantation is the current treatment for adults with severe-to-profound hearing  
94 losses in the UK (NICE, 2009), the restoration of binaural hearing whether through bilateral  
95 implantation or bimodal listening has been recommended for this patient group (point 1.1;  
96 NHS, 2013).

97

98 A systematic review of the evidence for bimodal aiding in adults found that wearing a  
99 contralateral HA in addition to a CI can provide benefits to speech perception, particularly in  
100 the presence of background noise (Olson and Shinn, 2008). These bimodal benefits to  
101 speech perception have been observed even when the information accessible to the non-  
102 implanted ear cannot support any useful speech perception on its own (Zhang et al., 2010),  
103 suggesting that there may be supra-additive benefits from combining acoustic with electric  
104 hearing. Other studies have suggested that the benefits are not supra-additive but simply  
105 reflect the fact that CI users may be able to integrate electric and acoustic information  
106 optimally (Micheyl and Oxenham, 2012). Bimodal aiding has also been shown to improve  
107 music perception (Kong et al., 2004) and the naturalness of speech (Sucher and McDermott,  
108 2009), and may improve sound localisation in some listeners (Dunn et al., 2005). The  
109 evidence has led some to recommend that bimodal aiding should be offered routinely when  
110 listeners are able to make some use of both devices (Ching et al., 2004).

111

112 The size of bimodal benefit that patients receive has been found to relate to the level of  
113 acoustic hearing in their non-implanted ear (Zhang et al., 2013). Accordingly, many studies  
114 that have demonstrated bimodal benefits have done so in patients who have access to a  
115 level of hearing in their non-implanted ear that is readily aidable using an acoustic hearing  
116 aid (Morera et al., 2005, Yoon et al., 2012) and therefore greater than that typically  
117 available to patients in the UK who meet NICE criteria. Despite this, there is evidence that  
118 UK patients report benefits from wearing a HA in addition to their CI and may derive  
119 benefits to speech perception from doing so (Visram, 2012). Other bimodal benefits that

120 have been observed in UK patients include some ability to distinguish emotions in spoken  
121 sentences and an improved ability to determine the location of sounds (Goman, 2014).

122

123 The importance of an appropriately fit HA for use in combination with a CI has been well  
124 documented (Ching et al., 2004, Dunn et al., 2005, Gifford et al., 2007, Kong et al., 2005,  
125 Mok et al., 2006, Gifford et al., 2010). To date, professional bodies in the UK including the  
126 British Cochlear Implant Group (BCIG), the British Society of Audiology (BSA) and the British  
127 Academy of Audiology (BAA) have yet to issue guidance on the provision of HAs that are to  
128 be used simultaneously with a CI in the other ear, and how the two devices should be fit to  
129 work sympathetically together. It is therefore unclear whether clinicians providing CI  
130 services in the UK undertake HA evaluations or consider the potential benefits of bimodal  
131 aiding when assessing candidacy, when considering which ear should be implanted to  
132 maximise benefit, when fitting the CI, or when reviewing progress following implantation.  
133 The aim of this study was therefore to survey audiologists across UK adult CI centres about  
134 their current practice around bimodal aiding. The objectives of the survey were:

- 135 1. To describe current clinical practice in the UK around bimodal aiding in adults
- 136 2. To identify factors potentially limiting clinical practice around bimodal aiding
- 137 3. To characterise audiologists' views of bimodal aiding

138

## 139 **Methods**

### 140 **Design**

141 The survey (Supplementary Material 1) was designed to characterise clinical practice around  
142 bimodal aiding by following the temporal progression of a patient through the care pathway



143 from candidacy assessment through to the choice of ear for implantation, initial activation  
144 of the CI, and post-implantation follow up. Questions types were varied and included: (i)  
145 scaling to estimate patient numbers or importance ratings; (ii) agreement/disagreement  
146 using a five-point Likert scale; (iii) frequency of occurrence using both yes/no and  
147 always/sometimes/rarely/never response sets (reflecting degree of certainty); and (iv)  
148 open-ended questions where free-text responses were permitted.

149

150 Most questions were designed to elicit a response, and respondents were not permitted to  
151 proceed to the next question until a response to the current question had been provided.  
152 Responses to open-ended questions were always optional. Conditional question pathways  
153 were included so that each respondent was presented with a set of questions that were  
154 deemed appropriate based on their previous responses. For example, questions about the  
155 manner in which HAs are fit at the candidacy assessment stage were not presented to  
156 respondents who had previously indicated that they never fit HAs at that stage of the care  
157 pathway.

158

## 159 **Distribution**

160 The survey was distributed online using the Survey Monkey software  
161 (<https://www.surveymonkey.com/>). The survey was targeted at audiologists working at CI  
162 centres within the UK. An invitation to complete the online survey was distributed to every  
163 BCIG member indicating it was for the attention of audiologists working with adult patients.  
164 The introductory text of the survey indicated that only those who work with adult patients

165 should complete the survey. No option was given to complete the survey on paper. Sixty-six  
166 audiologists were registered with audiology-related job titles on the BCIG mailing list at the  
167 time of mailing (January 2015), which included representatives from the 20 UK CI centres  
168 that work with adult patients. Programme coordinators were also invited to forward the  
169 survey to any audiologist who may not be a member of the BCIG. A follow up letter and  
170 poster for placement in communal areas such as staff rooms was sent to the coordinator of  
171 each CI centre one month after the initial invitation was sent. After a further three months,  
172 coordinators of CI centres who had not yet contributed were sent a reminder email or were  
173 contacted by telephone.

174

## 175 **Procedure**

176 Respondents were informed that the purpose of the survey was to investigate current  
177 practice around evaluating, fitting and reviewing patients who use (or could use) bimodal  
178 devices. Respondents were asked to name the CI centre in which they worked. This  
179 information was collected to determine the geographical distribution of responses and to  
180 assess whether the results were likely to be representative of current practice across the  
181 UK. Respondents were informed that their responses would be strictly anonymous.  
182 Accordingly, in reporting the results individual responses have not been associated with any  
183 particular CI centre. While acknowledging that every patient is an individual, respondents  
184 were asked to think about the things they would typically do and to focus on their practice  
185 within the last 5 years.

186

187 **Analysis**

188 The survey was divided into three sections based on relevance to the study objectives.  
189 Sections were not equal in length, given the greater complexity of certain aspects of clinical  
190 practice than others. No question contributed to more than one section. The number of  
191 responses varied across questions due to the use of conditional question pathways and the  
192 fact that respondents were not required to answer to all questions. Where possible,  
193 individual responses were converted to a binary outcome by grouping them into one of two  
194 categories (e.g. agree/disagree, yes/no, etc.). Responses were then summarised as the  
195 proportion of centres from which positive responses were received and as the proportion of  
196 individuals who responded positively. Ninety-five percent confidence intervals were  
197 calculated for each of these proportions (Newcombe, 1998).

198

199 The terms 'majority' and 'minority' were applied only to proportions that were found to be  
200 significantly greater than or less than 50% of respondents, respectively. For example, if data  
201 were available from 19 centres on a particular question, a proportion of 26% or less (5  
202 centres or fewer) was interpreted as a 'minority' (upper 95% confidence interval of  
203 proportion = 48.8%) and a proportion of 74% or more (at least 14 centres) was interpreted  
204 as a 'majority' (lower 95% confidence interval of proportion = 51.2%). Where questions  
205 contained an estimation of the frequency of a clinical activity or procedure  
206 (always/often/sometimes/rarely/never), practice was considered routine if respondents  
207 selected the 'always' or 'often' options. The statistical significance of the difference  
208 between two proportions was calculated using McNemar's test (McNemar, 1947).

209

## 210 **Results**

211 Nineteen of the twenty centres contributed to the survey resulting in a centre response rate  
212 of 95%. Complete responses were received from 33 individual audiologists, representing an  
213 estimated individual response rate of 50% based on the number of registered BCIG  
214 members with audiology-related job titles. The centres that chose to participate and the  
215 numbers of completed surveys received from each are shown in Table 1. As the number of  
216 responses differed across centres, the interpretation of the results was based on summary  
217 statistics of responses at the centre level, rather than at the individual level. A further five  
218 respondents completed part of the survey but did not identify which centre they practiced  
219 at. Their responses were included when calculating summary statistics at the individual  
220 level.

221

### 222 **Section 1: Current clinical practice in the UK**

223 The proportion of centres who indicated undertaking activities in various parts of the care  
224 pathway and the associated confidence intervals are listed in Tables 2 and 3.

225

#### 226 *(a) Hearing aid management during candidacy assessment (Table 2)*

227 Respondents estimated that 87% of patients who attend for candidacy assessment wear a  
228 HA in at least one ear (95% confidence interval: 83-92%). All but one centre reported that  
229 they do conduct HA evaluations as part of the candidacy assessment and a majority of those  
230 centres (14 out of 18) reported checking HA fittings routinely as part of this evaluation. The  
231 fact that some respondents in those 14 centres indicated that they do not check HA fittings  
232 routinely could suggest some level of inconsistency within centres but may also simply

233 reflect the division of responsibilities among staff. Eleven centres indicated that they would  
234 check the HA fitting in every patient who attended wearing HAs, but this did not represent a  
235 majority.

236

237 The need for HA fitting and evaluation appeared to be judged on an individual basis. When  
238 presented with the scenario of a CI candidate who does not wear HAs but has measurable  
239 hearing thresholds or a history of recent HA usage, a majority of centres (83%) indicated  
240 they would routinely attempt to fit HAs. When presented with an alternative scenario of a  
241 candidate attending wearing a single HA, the number of centres that reported routinely  
242 attempting a HA fitting in the unaided ear dropped to 61%, which did not represent a  
243 majority. Two respondents from a single CI centre commented that they would rarely  
244 attempt to fit a HA to the unaided ear as the result would be unlikely to affect the candidacy  
245 decision, where open-set speech discrimination scores in the quiet when in their best-aided  
246 condition must be <50% (NICE, 2009).

247

248 A variety of HA fitting and verification methods were reported including fitting to a  
249 prescription target (64%), Real Ear Measurement (61%), aided threshold measurement  
250 (50%) and speech discrimination testing (50%). The majority of centres reported using a  
251 combination of methods.

252

253 *(b) Hearing aid management following implantation (Table 2)*

254 Respondents estimated that 58% of patients who received their CI within the last 5 years  
255 wear a contralateral HA at initial activation of the CI (95% confidence interval: 51-64%), but  
256 hypothesised that only 41% of this group would still be wearing the HA after 5 years of  
257 implant use (mean decrease as a proportion of all CI users of 33%; 95% confidence interval  
258 28-38%). Only a minority of centres indicated that they take full responsibility for the  
259 maintenance of the contralateral HA once the CI is activated despite the fact that the  
260 majority of centres reported routinely conducting HA reassessments prior to implantation,  
261 and may have fitted the aid during the assessment. Instead, a majority of centres indicated  
262 that they refer patients elsewhere for their ongoing hearing aid maintenance, usually the  
263 implant user's local audiology team, who may or may not have fitted the HA originally.

264

265 A minority of centres indicated that they routinely conduct a contralateral HA evaluation  
266 within the first 12 months of CI use, and only 3 centres reported routinely reviewing the HA  
267 fitting after 12 months of CI use. Six centres indicated that they would attempt to re-fit a  
268 contralateral HA that a CI user had stopped wearing following implantation but this  
269 represented a minority view. All centres indicated that they would not routinely fit a new  
270 HA in an unaided contralateral ear within the first 3 months after CI activation, even if it had  
271 potentially aidable thresholds, although nine centres indicated that they would consider it  
272 but only at the patient's request. The post-operative HA fitting and verification methods  
273 reported by respondents were notably different to the methods chosen pre-operatively,  
274 with only 33% of respondents selecting the same combination of methods at the two time  
275 intervals.

276

277 (c) *Sympathetic bimodal fitting (Table 3)*

278 At initial CI activation, only one centre reported an agreed protocol for “bimodal switch-on”  
279 in the clinic; i.e. consideration of both devices when creating the first CI programme. Four  
280 centres did report taking the HA parameters into account when first activating the CI, but no  
281 centre indicated making any attempt to match device parameters such as compression  
282 settings or frequency allocations at this stage. Eleven centres reported attempting to match  
283 the two devices for loudness at the CI fitting stage but this did not represent a majority.

284

285 There was minimal evidence that devices are fit sympathetically at subsequent CI review  
286 appointments. Only one centre, which notably was not the centre that reported using a  
287 bimodal switch-on procedure above, reported following a protocol for programming  
288 bimodal patients in the clinic. Only a minority of centres reported taking the parameters of  
289 the HA into account when deciding how to reprogramme the CI, and only one respondent  
290 was consistent in using these parameters at both switch-on and subsequent reviews. Only  
291 two centres indicated that they attempt to match device parameters such as compression  
292 settings or frequency allocations at CI review appointments. However, a majority of centres  
293 reported balancing loudness across the two devices at review appointments.

294

295 In summary, inconsistencies in practices relating to bimodal fitting at both initial and  
296 subsequent CI programming appointments were apparent. It would therefore appear likely  
297 that any programming adjustments related to improving bimodal listening are made to the

298 implant only and not to the HA, given that the majority of centres do not routinely adjust HA  
299 fittings post-implantation.

300

301 *(d) Bimodal outcome measurement (Table 3)*

302 When a bimodal listener attends for a performance review, all but one centre reported  
303 routinely measuring listening outcomes using the CI alone, 12 centres (not a majority)  
304 reported routinely measuring bimodal listening outcomes, while a minority of centres  
305 reported routinely measuring outcomes from the HA alone following implantation. Only  
306 seven centres reported that they follow an agreed protocol for measuring bimodal benefit  
307 in the clinic, and three centres reported rarely or never measuring bimodal outcomes.

308

309 Of the 12 centres that report measuring bimodal outcomes routinely, four indicated that  
310 they choose additional listening tests specifically to measure bimodal benefit that would not  
311 normally be used with a unilateral CI listener. A free text box was provided for respondents  
312 to list any test used specifically to measure bimodal benefit. The following tests were listed:  
313 BKB sentences in adaptive noise test, the Star<sup>2</sup> (Sentence Test with Adaptive Randomised  
314 Roving levels) test (Joffo and Boyle, 2010), multiple speaker sound localisation, and the CRM  
315 (Coordinate Response Measure) sentence test (Kitterick et al., 2010, Kitterick et al., 2011).

316

317 *(e) Patient advice (Table 3)*



318 When a patient attends for initial activation wearing a HA in the non-implanted ear, advice  
319 about how to use the HA in addition to the CI was inconsistent across centres. Only a  
320 minority of centres recommend that both devices be worn together from the first day that  
321 the CI is activated, with 68% recommending intermittent use of the HA at first to allow time  
322 for CI-only listening. A separate minority reported advising patients not to wear the HA until  
323 they have been using their CI for around 3 months. Four centres indicated that they would  
324 not make recommendations about contralateral HA use and would leave it to the patient to  
325 decide.

326

327 In spite of the uncertainties about HA use evident at initial CI activation, a majority of  
328 centres (95%) reported actively encouraging CI users to wear a contralateral HA once they  
329 had used their implant for at least 3 months. No respondent reported actively discouraging  
330 contralateral HA usage after an initial 3-month CI acclimatisation period.

331

### 332 *Interim summary*

333 An overview of the consistencies and inconsistencies of clinical practice derived from this  
334 section is shown in Table 4. Centres almost universally reported evaluating HAs during  
335 candidacy assessment, a practice that is consistent with national guidance that requires the  
336 speech perception abilities of candidates to be assessed in the best-aided condition (NICE,  
337 2009). However, some variability in reported practice both within and between centres was  
338 apparent. The current reports suggest that most centres do not maintain the long term care  
339 of the contralateral HA, do not routinely optimise bimodal aiding through evaluating or re-

340 fitting the HA post-operatively, and do not practise sympathetic bimodal fitting. The focus of  
341 the audiologist seems primarily on optimising the CI. The two devices are therefore likely to  
342 be programmed independently after implantation, on separate occasions and not  
343 necessarily by the same person or at the same centre. Whilst there is reportedly some  
344 uncertainty about how to advise patients on bimodal listening at initial CI activation, most  
345 centres appear to actively encourage HA during later stages of CI use, implying a mismatch  
346 between their advice to listen bimodally and their clinical practice to optimise it.

347

## 348 **Section 2: Factors limiting bimodal practice**

349 Table 5 lists the proportion of CI centres and individual responses who agreed or disagreed  
350 with statements about factors that might limit the provision and optimisation of bimodal  
351 devices and their associated confidence intervals.

352

### 353 *(a) Hearing aid management*

354 A minority of centres indicated that a lack of time, rooms and equipment are significant  
355 factors limiting HA management during candidacy assessment. Six centres reported a  
356 shortage of available audiologists, and eight reported a lack of staff expertise in HA fittings.  
357 Only one centre suggested that insufficient residual hearing was a factor limiting HA fitting  
358 during candidacy assessment, which represented a minority view.

359

360 Three centres had at least one respondent report that they do not evaluate HAs as part of  
361 the candidacy assessment. The most frequent limiting factors cited by these respondents  
362 were a lack of staff expertise (3 centres), insufficient numbers of audiologists (3 centres) and  
363 a lack of rooms/equipment (2 centres). None of these centres indicated that time was a  
364 limiting factor. Further free text comments suggested that a lack of funding for HA provision  
365 at CI centres may be a contributing factor to the lack of HA evaluations during candidacy  
366 assessment.

367

368 During the initial CI activation period, a minority of centres indicated that lack of equipment  
369 was a limiting factor but 68% indicated that there was insufficient time to evaluate HAs in  
370 addition to the CI. The role of time, equipment, staffing or staff expertise in limiting HA  
371 management during subsequent routine CI review appointments were all listed as limiting  
372 factors, but were variable across centres suggesting that there is no single factor that  
373 presents a consistent barrier to the provision of bimodal aiding in established CI users.

374

375 *(b) Bimodal outcome measurement*

376 A minority of centres indicated that there is a lack of staff expertise within their centres to  
377 measure bimodal outcomes. Nine centres reported insufficient time to measure bimodal  
378 listening outcomes in addition to CI-only, and six centres reported insufficient equipment.

379

380 *(c) Sympathetic bimodal fitting*

381 Around half of all centres (58%) indicated that there is insufficient time to conduct  
382 sympathetic fitting of both devices in the same session. A similar number of centres agreed  
383 that there is a lack of guidance on how to optimise the two devices to work better together.  
384 Additionally, the fact that only a minority of centres reportedly retain responsibility for  
385 ongoing care of the contralateral HA post-implantation (Table 2) may also represent a  
386 significant factor limiting the provision of sympathetic bimodal fitting.

387

### 388 *Interim summary*

389 The pattern of responses suggests that in centres that currently undertake HA evaluations,  
390 resources for managing HAs both during candidacy assessment and after implantation are  
391 adequate. In centres that do not currently undertake HA evaluations as part of their service,  
392 there appear to be more limitations to overcome including lack of staff expertise, facilities,  
393 and possibly also a lack of funding. The fact that respondents from these centres indicated  
394 that time is not a limitation suggests that routine HA evaluations would be possible if these  
395 logistical factors were addressed. Measurements of bimodal outcomes would also appear to  
396 be feasible given the available resources and staff expertise reported by respondents, but  
397 longer review appointments may be necessary to ensure that they can be obtained  
398 consistently across all patients and centres. The sympathetic fitting of the CI and HA does  
399 not appear to be feasible at present due to the time constraints and lack of experience and  
400 guidance reported by respondents. Therefore, the data suggest that additional time may  
401 also be necessary during certain appointments to ensure that the HA and CI can be  
402 maintained and optimised at the same time.

403

404 **Section 3: Respondent views regarding bimodal issues**

405 Table 6 lists the proportion of CI centres and individual respondents who expressed  
406 agreement with a range of statements about bimodal aiding and the associated confidence  
407 intervals.

408

409 *(a) Hearing aid management*

410 A majority of centres (95%) indicated that it is beneficial both to attempt to optimise HAs  
411 during the candidacy assessment stage and to optimise the contralateral HA post-  
412 implantation. A majority of centres were also of the opinion that HA optimisation was  
413 within the role of the CI audiologist both during candidacy assessment and post-operatively  
414 (68% and 79%, respectively). Responses from individual audiologists about whether they  
415 feel it is within their role to evaluate HA fittings were more mixed both when considering  
416 candidacy assessment (42%) and post-operative appointments (61%). It is possible that this  
417 apparent variability within centres may have reflected the division of responsibilities among  
418 staff.

419

420 Respondents were invited to comment on the practicalities of maintaining both devices.  
421 Common themes in the responses to this open-ended question indicated that: (i) managing  
422 both devices may provide a smoother service for the patient throughout the care pathway;  
423 (ii) there are logistical difficulties around HA maintenance as many patients do not live near

424 their CI centre and may prefer to access HA repair services locally; (iii) there are difficulties  
425 with funding as CI services may not be commissioned to support and manage HAs; and (iv)  
426 there is limited staff expertise of the range of available HAs, software, stock, and spares  
427 within CI centres.

428

429 *(b) Bimodal benefit*

430 When asked to consider both the positives and the negatives of contralateral HA use, the  
431 majority of centres (84%) agreed that bimodal aiding provides more benefit than wearing  
432 the CI alone. No respondent indicated that wearing the CI alone was more beneficial than  
433 bimodal aiding. The majority of centres (84%) reported taking the possibility of bimodal  
434 aiding into consideration when choosing which ear to implant, although at an individual  
435 level 64% of respondents reported doing so, which did not represent a majority.  
436 Respondents were asked to list up to three potential advantages and three potential  
437 disadvantages of wearing a contralateral HA in addition to a CI that they had directly  
438 observed or heard from patients during their clinical practice. Figure 1 shows the reported  
439 categories of bimodal advantage, the largest of which was sound localisation. Figure 2  
440 shows the reported categories of bimodal disadvantage, the largest of which was related to  
441 wearing an earmould.

442

443 In spite of the majority of clinics not having an agreed protocol for measuring bimodal  
444 outcomes (Section 1d), the majority of centres (95%) reported that it is clinically useful to  
445 measure bimodal benefit. Respondents were asked to rate the most useful outcome

446 measures to demonstrate bimodal benefit and the proportion of respondents who selected  
447 each category of test is shown in Figure 3. A majority of respondents indicated that  
448 measuring speech discrimination in background noise was the most useful clinical measure  
449 of bimodal benefit.

450

451 *(c) Sympathetic bimodal fitting*

452 When asked to compare sympathetic with independent bimodal device fittings, a majority  
453 of centres (84%) felt that fitting the devices sympathetically (taking into account each  
454 other's settings) could somehow improve bimodal outcomes over fitting the two devices  
455 independently. A majority (79%) also rated a recently-refit contralateral HA as more  
456 beneficial than one that has not been recently re-fit. However, 84% of centres  
457 acknowledged that wearing a contralateral HA that was fit prior to receiving the CI may be  
458 sufficient to provide some bimodal benefits. Thus, the responses imply that the use of a  
459 contralateral HA, and not necessarily one that has been recently optimised, is better than  
460 not using a HA at all.

461

462 *(d) Further guidance*

463 Respondents from 18 centres completed this section. Every centre indicated that they  
464 would welcome guidance on: (1) how to maximise bimodal benefit; (2) how to optimise  
465 bimodal fitting; (3) which patients would be most likely to benefit from a contralateral HA  
466 fitting; (4) measuring bimodal benefit; and (5) how to advise patients about being a bimodal  
467 listener. A majority of respondents (83%) were unsure as to the best time to reintroduce a

468 HA following CI activation, presumably attributable to concerns about CI acclimatisation  
469 discussed previously.

470

471 *Interim summary*

472 Respondents indicated that it may be in the best interests of the patient to have both  
473 devices managed by a single centre but acknowledged the practical limitations of this  
474 model. The general view that the optimisation of HA fittings following implantation is within  
475 the role of the CI audiologist appeared to suggest that what respondents reported as being  
476 their current practice is not always able to reflect what they believe to be optimal for the  
477 patient. Bimodal aiding was viewed as potentially more advantageous to the patient than  
478 wearing the CI alone, and sympathetic bimodal fitting was also viewed more favourably  
479 than devices that had not been sympathetically fit. Bimodal outcome measurements appear  
480 to be considered clinically useful, although it is unclear if and how these measurements  
481 inform HA optimisation. Respondents acknowledged that further guidance on aspects of  
482 bimodal fitting is required to implement changes in routine fitting practice.

483

484 **Discussion**

485 A survey of CI audiologists across the UK characterised their reported clinical practice  
486 around bimodal aiding, identified factors that may be limiting the provision of bimodal  
487 aiding, ascertained their views on bimodal aiding, and demonstrated consistencies and  
488 inconsistencies in practice across the UK.

489



490 *Changing candidacy landscape*

491 Until relatively recently, few individuals with useful residual hearing in the contralateral ear  
492 received a CI in the UK. A large-scale UK study that collated outcomes from adults implanted  
493 between 1998 and 2000 demonstrated that most were unable to derive benefit from  
494 acoustic amplification pre-operatively (UKCISG, 2004a). Even candidates who had some  
495 measurable speech understanding using HAs ('marginal HA users') were receiving only  
496 minimal benefit from amplification in their better ear and had an average open-set speech  
497 discrimination score of only 13%. Respondents to the current survey estimated that  
498 approximately half of those implanted within the last five years will continue to wear a HA  
499 even after their CI is activated, suggesting that contemporary CI recipients may receive  
500 additional benefits from contralateral acoustic amplification. This estimate is compatible  
501 with the results of a recent survey of CI users, which found that 48% of respondents who  
502 had been implanted in the UK in the five years between 2010-2015 reported using a  
503 contralateral HA (Fielden et al., 2016a). It would therefore appear as if there has been an  
504 increase in the number of CI candidates who have aidable residual hearing since both the  
505 last UK-wide outcomes study and the publication of NICE guidance (NICE, 2009).

506

507 One impact of this change in who is receiving cochlear implants in the UK is that a large  
508 proportion of recipients may no longer be monaural listeners whose outcomes are  
509 determined solely by a single implanted ear as was previously the case, but rather binaural  
510 listeners who may derive benefits from the combination of the CI and the HA. In these  
511 patients, CI audiologists have had to shift their focus away from considering an outcome  
512 solely in terms of a patient's capacity to use their CI and towards an outcome based on

513 binaural listening. However, this apparent change in practice has occurred in the absence of  
514 any guidance or training and is therefore likely to be based predominantly upon clinical  
515 experience. The disconnect apparent in the survey between the role of audiologists working  
516 in CI centres today and the evidence available to them with which to inform their practice  
517 may explain why the current provision of bimodal aiding appears to be inconsistent and at  
518 odds with the views of those who deliver it.

519

#### 520 *Estimates of sustained bimodal usage*

521 While audiologists in the survey estimated that approximately half of those implanted  
522 within the last five years will wear a HA at activation, they also estimated that less than half  
523 of these patients will continue to wear their HA once they have used their implant for a  
524 further five years. This estimate of the proportion of longer-term bimodal users contrasts  
525 with previous estimates that have assumed a constant proportion of around 70% of implant  
526 recipients (Bond et al., 2009). The reasons for the estimated drop in the number of bimodal  
527 users over time are unclear, but at least five plausible explanations are apparent. First, the  
528 bimodal benefit perceived by the patient may lessen as they become more proficient at  
529 listening using the CI. Second, the amount of residual hearing may be so marginal that the  
530 natural progression of the hearing loss over time may reduce HA benefit leading to eventual  
531 non-use, perhaps because the better-hearing ear was selected for implantation. Third, the  
532 independent fitting of both devices may mean that some patients struggle to integrate the  
533 electric and acoustic signals and eventually stop using the HA. Fourth, as HAs are not  
534 typically maintained by CI centres there is a lack of cohesion between hearing services, and  
535 the bimodal patient may receive conflicting advice at each service or find it impractical to

536 access HA maintenance services over time. Finally, it is possible that only a small proportion  
537 of UK CI users can obtain consistent and useful bimodal benefits in spite of the previous four  
538 issues, and are therefore the ones to persist with contralateral HA usage. It is impossible to  
539 know which of these, if any, could potentially contribute to poor rates of sustained HA use.  
540 More research is needed to isolate the reasons that could contribute to non-use of  
541 contralateral HAs and to provide more direct evidence for the number and nature of  
542 patients who could receive ongoing bimodal benefits.

543

#### 544 *Nature of bimodal benefit*

545 While the majority of audiologists agreed that bimodal aiding can be beneficial and  
546 encourage patients to wear a contralateral HA, the survey highlighted some uncertainty  
547 around best practice. For example, uncertainty was evident about who could benefit from  
548 bimodal aiding, when to introduce the HA after CI activation and how to fit devices  
549 sympathetically. This uncertainty may be a result of the limited available evidence for what  
550 aspects of hearing status determine the degree of bimodal benefit available to the patient.  
551 A systematic review of the effectiveness for cochlear implantation as a treatment for  
552 severe-profound deafness found that studies comparing bimodal aiding with unilateral CI or  
553 bilateral CI were poor in quality and low in number (Bond et al., 2009). To date, there is a  
554 lack of agreement in the literature as to what aspects of the HA signal delivery contribute to  
555 bimodal benefit with the possibilities including access to low frequency acoustic cues (Zhang  
556 et al., 2010), spectral modulation detection (Zhang et al., 2013), or how effectively the  
557 modalities integrate (Yoon et al., 2015). Notably, these and other studies that have  
558 demonstrated bimodal benefit have been conducted almost exclusively on patients

559 implanted outside the UK who have greater levels of residual hearing in the non-implanted  
560 ear than are typically accessible to UK patients. Therefore, further research on UK patients is  
561 needed to ascertain whether similar benefits are possible given the current candidacy  
562 criteria. However, even if the benefits can be realised there appears to be both a lack of  
563 consistency for how to identify who may benefit from bimodal aiding and how to optimise  
564 bimodal devices to maximise benefit.

565

#### 566 *Influence on the choice of ear to implant*

567 Responses to the present survey suggest that audiologists are considering the potential  
568 benefits from preserving patients' access to residual acoustic hearing when recommending  
569 which ear to implant in at least some patients. Compatibly, a recent hypothetical decision-  
570 choice experiment suggested that clinicians may not always advise implanting the 'optimal'  
571 ear for CI outcomes in order to preserve residual hearing where possible (Fielden et al.,  
572 2016b). Given that little would be gained if residual hearing was preserved by  
573 recommending a physiologically-unresponsive ear for implantation, their willingness to  
574 consider residual hearing may suggest that centres are now seeing more patients in whom  
575 both ears are receptive to implantation; i.e. are likely to improve performance if implanted.  
576 The results may therefore suggest that audiologists are now able to be increasingly cautious  
577 about risking the loss of residual hearing in patients where the choice of ear is not strongly  
578 influenced by other factors. However, it remains unclear to what extent factors relating to  
579 residual hearing inform decision making around which ear to implant, how frequently, and  
580 in what proportion of patients. As the present results suggest that audiologists' practice  
581 remains focused on maximising outcome using the CI alone, it is likely that the choice of ear

582 is still influenced primarily by factors such as the physiological responsiveness and duration  
583 of deafness of each ear, which can be used to estimate the likelihood that implanting a  
584 particular ear will improve performance compared to the best-aided condition using HAs  
585 alone (UKCISG, 2004b).

586

### 587 *Commissioning arrangements*

588 The disconnect between the apparent willingness of the respondents to encourage bimodal  
589 aiding and the fact that services related to bimodal aiding are reportedly rarely provided  
590 may be attributable, at least in part, to the manner in which implantation services are  
591 commissioned in the UK. The guidance from NICE which informs current commissioning  
592 arrangements was based on an assessment of the effectiveness and cost-effectiveness of  
593 cochlear implantation in the UK that compared acoustic hearing aids to the provision of  
594 either unilateral implantation or bilateral implantation (Bond et al., 2009). While the  
595 economic evaluation did account for the fact that a subset of patients continue to use a HA  
596 following cochlear implantation and therefore incur additional costs to the health service,  
597 the evaluation did not assume any incremental benefit arising from the provision of a well-  
598 fit acoustic hearing aid in the non-implanted ear. The decision to not account for any  
599 bimodal benefit was based primarily on the lack of robust evidence for the impact that  
600 bimodal aiding has on the overall health and well-being of patients. In the absence of such  
601 evidence in UK patients and therefore evidence for the cost-effectiveness of bimodal aiding,  
602 it is unlikely that funding arrangements will change to include maintenance provision of two  
603 devices in those patients who may benefit from their use.

604

605 *Practical considerations*

606 The survey highlighted practical problems that would arise if a single service were to  
607 maintain both devices with respondents identifying issues related to staff time and funding  
608 as potential limiting factors. While an integrated model of service provision would likely  
609 provide a smoother service for the patient, create a more cohesive care pathway, and  
610 facilitate the sympathetic optimisation of the two devices, it may also be less convenient for  
611 the patient who may have to travel many miles to reach their nearest CI centre for minor  
612 adjustments to the HA or to obtain replacement parts. A more practical arrangement could  
613 be for the CI centre to take responsibility only for the fitting and reprogramming of HAs,  
614 while routine maintenance and spare parts continued to be provided by local audiology  
615 departments. A more radical approach would be for certain aspects of CI care to be  
616 undertaken by local audiology departments, perhaps with remote assistance from the CI  
617 centre. However, this approach would currently not meet the standard for quality of care as  
618 specified in the BCIG quality standards report (NICE 2007). This option would therefore  
619 require considerable investment to ensure that remote standards of care were achieved.  
620 Another option that is already being explored by CI centres nationally is the adoption of  
621 outreach clinics, which could be extended to support bimodal fittings.

622

623 Given the increasing numbers of CI users requiring ongoing maintenance and the numbers  
624 of patients who could now be aided bimodally, changes to the current model of service  
625 provision would appear to be inevitable. Audiologists generally appear to be willing to

626 consider changes in their practice to enhance the provision of bimodal aiding, but the lack of  
627 evidence with which to inform their practice and practical issues related to time and funding  
628 severely limit the nature and scope of any changes that could be made at the present time.

629

### 630 *Recommendations for future research*

631 This survey has demonstrated that UK audiologists are willing to consider changing their  
632 practice relating to bimodal aiding but have identified a need for guidance on best practice  
633 regarding: (a) the fitting and evaluation of HAs during candidacy assessment; (b) identifying  
634 who is likely to benefit from bimodal aiding; (c) providing advice on HA use at CI switch-on;  
635 (d) optimising bimodal aiding (including sympathetic bimodal fitting); and (e) using bimodal  
636 outcome measurement to both inform fitting and monitor changes in performance. The  
637 creation of guidance on these topics is currently hindered by a lack of evidence for the size  
638 and nature of bimodal benefits that are available to UK CI users and evidence for whether  
639 the methodologies that have been proposed for optimising the fitting of bimodal devices  
640 are applicable to clinical practice in the UK.

641

642 At the very least, the development of new guidance would require: (a) an up-to-date  
643 systematic review of the evidence for the effectiveness of bimodal aiding that includes  
644 patients with limited residual hearing similar to that of UK patients; (b) evidence that the  
645 provision of bimodal aiding is a cost-effective use of limited NHS resources; (c) evidence that  
646 existing bimodal fitting and assessment methods are appropriate for use UK patients; and  
647 (d) a consensus among clinicians on those aspects of bimodal fitting that are feasible to

648 implement and of benefit to patients. While the current survey has identified some aspects  
649 of practice and views that appear to be held consistently across UK CI centres, any  
650 consensus exercise to inform guidance would ideally be formed using an established  
651 methodology such as a Delphi process (Dalkey, 1969) and involve the broad range of  
652 healthcare professionals that deliver the current care pathway. Further research should also  
653 engage with UK CI recipients whose experience can contribute to a better understanding of  
654 the benefits and disadvantages of bimodal aiding, and why patients choose to use or not to  
655 use a contralateral HA.

656

657 Ultimately, an evaluation of the benefits that bimodal aiding provides to UK patients should  
658 be based on well-designed clinical controlled trials. It is only when such robust evidence is  
659 available that current clinical commissioning arrangements are likely to be amended to both  
660 recommend and fund bimodal aiding in the UK.

661



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761 **Figure Captions**

762 **Figure 1.** Categories of bimodal advantages reported by respondents from direct  
763 observation of patients. Error bars plot 95% confidence intervals. A proportion whose right  
764 error bar is entirely to the left of the 50% line demonstrates an observation that was  
765 observed only by a minority of respondents, whereas a proportion whose left error bar is  
766 entirely to the right of the 50% line represents the majority of respondents.

767

768 **Figure 2.** Categories of bimodal disadvantages reported by respondents from direct  
769 observation of patients. Error bars plot 95% confidence intervals. A proportion whose right  
770 error bar is entirely to the left of the 50% line demonstrates an observation that was  
771 observed only by a minority of respondents, whereas a proportion whose left error bar is  
772 entirely to the right of the 50% line represents the majority of respondents.

773

774 **Figure 3.** Outcome measures reported as being clinically useful in demonstrating benefit in  
775 bimodal listeners. Error bars plot 95% confidence intervals. A proportion whose right error  
776 bar is entirely to the left of the 50% line demonstrates an observation that was observed  
777 only by a minority of respondents, whereas a proportion whose left error bar is entirely to  
778 the right of the 50% line represents the majority of respondents.

779

780

781

782

783 **Table captions**

784 **TABLE 1.** A list of the UK adult cochlear implant centres which contributed to the survey  
785 dataset and the numbers of respondents from each. The 19 participating centres represents  
786 a response rate of 95%. The UK centre not listed either did not participate in the survey or  
787 did not complete the survey to the point where the centre name was requested.

788

789 **TABLE 2.** Mean responses to questions about current clinical practice in the UK relating to  
790 HA management. The number of CI centres from which positive responses were received to  
791 each question is reported together with the percentage and its 95% confidence interval. The  
792 table also lists the number of respondents who responded positively, also expressed as a  
793 percentage with 95% confidence intervals. The use of bold type indicates that a result  
794 represented a significant minority (<50%) or majority (>50%) of CI centres and/or  
795 respondents.

796

797 **TABLE 3.** Mean responses to questions about current clinical practice in the UK relating to  
798 bimodal fitting, outcome measurement, and advice. The number of CI centres from which  
799 positive responses were received to each question is reported together with the percentage  
800 and its 95% confidence interval. The table also lists the number of respondents who  
801 responded positively, also expressed as a percentage with 95% confidence intervals. The use  
802 of bold type indicates that a result represented a significant minority (<50%) or majority  
803 (>50%) of CI centres and/or respondents.

804

805 **TABLE 4.** A summary of clinical practice at different stages of the temporal clinical care  
806 pathway. A tick represents practice that is routine, i.e. conducted by a majority of  
807 respondents and centres; a cross represents practice that is not routine, i.e. conducted only  
808 by a minority of respondents and centres, and a question mark represents inconsistency in  
809 practice across respondents and centres. The table numbers that contain these data are  
810 shown in brackets.

811

812 **TABLE 5.** Mean responses to questions about factors that limit clinical practice in the UK  
813 relating to bimodal aiding. The number of CI centres from which positive responses were  
814 received to each question is reported together with the percentage and its 95% confidence  
815 interval. The table also lists the number of respondents who responded positively, also  
816 expressed as a percentage with 95% confidence intervals. The use of bold type indicates  
817 that a result represented a significant minority (<50%) or majority (>50%) of CI centres  
818 and/or respondents.

819

820 **TABLE 6.** Mean responses to questions about audiologists' views of bimodal aiding. The  
821 number of CI centres from which positive responses were received to each question is  
822 reported together with the percentage and its 95% confidence interval. The table also lists  
823 the number of respondents who responded positively, also expressed as a percentage with  
824 95% confidence intervals. The use of bold type indicates that a result represented a  
825 significant minority (<50%) or majority (>50%) of CI centres and/or respondents.

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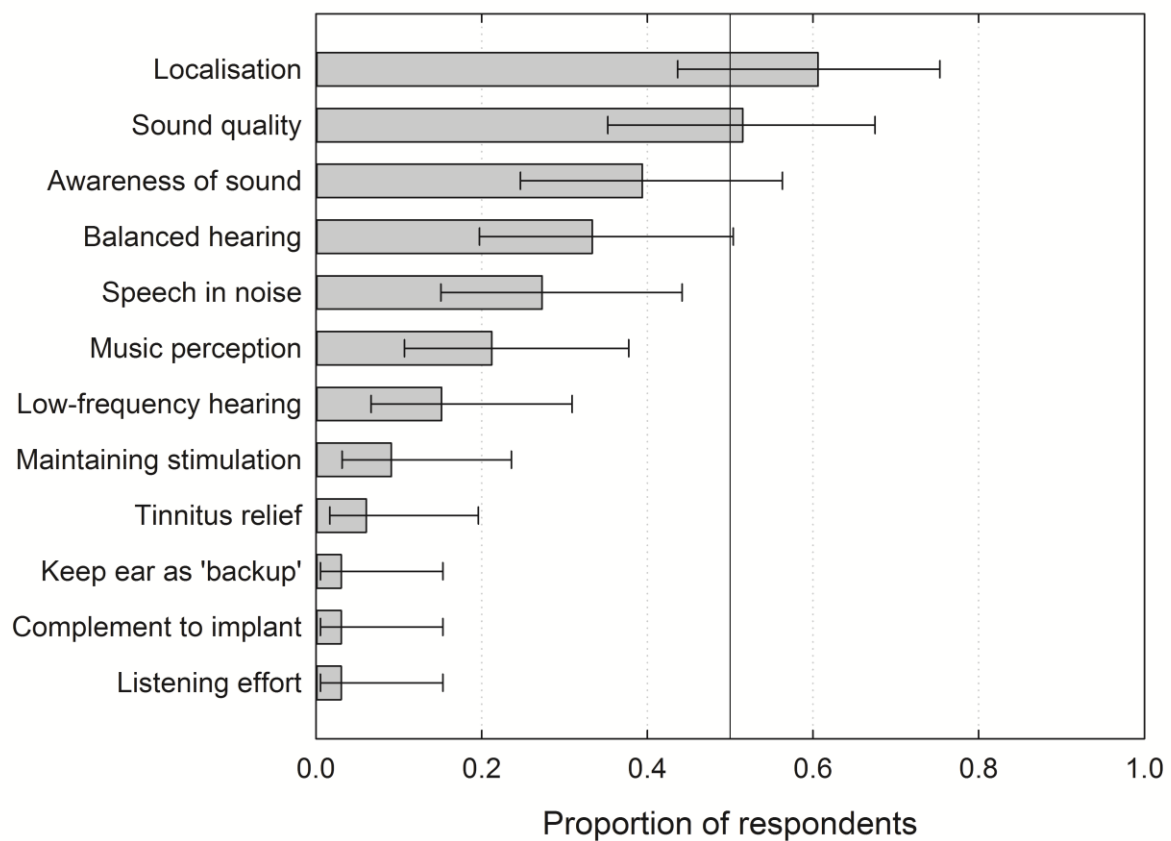


Figure 1

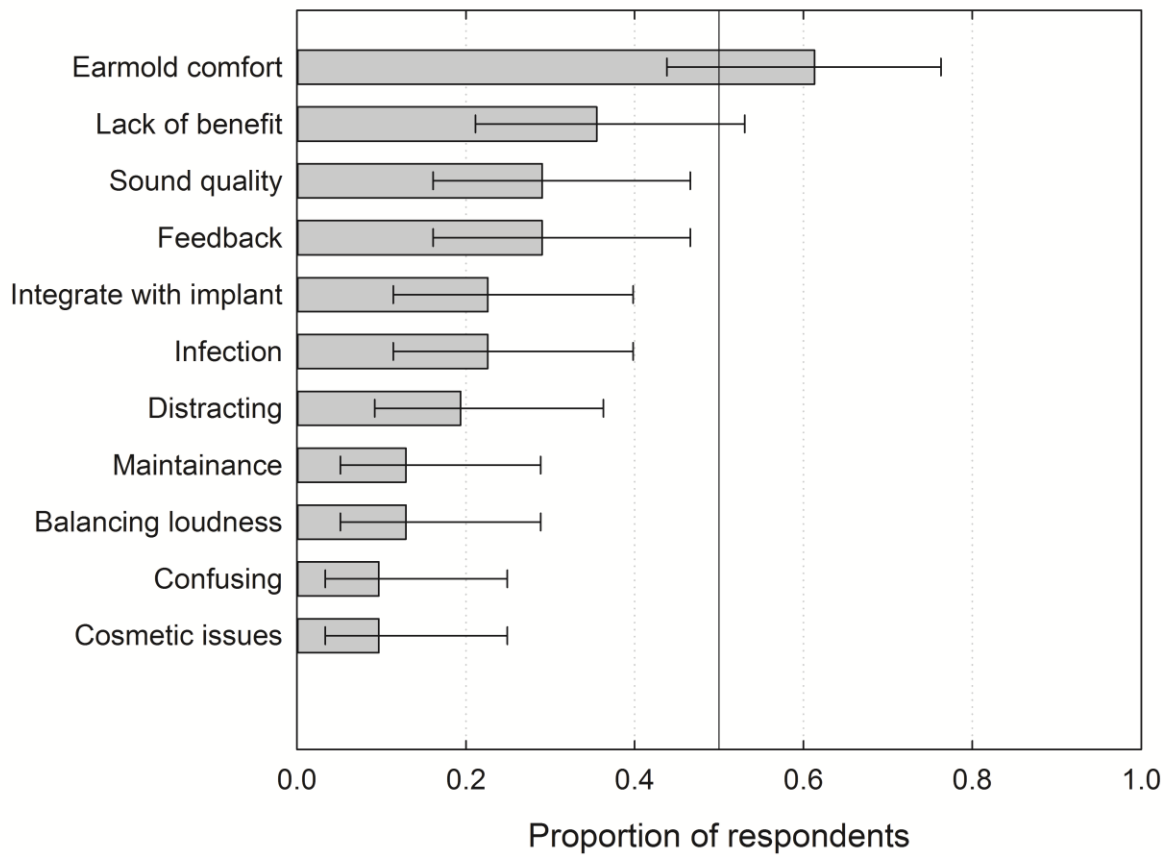


Figure 2

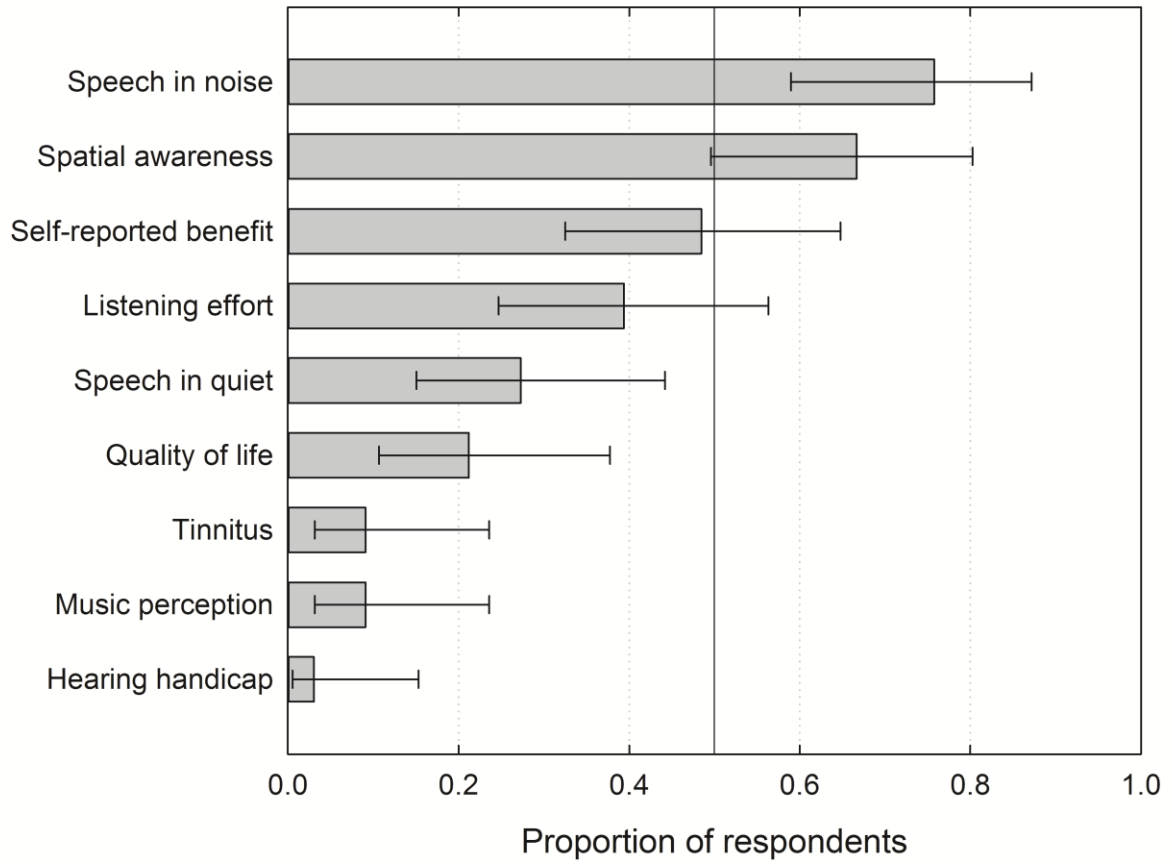


Figure 3

Participating Centres	Number of responses
Belfast Cochlear Implant Centre	1
Cardiff Adult Cochlear Implant Programme	1
Dublin Cochlear Implant Programme	1
Emmeline Centre, Cambridge	1
The Richard Ramsden Centre for Hearing Implants (Manchester)	3
The Midlands Hearing Implant Programme (Adults' Service)	3
North Wales Cochlear Implant Programme	1
Nottingham Auditory Implant Programme	3
The Oxford Cochlear Implant Programme	1
Portland Hospital Cochlear Implant Programme	1
RNTNE Adult Implant Programme	1
Scottish Cochlear Implant Programme	2
South Wales Cochlear Implant Programme, Bridgend	1
St George's Hospital Auditory Implant Service	1
St Thomas' Hospital Hearing Implant Centre	1
University of Southampton Auditory Implant Service	7
West of England Hearing Implant Programme	2
Yorkshire Auditory Implant Service (Bradford)	1
Yorkshire Auditory Implant Service (Sheffield)	1
<b>Total number of completed responses (with identifiable affiliation)</b>	<b>33</b>
Total number of incomplete responses (without identifiable affiliation)	5
<b>Total number of responses</b>	<b>38</b>

	No. centres (%; 95% CI)	No. respondents (%; 95% CI)
<b>HA management during candidacy assessment (Section 1a)</b>		
<i>Numbers who...</i>		
conduct HA evaluations as part of the candidacy assessment	<b>18 (95; 75-99)</b>	<b>28 (74; 58-85)</b>
routinely check HA fittings in patients attending for assessment	<b>14 (78; 55-91)</b>	<b>21 (75; 57-87)</b>
check HA fittings in <i>every</i> HA user during assessment	11 (61; 39-80)	16 (57; 39-73)
routinely attempt a HA fitting in a candidate with no HAs	<b>15 (83; 61-94)</b>	<b>24 (86; 69-94)</b>
routinely attempt to fit a HA to a single non-aided ear	11 (61; 39-80)	14 (50; 33-67)
use a combination of HA evaluation methods	<b>17 (94; 74-99)</b>	<b>23 (82; 64-92)</b>
<b>HA management following implantation (Section 1b)</b>		
<i>Numbers who...</i>		
routinely take responsibility for the contralateral HA	<b>5 (26; 12-49)</b>	<b>6 (18; 9-34)</b>
would refer to a different audiologist for HA issues	<b>15 (79; 57-91)</b>	<b>27 (82; 66-91)</b>
evaluate the contralateral HA during the first 12m of CI use	8 (42; 23-64)	10 (30; 17-47)
attempt to re-fit a HA the patient had stopped wearing	<b>6 (32; 15-54)</b>	<b>6 (18; 9-34)</b>
routinely attempt a HA fitting in an unaided contralateral ear	<b>0 (0; 0-17)</b>	<b>0 (0; 0-10)</b>
only fit a HA to an unaided contralateral ear at patient request	9 (47; 27-68)	<b>10 (30; 17-47)</b>
routinely review the HA fitting after 12m of CI use	<b>3 (16; 6-38)</b>	<b>3 (9; 3-24)</b>
use the same combination of HA evaluation methods as pre-CI	9 (47; 27-68)	10 (33; 19-51)

	No. centres (%; 95%CI)	No. respondents (%; 95%CI)
<b>Sympathetic bimodal fitting (Section 1c)</b>		
<b>At initial activation: Numbers who...</b>		
follow an agreed bimodal switch-on protocol	<b>1 (5; 1-25)</b>	<b>1 (3; 1-15)</b>
take HA parameters into account when programming the CI	<b>4 (21; 9-43)</b>	<b>4 (12; 5-27)</b>
match fitting parameters e.g. frequency ranges of HA and CI	<b>0 (0; 0-17)</b>	<b>0 (0; 0-10)</b>
balance the CI and HA for loudness	11 (58; 36-77)	12 (36; 22-53)
<b>At subsequent review appointments: Numbers who...</b>		
follow an agreed bimodal programming protocol	<b>1 (5; 1-25)</b>	<b>2 (6; 2-20)</b>
take HA parameters into account when programming the CI	<b>3 (16; 6-38)</b>	<b>3 (9; 3-24)</b>
match fitting parameters e.g. frequency ranges of HA and CI	<b>2 (11; 3-31)</b>	<b>3 (9; 3-24)</b>
balance the CI and HA for loudness	<b>15 (79; 57-91)</b>	18 (55; 38-70)
<b>Post-implant bimodal outcome measurement (Section 1d)</b>		
<i>Numbers who...</i>		
follow an agreed protocol for measuring bimodal benefit	7 (37; 19-59)	<b>8 (24; 13-41)</b>
routinely measure CI-only listening outcomes	<b>18 (95; 75-99)</b>	<b>27 (82; 66-91)</b>
routinely measure bimodal listening outcomes	12 (63; 41-81)	17 (52; 35-67)
routinely measure HA-only listening outcomes	<b>5 (26; 12-49)</b>	<b>5 (15; 7-31)</b>
choose specific outcome measures to measure bimodal benefit	4 (33; 14-61)	<b>4 (24; 10-47)</b>
<b>Advice given to patients (Section 1e)</b>		
<b>At initial activation: Numbers who...</b>		
recommend intermittent use of the HA at first	13 (68; 46-85)	19 (58; 41-73)
recommend not wearing the HA until 3 months post-CI	<b>4 (21; 9-43)</b>	<b>5 (15; 7-31)</b>
recommend both devices be worn together from the start	<b>3 (16; 6-38)</b>	<b>5 (15; 7-31)</b>
leave it to the patient to decide if bimodal aiding is beneficial	<b>4 (21; 9-43)</b>	<b>4 (12; 5-27)</b>
<b>At subsequent review appointments: Numbers who...</b>		
actively encourage established CI users to wear a HA	<b>18 (95; 75-99)</b>	<b>31 (94; 80-98)</b>

<b>Practice</b>	<b>Pre-implant</b>	<b>Initial activation</b>	<b>Post-implant</b>
Hearing aid management	✓ (2)	✗ (2)	✗ (2)
Sympathetic bimodal fitting	--	✗ (3)	✗ (3)
Advice to patients on bimodal aiding	--	? (3)	✓ (3)
Bimodal outcome measurement	--	--	? (3)

	<b>No. centres (%; 95%CI)</b>	<b>No. respondents (%; 95%CI)</b>
<b>HA management (Section 2a)</b>		
<b>During candidacy assessment. Numbers who indicated...</b>		
a lack of staff expertise in HA fitting	8 (42; 23-64)	18 (50; 34-66)
a lack of time	<b>3 (16; 6-38)</b>	<b>4 (11; 4-25)</b>
a lack of available audiologists	6 (32; 15-54)	<b>8 (22; 12-38)</b>
a lack of rooms/equipment	<b>5 (26; 12-49)</b>	<b>9 (25; 14-41)</b>
patients have insufficient residual hearing	<b>1 (5; 1-25)</b>	<b>1 (3; 0-14)</b>
<b>During initial activation. Numbers who indicated...</b>		
a lack of time	13 (68; 46-85)	17 (52; 35-67)
a lack of equipment	<b>5 (26; 12-49)</b>	<b>10 (30; 10-47)</b>
<b>During subsequent reviews. Numbers who indicated...</b>		
a lack of time	11 (58; 36-77)	15 (45; 30-62)
a lack of rooms/equipment	7 (37; 19-59)	11 (33; 20-50)
a lack of staff expertise in HA fitting	<b>5 (26; 12-49)</b>	14 (42; 27-59)
a lack of available audiologists	9 (47; 27-68)	18 (55; 38-70)
<b>Bimodal outcome measurement (Section 2b)</b>		
<i>Numbers who indicated...</i>		
a lack of time	9 (47; 27-68)	12 (36; 22-53)
a lack of staff expertise	<b>4 (21; 9-43)</b>	<b>5 (15; 7-31)</b>
a lack of equipment	6 (32; 15-54)	<b>6 (18; 9-34)</b>
<b>Sympathetic bimodal fitting (Section 2c)</b>		
<i>Numbers who indicated...</i>		
a lack of time to fit both devices in the same session	11 (58; 36-77)	17 (52; 35-67)
a lack of guidelines on optimising bimodal fittings	12 (63; 41-81)	18 (55; 38-70)



	No. centres (%; 95%CI)	No. respondents (%; 95%CI)
<b>HA management (Section 3a)</b>		
<b>During candidacy assessment. Numbers who indicated...</b>		
it is the role of the CI audiologist to evaluate HAs	<b>13 (68; 46-85)</b>	15 (42; 27-58)
it is beneficial to optimise HAs	<b>18 (95; 75-99)</b>	<b>33 (92; 78-97)</b>
<b>During subsequent reviews. Numbers who indicated...</b>		
it is the role of the CI audiologist to evaluate contralateral HAs	<b>15 (79; 51-88)</b>	20 (61; 50-80)
it is beneficial to optimise the contralateral HA	<b>18 (95; 75-99)</b>	<b>30 (91; 76-97)</b>
<b>Bimodal benefit (section 3b)</b>		
<i>Numbers who indicated...</i>		
Consideration of bimodal aiding when choosing the CI ear	<b>16 (84; 62-94)</b>	21 (64; 47-48)
bimodal aiding is more beneficial than CI-alone	<b>16 (84; 62-94)</b>	<b>28 (85; 69-93)</b>
it is clinically useful to measure bimodal benefit	<b>18 (95; 75-99)</b>	<b>30 (91; 76-97)</b>
<b>Sympathetic bimodal fitting (Section 3c)</b>		
<i>Numbers who indicated...</i>		
sympathetic device fitting could improve outcomes	<b>16 (84; 62-94)</b>	<b>27 (82; 66-91)</b>
a recently re-fit HA is more beneficial than an older fitting	<b>15 (79; 57-91)</b>	<b>26 (79; 62-89)</b>
wearing a previously-fit HA can still provide bimodal benefits	<b>16 (84; 62-94)</b>	<b>26 (79; 62-89)</b>
<b>Further guidance (section 3d)</b>		
<i>Numbers who indicated a need for guidance on...</i>		
maximising bimodal benefit	<b>18 (100; 82-100)</b>	<b>31 (97; 85-99)</b>
optimising bimodal fitting	<b>16 (89; 67-97)</b>	<b>29 (91; 76-97)</b>
identifying bimodal candidates	<b>14 (78; 55-91)</b>	<b>23 (72; 55-84)</b>
measuring bimodal benefit	<b>16 (89; 67-97)</b>	<b>28 (88; 72-95)</b>
when to reintroduce the HA post-CI	<b>15 (83; 61-94)</b>	<b>26 (81; 65-91)</b>
how to advise patients on bimodal listening	<b>16 (89; 67-97)</b>	<b>27 (84; 68-93)</b>