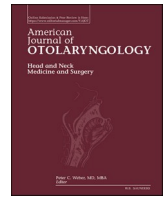


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Pilot study of a multidisciplinary single-day cochlear implant selection protocol

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ABSTRACT

Purpose: This study aimed to explore and introduce the potential of a MSCS (Multidisciplinary Single-day Cochlear Implant Selection) protocol. The primary objectives of this pilot were to reduce the duration between referral and surgery, minimize hospital visits and decrease the time healthcare professionals dedicate to the cochlear implant (CI) selection process.

Materials and methods: We established a pilot program at the CI center of the Erasmus MC, a tertiary referral center in the Netherlands, with the goal of improving and shorten the selection process. We evaluated our pilot, including 15 CI candidates, and conducted a retrospective analysis for time and cost savings.

Results: The results showed that the pilot of the MSCS protocol significantly reduced the length of the CI selection phase (84 days vs 1; standard intake vs MSCS protocol) and the number of hospital visits (6 vs 2 visits; standard vs MSCS protocol), resulting in less travel time and lower costs for the CI candidates. The total time of professionals spend on patients was also reduced with 27 %.

Conclusion: This study highlights the potential benefits of the MSCS protocol in terms of reducing the burden on patients and healthcare providers and improving the efficiency of the CI selection process.

1. Introduction

The selection process for cochlear implantation (CI) often involves a comprehensive and prolonged series of evaluations, which includes multiple visits to the CI center. The evaluations typically include audiological and otological assessments, imaging such as computed tomography (CT) and, if indicated, magnetic resonance imaging (MRI), as well as consultations with a variety of health care professionals, including speech therapists, social workers, psychologists, ENT specialists and audiologists [1,2]. For CI candidates, this high number of visits can be a significant burden in terms of time and travel costs. Moreover, for patients undergoing this multifaceted evaluation process, the extended waiting period for the outcomes of numerous appointments can engender heightened levels of anticipation, potentially affecting their psychological well-being. As severe hearing impairment is associated with a reduction of quality of life, a shorter interval between referral and surgery is desirable for these individuals [3,4].

In the Netherlands, the number of CI candidates is increasing due to both demographic changes, such as an aging population, as well as expanding indication criteria for CI [5–8]. In light of this trend, coupled

with the constraints of limited resources, CI centers have been motivated to improve the efficiency of their diagnostic and treatment protocols for this patient population. In order to do this, we have developed the multidisciplinary single-day CI selection (MSCS) protocol, which aims to reduce the time between referral and surgery, the number of hospital visits, and the time spent by healthcare professionals in the CI selection process. Currently, only one other CI center has described a similar selection protocol for cochlear implantation in a small pilot study [9,10].

The purpose of this paper is, therefore, to assess the effectiveness of the MSCS pilot. We evaluate the impact on the efficiency of the standard CI selection pathway, considering factors such as the time between referral, first visit, and surgery, as well as the frequency of hospital visits and the duration of face-to-face interactions with healthcare professionals. Additionally, we will quantify the resulting benefits in terms of reduced travel distances and associated time and cost savings.

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2. Materials and methods

2.1. Patients

A retrospective case review was conducted at the CI center of the Erasmus MC, a tertiary referral center located in Rotterdam, the Netherlands. The study population consisted of adult patients aged 18 years or older, and two datasets were analysed. The first dataset included CI users implanted in 2019 or 2022 who followed the standard CI selection pathway. The intervening years between 2019 and 2022 were excluded due to adapted care, prolonged referral times and lack of operating room capacity due to the COVID-19 pandemic. Patients with sudden deafness and those requiring other otologic surgeries or hearing aid adjustments during their selection process were excluded, as they did not follow the standard CI selection pathway. The second dataset included patients participating in the MSCS pilot, who were selected by experienced CI audiologists from referrals based on previous audiograms, speech recognition scores with hearing aids, and otologic and audiologic history. Among eligible candidates, suitability was defined as: 1. There was adequate information available about the current

functioning of the patient’s hearing. Recent audiometry was available and reliable. Older audiograms were available for assessing any progression if required. 2. There was a clear and direct referral from a peripheral audiological center or an ENT specialist. 3. The patient’s hearing aids had been recently examined and verified for their functionality. 4. Individuals did not have additional conditions such as cognitive problems. Patients meeting the criteria above were invited to participate in the pilot, which started the 6th of November 2022.

2.2. The standard CI selection pathway

The usual CI selection procedure in our CI center is a process with several visits to the hospital (Fig. 1). Hearing tests are often carried out before or on the day of intake (tone audiometry, speech audiometry in quiet, speech audiometry in quiet and noise with hearing aids). During the intake appointment, the audiologist and ENT specialist assess whether the patient is a potential CI candidate and discuss the considerations with the patient. Further diagnostics, such as radiological imaging and consultation with the medical social worker and speech therapist, are planned when indicated. The results are reviewed in a

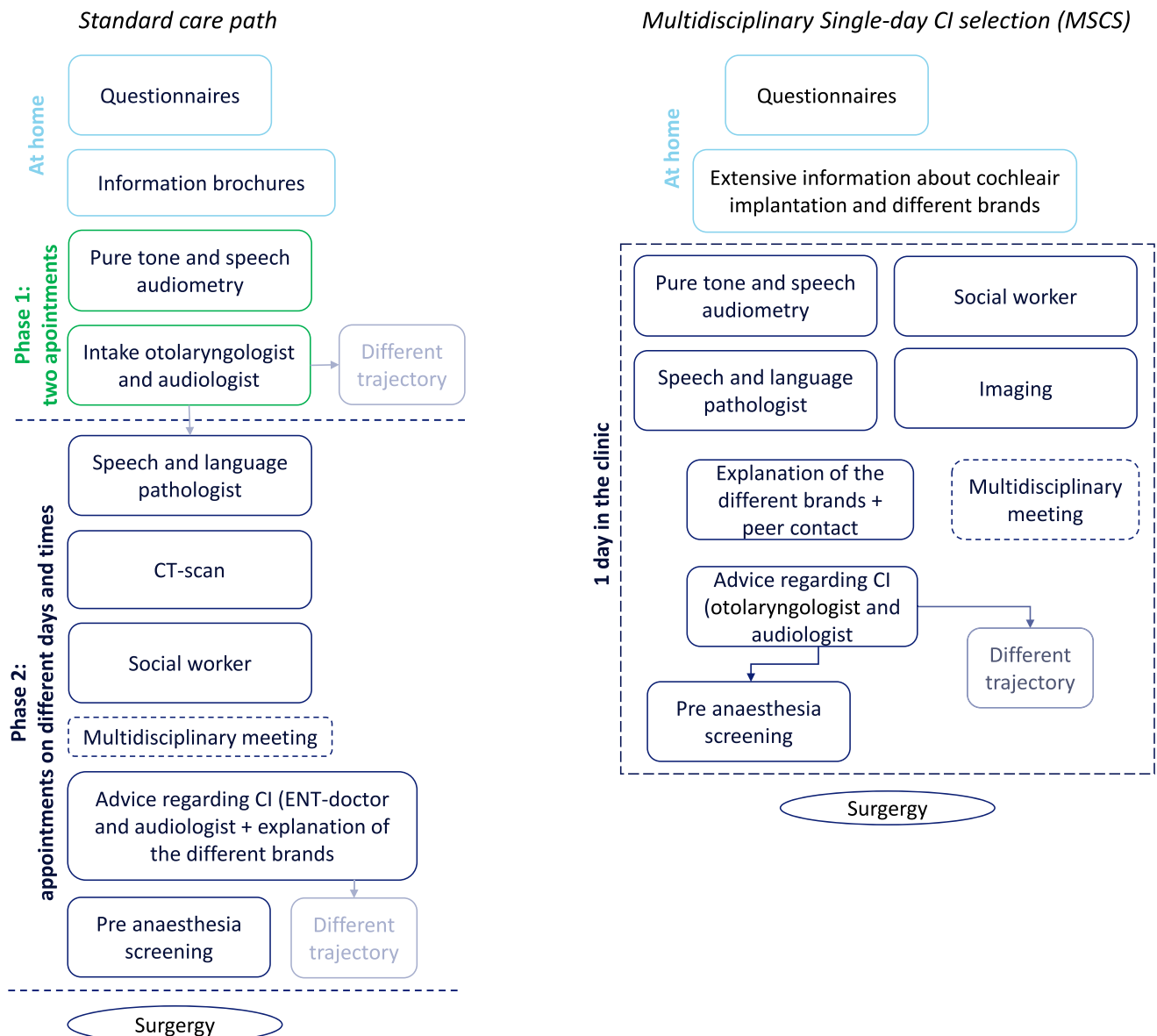


Fig. 1. The standard (left) and MSCS protocol (right).

multidisciplinary meeting in which the patient is not physically present. After the meeting, the CI candidate will have one more appointment with the ENT specialist and audiologist to discuss the advice from the multidisciplinary CI team. Afterwards, a pre-operative anaesthesia screening is planned.

2.3. The multidisciplinary single-day CI selection

Three MSCS pilot days were organised in our CI center. Prior to the selection day, patients received extensive educational information about the MSCS, the cochlear implant and the processor, the surgical procedure, the different CI brands and digital questionnaires by electronic mail. The patients were able to contact our centre for further questions by electronic mail, text apps or phone.

At the MSCS day, the CI candidates had four different appointments in the morning, including audiometry (tone audiometry, speech audiometry in quiet, speech audiometry in quiet and noise with hearing aids), consultation with a social worker, consultation with a speech therapist, and a CT scan. Because all appointments were consolidated into a single day, there was reduced redundancy in the advice and explanations provided. Throughout the lunch break, CI candidates had the chance to inquire about diverse brands of cochlear implants and received information regarding the different types of CI devices. If desired, patients also had the opportunity to interact with each other and share their personal experiences with hearing loss. In the standard CI selection pathway, CI candidates don't come into contact with each other because appointments are widely spaced in time. Some patients may specifically request peer support, but usually, this is not possible due to various factors. By now providing joint education sessions for CI candidates, patients, as well as their partners or children, gain insight into the challenges faced by individuals with hearing impairment. Meanwhile, the members of the CI team had a multidisciplinary meeting to discuss the results of all CI candidates. Since the ENT-specialist and audiologist only meet with candidates once (rather than twice in the standard process), they promptly received all information about the patients scheduled for the consultation in the afternoon.

Following the meeting, candidates had joint appointments with both the audiologist and ENT specialist, during which they received recommendations regarding CI candidacy. If the patient met the CI inclusion criteria and was identified as a surgical candidate, the surgery and risks were explained and a CI brand and type was chosen. Pre-operative anaesthesia screening was, when available, also carried out on the same day.

2.4. Short questionnaire

We posed three short questions to the patients who engaged in the MSCS through email. This was done to assess whether we were heading in the correct direction with the new protocol and to uncover any possible oversights. We asked patients the questions via mail after their MSCS appointment, and there was also room for free-text responses. The 3 questions were:

1. Did you have the opportunity to ask the questions you needed to make your choice during the final discussion? Possible answers were: No, not at all; Not really; Neutral; Yes, to some extent; Yes, I was able to ask all my questions. 2. Did you feel that you had enough information to make a choice for a CI-brand after you were informed that you were eligible for a cochlear implant? Answers: No, not at all; Not really; Neutral; Yes, to some extent; Yes, the choice was not a problem. 3. Did you find it pleasant to meet other people going through the same process? Answers: Not pleasant at all; Not pleasant; Neutral; Pleasant; Very pleasant; I didn't speak to other candidates.

2.5. Process indicators

To evaluate the impact of the MSCS on the efficiency of the standard

CI selection pathway, throughput times and number of hospital visits were used. Three different throughput times were distinguished: the time from referral to first appointment (*referral to first appointment time*), the time from start to finish of the selection phase (*selection phase*) and the time from referral to surgery (*referral to surgery time*). The time spent per patient by the different CI professionals was also measured.

In addition, using Google Maps the distance and travel time to the CI center was calculated for each patient individually. Savings in travel costs were calculated by saving in travel distance * €0.60 per kilometer, total costs of a small middle class car. [11] The difference in costs and travel time were then calculated between the usual care and MSCS protocol.

2.6. Statistical analysis

Data interpretation and analysis were performed using IBM SPSS Statistics 28 (SPSS Inc., Chicago, IL). Non-parametric statistical methods were used because of the non-normal distribution of the data. Differences in throughput time and hospital visits between the two groups were compared using the Mann Whitney *U* test. A *p*-value <0.05 was considered statistically significant.

3. Results

In 2019 and 2022 combined, a total of 108 adult patients received a cochlear implant following the standard CI selection pathway. In total 51 candidates were implanted in 2019, from which 7 were excluded as they did not follow the standard CI selection pathway due to other treatments or sudden deafness. Fifty-seven candidates were implanted in 2022 following the standard CI selection pathway, of which 13 were excluded. Until January 2023, 19 CI candidates participated in the MSCS of which 15 are included in the current study. The mean age of this pilot group was 64 years (SD 12,7) and 67 % was female. Four participants were excluded as they did receive a negative advice regarding cochlear implantation and one patient was excluded as he/she did not yet decide for surgery. Two patients were initially included but the surgery was postponed due to other medical treatments. For these two patients, we only included the referral to selection appointment time and total visits before surgery. The average distance travelled per visit was 68 km (round trip, SD 26 km) averaged over all included patients with an average travel time of 86 min (round trip, SD 20 min).

The median throughput time (Fig. 2) from referral to surgery (panel A) was 259 days for the standard cohort and 142 days for the MSCS cohort, which was significantly different (Mann Whitney *U*: $U = 104$, $p < 0.001$). Median throughput times for the referral until the patient was put on the waiting list (end of selection phase, panel B) was 145 days for the standard cohort, and 41 day for the MSCS cohort ($U = 25.5$, $p < 0.001$). Median throughput times for the selection phase (panel C) was 84 days for the standard cohort, and 1 day for the MSCS cohort ($U = 15$, $p < 0.001$). Time to gain access to the first consultation did not change significantly (panel D).

Median number of hospital visits for the standard cohort was six visits and for the pilot group two visits, which was significantly different ($U = 0$, $p < 0.001$).

The time spend per patient by CI professionals dropped with 27 % from 295 min during standard care to 215 min with the MSCS, see Table 1 for an overview per professional.

The average number of visits in the standard care path was 5.9, resulting in an average distance of 401 km and estimated travel time of 253 min per patient if travelled by car. In contrast, for the MSCS cohort, the average number of visits was 1.6, resulting in an average distance of 109 km and travel time of 68 min per patient. This represents a savings of €175 per patient compared to the standard cohort in travel costs, as well as a savings of 185 min in travel time.

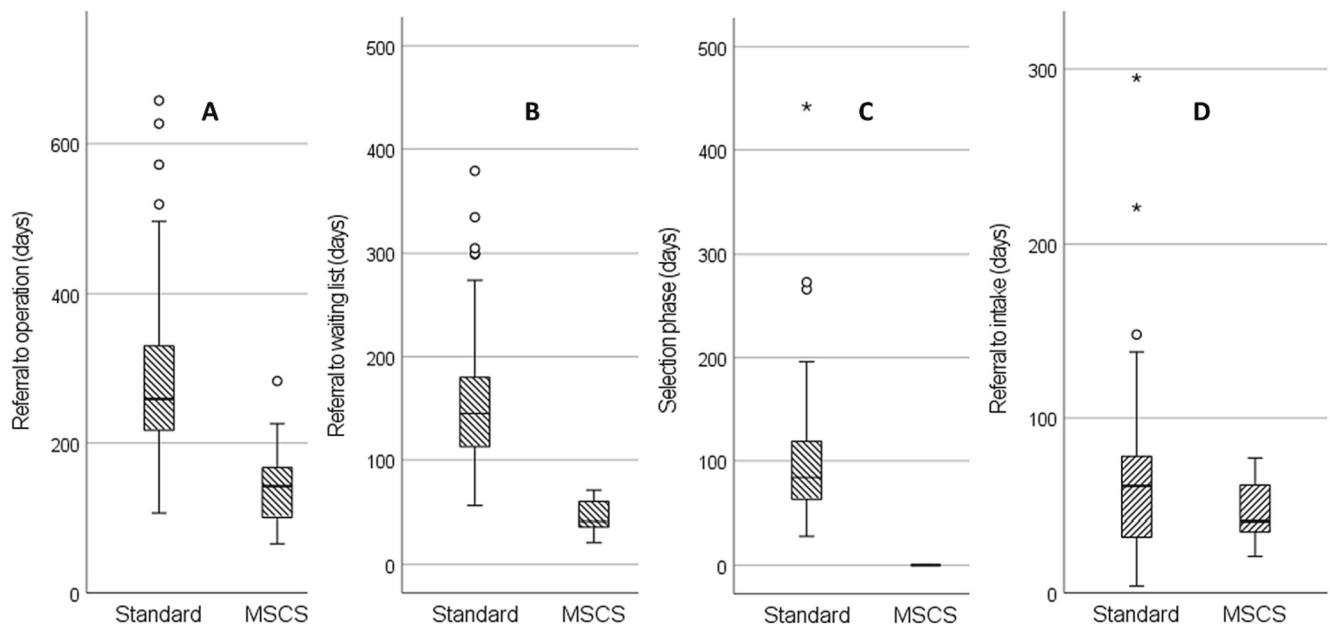


Fig. 2. Box-whisker plots of the number the different throughput times; Panel A is the time from referral to surgery, panel B is the time from referral to the end of the selection phase, panel C is the throughput time for the selection phase, panel D is time from referral to intake. Boxes represent the median (thick horizontal line), lower and upper quartiles (end of boxes), minimum and maximum values (ends of whiskers), and outliers (values between 1.5 and 3 times the interquartile range above the third quartile – circles, values below or above 3 times the third quartile - asterisks).

Table 1
Overview of time spend per professional per patient.

	Standard protocol	MSCS
	Time (min)	Time (min)
Audiologist	60	40
Otolaryngologist	60	30
Speech therapist	60	45
Medical social worker	60	45
Audiometrist	45	45
Total time	295	215

3.1. Questionnaire

The questions were answered by 10 individuals. For the question “Could you ask the questions you needed to make your choice during the final discussion?”, five patients (50 %) indicated that making a choice was not a problem, and two patients said they could make a choice to some extent. Two patients gave a neutral response, and one patient felt he could not make a choice yet.

For the second question “ Did you feel that you had enough information to make a choice for a CI-brand after you were informed that you were eligible for a cochlear implant?”, five people stated that it was not a problem to choose a brand, two patients gave a neutral response, and two patients indicated that they were informed to some extent. One person felt he was not (yet) adequately informed.

The patient who initially lacked sufficient information for a brand choice (questions 1 and 2) asked for more time during the consultation to explore the different brands and expressed gratitude for having been given the opportunity. Afterward, making the choice was no longer a problem.

The responses to the final question, “Did you find it pleasant to meet other people going through the same process?” provided a distinct and positive insight. Four individuals expressed satisfaction (pleasant) in meeting fellow peers, while six individuals (60 %) went as far as to describe it as “very pleasant”.

4. Discussion

In our research, we examined the impact of the MSCS protocol on the process of selecting candidates for cochlear implantation and show a significant reduction in the length of the selection phase and the number of hospital visits after implementing the MSCS protocol. Our MSCS protocol, along with the same-day consultation and cochlear implantation procedure described by Nassiri et al. (2020) and Patro et al. (2022) at the CI center of Vanderbilt University Medical Center, represent the sole studies comparing an efficient one-day cochlear implant selection protocol. In the Vanderbilt selection protocol, the surgical procedure is also conducted on the same day as the candidate selection. Another notable distinction with our pilot was that, in the Netherlands, specifically at the Erasmus Medical Center, patients underwent evaluation and counselling from social work and a speech therapist in addition to the medical assessment. In the Vanderbilt protocol, there was the option for telehealth-based treatment discussions prior to the consultation day. In our pilot, patients could inquire about specific practical aspects beforehand, but the majority of the information provided was discussed in-person by various disciplines on the consultation day. What aligns with colleagues Nassiri and Patro is the recognition that, in our pilot as well, pre-procedure information and brand-related details were found to be of great importance. Therefore, we substantially enhanced our pre-procedure information and solicited patient feedback for evaluation purposes. To further improve the pre-procedure information we are currently working on animated videos to educate patients and further motivate them to thoroughly review the information sent to them at home.

In the context of the MSCS pathway, which involves multiple appointments in a single day, and it is essential to ensure that only appropriate candidates are included for this pathway. To accurately assess whether individuals are suitable candidates for MSCS, we have informed referring providers through letters about the essential information our team requires to triage patients for the MSCS day. This entails the need to obtain as many old audiograms as possible, recent audiometry (pure-tone and speech audiograms), and a thorough medical history. This may have caused a selection bias in the patient selection for our pilot days, as we looked at the completeness of referrals.

When we asked patients if they felt adequately informed, most of them expressed satisfaction. However, a small portion of the patients was less specific or even dissatisfied with the information provided (one out of the ten surveyed patients). This appears to be related, in part, to the fact that we are a brand-independent center, while patients often wish to receive recommendations regarding which brand suits them best. Nevertheless, this decision should be made by the patient based on their individual characteristics and preferences. To encourage patients to seek out more information themselves, we have actively referred them to patient associations, and we also provided contact information for various CI brands.

The 27 % savings in face-to-face contact time with healthcare providers achieved by the MSCS protocol represents a significant opportunity in light of the increasing number of CI candidates due to both an aging population and the expansion of implantation criteria. As the number of CI candidates continues to rise, there is a need to improve the efficiency of the standard CI selection pathway in order to ensure that all patients receive timely and appropriate care. A reduction in interaction between healthcare providers and patients can also have a negative impact as there may be unanswered questions or unnoticed uncertainties. Therefore, in a follow-up study, we will further investigate patient satisfaction using questionnaires.

One potential disadvantage of the MSCS protocol is that it may lead to a shortened reflection period for patients, as the decision on whether a candidate will be placed on the waiting list for a CI is made on the same day as the MSCS. While this set-up could theoretically result in a shorter waiting period compared to the traditional selection process, it is important to consider the potential impact on the patient's decision-making process. To mitigate this, the CI team clearly communicates its contact details to all candidates and is easily accessible for questions or doubts. Further evaluation will be needed to determine whether patients still require a follow-up contact moment to briefly review the decisions taken during the MSCS.

A challenge when implementing the MSCS protocol is the initial investment of time and resources required to plan and organize the protocol in a different way. This includes creating educational materials, coordinating with other departments such as radiology to schedule appointments, and ensuring that the healthcare team is fully supportive of the new protocol. Therefore, it is important for the implementation team to have a clear plan, adequate resources and effective communication strategy in place to ensure a smooth and successful implementation of the final MSCS protocol.

For example, patients who require additional hearing aid fittings or who are not fluent in Dutch and require translators may not be suitable candidates for the MSCS. Therefore, it is important for referral letters to include detailed and accurate information in order to ensure that patients are properly selected for the MSCS protocol.

The number of hospital visits was drastically reduced after the introduction of the MSCS. As pre-operative anaesthesia screening was not always possible on the same day, future improvements could include scheduling the pre-operative anaesthesia screening on the same day by making appointments with colleagues from the anaesthesia department.

A limitation of the study's calculations for the savings in travel is that it assumed that all candidates travelled to the CI center by car. It is possible that some candidates, particularly those who lived nearby, used other forms of transportation such as public transportation, bicycle, or even walked. This could have resulted in an over or underestimation of the savings in travel time and costs (as public transport is quite expensive in the Netherlands).

5. Conclusion

In conclusion, this study has demonstrated the benefits of the MSCS protocol for the cochlear implant selection process. The pilot of the MSCS protocol resulted in a significant reduction in the length of the selection phase and the number of hospital visits, as well as a 27 % savings in face-to-face contact time with healthcare providers. Additionally, the MSCS protocol resulted in significant savings in travel time and costs for patients. The MSCS protocol represents a significant departure from traditional CI selection protocols and its effectiveness in other settings and comparison with traditional CI selection protocols needs to be further researched. However, in light of the increasing number of CI candidates and the need for efficient, high-quality care, the MSCS protocol has the potential to be an important tool for addressing these challenges.

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