Subtitled caption link: https://youtu.be/YZww_WdcMYQ

MELISSA: Hello, everyone. This is Melissa McCarthy from the RIDBC Renwick Centre. I'd like to welcome you all to today's LOCHI seminar, Predicting speech, language and functional outcomes of five-year-old children with hearing loss.

Our presenter today is Dr Teresa Ching, who will be familiar to many of you. Dr Ching She is the Senior Research Scientist and Leader of Rehabilitation Procedures Research at the National Acoustic Laboratories in Australia. Her current research focuses on many areas, including investigating efficacy of early intervention for populations of children with hearing loss, and identifying factors affecting outcomes.

On behalf of RIDBC Renwick Centre, please join me in welcoming Dr Teresa Ching. Over to you, Teresa.

TERESA: Thank you, Melissa. Hello, everyone. Good afternoon and welcome to the second lecture of the LOCHI series, which is supported by Cochlear and the Royal Institute for Deaf and Blind Children.
My name is Teresa Ching. I'm joined here by Linda Couples. We're going to present to you some findings from the LOCHI study, specifically looking at the spoken language development of children with hearing loss. We will talk about their performance levels and we will also identify the specific factors influencing the outcomes of the children who are using hearing aids at five years of age and separately also for children who use Cochlear implants.

About 2,000 to 3,000 newborns have a permanent childhood hearing loss. We know the presence of a hearing loss has a negative impact on children's development of speech and language, which has flow-on effects on their psychosocial development, their academic achievements and ultimately their chances in life.

For this reason, various governments right around the world have started to implement universal newborn hearing screening, because there is the expectation that with early detection and early intervention the outcomes of children born with hearing loss can be improved.

However, the effectiveness of early intervention for improving child outcomes at the population level has not been proven.

This slide summarises some of the current literature looking at outcomes of children with hearing loss.
The first two studies are population based outcomes. And the first one was conducted in Australia. The second was conducted in the Netherlands.

Neither of the studies actually found that children who received early intervention have better outcomes than children who received later intervention.

Further, they found that the language abilities of the children with hearing loss were well below the language achievements of children with normal hearing.

There are a few other studies on this slide which focuses on smaller groups of children or children from specific programs of intervention.

If we look at the last column, which says ‘Significant predictors’, you can see that several of these studies clearly indicated that the age of hearing aid fitting was not a significant predictor of outcomes of the children.

There was a study that showed that it was a significant predictor of outcomes, and another one that didn’t.

These studies also identified some specific factors that could potentially affect outcomes, which could include severity of hearing loss or maternal education. But again the findings are mixed, with
some showing a significant effect, and others not showing significant effects.

In a similar way, if we look at children with Cochlear implants, again there are studies looking specifically at the outcomes of young and older children who receive early intervention and early Cochlear implantation, and generally the studies show that, on average, the children with Cochlear implants have receptive and expressive language that are below their normal hearing peers.

When we look at the studies that specifically look at whether age of implantation was a significant predictor of outcomes, we found that several of these studies did show a significant effect. The first one did not look at the specific level of performance, but it did look at the rate of improvement of the children. And, again, finding that those children who received early implantations demonstrated a range which is more similar to normal hearing children compared to those who actually received implants after 18 months of age.

Interestingly, there is a very recent study in the Netherlands looking at a big group of children with Cochlear implants showing that the age of implantation was a significant predictor of outcomes, if you were to measure those outcomes at one or two years after implantation.

On the other hand, if you did measure the outcomes again at three years after Cochlear implantation, then the age of Cochlear implantation was longer a significant predictor of outcomes.
All in all, the literature clearly suggests that age of hearing aid fitting or age of Cochlear implantation or severity of hearing loss or parental level of education—that many of these factors do influence outcomes. However, the findings with regard to whether age of intervention was a significant predictor of outcomes and that it actually improved outcomes of children with hearing loss was as yet inconclusive.

This is an important question for governments and policy makers who would actually need to invest a lot of money into early intervention and into newborn hearing screening. The lack of evidence would mean that many of these fundings could be withdrawn from the population, such that children who do benefit from early intervention may then not have the opportunity to do so.

For that reason, we commenced the LOCHI studies in 2005, the longitudinal outcomes of children with hearing impairment study. The goal of the study was to really to look at the effectiveness of early intervention for improving outcomes of children with hearing loss at the population level.

We have a very unique opportunity in Australia whereby Australian Hearing is the single government funded organisation that provides hearing services to all children with hearing loss in Australia at no cost at all to the families up to the age of 26 years of age.
During a narrow time window around 2005, when different States were rolling out universal newborn screening, we had the opportunity of being able to invite families to come to Australian Hearing for services with a child with hearing loss, and yet depending on where they lived some of them would have access to newborn screening whereas others wouldn't.

Because the access to hearing services and the access to the educational services are fairly similar across the State, then if there were differences in the performance of these children, we could potentially relate that to whether that was the age at which they received intervention that could be affecting their outcomes.

So, being able to do it at a population level allowed us to address that particular evidence gap that I was referring to.

The study aimed to look at whether early intervention improves spoken language and functional performance of the children with hearing loss at a population level using a perceptive longitudinal study. We also aimed to find out what are the specific factors influencing the outcomes of children using hearing aids and the factors influencing outcomes of children using Cochlear implants.

A better understanding of these factors would enable us to fine tune the rehabilitation that we are going to be able to provide to those children so that we can optimise their outcomes.
In this presentation we’re going to talk about the results from 239 children with hearing loss. Some 228 of them were using hearing aids and 111 are using Cochlear implants.

We're going to cover mainly the evaluations that were conducted at five years of age, and this slide shows you some basic characteristics of the children.

Notice that about 35 per cent of them have additional disabilities. About 80 per cent of those children with hearing aids and about 70 per cent of those children with Cochlear implants used oral communication in early education. So, they used speech with no access to any form of sign or manual communication. Whereas the 16 per cent of children that were using hearing aids and 28 per cent of those using Cochlear implants were actually using a combination of sign and speech in communication.

When we look at maternal education level, about 40 per cent in each of those groups have mothers who completed university education, and roughly about 30 per cent of the mothers completed formal schooling up to about 12 years in each of those fields.

Let's look at the children with hearing aids. A fair distribution of hearing loss. Mostly moderate degrees of loss, but some with mild loss and some with severe loss.
When we look at the age of fitting of hearing aids for these children, notice that the median is six months. So, this is saying that 50 per cent of the children with hearing aids were fitted with hearing aids before six months of age, and the remaining were fitted after six months of age.

The interquartile range shows you that roughly we are looking at children fitted between 2 and 17 … 212 were using bilateral hearing aids, and 16 of them were using unilateral hearing aids.

When we look at children with Cochlear implants, again, the median is around 14 months. So, about half of those children have Cochlear implants, and … Cochlear implants from 14 months of age.

Some 79 of them were using bilateral Cochlear implants at five years of age. The remaining were using unilateral Cochlear implants, and about 23 of them were also using a hearing aid in each ear.

The nine who were using a unilateral Cochlear implant at that age had practically no useful hearing in the other ear for a hearing aid to be used.

So, at five years of age we collected a whole lot of information about these children, including the child related factors and the family and the intervention related factors, and we administered a whole range of tests of language, speech and functional
performance using either standardised tests that require direct administration to the child by a speech pathologist, or using parent reports.

These are the language measures that we used. We used the preschool language scale, which gives you two subscale scores. A subscale score on receptive language and a subscale score on expressive language. It also gives you a total language score, and the test is being administered by a speech pathologist using standardised procedures. And we derived the scores accordingly.

We also administered the picture vocabulary test. This is the PPVT, the Peabody Picture Vocabulary Test. It gives you a score on receptive vocabulary.

In addition, we also used the parent reports. This is the child development inventory. The inventory has a total of 300 statements, and parental care-givers are required to give a yes or no answer to each of the statements to see whether the child demonstrates that particular behaviour as described by the statement.

In this talk we're going to focus just on those 100 statements that gives us a score on receptive language and a score on expressive language.

Our speech pathologist also administered the DEAP, Diagnostic Evaluation of Articulation and Phonology test. This is a test in which
they presented 50 pictures to the children. Each of those pictures are used to elicit a word to be produced by the child.

The child's production was then used to generate a consonant correct score and a vowel correct score.

We also asked parents to complete the parents evaluation of aural/oral performance of children, or the PEACH scale. This is a scale in which we require the parents to observe the child’s performance in everyday life situations and we ask the parents to rate the child's auditory/oral behaviour in those situations. That gives us a total score of the child's functional performance in real life.

Let's look at the results. This graph shows you the standard score on the vertical axis and on the horizontal axis the four different outcomes measured that we used. The dotted line on the graph at 100 is the normative mean, and the green band is plus or minus one standard deviation of 15. So, if a child were to score within one standard deviation of the normative mean or within the normal range … then the score would sit within the green band.

The purple band denotes two standard deviations from the normative mean.

If we look at the PLS receptive score, we can see the square which is the mean score for the group of children with hearing aids sitting at the lower edge of the green band. Just at that lower edge within
one standard deviation of the normative mean for receptive language.

For expressive language or receptive vocabulary. But below one standard deviation for functional performance in real life.

These are the results for children with Cochlear implants. The mean scores are depicted by the purple square, and again plus or minus one standard deviation.

We can see that the results are fairly similar to the children with hearing aids on average, and in terms of language and functional outcomes we're looking at mean scores of roughly around 1 to 1.5 standard deviations below the performances of normal hearing children.

Recall that we also had language scores as rated by parents. This slide shows you the quotient of child development inventory scores for receptive language and for expressive language. Again, sitting at just that edge of the green band were children with hearing aids, and just below that green band for children with Cochlear implants. So, roughly at around 1 to 1.5 standard deviation below the norm.

This graph shows you the speech production outcomes. Here you find that the mean scores are actually well below the green band and sitting in the purple band, demonstrating that these children on average have serious problems with production of consonants and vowels. The same story applies to children with Cochlear implants.
Here we’re looking at speech production outcomes. There were actually two standard deviations below the norm. That’s possibly also related to the fairly low score that we saw earlier on for functional performance in real life. Because that functional performance relies a lot on the use of speech communication in everyday situations.

So, taking those results, we looked at some correlation analogies between the outcomes and a whole range of factors. This is the correlation table for each of the outcome measures labelled across each of the columns, on the first row. Down the vertical you can see each of the factors.

I suppose the one that turns out to be quite surprising for all of us would be that gender doesn't seem to affect any of the outcomes measured that we did at five years of age. This is unlike what you generally found in the normal hearing literature, which suggests that gender seems to be one of the significant predictors of language outcomes of children with normal hearing. But we didn't find anything in correlation here.

Hearing loss turned out to be only significantly correlated with the PLS score for expressive language. Interestingly, you can see the maternal education level, communication mode, presence of additional disabilities and cognitive abilities were significantly correlated with each and every one of those outcomes measured.
Age at hearing aid fitting was correlated with some measures but not the others.

This is looking at a whole group. We'll now look at just children who use hearing aids. We start to see for age of hearing aid fittings it's significantly correlated with many of those other measures of outcomes. Again, you also see that severity of hearing loss becomes—a fairly significant correlation between the degree of hearing loss and many of those outcomes measured.

Of course, if we look at children with Cochlear implants, you see a slightly different picture. The degree of hearing loss now becomes insignificantly correlated with many of those measures. Age of hearing aid fitting was significantly correlated with some measures. But age of Cochlear implantation was significantly correlated with many of those measures as well.

There is a significant correlation between the age of hearing aid fitting and the age of Cochlear implantation.

Basically, we see a slightly different picture in terms of correlation when we look at children with Cochlear implants compared to children with hearing aids.

For that reason, we performed multiple regression analyses separately for children with hearing aids and children with Cochlear implants. Correlation suggested to us that potentially there could be slight differences in the range of predictor that actually predict the
outcomes of children with hearing aids or children with Cochlear implants.

Firstly, results from children with hearing aids. This table shows you on the first column the predictor variables for age of first fitting, severity of hearing loss, interaction between the two, cognitive ability as measured using the Western Non-verbal Scale, gender, presence of additional disabilities, maternal education level, and communication mode.

If we look at PLS-AC, which is receptive language, age of first fit, severity of hearing loss, cognitive ability, maternal education level, communication mode—they were all highly significant predictors. And together they actually accounted for 70 per cent of the variance in scores of the children with hearing aids.

We see a very similar picture for the receptive language as measured by the parent report scale, the child development inventory, and a fairly similar picture for the Picture Vocabulary Test.

If we then look at the predictors for expressive language, based on the PLS and expressive language, again, we see a fairly similar picture showing that cognitive ability, age of first fitting, severity of hearing loss, maternal education were all significant predictors.

Interestingly, we saw that communication mode in early intervention was a significant predictor for the measures that required direct
administration of the test to the child, and not for those measures that are based on parent reports.

For speech production, if we concentrate on consonant production, again we saw that all of these factors were highly significant predictors except for gender. If we look at functional performance in real life, it was age of first fitting, cognitive ability and maternal education that were significant predictors.

Now let's look at children with Cochlear implants. So, we're looking at results very similar to what we saw earlier on except at this time we did not put in age of hearing aid fitting and instead we put in age at Cochlear implantation in the analyses, and that was highly significant right across each and every outcome measured.

Cognitive ability was again a highly significant predictor. So was the presence of additional disabilities. Maternal education was only a significant predictor for receptive vocabulary but not for the other measures. And communication mode again was only significant for receptive vocabulary and expressive language based on the preschool language scale but not for those based on parent reports.

For speech production, again age of Cochlear implant switch-on, cognitive ability and the presence of additional disabilities were the three significant predictors of outcome for vowel production and … for consonant production.
For functional performance it was the cognitive ability that was the highest predicting factor of outcomes for children with Cochlear implants.

So, let's think of those two sets of regression analyses and think of which are the predictors that significantly predicted outcomes of children. Clearly, the age at intervention, and in this case it means age at fitting hearing aids for children with hearing aids, and it means age at Cochlear implanting for children with Cochlear implants, and that appears to be a highly significant predictor right across for most of the measures that we have shown you today.

So, clearly, the LOCHI study provides very solid evidence on the effectiveness of early intervention for improving outcomes of children using hearing aids or using Cochlear implants.

Severity of hearing loss was a significant predictor for children with hearing aids but it was not a significant predictor for children with Cochlear implants.

We reasoned that once a Cochlear implant has been implanted into the child’s ear, whatever residual hearing or whatever hearing the child had before implantation no longer has a significant effect on the child's outcome.

Nonverbal cognitive ability was a highly significant predictor right across-the-board for all measures for all children irrespective of whether they were using hearing aids or Cochlear implants.
The presence of additional disability has a much more profound effect on children with Cochlear implants but less so on children with hearing aids. This is possibly related to the fact that for children with additional disabilities who use Cochlear implants they actually have more severe degrees of additional disabilities compared to those children with hearing aids.

If you recall that some slides where I showed the demographic characteristics of the two groups of children, we are really looking at very similar proportions of children; around 34 to 35 per cent of the children in each of those groups have been diagnosed with additional disabilities. However, there was a higher proportion of children who have disabilities associated with diagnosed developmental delay or autism in the children with Cochlear implants compared to the children with hearing aids. So, it is not surprising that the presence of additional disability actually has a greater impact on those children with Cochlear implants.

Maternal education appears to have a greater effect on children with hearing aids than on children with Cochlear implants. Again, recall that we have roughly very, very similar characteristics of parental education levels in the two groups.

Finally, when we looked at communication mode, we found that communication mode was a significant predictor mainly and only for those test measures that involve the direct administration of the template speech pathology to the child.
Communication mode was not a significant predictor when the assessment was based on parent reports.

So, in summary, we found that, on average, children's language performance and speech production and functional performance were actually at around 1 standard deviation below the means of their normal hearing peers, and for speech production it was more like two standard deviations below their peers.

Coming back to the questions that we started off with in this presentation, does early intervention improve language and functional outcomes of children with hearing loss? We have created the LOCHI study, a population based study that is a prospective and non-continuing study—do provide solid evidence to say, yes, early intervention helps. Early fitting of hearing aids helps and early fitting of Cochlear implants help to improve outcomes of children with hearing loss.

What are the factors influencing their outcomes? Clearly, cognitive ability was a highly significant predictor of outcomes. Severity of hearing loss was only a significant predictor for children with hearing aids but not for children with Cochlear implants. We found that the presence of additional disabilities has a greater impact on children with Cochlear implants than those with hearing aids.
On the other hand, we found that maternal education levels has a greater impact on children with hearing aids and less so on children with Cochlear implants.

We also found that there was some significant effect of communication mode, but then that only applied to test measures that involved direct administration of the test, and not to those that require parent reports.

What have we learnt from the study? The clear evidence of the effectiveness of early intervention for improving child outcome is a very strong message for us that we need to streamline the clinical pathways to ensure that hearing aids are fitted early and that Cochlear implants are implanted early after diagnosis of hearing loss.

For this reason, Australian Hearing has actually streamlined its clinical protocols so that we are now able to refer children for Cochlear implantation well in advance, roughly by about six months of age, so that if a child needs a Cochlear implant, the child gets the Cochlear implant before 12 months of age.

Furthermore, we need to devise more efficient methods for paediatric Cochlear implant candidacy referral than is currently available.

We know that in adults people may be referred for Cochlear implantation on the basis of not only their audiograms but also on
the basis of their speech perception abilities. But in babies there is really currently no method, no standard clinical method, that we can actually use to assess the speech perception of the ability of an infant and be able to say that this child needs a Cochlear implant.

So, we're currently working on the research to come up with some measure using brain waves of children to help us decide whether the child could potentially have problems with learning speech at a very young age, hopefully at a few months old.

Furthermore, we clearly saw an impact of parental education levels or perhaps socioeconomic status of the families on the child's outcome. So, we need to be able to develop more effective ways than is currently available to better support those families, and to be able to help those children so they can be provided with additional intervention or improved methods of intervention to help them achieve the best possible outcomes commensurate with their cognitive potential.

This is the team who worked on the outcomes study. We acknowledge all the funding that we have received from the NIH, from the Commonwealth Government of Australia, and all of the support that we're getting from all of the early intervention agencies, the logos on this slide. I invite you to visit the outcomes website, which is given on this slide. We will be providing updates of the outcome study and you will also be able to learn a lot more about other aspects of the findings of the outcomes study on this website. Thank you very much for listening.
MELISSA: Thank you very much, Teresa. It's always so interesting to hear about the latest research that's coming out of the longitudinal outcomes for children with hearing impairment study. We do have a couple of questions already, which I'll get to momentarily. If there are any other questions out there, please feel free to just type them in the chat box and I'll ask them for you.

Also, just a quick reminder that today's event has been recorded and you will receive a link to the captioned presentation in approximately two weeks time.

So, Teresa, the first question that I have is around the age of Cochlear implantation and whether the average age of Cochlear implantation would have lowered over time. So, comparing the age of a child who is implanted in 2005 versus a more recent average age, did that factor into results of overall outcomes at all when the whole timeframe was aggregated?

TERESA: Absolutely. For those of you who may be interested, and you're very welcome to get in touch with me. I have a slide that clearly shows you the change in the age at Cochlear implantation. So, when we look at 2005, most of the children would not have received an implant until they are 12 to 15 months of age. So, if you imagine a distribution occur, you'd expect the peak to be, sort of, around 15 to 24 months at the time, and then a whole lot more children to be implanted much later than that.
If you imagine the same curve to be in 2015, then you see that peak actually around nine months of age. That's partly related to the benefits of the findings of this study that we are able to take advantage of universal newborn hearing screening, Australian Hearing modifying its clinical protocol for referral for Cochlear implantation. So, the peak is now really around nine months of age rather than the sort of 15 to 24 months of age that we saw earlier on. Clearly, there is a trend for implants to be put in much, much earlier than what we saw 10 years ago.

MELISSA: Great. Thank you. Another question is: which communication modes were used in the testing? Were children who were using mixed communication modes tested with oral assessment methods or were you using a mixed communication mode?

TERESA: The results that I showed today, they are based on language assessments that were administered. So, PLS and PPVT, that were administered using the standard administration procedures, that is, using the speech-only mode of communication.

I would qualify it to say that for those children who were using a mixed mode of communication we would only administer the test if there is evidence that the child was using speech only for more than 50 per cent of the time of communication at home and an early intervention. So, any child who is recorded as spending less time using speech only but more time using a mixed mode, they would have been assessed using a mixed mode, but their results would
have not been included in this presentation that I showed you earlier on.

MELISSA: Okay. Thank you for that, Teresa. I don't think we have any more questions, unless there's any last minute questions you want to get in. We might just take the opportunity to thank Teresa and Linda Couples again on behalf of RIDBC Renwick Centre. If you do have any other questions in the future, please feel free to email Teresa. There are some contact details there. We look forward to hearing the next installment of the LOCHI series later on.

TERESA: Thank you very much and thanks for your attention and thank you, Melissa, and thanks to the Royal Institute for Deaf and Blind Children for making this possible.