Author	Year of publication	Title	Country	Type of study	Perspective	N for CI group	NH control group	Exclusion criteria	Mean Age at testing in years (SD)	Age at identification in months (SD)	Mean Age at first implantation in months (SD)	% bilateral	Gender Female %	Mean IQ (SD)	Family variables	Family variable measures	Language outcomes linguistic dimension	Language measures	Main results
Boons et al.	2012	Predictors of spoken language development following pediatric cochlear implantation	Belgium	Cross-sectional Retrospective	288	No	Cognitive impairment (<80)	n.a.	9 (8)	26.4 (13.2)	18.8 (3 yr after first CI)	47	n.a.	Family involvement	Binary scale: parental involvement in rehabilitation	Vocabulary expressive Grammar expressive Global receptive	SELT Word development SELT Sentence development RDLS III	Family involvement (compliance) correlates sig. pos. with receptive language and word development two and three year after CI and non sig. pos. with sentence development
Boons et al.	2013	Expressive vocabulary, morphology, syntax and narrative skills in profoundly deaf children after early cochlear implantation	Belgium The Netherlands	Cross-sectional Prospective	70	Yes	Cognitive impairment (<80)	8.2 (MEDIAN), 3;10 (IQR)	n.a.	21.6 (MEDIAN) 22.8 (IQR)	39	56	n.a.	Family involvement Maternal education level	Expert questionnaire: Calderon 2000 Binary (high school or college/university)	Vocabulary expressive Vocabulary others Grammar expressive Social conversational skills	Expressive One Word Picture Vocabulary Test CELF Word Structure CELF formulating sentences Renfrew Language Scale (Bus Story)	Family involvement correlates sig. pos. with all language outcomes
Ceh et al.	2013	Early literacy gains in children with cochlear implants	USA	Cross-sectional Prospective	39	No	Implanted >24 months	5.78 (1.4)	5.7 (5)	15 (3.6)	n.a.	56	n.a.	Parental linguistic input quantity Parental linguistic input quality Parental income level	Frequency exposure to books Use of open ended questions while book reading Household annual income and parent education	Global receptive	OWLS or RDLS	Frequency of exposure to books at home and parental use of open ended questions correlate sig. pos. with language outcomes
Chen et al.	2015	A structural equation modeling approach to examining factors influencing outcomes with cochlear implant in mandarin speaking children	Mainland China	Cross-sectional Prospective	115	No	Cognitive impairment Multilingualism No other comorbidities bilateral CI	4.16 (1.05)	n.a.	32.04 (12.96)	0	n.a.	n.a.	Maternal education level	Years of education	Speech perception Vocabulary expressive	Single speech perception score (MAIS, MESP, MPSI) Total vocabulary score (Chinese CDI, CCDI, MERVT)	Direct and indirect effects of MEL on vocabulary (via age at implantation) Indirect effect of MEL on speech perception (via age at implantation)
Cruz et al.	2013	Identification of effective strategies to promote language in deaf children with cochlear implants	USA	Longitudinal Prospective	93	Yes	Cognitive impairment <70 (Bayley) or <66 (Leiter) Multilingualism	1.22 (0.48)	5.14 (5.36)	16.5 (4.78)	n.a.	46	n.a.	Parental linguistic input quality Parental income level	FLTs, MLUs, different word types Parental income	Global receptive Global expressive	RDLS verbal comprehension RDLS expressive language scale	Number of different word types correlates sig. pos. with receptive language Higher level FLT correlate sig. pos. with expressive language
Cuda et al.	2014	Pre-school children have better spoken language when early implanted	Italy	Cross-sectional Retrospective	30	No	No other comorbidities Multilingualism Cognitive impairment Etiology other than connexin 26 mutation	3	3.7 (1.4)	11.8 (3.2)	10	57	n.a.	Maternal education level	University, High School, Middle School	Vocabulary expressive Grammar expressive Grammar expressive	MCDI MCDI sentence complexity MCDI mean of three longest utterances	MEL correlates sig. pos. with child sentence complexity
Cupples et al.	2016	Language and speech outcomes of children with Australia hearing loss and additional disabilities: identifying the variables that influence performance at five years of age	Australia	Cross-sectional Prospective	49	Yes	No other comorbidities	n.a.	n.a.	20 (13.1)	17.8	n.a.	n.a.	Maternal education level Parental income level	University, diploma or certificate, ≤12 years of schooling IRSAD	Speech production Vocabulary receptive Global receptive Global expressive	DEAP (subtest phonology) PPVT-4 CDI- receptive & PLS-4 receptive CDI expressive & PLS-4 expressive	MEL correlated non sig. pos. with language outcomes
DesJardin et al.	2009	Literacy skills in children with cochlear implants: the importance of early oral language and joint storybook reading	USA	Longitudinal Prospective	16	No	Cognitive impairment Other comorbidities	4.42 (1.05)	9.8 (6.71)	25.9 (6.93)	n.a.	56	n.a.	Parental linguistic input quality Parental income level	FLTs during story book reading Household annual income	Vocabulary expressive	OWLS	Parental use of recasts correlates sig. pos. with child oral vocabulary
Geers et al.	2003	Language skills of children with early cochlear implantation	USA Canada	Cross-sectional Retrospective	181	No	Cognitive impairment Multilingualism Other comorbidities	8.11 (0.6)	4 (8)	41 (10)	n.a.	50	102 (14.5)	Family involvement (participation in therapy) Parental income level Family size	Parent questionnaire Standardized sum of the ratings for family income and education All family members	Global expressive	Composite Score (IPSyn NP, IPSyn VP, IPSyn QN, IPSyn SS, Types, Morph, WD/Utt)	Smaller family size and parental income level correlated sig. pos.with spoken language and total language (controlled for child age, age at implant, age at onset, gender, IQ)
Geers et al.	2009	Spoken language scores of children using cochlear implants compared to hearing age mates at school entry	USA	Cross-sectional Prospective	153	No	Cognitive impairments70 Age at onset >20 months Duration of CI use >12 months Not enrolled in auditory verbal intervention programs	5.1 (0.6)	2.09 (5.75)	28 (11)	2.6	n.a.	105.6 (15.5)	Parental education level	Highest parent education in years	Vocabulary expressive Vocabulary receptive Global receptive Global expressive	EOWPVT or EVT PPVT- or ROWPVT CELF receptive CELF expressive	MEL correlates sig. pos. with expressive and receptive vocabulary and receptive and expressive language (controlled for gender, age at implant, PIQ)
Geers et al.	2011	Epilogue: factors contributing to long-term outcomes of cochlear implantation in early childhood	USA Canada	Longitudinal Prospective	112	Yes	Cognitive impairment <70 Multilingualism Other comorbidities	16.7 (0.6)	n.a.	39.6	n.a.	53	103.1	Parental education level Family size	In years All family members	Speech perception Speech production Global expressive receptive combined	Composite Score CI-E (LNT, Average ESP, BKB Sentences, WIPI) Composite Score CI-HS (LNT, BKB Sentences quiet, BKB sentences noise) Composite Score CI-E (High context keywords, low context keywords, transcribed consonant production, use of speech questionnaire) Composite Score CI-HS (High context keywords noise, low context keywords noise, high context keywords understood, low context keywords understood, transcribed consonant production) Composite Score CI-E (WISC similarities, different words/minute, words/utterance, IPSYN, TACL) Composite Score CI-HS (Best PPVT Scaled score, EOWPVT scaled score, CELF language content index, WISC Verbal IQ)	Smaller family size and parental income level correlate sig. pos. with speech perception, speech production, language (controlled for gender, PIQ)
Guerzoni et al.	2016	Social conversational skills development in early implanted children	Italy	Cross-sectional Prospective	28	No	Cognitive impairment Multilingualism Other comorbidities CI >2 year <12 months CI experience other than auditory verbal therapy, hearing impaired parents, Inner ear malformations	2.16 (0.38)	4.9 (3.9)	13.3 (4.2)	18	46	n.a.	Parental education level	Number of years legally required	Vocabulary expressive Social conversational	MCDI Words and Sentences Social Conversational Skills rating scale	MEL correlates non. sig. pos. with vocabulary and social conversational
Holt & Svirsky	2008	An exploratory look at pediatric cochlear implantation: is earliest always best	USA	Longitudinal Prospective	96	No	Cognitive impairment Other comorbidities	n.a.	0	Group1: 10.2 Group2: 18.6 Group 3: 29.9 Group 4: 40.8	n.a.	Group1: 50 Group2: 41 Group3: 49 Group4: 48	n.a.	Parental income level	Indirect measure of family income TIGER database	Speech perception Global receptive Global expressive	Mr Potato Head Word recognition RDLS III receptive or MCDI RDLS III expressive or MCDI	Parental income level correlates sig. pos. with receptive vocabulary (controlled for age at implantation)
Holt et al.	2013	Developmental effects of family environment on outcomes in pediatric cochlear implant recipients	USA	Cross-sectional Retrospective	59	No	Cognitive impairment Other comorbidities	Preschool: 3.3 (1.2) School: 10.7 (3.5)	n.a.	Preschool: 16.8 (7.2) School: 31.2 (16.8)	30.5	Preschool: 35 School: 49	n.a.	Family values Family relationships Maternal education level	FES FES family relationships <high school, high school, < bachelor, bachelor	Vocabulary receptive Global receptive Global expressive Global expressive receptive combined	PPVT-4 PLS-4 comprehension PLS-4 expressive PLS-4 or CELF	Lower levels of control and higher levels of organisation within the family correlate sig. pos. with larger receptive vocabularies
Huber & Kipman	2012	Cognitive skills and academic achievement of deaf children with cochlear implants	Austria	Cross-sectional Prospective	40	Yes	Onset of deafness later than 24 months Hearing experiences with CI below 3 years	10.1 (1.3)	85% congenitally deaf	27.6 (14.4)	37.5	53	<8.5y=102.7 (13.7) >8.5y=104.2 (12.8)	Education level father and mother 4 levels Skill level father and mother 4 levels	Vocabulary expressive	HAWIK-3 vocabulary	Maternal skill level correlated non. sig. pos. with vocabulary expressive
Ketelaar et al.	2017	Children with cochlear implants and their parents: relations between parenting style and childrens social-emotional functioning	The Netherlands	Cross-sectional Prospective	46	Yes	No exclusion criteria	3.14 (1.18)	n.a.	16 (6.7)	50	39	Gross motor: 0.68 (0.23) Fine motor: 0.65 (0.22) on CDI	Parenting style Parental income level Maternal education level	positive parenting scale, negative parenting scale, uninvolved parenting scale Net household income 4 levels	Vocabulary expressive Grammar expressive Global receptive Global expressive	SELT word production SELT sentence production CDI comprehension and Reynell Comprehension CDI expressive	Negative parenting and uninvolved parent affect correlate with language comprehension MEL correlates non. sig. with global expressive language
Klein & Wie	2015	Long-term predictors of narrative skill in children with early bilateral cochlear implants	Norway	Longitudinal Prospective	21	No	Cognitive impairment Other comorbidities Not implanted bilateral simultaneously between 2004 and 2007 in Norway	7.05 (0.3)	n.a.	11.5 (4.1)	100	48	n.a.	Family involvement Parental linguistic input quantity Mode of communication	Frequency of parent counseling Amount of parent focus on speaking and listening Primary oral mode of parental communication	Social conversational	Renfrew Bus story	Parent spoken language focus and frequency of parent counseling at 9 months and use of auditory verbal language correlate sig. pos. with narrative skills
Moreno-Torres et al.	2016	Sensitive periods and language in cochlear implant users	Spain	Longitudinal Prospective	14	Yes	Cognitive impairment Multilingualism	n.a.	within first 3 months of life	17.2 (2.2)	28.57	36	n.a.	Family involvement Maternal education level	Moeller Family Participation Rating Scale 3 levels	Speech production Vocabulary expressive Grammar expressive	Combination 4 tasks MacArthur parental questionnaire Sentence repetition	Parental education correlates sig. pos. with vocabulary (12 months) and phonology (24 months) and correlates sig. pos. with grammar (36 months)
Murri et al.	2015	Narrative abilities in early implanted children	Italy	Cross-sectional Retrospective	30	No	Cognitive impairment Multilingualism Other comorbidities	5.25 (0.02)	7.2 (5.2)	14.7 (5.3)	26.7	70	n.a.	Parental education level	In years	Social conversational	Renfrew Bus Story Total information score, mean length of sentences, complexity	Family involvement correlates sig. pos. with narrative complexity MEL correlates sig. pos. with narrative complexity
Quittner et al.	2013	Effects of maternal sensitivity and cognitive and linguistic stimulation on cochlear implant users language development over four years	USA	Longitudinal Prospective	188	Yes	Cognitive impairment Multilingualism	2.22 (1.21)	10.56 (10.56)	n.a.	n.a.	52	96.5 (21.2)	Parenting style Parental income level Parental education level	Videotapes household income >50,000 5 levels	Global expressive receptive combined	CDI Words and Gestures+CDI Words and Sentences +RDLS Verbal Comprehension	Maternal sensitivity and linguistic stimulation predicts increases in oral language growth Linguistic stimulation is related to language growth only in context of high maternal sensitivity
Rüter	2011	Influence of expansions on grammar acquisition in children with cochlear implants	Germany	Longitudinal Prospective	21	No	Cognitive impairment Multilingualism Other comorbidities Bilateral (deaf/HoH parents)	n.a.	n.a.	30	0	52	n.a.	Parental linguistic input quantity	CHILDES	Grammar expressive	CHILDES transcriptions of spontaneous language	Parental expansions correlates sig. pos. with child grammar acquisition
Sarant & Garrard	2014	Parenting stress in parents of children with cochlear implants: relationships among parent stress, child language and unilateral versus bilateral implants	Australia	Cross-sectional Prospective	70	No	Cognitive impairment	6.6 (1.4)	7.5 (7.5)	18.6 (9.6)	77.1	49	104.3 (12.3)	Family involvement Parental stress Parental higher education 6 levels	Moeller Family Participation Rating Scale Parental Stress Index	Vocabulary receptive Global receptive Global expressive Global expressive receptive combined	PPVT-4 PLS-4 PLS-4 EL PLS-4 total language; CELF-4 Core	Parent stress levels correlate sig. neg. with language outcomes Family involvement correlates sig. pos. with language outcomes
Sarant et al.	2014	Bilateral versus unilateral cochlear implants in children: a study of spoken language outcomes	Australia	Cross-sectional Prospective	91	No		n.a.	6.68 (7.46)	Bilateral: 16.44 (9) Unilateral: 23.88 (9.96)	73.63	52	Bilateral: 105.36 (13.13) Unilateral: 103.67 (12.07)	Family involvement Parental linguistic input quantity Parental education level Screen time	Moeller Family Participation Rating Scale Adult reading time Tertiary educated Hours/week	Vocabulary receptive Global receptive Global expressive Global expressive receptive combined	PPVT-4 PLS-4 PLS-4 EL PLS-4 Total Language; CELF-4 Core	High parental involvement, low screen time and more time spend reading to children correlate pos. with vocabulary and language outcomes
Szagun	1997	A longitudinal study of the acquisition of language by two German-speaking children with cochlear implants and of their mothers' speech	Germany	Longitudinal Retrospective	2	No		3.10	0.8	2.9		50	n.a.	Parental linguistic input quality	mothers degree of exaggerated intonation degree of clarity of segmentation frequency of pragmatic categories	Grammar expressive Social conversational	MLU, morphological marking, distribution of pragmatic categories	Substantial differences in child language outcomes and mother's speech between the two cases. No indication for a direct influence of maternal language on children's language development, since changes in maternal language do not precede developmental changes in child language.
Szagun & Stumper	2012	Age or experience? The influence of age at implantation and social and linguistic environment on language development in children with cochlear implants	Germany	Longitudinal Prospective	25	No	n.a.	n.a.	0	20.4 (11)	16	48	n.a.	Parental linguistic input quality Maternal education level	CHILDES parental expansions Maternal education in years	Vocabulary expressive Grammar expressive Grammar receptive	CDI+CHILDES wordtypes CDI MLU	Higher MEL, maternal MLU and maternal expansions correlate sig. pos. with child linguistic progress (independently of age at CI)
Szagun & Schramm	2016	Sources of variability in language development of children with cochlear implants: age at implantation, parental language, and early features of children language construction	Germany	Longitudinal Prospective	48	No	Cognitive impairment Multilingualism Other comorbidities	n.a.	n.a.	24 (1.2)	n.a.	50	n.a.	Parental linguistic input quality	Parental expansions	Vocabulary expressive Grammar expressive Grammar expressive	Type frequencies of lexical words MLU in morphemes Type and toke frequencies of determiners	Parental expansions at 11 to 12 months post CI correlate sig. pos. with child MLU at 24 at 30 months post CI (controlled for age at implantation)
Yanbay et al.	2014	Language outcomes for children with cochlear implants enrolled in different communication programs	Australia	Longitudinal Retrospective	42	No	Cognitive impairment Other comorbidities	AO: 4.86 (1.16) SS: 4.65 (1.18) AVT: 4.78 (1.19)	AO: 5.04 (4.56) SS: 8.16 (8.04) AVT: 4.08 (5.28)	AO: 14.52 (8.64) SS: 18.36 (9.6) AVT: 12.48 (5.76)	70.45	55	n.a.	Family involvement Other comorbidities	Moeller Family Participation Rating Scale IRSAD	Vocabulary receptive Global receptive Global expressive	PPVT-4 PLS-4 PLS-4 EC	Family involvement correlates sig. pos. with all language outcomes Parental income level correlates non sig. pos. with expressive communication

AO=auditory-oral; AVT=auditory-verbal therapy; CASL= Comprehensive Assessment of Spoken Language; CCDI= Chinese Communicative Development Inventories; CDI=Communicative Development Inventories; CELF 4=Clinical Evaluation of Language Fundamentals Fourth Edition; CH=Cochlear Implant; DEAP=Diagnostic Evaluation of Articulation and Phonology; EOWPVT= Expressive One-Word Picture Vocabulary Test; EVT=Expressive Vocabulary Test; FES=Family Environment Scale; FLTs=Facilitative Language Techniques; IRSAD= Index of Relative Socio-economic Advantage and Disadvantage; IQR=interquartile range

HAWIK-III= Hamburg-Wechsler-Intelligenztest für Kinder Third Edition; IPSyn NP=Index of productive Syntax Noun Phrase; IPSyn VP=Index of productive Syntax Verb Phrase; IPSyn QN=Index of productive Syntax Question/Negation; IPSyn SS=Index of productive Syntax Sentence Structure; MAIS=Meaningful Auditory Integration Test; MCDI=MacArthur-Bates Communicative Development Inventories; MEL=Maternal education level; MERVT= Mandarin Expressive and Receptive Vocabulary Test; MESP= Mandarin early speech perception test; MPSI=Mandarin pediatric speech intelligibility test;
MLU=Mean Length of Utterance; Morph=Number of bound morphemes; OWLS=Oral and Written Language Scales; PIQ=Performance Intelligence Quotient; PLS-4=Preschool Language Scale Fourth Edition; PLS-4 EC=Preschool Language Scale Expressive Communication Fourth Edition; PPVT-4=Peabody Picture Vocabulary Test Fourth Edition; pos=positive; RDLS=Reynell Developmental Language Scales; ROWPVT=Receptive One-Word Picture Vocabulary Test; SELT=Schlichting Expressive Language Test; SES=Socio-economic Status; sig=significant; SL=sign and spoken language; TIGER=Topologically Integrated Geographic Encoding and Referencing; Types=Number of different words; WD/Utt=Words per Utterance